CBCS SYLLABUS

FOR

M.Sc. BIOTECHNOLOGY

(w.e.f. MO-2018 Batch)

DEPARTMENT OF BIO-ENGINEERING

BIRLA INSTITUTE OF TECHNOLOGY

MESRA, RANCHI – 835 215

Department of Bio- Engineering

Birla Institute of Technology, Mesra, Ranchi - 835215 (India)

Institute Vision

To become a Globally Recognized Academic Institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research and technological service to the National needs.

Institute Mission

- To educate students at Undergraduate, Post Graduate Doctoral and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.
- To provide excellent research and development facilities to take up Ph.D. programmes and research projects.
- To develop effective teaching and learning skills and state of art research potential of the faculty.
- To build national capabilities in technology, education and research in emerging areas.
- To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society.

Department Vision

The Department of Bioengineering has a vision to impart international standard quality education in the field of Bioscience, Biotechnology and Bioengineering.

Department Mission

- To create state-of-the-art infrastructure for Research and Training in Biotechnology and Bioengineering.
- To provide globally acceptable technical education in Bioscience, Biotechnology and Bioengineering.
- To nurture graduates for innovation and creativity in the field of Bioscience, Biotechnology and Bioengineering having ethical and social concern.
- To promote collaboration with Academia, Industries and Research Organizations at National and International level to enhance quality of education and research.
- To contribute to socioeconomic development through education and bioentrepreneurship.

M. Sc. (Biotechnology)

Programme Educational Objectives (PEOs)

PEO1	Students will gain necessary knowledge and develop specialized skills in the different areas of Biotechnology.
PEO2	Students will think critically and creatively about the use of biotechnology to address local and global problems.
PEO3	Students will be able to implement the scientific skills for development of industrial applications and entrepreneurship.

Program Outcomes (POs)

PO1	Ability to carry out research /investigation independently in specialized area of Biotechnology.
PO2	Ability to write and present a substantial technical report/document.
PO3	Able to demonstrate a degree of mastery in the area of biotechnology to enable them in collaborative and multidisciplinary research.
PO4	Recognise the need for continuous learning and will prepare oneself to create, select, learn and apply appropriate techniques, resources, and modern instrumentation to solve complex biotechnological activities with an understanding of the limitations.
PO5	Demonstrate knowledge of biotechnology and management principles and apply to manage projects efficiently and economically with intellectual integrity and ethics for sustainable development of society.

COURSE INFORMATION SHEET

Course code: BT401
Course title: MOLECULAR CELL BIOLOGY
Pre-requisite(s): Basics of Cell Biology
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc
Semester / Level: I/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Recapitulate the previous knowledge of cell biology and to establish thorough understanding of various cell structure and function at molecular level.
2.	Provide a thorough understanding of the various molecular biology concepts in study of cell biology and to study the different tools and techniques used to study the biology of cell at molecular level.
3.	Provide students with a deep insight about the motility of the cell with emphasis on the molecular motors, cell adhesions, molecular biology involved in the movement process involved in movement of Cilia and Flagella.
4.	Teach our students to have a concrete knowledge about cell to cell communication in animals as well as plants and to study about the basis of the interaction as well as the genes involved in it.
5.	Acquire in-depth knowledge of the molecular events involved in cell division which includes mitosis, meiosis, cell cycle and its regulation. Including. To provide wider and global perspective of cell cycle regulation and cancer, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Apply knowledge of cell biology and molecular Biology in various cellular functions, inculcate a knowledge of various issues related to molecular cell biology, the application and research involved in functioning of the different cell organelles.
CO2	Design and analyze the experiments related with the different molecules involved in cell biology and use of the various techniques in the molecular cell biology to study the kinetics and rationale behind each phenomenon.
CO3	Identify, formulate, and solve problems arisen due to the inefficient functioning of the various life processes like cell to cell communication, cell cycle regulation, movement processes of a cell or system.
CO4	Use the techniques, skills, and modern tools necessary for imbalances in various life processes, design a molecular cell biology research project, collect and analyze data, and interpret results

Syllabus

Module I: Cell Basics- Structure of prokaryotic and eukaryotic cells, membranes and cellular compartments, Structure, function and organization of all cell organelles. Biomembrane structure: Membrane carbohydrates and their roles in cell-cell recognition, Transmembrane: Transport of Ions and Small Molecules, Moving Proteins into Membranes and Organelles: Intracellular Vesicular Traffic, Secretion, and Endocytosis. Neurotranmission and regulation, Overview about genes in various cell organelles. (8L)

