St. Xavier's College (Autonomous), Ahmedabad-9

MSc. Biotechnology
(Syllabus)
(Effective 2020-2023).

Programme Outcomes

PO1. Create a strong knowledge domain

PO2. Develop critical thinking, Problem solving and research aptitude

PO3. Skill development

PO4. Encouraging social interaction, service learning and develop equity centred national development (Social Extension work)

PO5. Self-directed and lifelong learning

PO6. Developing employability and entrepreneurial skills

PO7. Promoting Ecological sustainability development

PO8. Nurturing creativity and humane values

Programme Specific Outcomes

PSO1 Understanding and proposing experimental designs, develop problem solving abilities of the protocols developed for commercially viable biotech products

PSO2 Learning bioprocessing techniques used in large-scale production units

PSO3 Developing skill sets for research, employability and entrepreneurship

PSO4 Finding sustainable solutions to issues pertaining to environment, health, agriculture etc.

PSO5 Understanding the computational biology, omics interventions in development of novel molecules/ drugs/ products etc

St. Xavier's College (Autonomous), Ahmedabad
MSc. Biotechnology
Semester I

Semester	Course		No. of hours per week			Course Credit
I			Lectures	Lab sessions	Total	
	PBT 1801	Proteins: Concepts and Applications	4		4	4
	PBT 1802	Nucleic acids: Structure and Working	4		4	4
	PBT 1803	Carbohydrates And Lipids	4		4	4
	PBT 1804	Biophysical Techniques	4		4	4
	PBT 1805L	Practical Biochemistry		6	6	4
	PBT 1806L	Bioanalytical Techniques		6	6	4
		Total	**16**	**12**	**28**	**24**

Note: An average of 15 lectures per unit and a total of 60 hours per paper.

CORE Paper: Proteins: Concepts and Applications
Course Code: PBT 1801
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Outcome

By the end of the paper, a student should be able to:

CO1: To describe the structure of protein and correlate with its functions such as like molecular motors, interaction, carriers, signalling, repair and structure

CO2: To describe the synthesis of protein, its sorting and degradation

CO3: To understand and interpret the original experiments carried out to propose structure and functioning of various proteins

CO4: Ability to interpret Ramachandran plot and explaining proteins structure using bioinformatics tool

CO5: To explain techniques used in understanding the working of the proteins

CO6: To appreciate the importance of proper folding of proteins and relate to health, agriculture, and environmental issues arising from its expression.

Unit-1: Proteins: structure and functions

Amino acids: classifications. Primary, secondary, tertiary (*motifs and domains*), and quaternary structure of proteins, Ramchandran Plot, subunit interactions, coiled coil structures, symmetry and functional properties-haemoglobin; Functions of proteins; Evolutionary variation in proteins.

Unit-2: Protein synthesis and its working

Eukaryotic translation machinery, structure and assembly of the ribosome, Synthesis of proteins, Molecular Chaperones, Protein folding- role of chaperones; Protein modifications: structure – function relation. Working of proteins: as molecular motors, as structural molecules, in cell – cell interactions and recognition, as carriers, in transmitting signals, in catalysis; in repair systems; Proteins as multi enzyme complexes; single molecular dynamism (*molecular simulation)*

Unit-3: Protein sorting and degradation

Intracellular protein sorting, movement of proteins between cellular compartments: gated, transmembrane and vesicular transport. Protein transport and translocation to nucleus, mitochondria, chloroplast, peroxisomes, endoplasmic reticular system. Protein degradation, TAG protein destruction, SUMO.

Unit-4: Production of proteins in Biotechnology

Expression vectors; Heterologous expression and use of different host cells – bacteria, insect cells, animal cells and plant cells; Protein engineering; *de novo* protein design; Production of therapeutic proteins: erythropoietin, GM – CSF, Hepatitis B – Virus vaccine, monoclonal antibodies; Production of therapeutic enzymes: Urate oxidase, L – asparaginase, Human alpha – galactosidase; Production of diagnostic enzymes: Glucose oxidase, cholesterol oxidase, horse radish peroxidase.

References

Various articles from journals

Suggested Books as references

1. Modern Protein Chemistry: Practical Aspects Published: September 12, 2001 by CRC Press - 272 Pages Edited By: Gary C. Howard
2. Biochemistry. 7th edition. Berg JM, Tymoczko JL, Stryer L. New York: W H Freeman; 2014
3. Proteins: Structures and Molecular Properties: Thomas E. Creighton Publisher: W. H. Freeman 1992 Edition: Second Edition
4. Protein Engineering Protocols (Methods in Molecular Biology) Kristian Müller (Editor), Publisher: Humana Press; Softcover reprint of hardcover 1st ed. 2007 edition (November 10, 2010)
5. Protein Degradation Series, 4 Volume Set (v. 1) R. John Mayer (Editor), Publisher: Wiley-VCH; 1 edition (March 4, 2008)
6. Structural Aspects of Protein Synthesis Anders Liljas (Author) Publisher: World Scientific Pub Co Inc; 1 edition (November 2004)
7. Protein Targeting, Transport, and Translocation Ross Dalbey (Editor), Publisher: Academic Press; 1 edition (May 13, 2002).
8. How Proteins Work Mike Williamson, Publisher: Garland Science, 2012.

CORE Paper: Nucleic Acids: Structure and Working
Course Code: PBT 1802
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Outcome

By the end of the paper, a student should be able to:

CO 1: To explain the synthesis, breakdown of nucleic acids and role of inhibitors which has applications in medical field.
CO 2: To demonstrate the existence of various forms of nucleic acids and its relevance and to comprehend that the modern concepts of DNA structure beyond what Watson – Crick proposed.
CO 3: To analyze how topological changes and condensation of DNA influences gene expressions
CO 3: To explain the concept of RNA interference and its applications in various fields
CO 4: To describe and interpret experimental result arising from various DNA based studies
CO 5: To apply the concepts of regulation of gene expression as a tool in research and industry
CO 6: To assess how genetic complexity is associated with repetitive sequences and gene duplications.

Unit-1: Bases of Nucleic acids
Synthesis of purine and pyrimidine – de novo and salvage pathways. Synthesis of deoxy and oxy-ribonucleotides, various functions of Nucleotides, Nucleotide degradation. Disorders in purine and pyrimidine metabolism, Inhibitors of nucleotide synthesis and their role in chemotherapy.

Unit-2: Nucleic acid Basic structure
Nucleic acids, correlating structure with functions, Hoogstein base pairing and its implications; Assembly of DNA into chromosomes, structure and function of centromeres and telomeres, packing and functions, importance of topological changes, chromatin and its remodeling, Kinetoplast, DNA super coiling, DNA-protein interactions, Cp and Mt DNA

Unit-3: RNA and interference
RNA, various forms, 3D structure, secondary and tertiary structure and significance, role of metals in folding of RNA; RNA as enzymes; evolutionary tree construction, RNA interference in plants, animals, and its applications; RNA in antisense technology

Unit-4: Working of DNA
Eukaryotes - C value paradox, repetitive DNA, gene dosage and gene amplifications;
Gene expression and regulations, molecular mechanism of regulation, operon model, lac, trp, arabinose operons, repression and attenuation; manipulating gene expression for product formation.

