



**SRI SATHYA SAI INSTITUTE OF HIGHER LEARNING**  
(Deemed to be University)

**SYLLABUS FOR  
M.Sc. BIOSCIENCES**

**(Effective from 2018 – 2019)**

**DEPARTMENT OF BIOSCIENCES**

**SRI SATHYA SAI INSTITUTE OF HIGHER LEARNING**  
(Deemed to be University)

Unit-wise Syllabus for the two year  
**M.Sc. (Biosciences)**

**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
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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
		<b>21</b> Credits	<b>30</b> hours			<b>650</b> 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
		<b>21</b> Credits	<b>30</b> hours			<b>650</b> marks

Paper Code	Title of the Paper	Credits	Hours	Mode of Evaluation	Theory / Practicals	Maximum Marks
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Semester III						
PBIO-301	Intermediary metabolism	<b>4</b>	4	IE2	T	100
PBIO-302	Plant Systematics and Conservation	<b>4</b>	4	IE2	T	100
PBIO-303	<b>Elective - I*</b>	<b>3</b>	3	IE2	T	100
PBIO-304	<b>Elective - II*</b>	<b>3</b>	3	IE2	T	100
PBIO-305	Practical Course - 9	<b>3</b>	9	I	P	100
PBIO-406	Project Work (Review)** (see note below)	<b>Non-Credit#</b>	2	I	PW	50**
PAWR-300	Awareness Course -III: Guidelines for Morality	<b>1</b>	2	I	T	50
		<b>18#</b> Credits	<b>27</b> hours			<b>600</b> marks

Semester IV						
PBIO-401	Molecular Evolution and Human Genetics	<b>4</b>	4	IE2	T	100
PBIO-402	Cytogenetics and Plant Breeding	<b>4</b>	4	IE2	T	100
PBIO-403	<b>Elective - III*</b>	<b>3</b>	3	IE2	T	100
PBIO-404	<b>Elective - IV*</b>	<b>3</b>	3	IE2	T	100
PBIO-405	Practical Course-10	<b>3</b>	9	I	P	100
PBIO-406	Project Work in lieu of two Practicals*** (see note below)	<b>6#</b>	18	E2	PW	200 ***
PAWR-400	Awareness Course -IV: Wisdom for Life	<b>1</b>	2	I	T	50
		<b>18#</b> Credits	<b>25</b> hours			<b>550</b> marks

<b>GRAND TOTAL</b>		<b>78</b> Credits	<b>112</b> hours			<b>2450</b> marks
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**Modes of Evaluation**

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

**Types of Papers**

Indicator	Legend
<b>T</b>	Theory
<b>P</b>	Practical
<b>V</b>	Viva voce
<b>PW</b>	Project Work
<b>D</b>	Dissertation

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

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 3<sup>rd</sup> and 4<sup>th</sup> 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 4<sup>th</sup> semester + **100 marks** for the double evaluation of the Project Report submitted at the end of the fourth semester.

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## **INTRODUCTION**

### Unit-wise Syllabus for the two year **M.Sc. (Biosciences)**

#### **Programme Objectives:**

The curriculum of the 2-year postgraduate M.Sc. Biosciences programme builds on the basic concepts taught in the undergraduate B.Sc. Biosciences course of the 5-year integrated programme. The curriculum equips students with knowledge in a wide range of sub-disciplines under the canopy of Biosciences.

#### **Programme Specific Objectives:**

The first two semesters of the programme cover the four major areas of Molecular Biology, Molecular Cell Biology, Biochemistry and Immunology. The syllabus has been updated to include advanced topics in Molecular Developmental Biology, Instrumentation for Biological Applications and Bioinformatics in the first year of the course. The second year marks a shift to more specialized subjects such as Cytogenetics & Plant Breeding, Molecular Evolution & Human Genetics and Plant Systematics & Conservation Biology. The Department also offers elective papers in the domains of Biotechnology and Structural Biology.

All theory courses in the first two semesters have corresponding practical courses that provide students necessary training to hone their interests so that they can take up higher studies in any area of biological sciences that they wish to. Students are also given the option of taking up project work that extends across the final two semesters of the programme (in lieu of two practical courses). The Department endeavours to produce postgraduate students well-versed in the nuances of frontier areas in the life sciences, both in terms of theoretical knowledge and hands-on laboratory skills.

