SRI SATHYA SAI INSTITUTE OF HIGHER LEARNING

(Deemed to be University)

SYLLABUS FOR
M.Sc. BIOSCIENCES

(Effective from 2018 – 2019)

DEPARTMENT OF BIOSCIENCES

Unit-wise Syllabus for Two Year M.Sc. (Biosciences) Programme

Introduction:

The two-year Post-graduate programme in M.Sc. (Biosciences) is an advanced course that leverages and further builds on the fundamentals taught in our three-year B. Sc. (Hons) in Biosciences program. During the first year (two semesters) the emphasis is on acquainting the student with contemporary knowledge of various areas of modern biology. In the second year the objective is to expose the student to highly specialized and applied areas. Theory courses are complemented by respective practical courses. The programme offers a range of electives and also includes a project work in lieu of two practical courses.

Program Outcomes:

Student passing through the Master of Science (M.Sc.) program in the institute would:

1. receive sound knowledge and understanding of the basic principles of Science
2. possess necessary competency to pursue a career in academia, research institutions or industry in basic or applied sciences
3. achieve proficiency in use of various scientific instruments and be in a position to design, plan and execute sophisticated experimental protocols
4. acquire good oral and written communication skills and be ready to take on competitive examinations both at national and international levels.
5. develop into an individual with a right balance of scientific temper and ethics
6. grow up into a self-confident individual with innovative ideas and entrepreneurial spirit

Programme Specific Outcomes:

1. The two-year M. Sc. (Biosciences) program Equips the student with thorough knowledge in a wide range of sub-disciplines of Biosciences.
2. Courses like Molecular Biology, Molecular Cell Biology, Biochemistry and Immunology studied during the first year help the student to gain in-depth understanding of the way the organism functions at the molecular level.
3. Advanced courses such as Molecular Developmental Biology, Genetic Engineering Instrumentation for Biological Applications and Bioinformatics endow the student with ability to think in terms of translating basic knowledge in to useful technologies.
4. Specialized courses such as Cytogenetics & Plant Breeding, Molecular Evolution & Human Genetics and Plant Systematics & Conservation Biology; Elective courses in the domains of Biotechnology and Structural Biology promote innovation and encourage innovative thinking towards developing solutions to emerging challenges.

5. Practical courses corresponding to theory courses provides the student with adequate training to hone their laboratory skills and prepare to take up higher studies in any field of biological sciences or join industry.

6. Project work undertaken in the final two semesters of the programme (in lieu of two practical courses) enables the student to take up focused research that may get published in scientific journals.
7.The breadth and depth of the syllabus and evaluation process prepares the student to confidently face any national and international competitive examinations like CSIR-UGC NET, GATE, Subject specific GRE etc,

SRI SATHYA SAI INSTITUTE OF HIGHER LEARNING

(Deemed to be University)

M.Sc. (Biosciences) SYLLABUS
and
SCHEME OF INSTRUCTION AND EVALUATION

(Effective 2018-19 batch onwards)

Paper Code	Title of the Paper	Credits	Hours	Mode of Evaluation	Theory / Practicals	Maximum Marks
Semester I						
PBIO-101	Molecular Cell Biology	4	4	IE2	T	100
PBIO-102	Molecular Biology	4	4	IE2	T	100
PBIO-103	Instrumentation for Biological Applications	4	4	IE2	T	100
PBIO-104	Immunology	4	4	IE2	T	100
PBIO-105	Practical Course - 1	1	3	I	P	50
PBIO-106	Practical Course - 2	1	3	I	P	50
PBIO-107	Practical Course - 3	1	3	I	P	50
PBIO-108	Practical Course - 4	1	3	I	P	50
PAWR-100	Awareness Course – I: Education for Life	1	2	I	T	50
		21 Credits	**30** hours			**650** marks
Semester II						
PBIO-201	Molecular Developmental Biology	4	4	IE2	T	100
PBIO-202	Genetic Engineering	4	4	IE2	T	100
PBIO-203	Biochemistry of Macromolecules	4	4	IE2	T	100
PBIO-204	Bioinformatics	4	4	IE2	T	100
PBIO-205	Practical Course - 5	1	3	I	P	50
PBIO-206	Practical Course - 6	1	3	I	P	50
PBIO-207	Practical Course - 7	1	3	I	P	50
PBIO-208	Practical Course - 8	1	3	I	P	50
PAWR-200	Awareness Course – II: God, Society and Man	1	2	I	T	50
		21 Credits	**30** hours			**650** marks

Paper Code	Title of the Paper	Credits	Hours	Mode of Evaluation	Theory / Practicals	Maximum Marks
Semester III						
PBIO-301	Intermediary metabolism	**4**	4	IE2	T	100
PBIO-302	Plant Systematics and Conservation	**4**	4	IE2	T	100
PBIO-303	**Elective - I***	**3**	3	IE2	T	100
PBIO-304	**Elective - II***	**3**	3	IE2	T	100
PBIO-305	Practical Course - 9	**3**	9	I	P	100
PBIO-406	Project Work (Review)** (see note below)	**Non-Credit#**	2	I	PW	50**
PAWR-300	Awareness Course – III: Guidelines for Morality	**1**	2	I	T	50
		18# Credits	**27** hours			**600** marks
Semester IV						
PBIO-401	Molecular Evolution and Human Genetics	**4**	4	IE2	T	100
PBIO-402	Cytogenetics and Plant Breeding	**4**	4	IE2	T	100
PBIO-403	**Elective - III***	**3**	3	IE2	T	100
PBIO-404	**Elective - IV***	**3**	3	IE2	T	100
PBIO-405	Practical Course-10	**3**	9	I	P	100
PBIO-406	Project Work in lieu of two Practicals*** (see note below)	**6#**	18	E2	PW	200 ***
PAWR-400	Awareness Course –IV: Wisdom for Life	**1**	2	I	T	50
		18# Credits	**25** hours			**550** marks
	GRAND TOTAL	**78** Credits	**112** hours			**2450** marks

Modes of Evaluation

Indicator	Legend
IE1	CIE and ESE ; ESE single evaluation
IE2	CIE and ESE ; ESE double evaluation
I	Continuous Internal Evaluation **(CIE)** only Note: 'I' does not connote 'Internal Examiner'
E	End Semester Examination **(ESE)** only Note: 'E' does not connote 'External Examiner'
E1	ESE single evaluation
E2	ESE double evaluation

Continuous Internal Evaluation (CIE) & End Semester Examination (ESE)

Types of Papers

Indicator	Legend
T	Theory
P	Practical
V	Viva voce
PW	Project Work
D	Dissertation

PS: Please refer to guidelines for 'Modes of Evaluation for various types of papers', and Viva voce nomenclature & scope and constitution of the Viva-voce Boards.

Note - 1: The electives offered are at the discretion of the Head of the Department.
2: Any student can choose to take Project Work in lieu of one Practical each in 3rd and 4th semesters.

Credit structure in Semesters III and IV for students opting for project work (PBIO-406) in lieu of practicals (PBIO-305 and PBIO-405):
Total Credits in Semester III: 15 credits
Total Credits in Semester IV: 21 credits

* **Students must opt from the following electives:**
BT-1: Mycology, Pathology and Fungal Biotechnology
BT-2: Plant Biotechnology
BT-3: Microbial Biotechnology
BT-4: Environmental Biotechnology
BT-5: Biotechnology of Secondary Metabolites
BT-6: Biomolecular Structure and Function

** The Project Work topic would be finalized by the end of the second semester, and the Project Work starts in the third semester and culminates in the fourth semester. The work progress in the third semester is reviewed based on an interim report submitted by the student and is evaluated for 50 marks; which is later included as part of the total marks of 200 in the fourth semester.

*** Total marks for the Project Work would be **200 marks**, which includes **50 marks** for the interim report submitted by the student at the end of the third semester (please see ** above) + **50 marks** for the Project Work Viva-Voce conducted at the end of the 4th semester + **100 marks** for the double evaluation of the Project Report submitted at the end of the fourth semester.

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PBIO-101 **(4 CREDITS)**

MOLECULAR CELL BIOLOGY

Course Objective: This course deals with molecular mechanisms underlying cell structure and functions.

Course Outcomes: The course helps the student to understand and appreciate different techniques employed to discern the cellular process, their function and regulation and hence their relevance from the perspective of biology of cell as a unit of life. It makes the student understand:

1. the mechanism of action of transporters and channels
2. the structure and mechanism of molecular motors
3. membrane fusion and its implication during exocytosis or endocytosis
4. mechanisms of intracellular transport of cargo to different compartments
5. extracellular and intracellular signalling
6. programmed cell death and its importance in health and disease
7. the mechanism and regulation involved in cell divisions and their regulation or check points with implications for various diseases.

1. Membrane Transport mechanisms: Principles of membrane transport; Types of carrier proteins and active membrane transport (Na+ and K+ pump, Ca++ pump, H+ pump); Ion channels - Family of membrane transport proteins. **6hrs**
2. Protein sorting: Transport of molecules between nucleus and cytosol; Transport of proteins to cellular organelles (ER, Mitochondria, Chloroplast etc). **5hrs**
3. Intra-vesicular traffic: Transport vehicles, SNAREs, Clathrin coat assembly; Transport from ER to Golgi and then to lysosomes; Molecular basis of endocytosis and exocytosis. **7hrs**
4. Cellular Communication: Types of extra cellular signal molecules and their binding mechanisms. Intracellular signalling. Types of signalling pathways: G-protein linked cell surface receptor mediated system, Enzyme-linked cell surface receptors; Signalling in plants. **7hrs**
5. Molecular Motors: Molecular motor protein super family; Movement of myosin along actin filaments; Movement of Kinesin and Dynein along microtubules. **7hrs**
6. Cell Junctions, Cell adhesion and extra cellular matrix (ECM)
   a. Cell Junctions: Types, molelcular basis and functions. **3hrs**
   b. Cell-Cell adhesion - Cadherins, Selectins, their mechanisms and functions. **3hrs**
   c. ECM: Glycosaminoglycans (GAG), Collagens, Elastin, Fibronectin, Basal- lamina, their structure and functions. **4hrs**
7. Cell Death: Apoptosis, Mechanisms of cellular death. Regulation of Programmed Cell Death. **5hrs**
8. Cell Cycle: Cyclins and CDKs- their types and pathways. Molecular basis of G1/S Check point and of G2/M Checkpoint. **5hrs**

Basic texts:

1. Alberts, B. (2008). *Molecular Biology of the Cell*. Garland Science.
2. Berg, J. M., Tymoczko, J. L., & Stryer, L. (2002). *Biochemistry, Fifth Edition*. W.H. Freeman.
3. Cooper, G. M., & Hausman, R. E. (2004). *The Cell: A Molecular Approach*. ASM Press.