References
Various articles from journals

Suggested Books as references

1. Nelson and Cox (2012) : Principles of Biochemistry (Worth Publ. Inc. USA)
2. Rawn, J.D. (1989) : Biochemistry (Neil Patterson Publ. North Carolina)
3. Biochemistry. 7th edition. Berg JM, Tymoczko JL, Stryer L. New York: W H Freeman; 2014
4. Voet, D. and Voet, J.G. (2012) : Biochemistry (John Wiley & Sons Inc/, New York)
5. Genes IX: Benjamin Lewin (2015); Jones and Bartlett Publishers
6. Watson J et al, Molecular Biology of the gene, Edition 7, 2013; Benjamin Cummings
7. David Friefelder. Essentials of Molecular Biology. 4th Edition. Jones and Bartlett Publishers
8. Bruce Alberts *et al*., Molecular Biology of the Cell. 4th Edition. Garland Science
9. Lodish et al. Molecular Cell Biology. 4th Edition. W. H. Freeman and Company.

CORE Paper: Carbohydrates and Lipids
Course Code: PBT 1803
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Outcome

By the end of the paper, a student should be able to:

CO 1: To identify biological importance of carbohydrates and lipids
CO 2: To distinguish between anabolic and catabolic processes of carbohydrates and lipids
CO 3: Compare and contrast metabolic pathway of complex carbohydrates in different living system
CO 4: To elucidate the role of lipids in maintaining homeostasis at cellular and systemic level
CO 5: Recognize and explain the contribution of lipid biochemistry in understanding the development of certain human diseases such as Niemen-peck disease, Tay-Sachs syndrome, hypercholesterolemia etc.
CO 6: Appreciating biotechnological intervention in microorganism to use them as cell factories for production of biomolecules of commercial importance

Unit-1: Carbohydrates: Structure – function relation

Structure and physiological functions of mono and oligosaccharides, Polysaccharides: starch, glycogen, cellulose, dextrin, inulin, chitosan, cellulose and hemicelluloses derivatives; Structure – function relationship and properties of heteroglycans, agar, alginic acid (seaweed polysaccharides), pectins, glycosaminoglycans (mucopolysaccharides) and glycocalyx oligosaccharides, Lectins and its significance

Unit-2: Carbohydrate Metabolism

Metabolism and regulation of carbohydrates, glycolysis, alternate pathways, feeder pathways, glycogen metabolism. Cell surface carbohydrates, L and P Selectins, advances in glycobiology; glycans in Biotechnology and Pharmaceutical industry, Glycomics

Unit-3: Lipid Metabolism

Utilization of fatty acids for energy production, alpha, beta and gamma oxidation of fatty acids. Integration and control of animal acylglycerol metabolism. Biosynthesis of fatty acids, Fatty acid desaturase and elongase. Biosynthesis of eicosanoids and its biological importance, prostaglandins, prostacyclins, thromboxanes. Formation of ketone bodies. Biosynthesis of phospholipids and their biological functions, Biosynthesis of cholesterol, its regulation and excretion, surfactants, Lipoprotein metabolism; bile acids; Biosynthesis of prostaglandins. Waxes: structure, different types, synthesis and functions (egs. microbial waxes, plant waxes, insect waxes and mammalian waxes). Glycospingolipids and role.

Unit-4: Production of carbohydrates and lipids in Biotechnology

Strategic upregulation of metabolic pathways for production; Metabolomics and fluxomics as concepts to enhance production; Enhanced exopolysaccharide production by metabolic engineering; Alginate production; Polysaccharide production by lactic acid bacteria and fungi; Microbial lipid production; Production of short chain fatty acids *in vitro;* Maximizing production of lipids by algal systems.

References

Various articles from journals

Suggested Books as references

1. Bohinski, R.C.(1987): Modern concepts in Biochemistry (Allyn & Bascon Inc. Boston)
2. Caret et al.(2013): Inorganic, Organic and Biological Chemistry (WMC Brown Publ.USA)
3. Nelson and Cox (2012) : Principles of Biochemistry (Worth Publ. Inc. USA)
4. Montgomery, R. et al (1990): Biochemistry: A case Oriented Approach (The C.V. Mosby Co., St. Louis)
5. Rawn, J.D. (1989) : Biochemistry (Neil Patterson Publ. North Carolina)
6. Biochemistry. 7th edition. Berg JM, Tymoczko JL, Stryer L. New York: W H Freeman; 2014
7. Voet, D. and Voet, J.G. (2012) : Biochemistry (John Wiley & Sons Inc/, New York)
8. Bhagwan N V, Medical biochemistry, 4th Edition, Bartlet and Jones.
9. Minoru Fukuda and Ole Hindsgaul, Molecular Cellular Glycobiology, Oxford 2000.
10. Gurr, M.I. et al (2016): Lipids: Biochemistry, Biotechnology and Health, 6th Edition, Wiley-Blackwell.
11. Ajit Varki, et al (2017): Essentials of Glycobiology, 3rd Edition, CSH Press

CORE Paper: Biophysical concepts in Biotechnology
Course Code: PBT 1804
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Outcome

By the end of the paper, a student should be able to:

CO 1: To describe the various centrifugal techniques used for fractionation of cells, cell organelles and bio-molecules.

CO 2: To apply the techniques of chromatography and electrophoresis to separate bio-molecules.

CO 3: To be able to explain individual components of different instrument.

CO 4: To device a suitable and workable experimental strategies for separation, purification, identification and characterization of a specific bio-molecules from a biological sample

CO 5: Enable to define the principles of various spectroscopic techniques used for characterization of bio-molecules

CO 6: Acquire adequate skills to use the instruments and analyze the experimental data.

CO 7: Implement the theoretical knowledge gained experimentally all the analytical techniques for characterization of bio-molecules.

Unit-1: **Methods employed for separation: Centrifugation**
Preparative ultracentrifugation - differential centrifugation and density gradient centrifugation. Analytical centrifugation -Schlieren optical system - applications - determination of molecular mass and purity of macromolecules, characterization and molecular weight determination of macromolecules,

Unit-2: Electrophoresis
Migration of Ions in an electric field, factors affecting mobility, types of electrophoresis-Free and Zonal, General techniques of zonal electrophoresis, Specialized electrophoretic techniques-DISC, Gradient, High Voltage Electrophoresis, Isoelectric focusing, 2D electrophoresis, Immuno-electrophoresis, Pulse Field Gel Electrophoresis, Di-electrophoresis. Capillary electrophoresis.

Unit-3: Chromatography
Chromatographic techniques - General principles of partition and adsorption chromatography. Thin layer, column, ion - exchange, molecular exclusion, gas - liquid and HPLC, normal phase, reverse phase, chromatofocusing, immune affinity, capillary elctrochromatography.