Module II: Cell Chemistry and Biosynthesis, Shape, Structure and Function of Nucleic acid, Proteins. Energy Conversion: Mitochondria and Chloroplasts, Fundamentals of Molecular Biology, chromatin packing, Manipulating Proteins, DNA, and RNA**,** Microscopy, Heamocytometry, Centrifugation, Freeze Fracture technique, Patch clamp method, FRAP etc. (8L)

Module III: Self assembly and structure of cytoskeleton filaments, Cytoskeleton filaments regulation by cells, molecular motors, cilia, and flagella of prokaryotes and eukaryotes. Cell-Cell and cell matrix adhesion; Extracellular Matrix, Plant cell wall, Cell junctions, plasmodesmata, gap junctions, desmosomes and tight junction, Overview about genes in involved in cell motility. (8L)

Module IV: General principles of cell communication, signal transduction pathways, signaling through G-protein linked cell surface receptors, signaling through enzyme linked cell surface receptors, signaling pathways that depend on regulated proteolysis. Signaling Pathways that Control Gene Expression, plant growth factors and hormones-auxins, gibberlines, cytokines, Host parasite interaction, Overview about genes involved in cell-cell interaction. (8L)

Module V: Overview of the cell cycle control system, components of the cell cycle, cell cycle progression, intracellular control of the cell cycle events, extracellular control of cell division, cell growth, and apoptosis. Cell differentiation in plants and animals including terminal cell differentiation, Role of Oncogenes, Tumor suppressor genes, hormones and growth factors in cell transformation and etiology of cancer, Overview about genes in involved in cell cycle regulation. Cell cycle synchronization. (8L)

Books recommended:

TEXT BOOK

1. Molecular biology of the gene by Watson et. Al (5th edition) ISBN: 8177581813
2. Molecular biology of the cell by Bruce Albert et al (4th edition) ISBN: 815332181

REFERENCE BOOK

1. Genes VII by Benjamin Lewin, Oxford University Press ISBN: 019879276X
2. Molecular Cell Biology, by Harvey Lodish, Matthew P. Scott, P Matsudaira, J Darnell, L Zipursky, Chris A. Kaiser, A Berk, M Krieger, publisher: W. H. Freeman; 5th edition, ISBN: 0716743663

Course Evaluation:
Individual assignment, Presentation, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time research projects.
POs met through Gaps in the Syllabus: PO2, PO3, PO5

Topics beyond syllabus/Advanced topics/Design:
Design optimization for molecular cell biology projects.
POs met through topics beyond syllabus/Advanced topics/Design: PO1, PO2, PO3, PO4, PO5.

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2		2	2	1
CO2	1	3	3	3	-
CO3	1	3	3	3	-
CO4	1	3	3	2	-

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD3, CD6
CO2	CD1, CD2, CD3,CD4, CD6
CO3	CD1, CD2, CD3,CD4, CD6
CO4	CD1, CD3,CD6,CD7

COURSE INFORMATION SHEET

Course code: BT402

Course title: METABOLISM & BIOENERGETICS

Pre-requisite(s): Nil

Co- requisite(s): Nil

Credits: 3 L:3 T:0 P:0

Class schedule per week: 03

Class: M.Sc

Semester / Level: I/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Give basic knowledge about catabolism, anabolism, regulation of metabolism and pathway analysis.
2.	Acquire knowledge and understanding of how enzymes and metabolites in living system work to produce energy and synthesizing different biomolecules.
3.	Extend comprehensive knowledge about biochemical pathways involved in intermediary metabolism of carbohydrate, protein, lipid and nucleic acid.
4.	Gain knowledge about the thermodynamic aspects of energetics in living system.

Course Outcomes

After the completion of this course, students should be able to:

CO1	Demonstrate an understanding of carbohydrate, protein, lipid and nucleic acid metabolism.
CO2	Distinguish between different metabolic processes and their impact in metabolism of biomolecules.
CO3	Select particular metabolic pathway involved in carbohydrate, protein and fat related metabolic issues
CO4	Apply and analyse the knowledge related to bioenergetics in living system.