Additional reading:

1. Lodish, H. (2008). *Molecular Cell Biology*. W. H. Freeman.
2. Gilbert, S. F., & Singer, S. R. (2006). *Developmental biology*. Sinauer Associates, Inc. Publishers.

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PBIO-102 **(4 CREDITS)**

MOLECULAR BIOLOGY

Course Objective: This course deals with gene expression and regulation systems among prokaryotes and eukaryotes.

Course Outcomes: Upon completion, the student will be able to understand:

1. the differences between prokaryotic and Eukaryotic gene expression
2. the concept of operon along with positive and negative gene regulation in prokaryotes
3. various types of RNA's and their processing in Eukaryotes
4. aspects of transcriptional, post transcriptional gene regulation and post translational regulation in Eukaryotic systems
5. mechanisms of DNA damage and repair in prokaryotic and Eukaryotic systems
6. and gain insights into the mechanisms of DNA recombination

1. Regulation of Gene expression in Prokaryotes: Control of gene expression at Transcription; Sigma cascade (stress response in *Salmonella typhemurium*), two-component regulatory system, heat shock genes; Operon concept; Positive and negative regulatory switches – Tryptophan operon, Arabinose operon and Galactose operon. **9hrs**
2. Gene expression and processing in Eukaryotes: mRNA transcription; Processing (splicing) of pre mRNA, rRNA and pre tRNA, Overview of RNA editing. **7hrs**
3. Eukaryotic gene regulation at transcriptional level:
    a. Control of gene expression at chromatin level: Chromatin remodelling – HATs, HDAC, histone methylation, phosphorylation and DNA methylation. **2hrs**
    b. Control of gene expression at transcription: Protein – DNA interactions –general and specific transcription factors- structure of Zn fingers, Helix-turn-helix, Leucine Zippers, Helix-loop-Helix and Homeodomain; Nucleocytoplasmic mRNA transport. **7hrs**
    c. Control of gene expression by RNA processing- mRNA - alternate splicing (Drosophila sex differentiation), editing (*trypanosome*-cox II gene), trans- splicing (*C. elegans/ trypanosome)* and self-splicing - Intron types. **5hrs**
4. Post transcriptional regulation in Eukaryotes:
    a. mRNA stability (histone mRNA, ferritin and transferrin receptor mRNA), RNAs in gene regulation – **4hrs**
    b. Translational regulation: TOR pathway, EIF2 kinases; post-translational modifications and protein degradation - **5hrs**
5. DNA Repair and Damage: DNA damage (mutagenic and carcinogenic), Loss of function mutations, gain of function mutations; DNA repair mechanisms: Base excision repair, Nucleotide excision repair; Mismatch-repair system, SOS repair system - **7hrs**
6. Genetic Recombination: Molecular mechanisms of Homologous; and site specific recombination - **6hrs**

Basic texts:

1. Lewin, B. (2008). *Genes 9*. Jones & Bartlett Learning.
2. Alberts, B. (2008). *Molecular Biology of the Cell: Reference edition*. Garland Science.

3. Berg, J. M., Tymoczko, J. L., & Stryer, L. (2002). *Biochemistry, Fifth Edition*. W.H. Freeman.

Additional reading:

1. Watson, J. D. (2008). *Molecular Biology of the Gene*. Pearson/Benjamin Cummings.
2. Lodish, H. (2008). *Molecular Cell Biology*. W. H. Freeman
3. Malacinski, G. M. (2003). *Essentials of Molecular Biology*. Jones and Bartlett.
4. Allison, L. A. (2007). *Fundamental Molecular Biology*. Wiley.

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PBIO-103 **(4 CREDITS)**

INSTRUMENTATION FOR BIOLOGICAL APPLICATIONS

Course Objective: This course deals with bio-analytical methods and their biological applications.

Course Outcome: Upon completion, the student will

1. become familiar with the working principle of electron microscopy and confocal microscopy techniques.
2. Understand the principles of purification of small and large biomolecules using liquid chromatography techniques.
3. understand the working principles of spectroscopic techniques.
4. become conversant with the fundamentals of electrochemical cell and radioactivity.
5. become acquainted with the working principle of various mass spectrometers.
6. understand the principles of Nuclear magnetic spectroscopy.
7. learn the fundamental principles of Biosensors.

1. Microscopy: Principles and working of fluorescence microscope, confocal microscope, Electron Microscopes -TEM and SEM; Preparation of specimens for electron microscopy. **6hrs**
2. Chromatographic Techniques: Principle of separation and applications of RP HPLC, Size-exclusion, Affinity chromatography; Gradient elution. **6hrs**
3. Electrophoretic Techniques: General principles, applications and factors effecting electrophoresis of Native-PAGE; Isoelectric focusing (IEF) - pH gradient gels, Two Dimensional Gel Electrophoresis (2-DE) Blotting Techniques: Western, Northern and Southern Blots. **6hrs**
4. Spectroscopic Techniques: Principles, instrumentation and application of FTIR, MS and CD. **6hrs**
5. Fluorescence methods: fluorescent assorted cell sorting (FACS) - magnetic assisted cell sorting (MACS). **3hrs**
6. Electrochemical Techniques: Preparation of Buffers using Henderson-Hasselbalch equation, Kinds of buffer, Physiological saline; Nernst equation; Ion selective electrodes (Calcium or Fluoride); Principles of Biosensors, Dialysis and ultra-filtration. **6hrs**
7. Tracer Techniques: The nature of radioactivity, Units of radioactivity; Detection and measurement of radioactivity - liquid scintillation counting – Basic principles of radioactive labeling. **4hrs**

8. Centrifugation Techniques: Overview of principles of sedimentation; Density gradient centrifugation –principle and applications; Applications of preparative and analytical ultracentrifuges. **4hrs**
9. Nuclear Magnetic Resonance: General principles of NMR phenomenon; classical description of NMR-NMR parameters- intensity, line width, relaxation parameters, spin-spin coupling-Nuclear over Hauser effect; Application in biological sciences. **6hrs**
10. Biosensors – components and working principle of a typical Biosensor. Types of Biosensors – Electrochemical, Optical, Whole-cell and Immuno-biosensors. Methods of bio-receptor immobilization. Examples of Biosensors. **5hrs**

Basic texts:

1. Wilson, K., & Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press.
2. Boyer, R. (2000) *Modern Experimental Biochemistry*. Pearson Education.
3. Kumar, P. (2016). Fundamentals and Techniques of Biophysics and Molecular Biology. Pathfinder Publications.
4. Pattabhi, V., & Gautham, N. (2009). *Biophysics*. Alpha Science International.

Additional reading:

1. Subramanian, M. A. (2008). Biophysics: Principles and Techniques. Neha Publishers & Distributors.
2. Skoog, D. A., Holler, F. J., & Nieman, T. A. (1998). *Principles of Instrumental Analysis*. Saunders College Publishers.

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PBIO-104 **(4 CREDITS)**

IMMUNOLOGY

Course objective: This course deals with cellular and molecular processes that represents the human immune system

Course Outcomes: Upon completion, the student will be able to

1. have an understanding of the types of blood cells and identify organs that make up the immune system.

2) have a comprehensive understanding of the cellular and the molecular basis of immune responsiveness.

3) develop an understanding about the role of the immune system in both maintaining health and contributing to disease.

4) understand and explain the basis of hypersensitive reactions, involvement of immune system in cancer, role of immune system in transplantation.

1. Overview of the Immune system: Cells and organs of Immune system; Innate and adaptive Immunity- Cells and Molecules involved in innate and adaptive Immunity **3hrs**
2. Antigens: Antigen processing and presentation - Antigens- antigenicity and immunogenicity, epitopes- B cell and T cell epitopes, haptens - **2hrs** - Role of Ag presenting cells; Evidence of two processing and presentation pathway (Endogenous and Exogenous pathway of Ag processing and presentation; Cross presentation of non-peptide Antigens **3hrs**

3. Antibody: Antibody structure and function, Antibody Engineering, Isotypes, allotypes, idiotypes, immunoglobulins superfamily - **2hrs** - Organization and expression of Ig genes: Generation of antibody diversity, germ line theory and somatic hypermutation theory - **3hrs** - Immunoglobulin genes, somatic recombination of V D J gene segments **2hrs** – Monoclonal antibodies in Cancer treatment – Autoimmune disorders – Recombinant antibodies (scFv) **3hrs**
4. Major histocompatibility complex: Structure and function of MHC molecules; General organization and inheritance of MHC Class I, II and III molecules and genes (Details genomic maps) - **2hrs** - Role of the MHC and expression patterns; Cellular distribution and regulation of MHC molecules; MHC and immune responsiveness, MHC and disease susceptibility **3hrs**
5. T cell receptor complex-T cell accessory membrane molecules; CD3 -TCR membrane complex; CD4 and CD8 accessory molecules; CD2, LFA1 - **3hrs** - Role of thymus in T cell maturation and selection; Peripheral T cell subpopulations characterized by the expression of T cell receptors **2hrs**
6. Generation of humoral response; Identification of cells required for induction of humoral immunity; Use of hapten-carrier conjugates to study cellular interactions - **2hrs** - steps in B cell activation, proliferation and differentiation. Changes characterizing secondary humoral response **3hrs**
7. Cell mediated immunity and lymphokines: Activation and Differentiation of Tcells - **2hrs** - T helper cells and CTL, general properties of cytokines and chemokines - **1hr** - classification of cytokines and associated receptor molecules - **2hrs** - Signaling pathways for proinflammtory cytokines (IL-1 and IL-17, and TNF-alpha superfamily of receptors), cytokine antagonists and cytokine related diseases **2hrs**
8. Complement system: Classical, alternative and lectin pathways; Formation of membrane attack complex, biological consequences, complement deficiencies **4hrs**
9. Hypersensitivity-Gel and Coombs classification, IgE mediated hypersenstivity, General outlines of type I, II, III and IV hypersensitivity **3hrs**
10. Clinical immunology: Transplantation immunology, inflammation - **2hrs** - Tumor Immunology, Congenital and acquired Immunodeficiency diseases **2hrs** – Immunotherapeutics and its applications **1hr**

Basic texts:

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2007). *Kuby Immunology*. W. H. Freeman.
2. Murphy, K. P., Travers, P., Walport, M., & Janeway, C. (2008). *Janeway's Immunobiology*. Garland Science.

Additional reading:

1. Male, D., Brostoff, J., Roth, D., & Roitt, I. (2012). *Immunology*. Elsevier Health Sciences UK.

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PBIO-105 **(1 CREDIT)**

PRACTICAL COURSE – 1

(Related to theory course PBIO 101 - Molecular Cell biology)

(Minimum of SIX experiments; 1-3 mandatory)

Course Objective: This laboratory course introduces students to safety protocols and study of proteins and enzymes.

Course Outcome: Upon completion the student will become conversant with

1. concepts of laboratory safety
2. understand the importance of documentation of material safety data sheets
3. become familiar with safe disposal of chemical wastes.
4. Analysis of proteins extracted from various sources.