Unit-4: Characterization of macromolecules: Spectrophotometric techniques

UV – Visible Spectroscopy, Infra-red (IR), Electron Spin Resonance (ESR), Nuclear Magnetic Resonance (NMR) and Fluorescence Spectrophotometry, Rayleigh and Raman Scattering, Mass spectroscopy (GC/LC – MS)

References

Various articles from journals

Suggested Books as references:

1. Kensl. E. van Holde, W. Curtis Johnson, P. Shing Ho., Principles of Physical Biochemistry-Pearson Prentice Hall, 2nd Edition.
2. G. Rhodes., Crystallography made crystal clear, 1993. Academic Press.
3. Wilson Keith and Walker John., Principles and Techniques of Biochemistry and Molecular Biology, 6th Edition, (2005), Cambridge University Press, New York.
4. R. R. Bergethon (2010) the Physical Basis of Biochemistry: The Foundations of Molecular Biophysics, 2nd Ed., Springer, and NY.
5. P. J. Walla (2009) Modern Biophysical Chemistry, Wiley-VCH.
6. D. Sheeham (2009) Physical Biochemistry 2nd Ed., Wiley-Blackwell.
7. J. A. Goodrich and J. F. Kugel (2006) Binding and Kinetics for Molecular Biologists. Cold Spring Harbor Press.
8. van Holde, K. E. (1998) Principles of Physical Biochemistry, Prentice Hall.
9. Freifelder, D., 1982, Physical biochemistry: applications to biochemistry and molecular biology
10. Galen Wood Ewing Instrumental Methods of Chemical Analysis McGraw-Hill College; Fifth edition (1985).
11. Robert D. Braun, Introduction to Instrumental Analysis Pharma Book Syndicate (2006)
12. Sambrook, Manniatis, 3rd Edition, Cold Spring Harbor.

Practical Paper: Practical Biochemistry
Course Code: PBT 1805 L
No. of Credits: 04
Learning Hours: 90 hrs

I. Course Outcome

By the end of the paper, a student should be able to:

CO 1: To learn good lab practices
CO 2: To explain use of various instruments required in bioscience lab

CO 3: Ability to isolate and estimate various biomolecules

1. Introduction to Good Lab practices
2. Use of micropipettes and calibration of instruments
3. Preparation of buffers and pH and pKa measurements
4. Titration curve of amino acids and calculation of pI
5. Comparative study of protein estimation by Folin – Lowry method and Bradford's method.
6. Isolation of cholesterol and its estimation by Zlatki's method
7. Isolation of lecithin from egg yolk
8. Extraction and characterization of starch (Reference 3)
9. Estimation of glucosamine
10. Denaturation studies of DNA (Heating, NaOH and DMSO)
11. Modified Orcinol method for RNA determination

Practical Paper: Bioanalytical Techniques
Course Code: PBT 1806L
No. of Credits: 04
Learning Hours: 90 hrs

By the end of the paper, a student should be able to:

CO 1: To explain techniques used in understanding the nature of proteins

CO 2: Ability to isolate and estimate chloroplast

CO3: To learn use instruments to interpret the results

CO 4: Apply the techniques of chromatography and electrophoresis to separate bio-molecules.

1. Separation of albumin and globulin using centrifugation
2. Preparation of sucrose gradient to isolate chloroplasts
3. Separation of serum proteins using agarose gel electrophoresis
4. Factors affecting electrophoresis mobility (pore size/ voltage/ ionic strength of buffer)
5. Molecular weight determination of sample protein by SDS PAGE
6. Separation of amino acids, sugars and lipids by thin layer chromatography
7. Separation of plant pigments by column chromatography
8. Separation of components of extracts by HPTLC (Demonstration)
9. Analysis of caffeine in different beverages using UV – Vis spectrophotometer
10. Detecting Azadirachtin in an extract of Neem leaves using spectral scan

References:

1. Introduction to Practical Biochemistry. Plummer D, Plummer M. Tata McGraw Hill Publications
2. Practical Textbook of Biochemistry for Medical Students. Vasudevan DM et al. 2nd Edition, 2013. Jaypee Brothers publishers.
3. Extraction and Characterisation of Starches from Four Varieties of *Mangifera indica* Seeds http://www.iosrjournals.org/iosr-jac/papers/vol3-issue6/D0361623.pdf?id=3135
4. Modified Orcinol Reaction for RNA determination. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.616.8668&rep=rep1&type=pdf
5. Optimization of a UV-Vis spectrometric method for Caffeine analysis in tea, coffee and other beverages http://pubs.ub.ro/dwnl.php?id=CSCC6201302V02S01A0001

Semester II

Semester	Course		No. of hours per week			Course Credit
II			Lectures	Lab sessions	Total	
	PBT 2801	Cell Biology	4		4	4
	PBT 2802	Enzymes: Structure to Function	4		4	4
	PBT 2803	Immunology	4		4	4
	PBT 2804	Genetics and Bioinformatics	4		4	4
	PBT 2805L	Cell Biology and Enzymology Lab		6	6	4
	PBT 2806L	Immunology, Genetics and Bioinformatics Lab		6	6	4
		Total	**16**	**12**	**28**	**24**

Note: An average of 15 lectures per unit and a total of 60 hours per paper.

CORE Paper: Cell Biology
Course Code: PBT 2801
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Outcome

By the end of the paper, a student should be able to:

CO 1: To describe the molecules of life and conserved structures; recount how the working of the cell was discovered through model organisms
CO 2: To be able to recognize and identify the importance and functions of cell membrane
CO 3: To develop capacity to distinguish signalling pathways for regulation of various cellular mechanisms
CO 4: To be able to explain mechanism of development across species
CO 5: To evaluate the use of various model organisms to relate the development of vertebrates

Unit-1: Cells and evolution

The molecules of life: DNA, RNA, ATP, proteins, water, phospholipids with emphasis on why each was chosen as the building block.

How working of cell was discovered: Common experimental organisms and role of each to understand the functioning of a cell; Viruses to understand molecular cell biology; bacteria to understand fundamental functions of cell; yeast for cell cycle study, mice for study of human disease.

Evolutionary evidences of common ancestor - Helical motifs across various molecules like DNA, alpha-helix to microtubules; Conserved enzymes and primer sequences.

Unit-2: The cell boundary

Overview of membrane structure: Membrane lipids, membrane proteins and glycocalyx; Physical and chemical parameters that affect membrane fluidity; Membrane rafts; Lipid movement – ABC proteins; Gated and non-gated channels; Uniporters, Symporters and antiporters; Role of cytoskeleton in maintaining cell membrane.

Role of membrane in energy generation: Role of membrane in electron transport chain; Bacteriorhodopsin; ATP generation; the structure of F0-F1 complex, its assembly, movement of ATP synthase and production of ATP; The importance of proton motive force emphasizing the importance of membrane.

Unit-3: Regulatory molecules of the cell

Introduction to signal transduction. How signal reaches from extracellular to intracellular response. The role of signaling molecules, receptors, G-protein coupled receptors-Structure and

mechanism; secondary messengers- amplifiers, GTP-binding protein-ON/OFF switch. Why protein kinases and phosphatases are mostly involved in regulation.
Tyrosine kinases- role in cell division, epidermal growth factor, cytokines mediate through it. JAK/STAT pathway.