Syllabus

Module 1: Introduction to Metabolism: Catabolism, anabolism, metabolic classifications of organisms, metabolic strategies and regulation, methods employed to study metabolism and pathway analysis, Integration of metabolic pathways. (8L)

Module 2: Carbohydrate Metabolism: Glycolysis, Citric acid cycle, Gluconeogenesis, Glycogenesis, Glycogenolysis, Hexose monophosphate shunt, uronic acid pathway, Galactose metabolism, Fructose metabolism, aminosugar and mucopolysaccharides metabolism, and their integration. (8L)

Module 3: Lipid Metabolism: Lipid profile, degradation and biosynthesis and regulation of fatty acids, Metabolism and regulation of membrane lipids, Metabolism, regulation and fate of cholesterol. (8L)

Module 4: Protein and Nucleic Acid Metabolism: Metabolism and regulation of amino acid, Metabolism and regulation of ammonia as well as urea cycle, Metabolism and regulation of nucleotides. (8L)

Module 5: Bioenergetics/Thermodynamics: Laws of thermodynamics, Concept of free energy, entropy, enthalpy and their relationship, Application of free energy function, Integration of metabolic pathways of energy metabolism. (8L)

Books Recommended:

TEXT BOOKS

1. Geoffrey L. Zubey, Biochemistry, Fourth Edition: Wm.C. Brown Publishers, 1998
2. U. Satyanarayana and U. Chakrapani: Biochemistry
3. Biochemistry by Robert Roskoski. W.B. Saunders, Philadelphia, ISBN 0-7216-5174-7

REFERENCE BOOK

1. D.L. Nelson and M.M. Cox Lehninger Principles of Biochemistry, Publisher: WH Freeman; *8th ed.*NewYork.
2. Biochemistry 5th Revised edition by Lubert Stryer, Jeremy M. Berg, John L. Tymoczko (ISBN: 8601300395166)

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

POs met through Gaps in the Syllabus:
Topics beyond syllabus/Advanced topics/Design:

POs met through topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	-	1	3	2	-
CO2	-	1	3	2	-
CO3	-	1	3	2	-
CO4	-	1	3	2	-

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2,CD6
CO5	CD2, CD2, CD6

COURSE INFORMATION SHEET

Course code: BT403
Course title: APPLIED MICROBIOLOGY
Pre-requisite(s):
Co- requisite(s):
Credits: 2 L:3 T:0 P:4
Class schedule per week: 04
Class: M.Sc
Semester / Level: I/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Establish an understanding of the basic techniques (concept of aseptic work, cultivation and identification) in microbiology
2.	Describe different aspects of microbial nutrition and growth
3.	Describe microbial interactions and their significance in environment
4.	Describe microbial interactions and their significance in agriculture, food and pharmaceuticals
5.	Describe nonspecific body defenses and the immune responses and apply this understanding to the infectious disease process as well as the prevention and control of infectious diseases
6.	Develop and execute oral and writing skills necessary for effective communication of the course, the ability to think critically regarding a topic and the delivery of scientific principles to both scientists and non-scientists community

Course Outcomes:
At the end of the course, a student should be able to:

CO1	Identify microbiological techniques, the defining characteristics of the major groups of microorganisms and apply to study microbial phylogeny
CO2	Classify the nutritional types of microorganisms and measure microbial growth
CO3	Evaluate how microorganisms interact with the environment in beneficial or detrimental ways
CO4	Assess impact of plant- microbe interaction on agriculture in both beneficial and detrimental ways. Identify industrially important microbes
CO5	Determine ways in which microorganisms play an integral role in disease, and the microbial and immunological methodologies are used in disease treatment and prevention
CO6	Apply the scientific method by stating a question; researching the topic; determining appropriate tests; performing tests; collecting, analyzing, and presenting data and effective communicate with both specialist and non-specialist audiences/community

Syllabus

Module I: Techniques in Microbiology & Microbial Diversity: Microscopy, Staining in Microbiology, sterilization, Pure culture Methods, Culture Media and its types, Micrometry, Air Sampling, Waste water analysis, Measurement of Microbial Growth, Types of microorganisms, Methods of identification of microorganisms (8L)