1. Laboratory safety- Handling toxic, carcinogenic, acidic and basic chemicals
2. Material safety data sheet for the chemicals in the laboratory (Ethidium bromide, SDS-PAGE chemicals etc.)
3. Safe disposal of chemicals and be responsible for the society
4. Isolation of erythrocyte ghost
5. Study of erythrocyte membrane proteins by SDS-PAGE
6. Study of serum proteins by SDS-PAGE
7. Analysis of isozymic patterns of peroxidase enzyme extracted from radish
8. Analysis of isozymic patterns of peroxidase enzyme extracted from different leaf samples

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PBIO-106 **(1 CREDIT)**

PRACTICAL COURSE – 2

(Related to theory course PBIO 102-Molecular biology)

(Minimum of SIX experiments)

Course Objective: To study laboratory techniques corresponding to molecular biology.

Course Outcomes: Upon completion the student will

1. understand and gain practical, hands on experience of handling of micropipettes.
2. learn to prepare stock solutions and buffers.
3. Develop hands on experience in culturing and long-term storage of bacteria.
4. learn Whole Genome/Plasmid DNA/RNA extraction
5. be able to prepare competent cell preparation and use them for transformation

1. Accurate Micro pipetting of variable volumes (1-1000µl)
2. Preparations of Stock solutions (Molarity, Normality, percentages etc.)
3. Sterilization: a) Preparation of liquid and solid media for bacterial and fungal cultures by steam sterilization b) Sterilizing glassware by dry heat
4. Bacterial culture: a) Isolation of single bacteria colony by different types of streaking; b) Inoculation of liquid media with single colony; c) Preservation of stock culture: (i) glycerol stock at -80˚C (ii) Stab stock at room temperature
5. Isolation of Plasmid
6. Agarose gel electrophoresis
7. Elution of DNA fragment form Agarose gel
8. Preparation of competent cells
9. Transformation of plasmid
10. Isolation of RNA
11. Isolation of human genomic DNA from human blood

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PBIO-107 **(1 CREDIT)**

PRACTICAL COURSE – 3

(Related to theory course PBIO 103 - INSTRUMENTATION FOR BIOLOGICAL APPLICATIONS)

(Any SIX experiments using minimum FOUR equipment)

Course Objective: To understand and gain hands-on experience in bio-analytical techniques.

Course Outcome: Upon completion the student will

1. understand and gain practical & hands-on experience win the use of pH meter and preparation of buffers.
2. be able to work with a UV-Visible spectrophotometer and use it to determine concentration of biomolecules using standard curve method and direct absorbance method.
3. be able to carry out separation of proteins and determine their molecular weights using SDS-PAGE.
4. Become familiar with the procedure of purifying biomolecules using liquid chromatographic techniques like HPLC/FPLC
5. be able to independently carry out centrifugation procedures.
6. become familiar with the process involved in western blotting.

pH meter:

1. Preparation of stock solutions Tris HCl, EDTA (TE, TAE, TBE)
2. Preparation of buffers - Phosphate buffer, sodium acetate pH 5.2 etc.

UV-Vis spectrophotometer:

3. Estimation of total proteins by Bradford method
4. Quantification of protein and nucleic acids through UV absorbance measurements at 280nm and 260nm
5. Study of bacterial growth dynamics
6. Estimation of total phenolic content.

Electrophoresis:

7. Agarose gel electrophoresis - Separation of DNA/RNA
8. SDS- PAGE – separation of protein from bacteria lysate

Chromatography:

9. Protein purification using column or affinity beads or ion-exchange resins (any one method)
10. Separation of plant metabolites using Thin layer or column or RP-HPLC

Microscopy:

11. Demonstration of Inverted, Fluorescence, Stereo or Phase contrast (any two)

Centrifugation (Any one):

12. Density gradient centrifugation
13. Isolation of DNA/RNA

Blotting technique (only blotting, hybridization not essential):

14. Southern blotting
15. Western blotting

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PBIO-108 **(1 CREDIT)**

PRACTICAL COURSE – 4

(Related to theory course PBIO 104 - IMMUNOLOGY)

(Minimum of SIX experiments)

Course Objective: To understand and gain hands-on experience in immunological techniques.

Course Outcome: Upon completion the student will

1. understand and gain practical, hands on experience in the handling of blood samples
2. learn to process blood samples for Serum/plasma and PBMCs
3. gain hands on experience in performing specific immunological assays

1. Separation of Serum from whole blood
2. Separation of Plasma from whole blood
3. Isolation of PBMCs from whole blood
4. Agglutination test
5. Radial Immunodiffusion (Demonstration using kits)
6. Ouchterlony Double Diffusion (Demonstration using kits)
7. DOT Blot Analysis (Demonstration using kits)
8. Rocket Electrophoresis (Demonstration using kits)

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PBIO-201 **(4 CREDITS)**

MOLECULAR DEVELOPMENTAL BIOLOGY

Course Objective: This course deals with the molecular basis of developmental processes of animals and plants

Course Outcomes: Upon completion, the student will

1. understand the events resulting from with epithelial-mesenchymal interactions
2. understand the molecular mechanisms involved in axis specification in animal development
3. understand the processes associated with limb development and regeneration
4. understand the genetic and hormonal control of sex determination in mammals
5. obtain a broad understanding of plant developmental processes

1. An Introduction to molecular developmental biology: Basic understanding of potency, commitment and specification – Autonomous, Conditional, Syncytial **3hrs,** Morphogenetic gradients (Flatworm regeneration) **1hr**
2. Cell-Cell Communications: Induction, Competence, Epithelial-Mesenchymal interactions, Regional and genetic specificity of induction **3hrs.** Factors and Receptors **2hrs** Eye lens induction, Instructive & permissive interactions, **2hrs** Signal transduction pathways - RTK (Vulval induction in *C. elegans*) Wnt, Smad, JAK-STAT, Hedgehog **4hrs**
3. Axis and Pattern formation:
    a. Drosophila - Anterior-Posterior **4hrs;** Dorsal- Ventral **2hrs**
    b. Amphibia - Anterior-Posterior **2hrs;** Dorsal- Ventral **2hrs**
    c. Chick - Anterior-Posterior, Left-Right **3hrs**
4. Development and Regeneration of limb:
    a. Tetrapod limb - Proximal-Distal, Anterior-Posterior axes **3hrs**
    b. Regeneration - Salamander limbs **2hrs**
5. Sex determination in Mammals:
    a. Genetic mechanism of primary sex determination **3hrs**
    b. Hormonal regulation of secondary sex determination **2hrs**
6. Epigenetics and development: Epigenetics in cellular differentiation **3hrs**
7. Development of Blood cells : The stem cell concept **1hr**, Pluripotent stem cells and Hemopoietic microenvironments, Sites of hemopoiesis **3hrs**
8. Morphogenesis and Organogenesis in plants: Organisation of shoot and root apical meristem; shoot and root development **3hrs**; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in *Arabidopsis* **4hrs**

Basic Texts:

1. Gilbert, S. F., & Singer, S. R. (2006). *Developmental biology*. Sinauer Associates, Inc. Publishers.
2. Lewin, B. (2008). *Genes 9*. Jones & Bartlett Learning.
3. Wolpert, L. (2011). *Principles of Development*. Oxford University Press.

Additional reading:

1. Gilbert, S. F., & Epel, D. (2009). *Ecological Developmental Biology: Integrating Epigenetics, Medicine, and Evolution*. Sinauer Associates.
2. Slack, J. M. W. (2009). *Essential Developmental Biology*. Wiley.

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PBIO-202 **(4 CREDITS)**

GENETIC ENGINEERING

Course Objective: This course deals with basic concepts in Genetic Engineering and exposes the students to the tools and techniques employed in Recombinant DNA technology.

Course Outcomes: Upon completion, the student will

1. have an understanding of the application of the tools and strategies used in genetic engineering
2. develop knowledge of enzymes used in DNA cloning experiments
3. gain insights into cloning strategies, plasmid vectors for cloning, over-expression and expression systems
4. be able to understand the screening techniques for recombinant clones
5. learn the principles of gene knockout and knockdown
6. understand the importance of genetic engineering in the development of pharmaceutical products.

1. Introduction to genetic engineering**:**
    a. Enzymes: restriction endonucleases, DNA polymerases, DNA and RNA nucleases, kinases, phosphatases, ligases - types, properties and applications. **2hrs**
    b. Molecular tools: (i) Plasmid: construction of plasmid vectors; structures, properties and functions of - Shuttle, expression. (ii) Viral vectors: (a) vectors for *E.coli* - lambda vectors- insertion, replacement; cosmids-pJB8; M13. (b) Vectors for animal cells- simian virus, SV40, CMV. **5hrs**
2. Molecular cloning strategies:
    a. Vector preparation; Insert preparation- restriction digest, PCR with adaptor primer. Ligation – cohesive end, blunt end, homopolymer tailing and linker. **3hrs**
    b. Transformation: biological – Phage; non-biological – heat shock, bombardment, electroporation, microinjection. **2hrs**
    c. Screening techniques for identification of transformed host cells: genetic, immunological, recombination, fluorescent tagging. **2hrs**
3. Study of expression of cloned genes:
    a. Manipulation of gene expression in prokaryotes: (i) Regulatable promoters – large scale expression (ii) Fusion proteins – surface display- tandem array – protein stability – overcoming oxygen limitation; Viral promoters. **5hrs**
    b. Heterologous protein production in Eukaryotes: (i) Yeast – *Saccharomyces cerevisiae* and *Pichia pastoris* system (ii) Baculovirus-insect cell expression system. (iii) Mammalian expression system. **9hrs**
4. *In vitro* synthesis of DNA:
    a. Single stranded DNA (Oligonucleotides) and its applications in recombinant technology. **1hr**

b. Double stranded DNA - Polymerase chain reaction (PCR) technology; Molecular diagnostic techniques: PCR/OLA procedure, padlock probes, fluorescence labelled probes technology. **3hrs**
c. Gene libraries establishment - cDNA library and Genomic library. **2hrs**

5. Genetic Manipulation of Animals:
   a. Principles of production of transgenic animals: retrovirus, DNA microinjection and, stem cell methods. **3hrs**
   b. Knockout animals: integration of construct into chromosome - negative and positive selection, *Cre-lox*P system, antisense RNA and RNAi. **6hrs**
   c. CRISPR-Cas 9 gene editing system. **2hrs**
6. Pharmaceutical products:
   a. Protein replacement: insulin, human growth hormone, factor VIII. **2hrs**
   b. Therapies: tissue plasminogen activator, interferon. **2hrs**
7. Gene therapy: Vectors in gene therapy: adenovirus - cystic fibrosis, retroviral-SCID; Aggressive gene therapy - anti-cancer therapy; Non viral delivery liposome. **3hrs**

Basic Texts:

1. Glick, B. R., & Pasternak, J. J. (2003). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. ASM Press.
2. Brown, T. (2010). *Gene Cloning and DNA Analysis: An Introduction*. John Wiley & Sons.