Ras/MAP kinase pathway: Down regulate the JAK/STAT pathway, regulates GTPase switch proteins, SOS binding and Scaffold proteins in eukaryotic cells.

Regulation by altering the protein structure - Acylation, nucleotidation, Ubiquitination, Notch/Delta pathway.

Unit-4: Cells to multicellular organisms

Germ cells and fertilization; Cellular Mechanisms of development; Morphogenetic movements and the shaping of the body plan; Differentiated cells and the maintenance of tissues; Cell diversification in the early embryo; Cell memory, cell determination and concept of positional values; Developmental control genes and the rules of cell behavior (nematodes/ C. elegans); Genesis of the body plan and homeotic selector genes and the patterning of body parts in Drosophila. Early development of Drosophila: cleavage and mid blastula transition, Gastrulation, genetic mechanism of patterning, Maternal effect genes, Segmentation, Para segmentation and genes involved in it. Role of homeotic sector genes; neural development.

References

Various articles from journals

Suggested Books as references:

1. Molecular cell Biology: Lodish, Berk, Kaiser, Krieger et al. 8th ed, WH Freeman, 2016
2. Molecular Biology of the Cell The problems Book (6ed): John Wilson and Tim Hunt
3. The Cell: Bruce Alberts, Alexander Johnson, Julian Lewis (2015) 5th ed, 2008, Garland Science
4. The Cell: A molecular approach (7ed) Geoffrey Cooper and Robert Hausman
5. World of the Cell (8ed): Jeff Hardin and Gregory Paul Bertini
6. Cell and Molecular Biology: Concepts and Experiments (7ed): Gerald Karp.

CORE Paper: Enzymes: structure to function
Course Code: PBT 2802
No. of Credits: 04
Learning Hours: 60 hrs
I. Course Outcome

By the end of the paper, a student should be able to:

CO1: To describe the different models of enzyme catalysis and the mechanisms for its assessment
CO2: To explain various methods for identifying active site residues
CO3: To illustrate the several methods for the enzyme regulation
CO4: To appreciate the applicability of enzymology in various industries for growth and sustainability
CO5: To develop skill for analyzing kinetic data of enzyme substrate reaction

Unit-1: How enzymes work
Acid-base catalysis, covalent catalysis, proximity, orientation effect, role of metal ion in enzyme catalysis. Strain & distortion theory. Measurement of enzyme activity - two point assay, kinetic assay, using radiolabelled substrates. Determination of active site amino acids - chemical probe, affinity label, and site-directed mutagenesis, intrinsic and extrinsic regulations. Investigation of 3-D structure of active site. Mechanism of action of lysozyme, carboxypeptidase, serine proteases, nitrogenases and examples from other classes of enzymes.

Unit-2: Enzyme regulation
General mechanisms of enzyme regulation, Different plots for the determination of K_m & V_{max} and their physiological significances, product inhibition. Reversible (glutamine synthetase & phosphorylase) and irreversible (proteases) inhibition; Competitive, non-competitive, uncompetitive, linear-mixed type inhibitions and their kinetics, determination of Ki and numerical based on these. Importance of Kcat/Km; Suicide inhibitors; Covalent modifications of enzymes. Mono cyclic and multicyclic cascade systems with specific examples; feed forward stimulation. Allosteric enzymes, its physiological significance, qualitative description of "concerted" & "sequential" models for allosteric enzymes, Co-operatively phenomenon, MWC and KNF models. Half site reactivity, Flip-flop mechanism, positive and negative co-operativity with special reference to aspartate transcarbamoylase & phosphofructokinase.

Unit-3: Kinetics and drug designs for enzymes
Use of initial velocity, Review of unisubstrate enzyme kinetics, multisubstrate enzyme kinetics, Protein-ligand binding and its measurement, Hill and Scatchard plots, analysis of binding isotherms, inhibition and exchange studies to differentiate between multi substrate reaction mechanism, Drug discovery, delivery and mechanism of action, specific emphasis on designing of drugs which can block the action of an enzyme or can activate it, catalytic antibodies, Ribozymes and DNAzymes, methods to improve biocatalysts, Pathway engineering

Unit-4: Industrial and clinical uses of enzymes

Industrial uses of enzymes - sources of industrial enzymes, thermophilic enzymes, amylases, glucose isomerases, cellulose degrading enzymes, lipases, proteolytic enzymes in meat and leather industry, detergents and cheese production, enzymes in textile industry, paper industry, food industry etc.; biofuel cells, Bio refinery, Biosensors.

Immobilized enzymes: methods, kinetics and their industrial applications. Nanomaterials for Enzyme immobilization.

Pharmaceutical industry- Enzymes as thrombolytic agents (tissue plasminogen activator), anti-inflammatory agents, digestive aids. Enzymes and isoenzymes in diagnosis – Lactate Dehydrogenases, Creatine Kinases, transaminases, phosphatases, sitagliptin and artemisinin project.

References

Various articles from journals

Suggested Books as references:

1. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry-Trevor Palmer
2. Principles of Biochemistry- Lehninger, David L. Nelson and Michael M. Cox
3. Biochemistry-Donald Voet, Judith G. Voet
4. Fundamentals of Enzyme Kinetics: Athel Cornish and Bowden, Portland Press, 2004
5. Understanding the control of metabolism: David Fell, Portland Press, 1996
6. Fundamentals of Enzymology: Price and Stevens, OUP, 1999
7. Enzyme structure and mechanism: Alan Fersht, WH Freeman, 1984
8. The Enzymes: Dixon and Webb, Academic Press
9. Industrial Enzymology: Tony Godfrey, Jon Reichelt

CORE Paper: Immunology
Course Code: PBT 2803
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Outcome

By the end of the paper, a student should be able to:

At the end of course students will be able to
CO 1: To have an in depth understanding on the history of important landmarks in the mammalian immune system
CO 2: To be able to correlate the molecules and organs of immune system
CO 3: To be able to understand and infer the use of immunological for methods diagnosis and therapeutics
CO 4: To be able to analyse the negative connotations of the immune system
CO 5: Compare and contrast the response of the host immune system to different pathogens

Unit-1: Cells and Molecules of immune system

Granulocytes: Eosinophils, Basophils, Neutrophils; Natural killer cells, Antigen presenting cells: structure and function, B cells, T cells, Peripheral γδ T cells, Antigens: Antigenicity vs immunogenicity, Factors that influence immunogenicity, B and T – cell epitopes, haptens - adjuvants. Antibodies: Structure, Antibody classes and biological activities, the immunoglobulin superfamily, organization and expression of immunoglobulin genes. Camelids; Cytokines: Properties, cytokine receptors,. MHC: General organization and inheritance of MHC, cellular distribution of MHC molecules, TOLL receptors, The complement system: The components and functions of complements

Unit-2: Pathways of immune system

Antigen presenting cells Processing and presentation pathways - the cytosolic and endocytic pathway, presentation of non-peptide antigens. Activation of complement, regulation of the complement pathways B cells: Maturation, activation and proliferation, antigen induced B- cell differentiation, regulation of B-cell development. T cells: T cell maturation, Thymic selection of T cells, T_H cell activation, T cell differentiation, Role of T – cells in cell death,