Module II: Microbial Nutrition and Growth: Nutritional and Growth Factors requirement of microorganisms, Nutritional Types of Microorganisms, Uptake of Nutrition, Microbial Growth, Influence of Environmental Factors of Growth, Batch Culture, Continuous Culture, Synchronous Growth, Fed-batch Culture. Control of microbial growth by physical and chemical agents (8L)

Module III: Environmental Microbiology: Distribution of Microbes in Air and water, Allergic disorders by air microflora, air sampling, Water treatment, Bacteriological analysis of water, Bioleaching, Bioremediation (8L)

Module IV: Agricultural Microbiology and Industrial Microbiology: Plant-microbes interactions, Microbial Biodeterioration of agricultural products, control of microbes and safe storage of agricultural products, Biofertilizers, industrially important micro-organisms, secondary metabolites from micro-organisms, Microbiology of foods, Single cell Protein (8L)

Module V: Medical Microbiology: Diseases caused bacteria, virus, fungi, and protozoans; Fungal diseases, Host parasite interaction-recognition and entry process of different pathogens in plants and animals, Toxins produced, Vaccines, Anti-microbial agents, Antibiotics and disinfectants, National Immunization Programme (8L)

Books recommended:

Text books:

1. Willey, Sherwood, Woolvertan, Prescott/Harley/Klein's Microbiology, 7th Ed., TMH, 2007
2. Tortora, Microbiology: an Introduction, 12th Ed., Pearson, 2016
3. Frazier and Westhoff, Food Microbiology, 4th Ed., TMH, 1995

Reference books:

1. Pelczar, Chan and Krieg, Microbiology, 5th Ed., McGraw Hill, 1985
2. Stanier, General Microbiology, 1st Ed., MacMillan, 1958

Course Evaluation:
Individual assignment, Presentation, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
POs met through topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	1	3	3	1
CO2	1	2	3	3	1
CO3	2	3	3	2	2
CO4	2	3	3	2	2
CO5	2	3	3	2	2
CO6	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3 and CD6
CO2	CD1, CD2, CD3 and CD6
CO3	CD1, CD2, CD4, and CD6
CO4	CD1, CD2,CD4, CD5 and CD6
CO5	CD1, CD2, CD4, and CD6
CO6	CD1, CD2, CD3, CD4, CD5 and CD6

COURSE INFORMATION SHEET

Course code: BT404
Course title: MATHEMATICS AND STATISTICS FOR BIOLOGISTS
Pre-requisite(s):
Co- requisite(s): Nil
Credits: 3 L: 03 T:0 P: 0
Class schedule per week: 03
Class: M. Sc.
Semester / Level: I
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Work on basic science as well as biotech industry in multidisciplinary teams and independently.
2.	Learn various tools to design, conduct, mathematical & statistical analysis new experiments, measurements and interpreting experimental data from biological system and addressing the challenges associated with the interaction between living systems and non-living materials.
3.	Grab the knowledge theory of basic mathematical & statistical tools used in biological research/ biotechnology industry and research lab (Probability, Sampling Theory and Test of Hypothesis).
4.	Enable the students to understand the principle and application of Differential Calculus, Differential Equations and various Computational Techniques
5.	A Master's degree in this field prepares a student for careers in biotech research in different domains including industry.

Course Outcomes

After the completion of this course, students will gain:

CO1	An ability to apply knowledge of mathematics and statistics to design and conduct experiments, as well as to analyze and interpret data related to domain of biology.
CO2	An ability to design a system, component, or process to performing research in biological system and addressing the challenges associated with the interaction between living systems and non -living materials. Know how to meet the desired needs within realistic constraints, such as, economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
CO3	An ability to apply the knowledge of basic mathematical & statistical tools used in biological research/ biotechnology in industry and research lab.
CO4	An ability to understand the principle and application of Differential Calculus, Differential Equations and various Computational Techniques
CO5	A Master's degree in this field prepares a student for careers in higher education, as well as in pharmaceutical and biotechnology industries in government and private agencies. An ability to function in multidisciplinary teams. An ability to identify, formulate, and solve Science/Engineering problems.