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PBIO-203 **(4 CREDITS)**

BIOCHEMISTRY OF MACROMOLECULES

Course Objective: This course deals with the understanding on the role of biomolecules and their functions

Course Outcome: Upon completion, the student will be able to

1. understand the classification, chemical properties, structural and functional diversity of carbohydrates
2. understand the physical and chemical properties of amino acids, the different levels of organization of protein structures.
3. explain the different models of protein folding and understand the role of chaperones in protein folding.
4. describe enzyme catalysis and derive a mathematical expression to represent and elucidate different parameters of enzyme catalyzed reactions.
5. discuss the role of enzymatic inhibitors, their mechanisms and types.
6. explain the role of cofactors and the mechanisms involved in enzyme catalyzed reactions and learn the catalytic mechanisms of different classes of enzymes
7. understand the structural diversity of lipids, fatty acids etc.

1. An overview of Biomolecules: Biomolecules – Chemistry and properties of aminoacids, Carbohydrates, Proteins, Lipids, Nucleic acids. **3hrs**
2. Proteins:
   a. Protein Characterization and Purification: Methods of isolation, and purification, ultracentrifugation, amino acid sequence determination and mass spectrometry. **4hrs**
   b. Protein structure and analysis: Amino acid structure, peptide bonds, alpha helical and beta pleated structures, Ramachandran plot, structures of keratin, collagen and elastin. **5hrs**
   c. Protein dynamics and stability: Protein structure, protein stability, protein confirmation, structural motifs and their functional relevance. **2hrs**
   d. Protein folding: Concepts of protein folding and their pathways, role of accessory

proteins in protein folding. **3hrs**

3. Enzymology:
   a. Enzyme Catalysis: Role of cofactors in enzyme catalysis: NAD/NADP+, FMN/FAD, coenzyme A, biocytin, cobamide, lipoamide, TPP, pyridoxal phosphate, tetrahydrofolate and metal ions with special emphasis on coenzyme functions. **3hrs**
   b. Acid-base catalysis, covalent catalysis, proximity and orientation effects, strain and distortion theory. **3hrs**
   c. Mechanism of action of chymotripsin, carboxypeptidase, ribonuclease and lysozyme. **3hrs**
   d. Enzyme purification: Methods for isolation, purification and characterisation of enzymes. **2hrs**
   e. Enzyme Kinetics: Factors affecting enzyme activity: enzyme concentration, substrate concentration, pH and temperature; Derivation of Michaelis-Menten equation for uni-substrate reactions. Km and significance; Line Weaver-Burk plot and its limitations. Importance of Kcat/Km. Bi-substrate reactions - Brief introduction to sequential and ping-pong mechanisms with examples. **7hrs**
   f. Kinetics of zero and first order reactions. Significance and evaluation of energy of activation and free energy. Reversible and irreversible inhibition, competitive, non-competitive inhibitions, determination of Km and Vmax in presence and absence of inhibitor. Allosteric enzymes. **4hrs**
   g. Mechanisms of actions of serine proteases, glutathione reductases, ribonuclease. **2hrs**
4. Carbohydrates structure and function: Monosaccharides and derivatives of sugars, polysaccharides - glycosaminoglycans, proteoglycans, protein glycosylations and their significance. **3hrs**
5. Lipids structure and function: Fatty acids, triacylglycerols, glycerophospholipids, sphingolipids, cholesterol lipid bilayers. **2hrs**
6. Membrane structure and function: Biological membranes, integral membrane proteins, lipoproteins and trafficking through membranes. **2hrs**
7. Biochemical problems. **4hrs**

Basic texts:

1. Berg, J. M., Tymoczko, J. L., & Stryer, L. (2002). *Biochemistry, Fifth Edition*. W.H. Freeman.
2. Nelson, D. L., Lehninger, A. L., & Cox, M. M. (2008). *Lehninger Principles of Biochemistry*. W. H. Freeman.
3. Segel, I. H. (2010). *Biochemical Calculations 2nd Edition*. Wiley India Pvt. Limited.

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PBIO-204 **(4 CREDITS)**

BIOINFORMATICS

Course Objective: This course deals with basic concepts of bioinformatics and its importance in biological data analyses.

Course Outcome: Upon completion, the student will

1. become familiar with different types of Biological data and public databases with biological data available online.
2. be aware of the concepts of different methods of sequence alignment.
3. understand the various methods of construction of phylogenetic trees using molecular data.

4. have awarness of the methods of prediction of protein secondary and tertiary structure from the amino acid sequences.
5. develop familiarity with protein sequence and protein structure databases available online.
6. get to understand the importance of bioinformatics in the drug discovery process and appreciate the role of computer aided drug design.

1. Introduction: History and scope of Bioinformatics; Types of biological databases– Primary and Secondary; Applications of databases - NCBI, EMBL-EBI, DDBJ, Expasy, UCSC, OMIM, BTISnet and Biogrid (India) **5hrs**
2. Pair-wise Sequence Alignment: Dot matrix, Scoring matrices – PAM, BLOSUM, Gap penalties. Dynamic programming: Global alignment - Needleman-Wunch algorithm, Local alignment - Smith-Waterman algorithm, k-tuple. **5hrs**
3. Sequence Similarity Search: FASTA, BLAST, PHI-BLAST, PSI-BLAST, PSSM. **5hrs**
4. Multiple Sequence Alignment (MSA): Significance, Types of MSA – Progressive methods (Clustal, PileUp, T-COFFEE), Iterative methods (PRRP), Other methods - DIALIGN, Profile Analysis, Block Analysis; Pattern searches – MOTIF, EM, MEME, The Gibbs Sampler, Hidden Markov Model (HMM). **7hrs**
5. Phylogenetics: Terms in Phylogenetics; Significance; Building phylogenetic trees; Phylogenetic software: PAUP, PHYLIP and MEGA; Methods of Phylogenetic prediction and limitations - Maximum parsimony, distance matrix methods (FM, NJ, UPGMA), Maximum likelihood. **8hrs**
6. Protein Structure and Analysis: Protein structure (1º, 2º, 3º, 4º); Protein families, MOTIFs and Domains. Protein databases for sequence and structure analysis – PDB and PDBSum; Molecular viewers – RASMOL, PyMOL; Classification of proteins in protein databases – SCOP and CATH. **7hrs**
7. Protein Structure Prediction: Ramachandran plot; Prediction using amino acid sequence; Prediction of protein secondary structure - Chou-Fasman/GOR method, NN models, Nearest neighbour method; Prediction of protein tertiary structure – Homology/Comparative Modelling, Threading, Ab initio method. **7hrs**
8. Rational Drug Design: Drug discovery process, Computer aided drug design – Structure based drug design and Ligand based drug design. Molecular docking. ADME/T properties - Lipinski's rule of five, Rule of three; Introduction to toxicity and levels of toxicity; *In silico* modelling methods of Toxicity prediction – Structural alerts, QSAR, Read-across, Dose and Time models, Pharmacokinetics and Pharmacodynamics. **8hrs**

Basic Texts:

1. Mount, D. (2005). *Bioinformatics Sequence and Genome Analysis,* 2nd Edition, CBS Publishers and Distributors
2. Baxevanis, A. D. & Ouellette, B. F. F. (2005). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd Edition*, John Wiley & Sons, Inc.
3. Petsko, G. A. & Ringe, D. (2004). *Protein Structure and Function,* Primers in Biology, New Science Press Ltd
4. Martis, E. A. & Somani, R. R. (2012). *Drug Designing, Discovery and Development Techniques*, In: Basnet, P. (Ed.), *Promising Pharmaceuticals*, INTECH.
5. Krieger, E., Nabuurs, S. B. & Vriend, G. (2003). *Homology Modeling*, In: Bourne, P. E. & Weissig, H. (Eds.), *Structural Bioinformatics*, Wiley-Liss, Inc.
6. Meng, X. Y., Zhang, H. X., Mexei, M. & Cui, M. (2011). *Molecular Docking: A powerful approach for structure-based drug discovery,* Current Computer Aided Drug Design, 7(2): 146–157
7. Raies, A. B. & Bajic, V. B. (2016). *In silico toxicology: computational methods for the prediction of chemical toxicity,* WIREs Computational Molecular Science, 6:147–172.

Additional reading

1. Gibas, C., & Jambeck, P. (2001). *Developing Bioinformatics Computer Skills*. O'Reilly.

2. Higgins, D., & Taylor, W. R. (2000). *Bioinformatics: Sequence, Structure, and Databanks : a Practical Approach*. Oxford University Press.

PBIO-205 **(1 CREDIT)**

PRACTICAL COURSE – 5

(RELATED TO THEORY COURSE PBIO 201 - MOLECULAR DEVELOPMENTAL BIOLOGY)

(Minimum of FIVE experiments)

Course objective: To study and gain hands-on-experience in laboratory techniques to understand developmental events of select model organisms

Course outcome: This course helps the student to

1. to apply the theoretical aspects studied in Molecular developmental biology course.
2. understand about animal models and its use in biomedical sciences
3. to get an overall understanding about Drosophila, its collection, culturing, identification of different species
4. get a bird's eye view of the developmental stages of a model organism, *C. elegans.*
5. gain practical, hands-on experience in culturing and maintaining the selected model organisms.

1. *Drosophila* collection and handling materials
2. Food preparation and maintenance of cultures
3. Life cycle stages: Adult, Eggs, Larva, Pupa observations
4. Male and female flies identification
5. Identification of local species: *Drosophila* and *Zaphrionus* – salient features
6. Dechorination of eggs, Identification of embryo stages
7. Wing venation in the wing of *Drosophila*
8. Observation of Polytene chromosomes from salivary glands of *Drosophila*
9. Life cycle stages of *Dictyostelium discoideum* (Video tutorials)
10. Observation of developmental stages in *C. elegans* (Video tutorials)

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PBIO-206 **(1 CREDIT)**

PRACTICAL COURSE – 6

(RELATED TO THEORY COURSE PBIO 202 - GENETIC ENGINEERING)

(Minimum of SIX experiments)

Course Objective: To study and gain hands-on experience in laboratory methods corresponding to Genetic Engineering.

Course Outcome: Upon completion the student will

1. gain practical, hands on experience in DNA cloning
2. be able to perform PCR protocols
3. be able to overexpress a recombinant gene and purify the protein
4. be able to confirm the overexpression by Western blotting

1. Restriction digestion of genomic DNA and observation on gel
2. Plasmid Mapping (Problems)
3. Amplification of DNA using Polymerase Chain Reaction
4. Expression of recombinant protein.