Unit-3: The immune response

The humoral response - primary and secondary response. Role of T_H cells in humoral response..,. Cell mediated response: Effector responses, General properties of effector T cells. Response to infectious agents: Virus, bacteria, protozoa; emerging infectious disease. Leukocyte migration and inflammation; Damage associated molecular mechanisms/platforms (DAMS); Pathogen associated molecular mechanisms/platforms (PAMS), MHC and immune responsiveness

Unit-4: Diseases related to immune system and treatment

Hypersensitive reactions- Gel and Coombs classification. Types of hypersensitive reactions. Cytokine-related diseases, therapeutic uses of cytokines MHC and disease susceptibility; Primary immunodeficiencies- Severe combined immunodeficiency, AIDS. Autoimmunity: Organ specific, systemic autoimmune disease, proposed mechanisms for autoimmunity; Treatment, Antibody Drug Conjugate (ADC), Immunotherapy, complement deficiencies

References

Various articles from journals

Suggested Books as references:

1. Kuby Immunology (2007) 6th ed., Kindt, T.L., Goldsby, R.A. and Osborne, B.A., W.H Freeman and Company (New York), ISBN: 13: 978-0-7167-8590-3 / ISBN: 10:0-7617-8590-0.
2. Immunology: A Short Course (2009) 6th ed., Coico, R and Sunshine, G., John Wiley& Sons, Inc (New Jersey), ISBN: 978-0-470-08158-7.
3. Janeway's Immunobiology (2012) 8th ed., Murphy, K., Mowat, A., and Weaver, C.T., Garland Science (London & New York), ISBN: 978-0-8153-4243-4.
4. Immunology: Jan Klain, Blackwell scientific
5. Immunology: Ivan Roitt, (10^{th} ed), Blackwell Scientific Press, 2010.
6. Roland Atlas, Microbiology
7. Microbiology: Willey, Sherwood, Woolverton, Microbiology 7^{th} ed. McGraw Hill, 2008

CORE Paper: Genetics and Bioinformatics
Course Code: PBT 2804
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Outcome

By the end of the paper, a student should be able to:

By the end of the paper, a student should be able to:

CO 1: To assess the variation of genes and their alleles that exist at a population level

CO 2: To evaluate, understand and become aware of the risk factors and ethical issues associated with inbreeding in humans and pre-natal diagnosis of genetic diseases.

CO 3: To analyse the impact of human migration on genetic material and utilizing this epigenetic data to map migration

CO 4: To expose students to use computational power to evaluate biological information

CO 5: Acquire skills to retrieve information from biological data-bases, analyze it and further remodel protein and genes to create their phylogeny

Unit-1: Population and evolution genetics

Sources responsible for changes in gene frequencies - Mutation, selection, migration and isolation; random genetic drift; insights into human migration, natural selection and evolution. Population substructure: Hierarchical population, Isolate breaking, Inbreeding, Assortative mating, concept of heritability, artificial selection and realized heritability. Organization and measure of genetic variation: Random mating population, Hardy-Weinberg principle, special cases of random mating – multiple alleles different frequencies between sexes (autosomal and X-linked).

Molecular Evolution**:** Evolution of origin of species and theories of evolution; The basic force of evolution – Mutation, recombination and gene flow; Variation and divergence of populations; Molecular evolution of genes and proteins; Evolution of genomes; Phylogeny and systematics; Molecular clock.

Unit 2: Quantitative and ethical Genetics

Johannsen pure line theory, multiple factor hypothesis, types of quantitative traits, components of phenotypic variation and genetic models for quantitative traits, Methods to study human gene diversity- Biochemical and molecular marker, VNTR, STR, microsatellite, SNP and their detection techniques RFLP, genotyping, RAPD, AFLP etc. Tracing human migrations with autosomal, Y chromosomal and mitochondrial markers

Ethical, legal and social issues in Human genetics: Prenatal/adult (individual/family/population) screening of mutation/risk factor for genetic diseases; effect of GM foods on human health.

Unit-3: Basic Bioinformatics

Introduction to databases-Primary, secondary, composite, Databases related to human diseases: OMIM, HGMD, Sequence similarity search: local, global, multiple and pairwise, Comparison of bacterial genome, Protein structure: PDB, protein structure prediction, Human genome variation, Functional genomics.

Unit-4: Applied Bioinformatics

Bioinformatics approach to RNA: eQtls: Understanding the Genetic basis of Variation in Gene expression, Protein analysis and proteomics, Molecular phylogeny & evaluation, Pharmacognosy: protein drug interaction, Protein - protein interaction, DNA-Drug interaction, Gene prediction, Analysis of gene expression by microarray, Homology Modelling.

References

Various articles from journals

Suggested Books as references:

1. Genetics (2012) 6th ed., Snustad, D.P. and Simmons, M.J., John Wiley & Sons.(Singapore)
2. Genetics - A Conceptual Approach (2012), 4th ed., Pierce, B.A., W.H. Freeman & Co. (New York)
3. An Introduction to Genetic Analysis (2010), 10th ed., Griffiths, A.J.F, Wessler, S. R, Carroll, S. B. and Doebley, J., W.H. Freeman & Company (New York)
4. Robert J. Brooker. Genetics: Analysis and Principles. 5th Edition. (2015) McGraw Hill Publications.
5. Terry Brown. Introduction to Genetics: A molecular approach. Garland Science
6. M.W. Strickberger. Genetics. 3rd Edition. MacMillan Publications
7. Xiong, J. (2006). Essential bioinformatics. Cambridge University Press. [Primary Book]
8. Dan E Krane and M. L Raymer. Fundamental Concepts of Bioinformatics. Pearson Publications. 2003
9. S. G. Sandhu. Bioinformatics and its applications. Neha Publishers. 2013
10. B.M. Purohit. Modern Entrepreneurship Development. Neha Publishers. 2013

Lall and Taylor. Entrepreneurship Development, Neha Publishers. 2014

Practical Paper: Cell Biology and Enzymology
Course Code: PBT 2805L
No. of Credits: 04
Learning Hours: 90 hrs

Course Outcome
At the end of course students will be able to

CO1: To describe the different models of enzyme catalysis and the mechanisms for its assessment
CO2: To develop skill for analyzing kinetic data of enzyme substrate reaction
CO3: To master immobilization techniques
CO4: To cultivate and analyse yeast growth

1. Isolation of yeast and study of its cell shape
2. Viability studies of yeast using Trypan Blue and MTT
3. Establishing synchronous cultures of yeast
4. Study of growth curve of yeast and determination of doubling time
5. Study of stages of cell division (onion roots)
6. Estimation of Riboflavin by Arnold's fluorimetric method
7. Effect of environmental factors such as pH, temperature, time and inhibitors on alkaline phosphatase.
8. Isolation and purification of peroxidase.
9. Molecular weight determination of enzyme by SDS PAGE.
10. Immobilization studies: Preparation of peroxidase entrapped in alginate beads and determination of percent entrapment

Practical Paper: Immunology, Genetics and Bioinformatics
Course Code: PBT 2806L
No. of Credits: 04
Learning Hours: 90 hrs

Course Outcome
At the end of course students will be able to
CO1: To study the techniques used in understanding the characteristics of immune system
CO2: To understand the bio-analytical tools used to study proteins and nucleic acids
CO3: To familiarise with softwares used in bioinformatics

1. Immunodiffusion techniques (Mancini and Ouchterlony)
2. Immunoelectrophoresis
3. Rocket immunoelectrophoresis
4. IgG purification
5. Identification of Barr body from salivary DNA
6. AMES Test
7. Study of Protein – Drug interaction (Bioinformatics)

8. Prediction of secondary structure of proteins
9. Prediction of secondary structure of RNA
10. Phylogenetic analysis of a gene
11. Offsite visit to institutions/industries (Demonstration of Instruments)

References:

1. Introduction to Practical Biochemistry. Plummer D, Plummer M. Tata McGraw Hill Publications
2. Practical Textbook of Biochemistry for Medical Students. Vasudevan DM et al. 2nd Edition, 2013. Jaypee Brothers publishers.