Syllabus

Module 1: Linear Algebra and Probability: Set Theory, Matrices, Scalars, Vectors, Determinants, Eigen values & vectors, Variance (Discrete, Continuous), Mean, Median, Mode, Standard Deviation. (8L)

Module 2: Sampling Theory and Test of Hypothesis: Introduction to sampling theory, Probability Distribution (Binomial, Poisson & Normal), Type I & Type II error, one tailed & two tailed test, Level of significance, t-test and chi-square test. (8L)

Module 3: Differential Calculus: Limit and continuity, Introduction to differentiation, Finding maxima and minima, Introduction to integration, Application to Biological Sciences. (8L)

Module 4: Differential Equations: Differential equations, HIV dynamics, Ludeking & Piret Model, Protein folding. (8L)

Module 5: Use of Computational Techniques: Application of Computational tools (MATLAB): case study, Plotting of equations, Statistical optimization tools, (8L)

Books recommended:

TEXT BOOK

1. Fundamentals of Mathematics by William M. Setek, Jr. And Michael A. Gallo, Prentice Hall, ISBN- 0 -13 -778341 -8.
2. Basic Technical Mathematics with Calculus by Allyn J. Washington, Addison- Wesley Publishing Company

REFERENCE BOOK

1. Mathematical Methods in Physical Sciences by Mary L. Boas, Wiley India, ISBN- 9/8-81-265-0810-5
2. Mathematical Biology I &II by J.D. Murray, Springer- Verlag Texts

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	-	-	-	-
CO2	-	-	2	-	-
CO3	3	-	-	2	-
CO4	1	-	-	-	-
CO5	-	-	-	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3 and CD6
CO2	CD1, CD2, CD3 and CD6
CO3	CD1, CD2, CD4, and CD6
CO4	CD1, CD2, CD4, CD5 and CD6
CO5	CD1, CD2, CD4, and CD6
CO6	CD1, CD2, CD3, CD4, CD5 and CD6

COURSE INFORMATION SHEET

Course code: BT 405
Course title: CELL BIOLOGY AND BIOCHEMISTRY LAB
Pre-requisite(s):
Co- requisite(s):
Credits: 2 L:0 T:0 P:4
Class schedule per week: 04
Class: M.Sc.
Semester / Level: 1/4
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students:

1.	To recapitulate the previous knowledge of cell biology and biochemistry in order to design experiments to analyze some of the established facts about cell biology and biochemistry. To use the techniques, skills, and modern tools necessary for detection of the presence of biomolecules and their estimation collection and analysis of data, and interpretation of results.
2.	To provide quantitative analysis of the macromolecules in the given sample and analyse the results.
3.	To provide students with a deep insight of the various biochemical reactions and cellular processes through quantitative and qualitative analysis of the samples provided.
4.	To inculcate in our students a concrete knowledge of reactions involved in the biological processes and to understand the rationale behind them.Identify, formulate, and solve problems arising due to the inefficient functioning of the systems in life sciences.
5.	Independently execute a laboratory experiment using the standard methods and techniques in molecular biology, with the appropriate analysis and interpretation of results obtained.

Course Outcomes:

At the end of the course, a student should be able:

CO1	To apply knowledge of cell biology and biochemistry in various cellular functions, inculcate a knowledge of various issues related to life processes and the application of research involved in functioning of the different cell organelles and accessories.
CO2	To design and analyze the experiments related with the different molecules involved in cell biology and use of the various techniques in the molecular cell biology to study the kinetics and rationale behind each phenomenon.
CO3	To identify, formulate, and solve problems arisen due to the inefficient functioning of the various life processes and anatomical aspects of plants and animals.
CO4	o use the techniques, skills, and modern tools necessary for imbalances in various life processes, design a research project, collect and analyze data, and interpret results

Syllabus

List of Experiments

1. Preparation of Buffers.
2. Qualitative Test for Carbohydrates.
3. Qualitative Test for Amino Acids.
4. Carbohydrate estimation by Anthrone.
5. Protein Estimation by Bradford Method.
6. Protein Estimation by Lowry Method.
7. Isolation and Estimation of DNA.
8. Protein precipitation and purification SDS PAGE.
9. Preparation of slides of mitosis from onion root tip cells.
10. Study of different types of cells in the human blood smear.
11. Identification of Barr bodies in the human cheek cells.
12. To study the effect of plasmolysis and deplasmolysis in onion peel.
13. To study the working of Compound microscope.
14. To measure the length and breadth of the given cell sample by using micrometer.
15. To identify the number of cells present in the given 1ml sample with help of haemocytometer.
16. To identify the different types cells present in the leaf cross section.