5. Testing induced protein expression by SDS-PAGE
6. Purification of fusion protein by affinity chromatography
7. Electroelusion of purified protein from SDS-PAGE
8. Dialysis
9. Western blot Transfer
10. Ponceau S staining to confirm the protein transfer
11. Cloning of PCR product
12. Rapid Amplification of Polymorphic DNA (RAPD)

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PBIO-207 **(1 CREDIT)**

PRACTICAL COURSE – 7
(RELATED TO THEORY COURSE PBIO 203 - BIOCHEMISTRY OF MACROMOLECULES)
(Minimum of SIX experiments)

Course Objective: To study and gain hands-on experience in laboratory techniques corresponding to the biochemistry of macromolecules.

Course Outcome: Upon completion the student will be able to

1. understand the concepts of enzyme kinetics.
2. gain hands-on experience to set up experiments to determine kinetic parameters viz., Km and Vmax.
3. prepare a crude extract of an enzyme from its source material and optimize the extract volume to use it for enzyme kinetics experiments.
4. estimate the concentration of cholesterol in an unknown physiological sample.
5. estimate the concentration of tyrosine in an unknown sample.
6. become familiar with Mascot database search for protein identification.

1. Protein estimation by Lowry's method
2. Enzyme Kinetics assays using any one enzyme (Tyrosinase / Alkaline phosphatase / Lactate dehydrogenase / Carbonic anhydrase)
   a. Find out K_m, V_{max}, K_i values using Line-Weaver Burke plot
   b. Find out the type of inhibition: Competitive, non-competitive or uncompetitive
      i) Effect of different substrate concentrations
      ii) Effect of different enzyme concentrations
      iii) Effect of incubation time
      iv) Effect of various pH conditions
      v) Effect of temperature
      vi) Effect of inhibitor
3. Estimation of Cholesterol by $FeCl_3$-H_2SO_4 method
4. Estimation of glycolipids
5. Estimation of iron and copper
6. Estimation of tyrosine
7. Estimation of cellulase and cellulase activity
8. Protein identification using *in silico* tools like Masscot

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PBIO-208 **(1 CREDIT)**

PRACTICAL COURSE – 8
(RELATED TO THEORY COURSE PBIO 204 - BIOINFORMATICS)
(Minimum of TEN experiments)

Course Objective: To study and gain hands-on experience in various bioinformatics software tools.

Course Outcome: Upon completion the student will able to

1. access and search different online databases.
2. use BLAST for pairwise sequence alignment.
3. indetify open reading frames in a given DNA sequence.
4. become familiar with the procedure of searching a sequence database for similar sequences using BLAST.
5. carry out multiple sequence alignment and build phylogenetic trees using sequence data.
6. visualize protein structures from their 3D coordinate files using softwares such as PyMol/ RasMol.
7. become familiar with the procedure of molecular docking using Autodock vina.
8. identify the interacting amino acids by studying the protein-ligand complex using LigPlot.
9. use MODELLER to predict protein 3D structure from its amino acid sequence.
10. become familiar with navigation in the UNIX environment through command line interphase.

1. Exploration of online databases: Journal articles – NCBI-Pubmed; Protein and Nucleotide sequences – NCBI-Protein, NCBI-Nucleotide; EMBL-EBI, DDBJ, OMIM, GEO, ZINC,
2. Sequence retrieval from Databases, Sequence Similarity search - Blast: Blastn, Blastp, Blastx.
3. Multiple Sequence Alignment (Ex: CLUSTAL-OMEGA, MAFFT, K-ALIGN) and Construction of phylogenetic tree.
4. Expasy tools: Protparam, Translate, SWISS-MODEL
5. Primer design using NCBI-Primer-BLAST and Primer Dimer check.
6. ORF finder in NCBI
7. Calculation of %GC content and molecular weight of a gene using MBCF Oligo calculator.
8. Making a restriction map of a gene sequence using restriction mapper.
9. Whole genome sequence database – NCBI – Genome
10. Search for conserved domains and identification of motifs in proteins.
11. How to find out transmembrane regions in a protein using TMHMM server.
12. Retrieval of 3D structure and protein sequence from Protein Data Bank and Protein 3D Structure visualization using Pymol / Rasmol
13. Protein ligand docking using AutoDock Vina – PyMOL interphase. Preparation of protein-ligand complex after docking and identification of ligand interacting amino acid residues using LigPlot software.

14. Basics of file creation and navigation in UNIX environment. Introduction to molecular dynamics simulations using GROMACS/AMBER MD software suite.
15. Prediction of 3D structure of proteins using MODELLER and test the quality of the structure using Ramachandran plot.
16. Pathway analysis using Cytoscape.

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PBIO-301 **(4 CREDITS)**

INTERMEDIARY METABOLISM

Course Objective: This course deals with biochemical pathways associated with metabolic processes of living organisms.
Course Outcome: Upon completion the student will be familiar with anabolic and catabolic processes associated with the basic biomolecules. The student will be able to

1. understand the central and critical role of ATP in biochemical reaction by virtue of its structure and properties as an energy rich molecule
2. explain the different pathways in carbohydrate metabolism like glycolysis, TCA and oxidative phosphorylation, gluconeogenesis and glycogen synthesis. The concept of energy charge and the regulation of critical enzymes in the metabolic process and the rationale for regulation.
3. describe photosynthesis as an integrated process involving the light and dark reactions and the enzymes involved in the process.
4. explain lipid metabolism as well as the fatty acid degradation and biosynthesis.
5. describe the amino acid metabolism and cluster amino acid synthesis based on the raw materials used by the cell and the products of amino acid degradation.
6. understand transamination reactions and urea cycle.
7. explain the purine and pyrimidine nucleotide biosynthesis.
8. develop an integrated view of cellular metabolism.

1. Introduction: Metabolism - Basic concepts, Central role of ATP in metabolism, Carbon fuel and its oxidation, Concept of energy rich compounds and intermediates, reactions involved in energy metabolism. **4hrs**
2. Carbohydrate metabolism:
    a. Glycolysis, Gluconeogenesis, glycogenesis and glycogenolysis Alcoholic and lactic acid fermentations – Energetics and ATP production. Entry of fructose, Galactose and mannose. Regulation of glycolysis, glycogen synthase, metabolic flux and its regulation by various metabolic intermediates. **6hrs**
    b. TCA cycle – Energetics, its role in generating ATP and biosynthetic intermediates and its regulation. **2hrs**
    c. Reactions and physiological significance of pentose phosphate Pathway, Calvin cycle, Photosynthesis. **5hrs**
3. Electron transport chain: Structure of mitochondria, sequence of electron carriers, sites of ATP production, inhibitors of electron transport chain, Redox reaction – Electron Transport Chain in Chloroplasts. **4hrs**
4. Oxidative phosphorylation: ATP synthesis, Chemi-osmotic hypothesis of ATP generation, inhibitors and uncouplers of oxidative phosphorylation. Transport of reducing potentials into mitochondria. **4hrs**
5. Lipid metabolism:
    a. Triacylglycerols – their hydrolysis and transport into mitochondria, β-oxidation of saturated fatty acids, ATP yield from fatty acid oxidation; Metabolism of ketone bodies, oxidation of unsaturated fatty acids and odd chain fatty acids. Regulation of cholesterol metabolism. **6hrs**
    b. Biosynthesis of saturated and unsaturated fatty acids. Biosynthesis of triglycerides and important phospholipids, glycolipids, sphingolipids and cholesterol. **3hrs.**
    c. Synthesis and degradation of steroids. **2hrs**

6. Amino acid metabolism:
    a. Overview of amino acid synthesis, Ammonium ion and its role in nitrogen fixation – Iron molybdenum cofactor, assimilation of ammonium ion into amino acid. Synthesis of amino acids from intermediates of citric acid cycle and other major pathways. **4hrs**
    b. Regulation of amino acid biosynthesis. Amino acids- precursors of other Biomolecules. **2hrs**
    c. Amino acid degradation, Urea cycle; Amino acids – source of carbon atoms for major metabolic pathways; Inborn errors of amino acid metabolism. **6Hr**
7. Nucleotide biosynthesis and metabolism; salvage pathways, its regulation and diseases. **4hrs**

Basic texts:

1. Berg, J. M., Tymoczko, J. L., &Stryer, L. (2002). *Biochemistry, Fifth Edition*. W.H. Freeman.
2. Nelson, D. L., Lehninger, A. L., & Cox, M. M. (2008). *Lehninger Principles of Biochemistry*. W. H. Freeman.
3. Zubay, G., Parson, W. W., & Vance, D. E. (1995). *Principles of Biochemistry*. McGraw-Hill Education.

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PBIO-302 **(4 CREDITS)**

PLANT SYSTEMATICS AND CONSERVATION

Course Objective: This course deals with identification, nomenclature and classification of plants and conservation biology

Course Outcome: Upon completion the student will

Course Outcomes: Upon completion the student will

1. Become familiar with the building blocks of plant taxonomy and phylogenetic systems of plant classification
2. Come to understand the contribution of other subdisciplines of biology to plant systematics
3. have an understanding of the description, evolutionary trends and economic importance of selected primitive and advanced plant families
4. come to appreciate the importance of biodiversity and associated threats
5. know about the efforts of IUCN towards (in situ and ex situ) conservation of biodiversity

Plant Systematics:

1. Introduction: Basic principles and significance of plant systematic - nomenclature, preparation and use of keys for identification, herbaria. Biosystematics - Categories and methods. **4hrs**
2. Contemporary phylogenetic systems of classification: Takhtajan and Cronquist's system (including merits and demerits). Angiosperm Phylogenetic Group (APG). **5hrs**
3. Modern trends in Taxonomy:
    a. Morphology, Anatomy, Ultrastructural systematics, Embryology. **4hrs**
    b. Palynology, Cytotaxonomy, Chemotaxonomy. **4hrs**
4. Molecular systematics – Principles; Molecular data – chloroplast and mitochondria genome and its application in phylogenetic analysis. **4hrs**
5. Phylogeny of Angiosperms: Theories on probable ancestors of angiosperms. Monophyletic or Polyphyletic origin; Origin of monocotyledons. **4hrs**

6. Study of taxonomically important families - their description, evolutionary trends, affinities and economic importance: Nymphaeaceae, Fabaceae, Brassicaceae, Solanaceae, Compositae, Liliaceae, Orchidaceae and Poaceae **10hrs**

Conservation:

1. Biodiversity - Types, distribution, assessment; Measurement of species diversity indices; Biodiversity Threats– natural and human causes. **3Hrs**
2. Conservation Biology: Principles; IUCN - World conservation strategy, IUCN Categories of protected areas; MAB & GAP programs. **3hrs**
3. *In situ* conservation: Commonness and rarity among species, Assessing and categorising threat at species level as defined by IUCN, Genetic management of species. Strategies - National parks, Nature reserves, Reserve wilderness, Wildlife sanctuary, Forest reserves, Aquatic system and Ecological restoration. **7hrs**
4. *Ex situ* conservation of plants: IUCN guidelines for species reintroduction; Strategies - Gene banks, International and national agricultural research institutes and germplasm crop centres, clonal repositories, botanical gardens and arboreta. **4hrs**

Basic Texts:

Plant Systematics

1. Singh, G. (2004). *Plant Systematics: An Integrated Approach*. Science Publishers.
2. Naik, V. N. (1984). *Taxonomy of Angiosperms*. Tata McGraw-Hill.
3. Pulliah, T. (2007). Taxonomy of Angiosperms. Regency Publications.
4. Soltis, D. E., Soltis, P., & Doyle, J. J. (1998). *Molecular Systematics of Plants II: DNA Sequencing*. Springer US.