**MOLECULAR CELL BIOLOGY**

**Course Objectives:** To study the molecular mechanisms underlying cell structure and function.

1. Membrane Transport mechanisms: Principles of membrane transport; Types of carrier proteins and active membrane transport (Na<sup>+</sup> and K<sup>+</sup> pump, Ca<sup>++</sup> pump, H<sup>+</sup> 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, molecular 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 Checkpoint 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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## MOLECULAR BIOLOGY

**Course Objectives:** To study the molecular mechanisms involved in gene expression and regulation.

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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**INSTRUMENTATION FOR BIOLOGICAL APPLICATIONS**

**Course Objectives:** To study the working principle of bio-analytical methods and their biological applications.

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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## IMMUNOLOGY

**Course Objectives:** To study the advanced aspects of mammalian immune system.

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 proinflammatory 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 hypersensitivity, 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**

(Minimum of SIX experiments; 1-3 mandatory)

**Course Objectives:** To study laboratory techniques corresponding to cellular studies.

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**

(Minimum of SIX experiments)

**Course Objectives:** To study laboratory techniques corresponding to molecular biology.

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**

(Any SIX experiments using minimum FOUR equipment)

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

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**

(Minimum of SIX experiments)

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

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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**MOLECULAR DEVELOPMENTAL BIOLOGY**

**Course Objectives:** To study the molecular events underlying the development of select model organisms.

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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## GENETIC ENGINEERING

**Course Objectives:** To study the mechanistic aspects of Recombinant DNA technology and its applications.

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-loxP* 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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**BIOCHEMISTRY OF MACROMOLECULES**

**Course Objectives:** To study the advanced aspects of chemistry of bio-macromolecules.

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<sup>+</sup>, 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 chymotrypsin, 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 2<sup>nd</sup> Edition*. Wiley India Pvt. Limited.

**BIOINFORMATICS**

**Course Objectives:** To study organization of biological data and the basis & application of bioinformatics tools to solve research problems.

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 (1°, 2°, 3°, 4°); 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*, 2<sup>nd</sup> 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*, 3<sup>rd</sup> 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**

(Minimum of FIVE experiments)

**Course Objectives:** To study and gain hands-on experience in laboratory techniques to understand developmental events of select 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**

(Minimum of SIX experiments)

**Course Objectives:** To study and gain hands-on experience in laboratory methods corresponding to recombinant DNA technology.

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. Electroelution 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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**PRACTICAL COURSE – 7**  
(Minimum of SIX experiments)

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

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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**PRACTICAL COURSE – 8**  
(Minimum of TEN experiments)

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

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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**INTERMEDIARY METABOLISM**

**Course Objectives:** To study mechanistic aspects of anabolism and catabolism of biomolecules.

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,  $\beta$ -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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**PLANT SYSTEMATICS AND CONSERVATION**

**Course Objectives:** To study advanced aspects of plant classification and conservation.

**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**

**Course Objectives:** To study laboratory techniques corresponding to fungal biology.

**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 Objectives:** To study laboratory techniques used in plant cell and tissue culture.

**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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**MOLECULAR EVOLUTION AND HUMAN GENETICS**

**Course Objectives:** To study molecular mechanisms of human heredity and evolution.

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, Duchene 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. Krukoni, 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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**CYTOGENETICS & PLANT BREEDING**

**Course Objectives:** To study the genetic mechanisms of breeding different plant varieties.

**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**

**Microbial Biotechnology** (Minimum of SIX experiments)

**Course Objectives:** To study the laboratory techniques used for analysing microbes of economic importance.

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.

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 DO in water
7. Preparation of Biodiesel

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**MYCOLOGY, PATHOLOGY AND FUNGAL BIOTECHNOLOGY**

**Course Objectives:** To study various aspects of fungi as pathogens and applications of fungi for human welfare.

**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. Mehrotra 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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## PLANT BIOTECHNOLOGY

## Plant tissue culture

**Course Objectives:** To study *in vitro* propagation and genetic manipulation of plants.

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 *in vitro* 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.

## MICROBIAL BIOTECHNOLOGY

**Course Objectives:** To study various procedures involved in application of microbes for human welfare.

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*, 2<sup>nd</sup> 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*, 1<sup>st</sup> 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.

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**ENVIRONMENTAL BIOTECHNOLOGY**

**Course Objectives:** To study various aspects of environment and procedures for its preservation and sustainability.

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.

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**BIOTECHNOLOGY OF SECONDARY METABOLITES**

**Course Objectives:** To study various aspects of application of secondary metabolites of plants for human welfare.

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 Characteristics 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:Phytoecdysterones, 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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**BIOMOLECULAR STRUCTURE AND FUNCTION**

**Course Objectives:** To study structural and functional attributes of proteins with special reference to x-ray crystallography

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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