Semester III

Semester	Course (MSc Biotechnology)		No. of hours per week			Course Credit
III			Lectures	Lab sessions	Total	
	PBT 3801	Molecular Biology	4		4	4
	PBT 3802	Genetic Engineering	4		4	4
	PBT 3803	Microbial Biotechnology	4		4	4
	PBT 3804	Applied Biotechnology	4		4	4
	PBT 3805L	Molecular Biology and rDNATechniques		6	6	4
	PBT 3806L	Microbial and Environmental Biotech Lab		6	6	4
		Total	**16**	**12**	**28**	**24**

Note: An average of 15 lectures per unit and a total of 60 hours per paper.

CORE Paper: Molecular Biology
Course Code: PBT 3801
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Outcome

By the end of the paper, a student should be able to:

CO 1: To compare the replication and repair mechanism in eukaryotic system with the prokaryotic system
CO 2: To explain the process of transcription in eukaryotes and its multi-level regulation
CO 3: To correlate the external signalling with the changes in gene expression
CO 4: To describe gene regulation and its significance in biological sciences
CO 5: To learn to apply various molecular biology techniques in research
CO 6: To explain methodologies that have been used to understand the concepts of molecular Biology
CO 7: To design simple experiments based on the concepts of gene expression in eukaryotes.

Unit-1: DNA replication in eukaryotes
Cell cycle and replication; Molecular identification of origin of replication; Formation of pre – replication complex; Initiation and elongation of replication; Regulation of pre – replication complex formation and activation; Finishing replication in eukaryotes: role of telomerase in solving end replication problem; Comparative study of replication in prokaryotes and eukaryotes; DNA repair systems in prokaryotes and eukaryotes; Repair by recombination; Translesion DNA synthesis.

Unit-2: Transcription in eukaryotes

RNA polymerases in eukaryotes; Core RNA pol II promoters; Transcription factors; Regulatory sequences: promoter proximal sequences, upstream activator sequences, enhancers, silencers, boundary elements and insulators; Transcription initiation and role of mediators, nucleosome modifiers and remodelers, transcriptional activators; Elongation and proof reading; Transcription by RNA polymerases I and III; Transcription termination; RNA processing : Splicing pathways, alternative splicing, exon shuffling, RNA editing.

Unit-3: Gene regulation in eukaryotes

Conserved mechanisms of transcriptional regulation from yeast to mammals; eukaryotic activators; Signal integration and combinatorial control; Transcriptional repressor; control of transcriptional regulators and signal transduction; Gene silencing by histone modification; Post transcription initiation regulation.

Unit-4: Special Techniques

Gene knocking and gene knock out; Eastern Blotting; Northeastern blotting; Reverse North Blotting; Southwestern blotting; Recombinase Polymerase amplification; Ribosome profiling; Promoter bashing; Branched DNA assay; Ligase chain reaction; Chromatin Immunoprecipitation (CHiP); Oligomer restriction; Genome editing; CRISPR/Cas systems for editing, regulating and targeting; Mutagenesis methods.

References

Various articles from journals

Suggested Books as references

1. Molecular Cell Biology. Lodish et al. 5th Edition. W.H. Freeman and Company
2. Molecular Cloning – A laboratory manual. Sambrook – Russel, Vol 1, 2, 3. Third edition. CSHL Press
3. Molecular Biology of the Gene. Watson et al. 7th Edition. CSHL Press, Pearson and Cummings
4. Molecular Biology of the Cell The problems Book (6ed): John Wilson and Tim Hunt
5. The Cell: Bruce Alberts
6. The Cell: A molecular approach (7ed) Geoffrey Cooper and Robert Hausman
7. World of the Cell (8ed): Jeff Hardin and Gregory Paul Bertini
8. Cell and Molecular Biology: Concepts and Experiments (7ed): Gerald Karp
9. Molecular Biology: Principles and Practice. Michael Cox and Jennifer Doudana
10. Molecular Biology: genes to Proteins: Burton Tropp
11. Molecular biology: Structure and dynamics of genomes and proteins: Jordanka Zlatanova and Kensal van Holde
12. Benjamin Lewin. Genes XI. Jones and Bartlett. 2014

CORE Paper: Genetic Engineering
Course Code: PBT 3802
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Outcome

By the end of the paper, a student should be able to:

CO1: To explain the basic tools required in recombinant DNA technology
CO2: To explore the methods used to study gene location and structure
CO3: To know the various techniques used to study the gene expression and regulation
CO4: To assess the techniques used in analyzing transcripts and proteins
CO5: To be discuss problems associated with production of recombinant molecules
CO6: To explore the use of recombinant DNA technology in betterment of the society
CO7: To comprehend the use of Omics and develop skills

Unit-1: Basics of gene manipulation
Introduction to Recombinant DNA (rDNA) technology, Isolation of DNA, RNA and Plasmids, Techniques used in rDNA technology (Types of PCR, DNA Sequencing & Automated DNA sequencing, FISH, Comet assay), Gene construction, Transformation

Unit-2: DNA manipulation in prokaryotes
Plasmids as cloning vehicles, Types of Plasmid vectors, Bacteriophage, specialized vectors like cosmids, phagemids etc, Construction of genomic and c-DNA libraries, recombinant selection and screening, Expression of cloned genes in *E.* coli, Cloning in bacteria other than *E. coli.*

Unit-3: DNA manipulation in eukaryotes
Cloning in *S. cerevisiae* and other microbial eukaryotes, Gene transfer to plants, Double Termination, Technique of Gene transfer to animal cells, Transferring genes into animal oocytes, eggs, embryos and other specific tissues, Targeted gene replacement; Generation of novel plants and animals, Disadvantages of rDNA technology, ethical concerns of rDNA technology

Unit-4: Omics in Biotechnology
Genome & Genomics: Genome mapping: Physical and Genetic Map, Genome Sequencing, Next generation sequencing methods ,Genome Annotation, Functional Genomics.
Transcriptomics: Transcription factor binding sites, RNA-Seq, Microarrays, Regulatory RNAs: small or large, Computational prediction of miRNA target genes.
Proteomics: Tools of proteomics- SDS PAGE, 2D PAGE , Liquid chromatography , Mass Spectrometry (ESI and MALDI), Protein identification by peptide mass fingerprinting, Applications of proteomics.
Metabolomics: Tools of metabolomics- Capillary electrophoresis, Gas chromatography, Electrochemical detectors, Case studies.
Lipidomics: Basic concepts and tools