Conservation

1. Pullin, A. S. (2002). Conservation Biology.Cambridge University Press.
2. Benson, E., & Benson, E. (2002). Plant Conservation Biotechnology.Taylor & Francis.
3. Sodhi, N. S., Gibson, L., & Raven, P. H. (2013). Conservation Biology: Voices from the Tropics. Wiley.
4. Hunter, M. L., & Gibbs, J. P. (2009). Fundamentals of Conservation Biology. Wiley.

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PBIO-303 **(3 CREDITS)**

ELECTIVE - I

(See pages 25-31 for details)

PBIO-304 **(3 CREDITS)**

ELECTIVE - II

(See pages 25-31 for details)

PBIO-305 **(3 CREDITS)**

PRACTICAL COURSE – 9

(RELATED TO THEORY COURSES PBIO 303 (ELECTIVE-I; BT-01) MYCOLOGY, PATHOLOGY AND FUNGAL BIOTECHNOLOGY AND PBIO 304 (ELECTIVE-II; BT-02)PLANT BIOTECHNOLOGY)

Course Objective: To study laboratory techniques corresponding to fungal biology.

Course Outcome: Upon completion the student will be able to

1. gain practical, hands on experience in isolation and culturing of fungi from various sources
2. learn to prepare various culture media
3. gain experience of sub-culturing and maintaining pure cultures

Mycology, Pathology and Fungal Biotechnology (Minimum of SIX experiments)

1. Cotton Blue staining and mounting of fungi
2. Scotch tape preparation for studying the morphology of fungi
3. Isolation of fungi by Warcup method and preparation of fungal stock solution
4. Isolation of fungal pathogens from leaves
5. Measurement of fungal growth by linear determination
6. Isolation and enumeration of microbes by serial dilution method
7. Optimization of volume of inoculum for fungal growth
8. Coverslip culture technique for preparing fungal slides

Course Objective: To study laboratory techniques used in plant cell and tissue culture.

Course Outcome: Upon completion the student will
1. learn about the importance of maintaining appropriate conditions in the culture room
2. gain practical, hands on experience in preparing suitable culture media
3. learns techniques of culturing in both liquid as well as solid cultures

Plant Biotechnology (Minimum of FIVE experiments)

1. Preparation of stock solutions of plant cell culture media
2. Initiation and establishment of callus culture
3. Suspension culture
4. Immobilization of cells
5. Elicitation of secondary metabolite
6. Anther culture/pollen culture

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PBIO-401 **(4 CREDITS)**

MOLECULAR EVOLUTION AND HUMAN GENETICS

Course Objective: This course deals with the molecular basis of evolutionary processes and human genetic disorders.

Course Outcomes: Upon completion the student will understand

1. How major forces drive evolutionary processes and speciation events
2. the mechanics of evolution of genes and gene families
3. about the significant milestones in human evolution
4. how pedigree charts help a genetic counsellor in studying inheritance patterns of genetic diseases
5. the characteristic features of diseases associated with chromosomal abnormalities and molecular diagnostics of select genetic disorders
6. the major steps involved in mapping of the human genome

1. Micro-evolutionary forces: Natural Selection, Quantifying natural selection, Types of Natural selection (Directional, stabilizing, disruptive, sexual and kin selection) **2hrs**. Forces affecting changes in allelic frequencies (selection, mutation, migration, genetic drift) **2hrs** Hardy-Weinberg equilibrium, Solving numericals based on Hardy-Weinberg Law **3hrs**
2. Biological Species Concept: Reproductive isolating mechanisms **2hrs**, modes of

speciation (allopatric, sympatric, parapatric, quantum speciation) - **1hr**

3. Molecular evolution: Gene duplication, Gene evolution, Evolution of gene families **4hrs** Exon shuffling, Concerted evolution, Molecular clock hypothesis **4hrs**
4. Evolutionary origin of man: Geologic time scale **1hr**- History of primates, significant stages in evolution of man **3hrs**, Comparison between humans and other primates – Fossil and Genetic evidence of origin of modern man **2hrs** Mitochondrial DNA polymorphism and Eve Hypothesis **2hrs**
5. Human Pedigree Analysis: Pedigree construction **1hr**, Autosomal Dominant and recessive inheritance, X-linked recessive and dominant inheritance, Y-linked genes, Mitochondrial genes **4hrs** - Analysis of pedigree charts **1hr**, Genetic counselling **2hrs**
6. Human Karyotype: Chromosomal nomenclature, Chromosome banding techniques **2hrs**, human chromosome aneuploidies, chromosomal parental disomy, chromosomal imprinting **2hrs**
7. Detection of genetic variability in populations: SNP, RFLP, RAPD, AFLP **2hrs** Molecular diagnostics of hereditary diseases: Cystic fibrosis, Ducchene muscular dystrophy, Sickle Cell trait, Huntington Chorea **6hrs**
8. Human Genome: Genetic maps and Physical maps - Contig maps, STS maps, EST maps, Chromosomal walking and jumping **2hrs** Gene annotations-finding genes in DNA sequences. (Zoo blotting and exon trapping) **4hrs**

Basic Texts:

1. Krukonis, G., & Barr, T. (2011). *Evolution For Dummies*. Wiley.
2. Graur, D., & Li, W. H. (2000). *Fundamentals of Molecular Evolution*. Sinauer Associates.
3. Foley, R. A., & Lewin, R. (2009). *Principles of Human Evolution*. Wiley. Mange, E. J., & Mange, A. P. (1999). *Basic Human Genetics*. Sinauer Associates, Inc.

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PBIO-402 **(4 CREDITS)**

CYTOGENETICS & PLANT BREEDING

Course Objective: This course deals with chromosomal organization in plants and principles of plant breeding.

Course Outcomes: Upon completion, the student will

1. have an understanding of the organization of chromosome in prokaryotes and eukaryotes
2. have knowledge of the effect of variations in chromosome structure and number
3. be familiar with breeding methods in self- and cross-pollinated plants
4. understand the need for inducing mutations in plant breeding and the applications
5. understand the genetics associated with production of hybrids

Plant Cytogenetics

1. Introduction - Basic tenets of Cytogenetics. **2hrs**
2. Chromosome structural organization in prokaryotes and eukaryotes. Meiosis, Mechanism of Crossover, significance in evolution. **3hrs**
3.
    a. Chromosomal variations in structure - Deletions, Duplications, Inversions (*Drosophila*) – its role in evolution. **3hrs**
    b. Translocations (*Oenothera*) and their role in Evolution. **3hrs**

c. Solving problems related to pericentric and paracentric inversions and translocations

4.
   a. Chromosomal variations in numbers – Classification and Cytogenetics of polyploids: allopolyploids, auto-polyploids. **3hrs**
   b. Meiosis in polyploids; Role of polyploids in evolution. **3hrs**
5. Aneuploids - monosomics, nullisomics, trisomic and their role in evolution. **3hrs**
6. Apomixis in plants. **2hrs**

Plant Breeding

1. Introduction - objectives of plant breeding, Centres of origin of crop plants. **3hrs**
2.
   a. Methods of breeding in self-pollinated crop plants – Selection and Hybridization. **3hrs**
   b. Pedigree method, bulk-population method, Single seed decent method, Back cross method, Multiline breeding. **4hrs**
3.
   a. Methods of Breeding in cross pollinated crop plants - Selection, Mass selection, Recurrent selection. **4hrs**
   b. Hybridization - Single cross, double cross, three way cross, back cross, synthetic cross methods. **2hrs**
4. Methods of breeding in asexual crops – clonal selection and hybridization. **2hrs**
5. Role of polyploidy, interspecific hybridization in plant breeding with special reference to Wheat, Rice and Cotton. **2hrs**
6. Mutation breeding - Kinds of mutations, Induction of mutations, use of induced mutations in breeding and genetics; Mutation Breeding experiments in Wheat, Rice, Barley. **5hrs**
7. Heterosis and inbreeding depression - genetic basis of inbreeding depression, genetic, physiological and biochemical basis of heterosis, production of hybrids, composites and synthetics. **3hrs**
8. Sterility - incompatibility and breeding. **2hrs**

Basic Texts:

1. Swanson, C. P., Merz, T., & Young, W. J. (1982). *Cytogenetics: The Chromosome in Division, Inheritance and Evolution*. Prentice Hall of India Ltd.
2. Hayward, D., Bosemark, N. O., & Romagosa, T. (1993). *Plant Breeding: Principles and prospects*. Springer Netherlands.
3. Sleper, D. A., & Poehlman, J. M. (2006). *Breeding Field Crops*. Wiley.
4. Fehr, W. R., Fehr, E. L., & Jessen, H. J. (1987). *Principles of Cultivar Development: Theory and technique*. Macmillan.
5. Acquaah, G. (2009). *Principles of Plant Genetics and Breeding*. Wiley.

PBIO-403 **(3 CREDITS)**

ELECTIVE - III

(See pages 25-31 for details)

PBIO-404 **(3 CREDITS)**

ELECTIVE - IV

(See pages 25-31 for details)

PBIO-405 **(3 CREDITS)**

PRACTICAL COURSE – 10
(RELATED TO THEORY COURSES PBIO 403 (ELECTIVE-III; BT-03) MICROBIAL BIOTECHNOLOGY AND PBIO 404 (ELECTIVE-IV; BT-04) ENVIRONMENTAL BIOTECHNOLOGY)

Microbial Biotechnology (Minimum of SIX experiments)

Course Objective: To study the laboratory techniques used for analysing microbes of economic importance.
Course Outcome: Upon completion the student will gain practical, hands on experience in

1. preparation of culture media
2. culturing microbes from various substrates/environments
3. quality analysis of water samples

1. Antibiotic sensitivity test by filter paper disc method
2. Microbiological examination of food
3. Isolation of lipolytic organisms from butter
4. Casein Hydrolysis
5. Determination of number of bacteria in milk sample by SPC method
6. Determination of quality of milk by Methylene Blue reduction test
7. Urease Test
8. Antibiotic sensitivity test to compare various antiseptics
9. Isolation of antibiotic producing microorganisms from soil

Environmental Biotechnology (Minimum of SIX experiments)

Course Objectives: To study the laboratory techniques used for the analysis of environmental samples.
Course Outcomes: Upon completion the student will understand and gain practical, hands on experience in
1. analysis of water samples
2. analysis of soil parameters

1. Test for free Carbon dioxide in water
2. Test for Alkalinity
3. Chloride Test for water sample
4. Determination of COD of water
5. Determination of Phosphate concentration in soil
6. Determination of dissolved oxygen (DO) in water
7. Preparation of Biodiesel

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ELECTIVE BT-1 **(3 CREDITS)**

MYCOLOGY, PATHOLOGY AND FUNGAL BIOTECHNOLOGY

Course Objective: This course deals with various aspects of fungi as plant pathogens and applications of fungi for human welfare.

Course Outcomes: Upon completion, the student will gain knowledge about

1. techniques for controlling fungal diseases in plants
2. culturing mushrooms
3. Techniques relating to sustainable agriculture and forestry
4. extraction of secondary metabolites

1. Understand the Economic importance of fungi and its role as food with special reference to cultivation methods of mushrooms.
2. Learn about different Host-pathogen interactions, Plant disease forecasting and control of plant diseases.
3. Learn about Fungal Symbionts - Ecto and Endomycorrhizae and its use in forestry and sustainable agriculture.
4. Learn about the fascinating sex hormones in fungi, parasexual cycle, heterothallism and production of secondary metabolites from fungi.

Mycology and Pathology

1. Introduction to mycology, history, general characters – Ultra structure, cell wall composition, nuclear division, growth, nutrition, reproduction and systems of classification, molecular methods of fungal taxonomy **– 6hrs**
2. Heterothallism, parasexual cycle of fungi and sex hormones **– 3hrs**
3. Introduction to pathology, economic importance and general symptoms **– 3hrs**
4. Host-pathogen interaction: Mechanism of attack, mechanism of defence, physiology of parasitism **– 3hrs**
5. Plant disease forecasting: Epidemiology and disease forecasting system for some important diseases. Late blight of potato, Apple scab, Stem rusts of wheat**. 3hrs**
6. Control of plant diseases: Breeding resistant varieties, control through protection (chemicals and environmental manipulation), legislation (Quarantine and regulatory measures), Eradication**.** IPM (integrated pest management) and INM (integrated nutritional management) – **4hrs**
7. General characteristics & life cycle of causative agents and etiology& control of the following diseases: Paddy blast, brown leaf spot of paddy, Tikka disease of groundnut, Red rot of Sugarcane, Black stem rust of wheat, Smut and bunt of wheat, wilts, Apple scab, Damping off, Late blight of potato, Ergot of rye, White rust of Brassica – **4hrs**

Fungal Biotechnology

1. Economic importance of fungi: list of fungal organism, its source and the product **- 7hrs**
2. Fungi as food: Nutritive and nutraceutical values of mushrooms, cultivation methods of button mushrooms and oyster mushrooms **- 3hrs**
3. Fungi and fungal symbionts – mycorrhiza (ecto and endo), endophytes and their use in the production of secondary metabolites **- 3hrs**

Basic texts:

1. Alexopoulos, C. J., Mims, C. W., & Blackwell, M. (1996). *Introductory mycology*. Wiley.
2. Mehrothra R. S. and Aneja K. R., *An Introduction to Mycology*, Wiley Eastern Ltd
3. Webster, J., & Weber, R. (2007). *Introduction to Fungi*. Cambridge University Press.
4. Agrios, G. N. (2005). *Plant Pathology*. Elsevier Science.
5. Mehrotra, R. S. (2003). *Plant Pathology*. McGraw-Hill Education (India) Pvt Limited.
6. Wainwright, M. (1992). *An introduction to fungal biotechnology*. J. Wiley & Sons.

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ELECTIVE BT-2 **(3 CREDITS)**

PLANT BIOTECHNOLOGY

Course Objective: This course deals with processes associated with in vitro propagation and genetic manipulation of plants.

Course Outcomes: Upon completion of the course the student

1. understand the general methods and techniques associated with plant tissue culture
2. understand the requirements and applications of tissue culture of specialized explants
3. understand the steps involved in production of secondary metabolites using plant Using cell cultures
4. understand different vector systems and genetic transformation methods in plants
5. understand how crop plants can be genetically modified for acquisition of stress resistance
6. understand hoe plant cell cultures can be used for commercial production of economically valuable compounds

Plant tissue culture

1. Introduction, approaches, history, and methods. **2hrs**
2. Types of culture - Toti-potency of plant cells - Techniques of embryo culture; Role in biology and Biotechnology; Endosperm culture and its importance; Anther and pollen culture; Significance of haploids in agriculture and crop improvement. **5hr**
3. Protoplast and Somatic hybridization: Genetic manipulations through protoplast culture - Isolation, culture and fusion of protoplast. **2hrs.** Somatic Hybrids and cybrids - Isolation and screening. **1hrs**
4. Micropropagation: Techniques of micro propagation: Methods, Stages – Mother plant selection, Establishment, Multiplication, Elongation, Rooting and Acclimatization. **3hrs** Role of morphogenesis, organogenesis, embryogenesis in micro propagation. **1hr** Cell Suspension and Secondary metabolites - **1hr**
5. Cell culture techniques - Batch culture and Continuous culture:
    a. Secondary metabolites - Commercial, Pharmaceutical and Economically important compounds. **2hrs**;
    b. Production techniques – Hairy root culture, Immobilization, Elicitation and Biotransformation. **3hrs**
6. Plant *invitro* germplasm and cryopreservation – Methods, approaches and applications. **1hr**

Plant Genetic Engineering

1. Current status of plant viruses - Potential DNA (Caulimoviruses and Gemini viruses) / RNA (BMV, TMV, PVX) vector systems. **3hrs**
2. Genetic transformation methods in plants:
    a. Viral transduction, bacterial gene delivery, chemical and physical direct gene transfer, *In planta* transformation. **1hr**
    b. Agrobacterium – mediated transformation – Ti plasmid derived vector systems, protocols for transformation and mechanisms of transformation. **2hrs**
    c. Direct DNA Transfer to plant – Target cells for transformation, Particle Gun Method and Electroporation. **3hrs**
3. Transgenic plants for crop improvement: Resistance to herbicides, Resistance to insects, Resistance to viral and fungal diseases. **3hrs**

4. Plant as a bioreactor: Concept, antibodies, polymers and edible vaccines. **3hrs**
5. Model systems:
    a. Arabidopsis and Rice; Organisation of plant genomes – Unique DNA sequences, types of repetitive DNA. **2hrs**
    b. Plant chloroplast and mitochondrial genomes **1hr**

Basic Texts:

1. Reinert, J., & Bajaj, Y. S. (1977). *Applied and fundamental aspects of plant cell, tissue, and organ culture*. Springer-Verlag.
2. Narayanaswamy, S. (1994). *Plant Cell and Tissue Culture*. Tata McGraw-Hill Publishing Company.
3. Plant Protoplast and Genetic Engineering- Y. P. S. Bajaj, 1989. Springer- Verlag, Berlin.
4. George, E. F. (1993). *Plant Propagation by Tissue Culture*. Exegetics.
5. Glick, B. R., & Pasternak, J. J. (2003). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. ASM Press.
6. Bhojwani, S. S., & Razdan, K. (1996). *Plant Tissue Culture: Theory and Practice: Theory and Practice*. Elsevier Science.

ELECTIVE BT-3 **(3 CREDITS)**

MICROBIAL BIOTECHNOLOGY

Course Objective: This course deals with the fundamental processes associated with industrial applications of microbes.

Course Outcomes: Upon completion the student will be familiar with large-scale culturing of microbes for production of enzymes, antibiotics and other commercially important products. The student will be able to

1. demonstrate familiarity with the wide diversity of microbes, and their potential for use in microbial biotechnology
2. display knowledge of microbial gene and genome structure and function, and how these can be manipulated
3. differentiate between classical genetic selection and recombinant or synthetic DNA technologies
4. demonstrate familiarity with methods to analyse and engineer genes for optimal expression
5. know the processes involved in small-scale and industrial scale bacterial fermentations
6. have competency in finding, interpreting and analysing relevant data, such as genes, patents and publications
7. demonstrate understanding of some of the legislative and ethical issues related to microbial biotechnology.

1. Introduction: Significance of microorganisms in Fermentation Technology. **1hr**
2. Microbial culture and screening: Principle - Batch culture, Continuous culture, Fed-batch culture; Primary screening – Isolation of industrially important microorganisms; secondary screening**. 2hrs**
3. Strain improvement: Mutations: Types of mutations – spontaneous, induced, point mutations; Microbial mutants. **2hrs** Directed Selection: Isolation - auxotrophic

mutants, constitutive mutants, mutants resistant to end product repression and catabolite repression. **2hrs**

4. Gene manipulation: Recombinant DNA approach to strain improvement; Strain construction; Fungal parasexuality; protoplast fusion; Manufacture of Food, Feed and Fodder: Single cell protein (SCP), SCP from algae – SCP from high energy sources, sewage wastes, wood, carbohydrates and agricultural crops – Acceptability, Toxicology and economic implications of SCP. **4hrs**
5. Bioprocess/Fermentation Technology:
    a. Fermentation Media: Criteria for ideal medium; Types and composition of medium; media formulations, mode of energy production; raw materials – carbon sources, nitrogen sources, growth factors, inorganic mineral salts, buffers, precursors, inhibitors and inducers. **2hrs**
    b. Sterilization: Microbial death pattern, conditions influencing antimicrobial agent, Principles of Thermal Kill; Fermentation media sterilization – steam sterilization, filter sterilization, sterilization by chemical agents and radiation; Fermenter sterilization; Air sterilization by fibrous materials and types of air filters; sterilization of liquid wastes and exhaust air. **2hrs**
    c. Inoculum development: Principles and various aspects; Development of inoculum for bacterial, yeast and mycelial processes. **1hrs**
    d. Fermenter Design: Fermenter vessel material; Components of a typical fermenter – base components, accessories, peripheral parts and instrumentation; Alternative vessel designs. **3hrs**
    e. Fermentation: Structural components of aeration-agitation system; Foam control – foam formation, foam breaking, anti-foam agents; Microbial aspects of scale-up, Scale-down. **2hrs**
    f. Downstream processing: Distillation, floatation, precipitation and flocculation, filtration, centrifugation, extraction methods. **4hrs**
6. Products of fermentation: Production of chemicals, enzymes and organic acids; Antibiotics - Biosynthesis, fermentation and properties of penicillin and streptomycin. **5hrs**
7. Dairy microbiology: Fermented dairy products; Biotechnology in food production and processing; Probiotics – Lactic acid bacteria; Cheese - Biotechnological approaches in accelerating cheese ripening – enzyme modified cheese; Designer milk; Applications of membrane separation processes; Bio-production and applications of flavour. **7hrs**
8. Protection of Biotechnological Inventions: Intellectual Property Rights; International harmonization of patent laws; Plant breeder's rights, plant variety protection; patenting of biological materials. **2hrs**

Basic Texts:

1. Modi, H. A. (2009). *Microbial Biotechnology*. Pointer Publishers.
2. Cruger, W. & Crueger, A. (2000). *Biotechnology:A Textbook of Industrial Biotechnology, 2nd Ed,* Panima Publishing Corporation.
3. Brown, C. M., Campbell, I., Priest, F. G. (1987). *Introduction to Biotechnology*, Blackwell Scientific Publications
4. Gupta, P. K. (2001). *Elements of Biotechnology, 1st Ed*, Rastogi Publications
5. Singh, B. D. (2005). *Biotechnology*, Kalyani Publishers
6. Dairy Technology Division (2003). *Applications of Biotechnology in Dairy and Food Processing,* National Dairy Research Institute, Indian Council of Agricultural Research.