References

Various articles from journals

Suggested Books as references:

1. Recombinant DNA: James Watson and Richrad Meyers
2. From genes to Genomes: Concepts and applications: Jeremy Dale and Malcolm von Schantz
3. Principles of Gene manipulation and Genomics: SB Primrose and RM Twyman, 7th ed, 2006, Blackwell Scientific
4. Advanced Genetic analysis: Philip Meneely, Oxford University Press, 2009
5. Genome science: A practical and conceptual introduction to molecular genetics analysis in eukaryotes: David Micklos, Bruce Nash and Uwe Hilgert
6. Sambrook and Manniatis

CORE Paper: Microbial Biotechnology
Course Code: PBT 3803
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Outcome

By the end of the paper, a student should be able to:

CO 1: To analyse the role of microbiology in the field of Biotechnology
CO 2: To learn how to work with microbes
CO 3: To explain bioprocessing using microbes to get different products
CO 4: To evaluate the way the microbes can be improved to enhance quality and yield of products
CO 5: To appraise the techniques that have been developed in Microbial Biotechnology

Unit 1: Basic Microbiology
Understanding the structure of Microbial cell, Archaea cell and Viruses; Classification of microbes based on their optimum growth conditions; understanding their metabolism (Basic prokaryotic metabolism, sulphur, phosphorous metabolism; etc.).

Unit 2: Cultivation and Control of Microbes
Cultivation of metabolic distinct microbes; Microbial Control (Physical and chemical methods) and Chemotherapeutics (Antibiotics and sulpha drugs); Microbial Growth and its kinetics; Understanding basics of Metagenomics for non-cultivable microbes.

Unit 3: Bioprocessing and Fermentation Technology
Fermentation design; Scale-up of bioprocess (Steps of scale up, Scale-up of sterilization, aeration and agitation inoculum); Upstream processing (Solids and liquid handling, sterilization of media, air and reactors; Inoculum development; Aeration and agitation; maintenance of optimum fermentation condition); Downstream processing (Characterization of products and by-products, flocculation and conditioning of broth, Methods of cell separation, disruption, product recovery and purification, Case study of antibiotics to be included)

Unit 4: Microbial Biotechnology Products
Fermentation related products: Bioconversion of Steroids, Antibiotic production and modification (at-least 2 antibiotics), Production of Vitamin B12, Production of Bioplastics, Food products (flavouring agents, Organic acids, bakery products and beverages), Microbial enzymes (Amylase, lipase, Proteases)

Non-fermentation processes: MEOR (Microbial enhanced oil recovery, Microbial fuel cell.

References

Various articles from journals

Suggested Books as references:

1. Atlas R: Microbiology: Fundamentals and Applications (2nd ed)
2. Frobisher, Hinsdill, Crabtree, Goodheart: Fundamentals of Microbiology
3. Pelczar Reid: Microbiology (5th ed)
4. Prescott: General Microbiology.
5. Stainer, Adelber,Ingraham: General Microbiology
6. Whittaker ; Fermentation Biotechnology

CORE Paper: Applied Biotechnology
Course Code: PBT 3804
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Outcome

By the end of the paper, a student should be able to:

CO 1: To explore how different techniques in plant biotechnology has contributed to the society
CO 2: Comprehend how biotechnology has helped in Drug Discovery and Development
CO 3: To explain the culturing of animal cells *in vitro* and its applications
CO 4: To describe the role that biotechnology concepts have helped in environment management
CO 5: To describe the innovations and development of tools in Biotechnology

Unit-1: **Plant Biotechnology**
Principles of plant tissue culture, Laboratory setup, sterilization techniques, Media preparation and components of media, Plant growth regulators, Single cell culture, Protoplast isolation, culture and fusion, haploid culture, endosperm culture, Embryo culture, Somatic embryogenesis, Germplasm conservation, Somaclonal variation, Virus free plants, Secondary metabolite production; Production of recombinant proteins; Control of gene expression in transgenic plants; Plant vaccines; Plantibodies; Understanding of genomics for crop improvement: Plant biotechnology in food industry

Unit-2: Introduction to Pharmacology (Medical Biotechnology)
Definitions and brief – (pharmacology, pharmacokinetics, pharmacodynamics, drug, pharmaco therapeutics, clinical pharmacology, chemotherapy, pharmacy and toxicology), drug Nomenclature (chemical name, non-proprietary name and proprietary name) and essential drugs concepts; Routes of Drug Administration – Local routes, systemic routes; Dosage and Forms of Drug – Definition and brief about the dosage forms – solid dosage forms, liquid dosage forms, semisolid dosage forms, sterile products, gas and novel drug delivery system (liposome, nanosome, nanoparticles, microspheres, osmotic pumps, transdermal, implantation); Sources of Drugs**:** – Natural sources and synthetic sources; Pharmacodynamics **-** Principles of drug action and mechanism of drug action, dose response curve and adverse drug reaction. Factors Modifying Drug Action - Body size, age, sex, species and race, genetics, environmental factors, psychological factor, pathological states, other drugs, accumulation, tolerance, etc. Pharmacokinetics – brief outline of absorption, distribution, metabolism and excretion

Unit-3: Animal Biotechnology
Historical Background, Definitions, Advantages of Tissue Culture, Limitations, Origin of Cells, Instability, Major differences *In vitro*, Biology of Cultured Cells: The Culture Environment, Cell Adhesion, Intercellular Junctions, Cell Motility Cell cycle and Control of Cell Proliferation, Induction and Maintenance of Differentiation, Plasticity of Differentiation and Dedifferentiation, Origin of Cultured Cells. Initiation of the Culture, Evolution of Cell Lines, Senescence, Transformation and the Development of Continuous Cell Lines; Media composition and

preparation; Primary Culture; Subculture and Cell Lines, Propagation in Suspension, Standardization of Culture Conditions, Use of Antibiotics, Organ Culture, Histotypic Culture. Maintenance Records. Cloning and Selection; Cryopreservation and Banking; Clonal Isolation, Derivation of Drug-Resistant Cell Strains; Cell Line Characterization; Differentiation: Expression of the *In Vivo* Phenotype Stages of Differentiation, Proliferation and Differentiation, Commitment and Lineage, Stem Cell Plasticity, Markers of Differentiation, Induction of Differentiation, Differentiation and Malignancy, Practical Aspects**.** Three- Dimensional Culture**:** Cell Interaction and Phenotypic Expression; Authentication and Validation**:** Authentication of Cell Lines, Validation, Quality Assurance, Bioethics.