ELECTIVE BT-4 **(3 CREDITS)**

ENVIRONMENTAL BIOTECHNOLOGY

Course Objective: This course deals with biotechnological approaches for solving environmental problems.

Course Outcomes: Upon completion the student will be able to

1. be familiar with the wide diversity of microbes, and their potential for use in Environmental biotechnology
2. understand Global Environmental Problems
3. understand and appreciate Eco Friendly processes for sustainable Environment
4. critically analyse Industrial problems and their remedial mechanisms.
5. Apply measures to use microbes to generate useful products or also degrade wastes (bioremediation)

1. Natural resource management: Types of Natural resources; Conservation and management – soil, water, minerals, forests, wild life, energy. **4hrs**
2. Sources of major environmental pollutants: Point source and non-point source; Air, water, soil and solid waste pollutants. **3hrs**
3. Biotechnology for Pollution Abatement: Air pollution and its control through Biotechnology. **3hrs**
4. Water pollution and its control: Waste Water Treatment – Aerobic and anaerobic processes. Solid waste and soil pollution management. **5hrs**
5. Industrial problems and their remedial mechanisms: Pulp and Paper, Dairy, Distillery, Tannery, Sugar, Petroleum, Antibiotic industries. **5hrs**
6. Biodegradation and conversion: biodegradation of xenobiotic compounds and hazardous wastes; TNT wastes, dyestuff wastes, pesticides and oil-spills. **4hrs**
7. Eco-friendly processes for sustainable environment:
    a. Modern fuels and their environmental impacts: Bio-methanation, Bioenergy, bioethanol and biodiesel- types of biofuels. **4hrs**
    b. Biopesticides and Biofertilizers: Thuringiensis toxin as natural pesticide, Algal, Fungal and Bacterial biofertilisers, composting, biopolymers and bioplastics. **4hrs**
8. Global environmental problems: Deforestation and loss of biodiversity, ozone depletion, green-house effect, global warming, acid rain, biotechnological approaches for management, Pollution control measures in India. **3hrs**
9. Biomineralisation: Significance and limitations. Microorganisms involved in Bioleaching of Ores, Mechanism and Biochemical reactions involved in Bioleaching, metal recovery. **4hrs**

Basic texts:

1. Thakur, I. S. (2011), *Environmental Biotechnology: Basic Concepts and Applications,* I.K. International Publishing House Pvt., Limited.
2. Agarwal, S. K. (2005), *Advanced Environmental Biotechnology*, APH Publishing Corporation.
3. Chatterji A. K.(2002), *Introduction to Environmental Biotechnology,* Prentice Hall of India Pvt Ltd.
4. Scragg, A. (1999). *Environmental Biotechnology,* Pearson Education Limited.
5. Srivastava, A. K., & Sohal, H. S. (1994). *Environment and biotechnology*. Published by S. B. Nangia for Ashish Publishing House.

Additional reading:

1. Mohapatra P.K. (2006), *Textbook of Environmental Biotechnology,* I.K. International Publishing House Pvt Ltd.

2. Miller, G., & Spoolman, S. (2011), *Living in the Environment: Principles, Connections, and Solutions*. Cengage Learning.
3. Chopra, V. L., Malik, V. S., & Bhat, S. R. (1999), *Applied Plant Biotechnology*. Science Publishers.

ELECTIVE BT-5 (3 CREDITS)

BIOTECHNOLOGY OF SECONDARY METABOLITES

Course Objective: This course deals with application of secondary metabolites of plants for human welfare.

Course Outcomes: Upon completion, the student will be able to

1. understand the concepts of secondary metabolites
2. become familiar with the natural sources of secondary metabolites
3. appreciate the role of Genetic Engineering in the secondary metabolite production
4. understand the role of plant tissue culture in secondary metabolite production in vitro
5. be familiar with the concepts of in vitro regulation of Secondary metabolite production.
6. understand the applications of secondary metabolites.

1. Introduction: Medicinal Plants Exploration, Resources; Wild and Cultivated Plants; – **2hrs -** Role of Biotechnological Approaches for the production of Secondary metabolites. – **2hrs**
2. Secondary Plant Products in Nature: Introduction, Synthesis of Major classes of Secondary Metabolites in Plants – Terpenes, Phenolic compounds and 'N' containing secondary metabolites – **3hrs**
3. Tissue culture techniques for the production of secondary metabolites in medicinal and aromatic plants: Stages of Secondary metabolites production in vitro – optimization, selection & stress conditions - **3hrs** Micro propagation of medicinal and Aromatic plants, use of Tissue Culture techniques for production of Secondary metabolites in Medicinal and Aromatic plants – **3hrs**
4. Genetic Transformation For Production Of Secondary Metabolites: Hairy Root Culture and Secondary metabolites production – Induction of hairy roots by *Agrobacterium rhizogenes*, Markers for conformation - **3hrs**
5. Establishment, Manipulation and Growth Characterstics of Hairy roots; secondary metabolites production by hairy roots culture – **3hrs -** Elicitation of products accumulation – Abiotic and Biotic elicitors – **3hrs**
6. Production of Secondary Metabolites by Bioreactors: General principles, Systems applied for Bioconversion, Kinetics of Immobilized system – **3hrs** Bioconversion of water – Insoluble precursors, synthetic precursors.– **2hrs** Bioreactors systems design and operation; Bioreactors types – Stirred – Tank, Airlift, Rotary drum, Bioreactors.– **3hrs**
7. Medicinal Plants: Plants affecting Human health – A General account of injurious plants, Remedial plants and Psychoactive plants – **3hrs** – Production of Pharmaceutical compounds – Antitumour compounds, Alkalodies, Steroids and saponins – **3hrs**
8. Production of Food Additives: Colours – Anthocyanines, Betalaines, Crocin&Crocetins and other capsaicinoids, flavours – Vanilla, Garlic and onion, sweeteners – Steviosides and Thaumatin – **3hrs**
9. Production of Insecticides:Phytocedysterones, Azadirachtin, Rotenoids, Pyrethirins, Nicotine and Anabasine, Quassin – **3hrs**
10. Mechanisms and Control in Secondary Metabolites Production: Molecular Mechanisms – Plant Growth Regulators, Elicitors, Sugars, and Signal Transduction, – **3hrs** Proteins & RNA, Genetic manipulations in control of secondary metabolites production. –

3hrs

Basic texts:

1. Ramawat, K. G., & Merillon, J. M. (1999). *Biotechnology: Secondary Metabolites*. Science Publishers.
2. Parthasarathy, V. A., Bose, T. K., & Das, P. (2001). *Biotechnology of Horticultural Crops*. Naya Prokash.
3. Khan, A. K. & Khanum, I. A. (2007). *Role of Biotechnology in Medicinal And Aromatic Plants*. Ukaaz Publications.
4. Lewis, W. H., & Elvin-Lewis, M. P. F. (2003). *Medical Botany: Plants Affecting Human Health*. Wiley.

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ELECTIVE BT-6 (3 CREDITS)

BIOMOLECULAR STRUCTURE AND FUNCTION

Course Objective: This course deals with structural and functional attributes of proteins with special reference to x-ray crystallography.

Course Outcomes: Upon completion, the student will be able to

1. understand the properties of X-rays
2. be familiar with the principles behind X-ray crystallography
3. know details of various crystallization techniques
4. gain insights into the applications of X-ray crystallography
5. interpret the x-ray crystallography data

1. Generation, detection and properties of X-rays – monochromators **– 3hrs**
2. Crystal systems and Bravais lattices – concept of unit cell and Miller indices – seven crystal systems – Bravais lattices – **3hrs**
3. Symmetry - point groups and space groups – X-ray diffraction - Bragg's law – **4hrs**
4. X-ray scattering: atomic scattering factor – structure factor equation – electron density and Fourier series- diffraction by real crystals – **5hrs**
5. Intensity estimation and deduction of structure factor amplitudes – Wilson plot – symmetry deduction and determination of space groups – **5hrs**
6. Crystallization techniques: slow evaporation technique-difference between the crystallization of small and protein molecules- crystallization of macromolecules – **5hrs**
7. Methods of structure analysis: Phase problem in crystallography – **2hrs**
8. Direct methods: normalized structure factors - Harker-Kasper inequalities - Sayre's relations - tangent formula - programs used for structure solution and refinement – **5hrs**
9. Refinement and interpretation of the results: Electron density map and location of atoms. least-squares techniques of refinement- **5hrs**
10. Interpretation of the results: Bond lengths, angles, torsion angles and conformation - accuracy and reliability of the results – **4hrs**
11. Outlines of Powder photograph - interpretation– applications -ASTM index **- 4hrs**

Basic texts:

1. Stout, G. H., & Jensen, L. H. (1989). *X-Ray Structure Determination: A Practical Guide*. Wiley.
2. Ladd, M. F. C., & Palmer, R. A. (2003). *Structure Determination by X-Ray Crystallography*. Kluwer Academic/Plenum Publishers.
3. Dunitz, J. D. (1995). *X-ray Analysis and the Structure of Organic Molecules*. Verlag Helvetica Chimica Acta.

4. Hammond, C. (2009). *The Basics of Crystallography and Diffraction*. OUP Oxford.
5. Blundell, T. L., & Johnson, L. N. (1976). *Protein crystallography*. Academic Press.

Additional reading:

1. Woolfson, M. M. (1997). *An Introduction to X-ray Crystallography*. Cambridge University Press.
2. Azaroff, L. V. (1968). *Elements of X-Ray Crystallography*. TechBooks.
3. McPherson, A. (1999). *Crystallization of Biological Macromolecules*. Cold Spring Harbor Laboratory Press.
4. Ducruix, A., & Giegé, R. (1999). *Crystallization of Nucleic Acids and Proteins: A Practical Approach*. Oxford University Press.
5. Cantor, C. R., & Schimmel, P. R. (1980). *Biophysical Chemistry - Part 1 The Conformation of Biological Macromolecules*. Freeman.

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