Unit-4: Biotechnology in Environmental Protection

Bioremediation and phytoremediation: Heavy metal remediation, genetics of microbe/ metal interaction, Plant/metal interaction, Production of biopesticides, bioherbicides, Study of Plant microbe interaction (Phosphate solubilizing and nitrogen fixing organisms), Decolorization of dyes: organisms involved, mechanisms of treatment, Industrial waste water treatment, Biofuel production by algae, Plant (*Jatropha curcas*) and micro-organism

References

Various articles from journals

Suggested Books as references:

1. Plant Tissue Culture, Theory and Practice, Rev Ed.,S. S. Bhojwani, M.K. Razdan
2. Biotechnology, B.D. Singh
3. Introduction to Plant Biotechnology, 3rd Ed., H. S. Chawla
4. Plant Tissue Culture, development and Biotechnology, Edited by Robert N. Trigiano and Dennis J Gray.
5. Plant Propagation: Principles and Practices – Hartmann, H.T and Kester D. E.
6. Animal Cell Culture and Technology– M Butler, 2nd Ed., 2004, BIOS Scientific Publishers
7. Freshney's Culture of Animal Cells: A Manual of Basic Technique and Special Applications, 6th Ed, Wiley online
8. Biotechnology – B.D. Singh, 2010, Kalyani Publishers
9. Microbial Biotechnology, Glazer et al, 2nd edition, 2007, Cambridge University Press
10. Principles of Fermentation, Whitaker et al, 2nd Edition, 1999, Butterworth – Heinemann publishers
11. Pharmaceutical Biotechnology, Second Edition, Michael J. Groves, CRC Press, 2005
12. Essential of Medical Pharmacology, K D Tripathi, 6th Edition, Jaypee Brothers Medical Publishers
13. Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems, Loyd V. Allen and Howard C. Ansel, 10th Edition

Practical Paper: Molecular Biology Techniques
Course Code: PBT 3805L
No. of Credits: 04
Learning Hours: 90 hrs

I. Course Outcome

By the end of the paper, a student should be able to:

CO1: To explain the basic tools required in recombinant DNA technology
CO2: To be discuss problems associated with production of recombinant molecules
CO3: To explore the use of recombinant DNA technology in betterment of the society

1. Isolation of DNA and gel electrophoresis and Using Gel Documentation System to analyze DNA
2. Random mutagenesis and screening
3. DNA amplification by PCR and its phylogenic analysis
4. Southern Transfer
5. Plasmid Isolation
6. Transformation of pBR322/pUC 8 in *E. Coli* (DH5 alpha) and its screening
7. Restriction digestion of Genomic DNA (Software)
8. Restriction digestion of Plasmid DNA
9. DNA Ligation
10. RNA Isolation
11. Recovery of DNA from Low-Melting-Temperature Agarose Gels: Organic Extraction
12. Isolation of Lambda phage

Practical Paper: Microbial and Environmental Biotechnology Lab
Course Code: PBT 3806L
No. of Credits: 04
Learning Hours: 90 hrs

I. Course Outcome

By the end of the paper, a student should be able to:

CO1: To isolate various microorganisms.

CO 2: To produce biofertilizer and explain the role that biotechnology concepts have helped in environment management

CO 3: Assessing and analyzing the effect of environmental, chemical factors on plant growth development

CO 4: To demonstrate the culturing of animal cells *in vitro*

1. Study of soil microbial ecology
2. Isolation of Nitrogen fixing bacteria
3. Isolation of microbes producing commercially important enzymes
4. Study of factors affecting growth of bacteria
5. Fermentative production of ethanol
6. Fermentative production of exopolysaccharides
7. Isolation of Agrobacterium
8. Isolation of phosphate solubilizing bacteria
9. Production of Biofertilizer
10. Determination of C/N ratio of biocompost
11. Physicochemical properties of water and its microbial analysis
12. Metal (Copper) bioremediation

References:

1. Molecular Cloning by Sambrook and Manniatis
2. Laboratory Manual and Workbook in Microbiology. McGraw – Hill, 2003

Semester IV

Semester	Course		No. of hours per week			Course Credit
IV			Lectures	Lab sessions	Total	
	PBT 4801	Research Methodology	4		4	4
	PBT 4802	Research Project		Min 24	24	20
		Total	**4**	**24**	**28**	**24**

Note: An average of 15 lectures per unit and a total of 60 hours per paper.

CORE Paper: Research Methodology
Course Code: PBT 4801
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Outcome

By the end of the paper, a student should be able to:

CO1: To enable to promulgate the understanding of formulating, pursuing and analyzing research benefitting human development
CO2: To sensitize students regarding the ethics of conducting research by enabling in-depth understanding of plagiarism
CO3: To impart necessary traits to analyze, compare, logically criticize and evaluate biological data
CO4: To developing competitive acumen to use modern-age computer programs to analyze and represent research data
CO 5: To be able to develop and elevate skills of scientific writing to present research interpretations in a form of research paper, presentation, book chapters and short communication

Unit-1: Basic concept to approach research
Searching interest of research, Defining the research question, Approaches and Methodology, objectives, significance and techniques of research, retrieving research materials (Literature review), compiling records. Introduction to kinds of scientific documents: research paper, review paper, book reviews, theses, conference and project reports (for the scientific community and for funding agencies); Patenting and IPR. Ethics in research: Honesty and integrity, Misconducts: Falsification, fabrication, plagiarism. Best/ standard practices and guidelines.

Unit-2: Biostatistics

Probability distribution: Normal distribution. Parametric and Nonparametric statistics, Confidence Interval. Quantitative Techniques: calculation of mean, dispersion, coefficient of variation and analysis of variance, standard error, t-test, chi-square test, correlation and regression, Levels of significance.

Unit-3: Computer applications and computational data management

Spreadsheet tools : Introduction to spreadsheet applications, features, Using formulae and functions, Data storing, Features for Statistical data analysis, Generating charts / graph and other features, Tools – Microsoft Excel or similar. Presentation tools: Introduction, features and functions, Presentation Tools and Skills; Web Search: Use of Publication search engines and libraries (PubMed, PubMed central, CrossRef, Google scholar). Use of Biological data bases to retrieve data.

Unit -4: Scientific writing

Components of a research paper– the IMRAD system, title, authors and addresses, abstract, acknowledgements, references, tables and illustrations. Use of automated referencing softwares (Mendley, EndNote, etc.), Introducing various Publishers (Nature, PlosOne, Elsevier, Springer, etc.), Understanding essential terms (Citations, Impact factor, h-index and i10-index), Selecting appropriate journal to publish an article. Preparing Manuscript, Dealing with publishers – submission of manuscript, ordering reprints. Basic formats of thesis and writing thesis, Oral and poster presentation of research papers in conferences/symposia. Preparation and submission of research project proposals to funding agencies. Redundant publication: duplication and overlapping of publications, selective reporting and misinterpretation of data. Conflict of interest, Violation of publication ethics: authorship and contributorship.

References

Various articles from journals

Suggested Books as references:

1. Ljubomir Todorovic. Original (Scientific) Paper – the IMRAD Layout. Archive of Oncology 2013. 11(3); 203 -05
2. Fundamental of Research Methodology and Statistics. Yogesh Kumar Singh. New Age International Publishers. 2006
3. Research Methodology: Methods and Techniques. C. R. Kothari. New Age International Publishers. 2004.