Books recommended:

1. **Gerczei Fernandez, Timea / Pattison, Scott:** Biochemistry laboratory manual for undergraduates: An inquiry-based approach, SCIENDO, Open Access PDF ISBN 978-3-11-041133-1
2. **Arun Rastogi**: Laboratory Manual in Biochemistry, Anmol Publisher (2011) ISBN-10: 8126144998

Course Evaluation:
Lab (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through topics beyond syllabus/Advanced topics/Design

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	2	1
CO2	3	2	2	2	1
CO3	3	1	2	2	1
CO4	2	3	3	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2,CD3

COURSE INFORMATION SHEET

Course code: BT406
Course title: MICROBIOLOGY LAB
Pre-requisite(s):
Co- requisite(s): BT403
Credits: 2 L:0 T:0 P:4
Class schedule per week: 04
Class: M.Sc
Semester / Level: I/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To establish an understanding of the basic techniques (concept of aseptic work, cultivation and identification) in microbiology
2.	To describe different aspects of microbial nutrition and growth
3.	To describe microbial interactions and their significance in environment
4.	To describe microbial interactions and their significance in agriculture, food and pharmaceuticals
5.	To develop and execute oral and writing skills necessary for effective communication of the course, the ability to think critically regarding a topic and the delivery of scientific principles to both scientists and non-scientists community

Course Outcomes:
At the end of the course, a student should be able to:

CO1	Identify microbiological techniques, the defining characteristics of the major groups of microorganisms and apply to study microbial phylogeny
CO2	Classify the methods to measure microbial growth
CO3	Evaluate how microorganisms interact with the environment in beneficial or detrimental ways
CO4	Identify industrially important microbes
CO5	Apply the scientific method by stating a question; researching the topic; determining appropriate tests; performing tests; collecting, analyzing, and presenting data and effective communicate with both specialist and non-specialist audiences/community

Syllabus

List of Experiments

1. Cleanliness, media preparation, culturing methods, dilution techniques, and isolation of pure cultures by different techniques
2. Staining techniques in microbiology
3. Biochemical tests for identification of unknown microorganisms.
4. Evaluation of disinfectants and antiseptics, evaluation of sterilization methods.
5. Bacterial growth curve.
6. Standard qualitative analysis of water.
7. Micrometry
8. Antibiotic sensitivity test; Isolation of antibiotic resistant bacteria from waste / sewage water.

Book Recommended:

TEXT BOOK

1. James G. Cappuccino and Natalie Sherman: Microbiology: A Laboratory Manual, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., 2005

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations
Gaps in the syllabus (to meet Industry/Profession requirements) :
POs met through Gaps in the Syllabus:
Topics beyond syllabus/Advanced topics/Design:
POs met through topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	3	1
CO2	3	2	1	3	1
CO3	3	2	2	3	2
CO4	3	2	2	3	2
CO5	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD3 and CD6
CO2	CD1, CD3 and CD6
CO3	CD1, CD2, CD3, CD4, CD5 and CD6
CO4	CD1, CD2, CD3, CD4, CD5 and CD6
CO5	CD1, CD2, CD3, CD4 and CD6

COURSE INFORMATION SHEET

Course code: BT407
Course title: GENOMICS
Pre-requisite(s):
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc.
Semester / Level: I/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To understand about differences between prokaryotic and eukaryotic genomes as well as forward and reverse genetics.
2.	To learn about techniques used in genomics, genome sequencing, annotation, database development as well as their applications.
3.	To impart knowledge about the advances in structural and functional aspect of newly sequenced genome
4.	To understand the use of genomics in the crop improvement, drug discovery, value added crops as well as development of recombinant protein.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Explain the detailed characteristics of prokaryotes and eukaryotes genome as well as application of forward and reverse genetics.
CO2	Get knowledge and design the experiments using various techniques of genome sequencing as well proper organization of generated biological data
CO3	Apply structural and functional genomics approaches on newly sequenced genome for functional characterization of genes.
CO4	Develop capacity to pin point the strategies used for crop improvement and development of drug, recombinant proteins or value added crop.

Syllabus

Module 1: Genomic Evolution & Organization: RNA world hypothesis, Genetics to Genomics, Forward and revers genetics. Eukaryotic and prokaryotic genomes, Chromosome structure and function, Chromatin re-modeling/organization, DNA as genetic material, Central dogma of molecular biology. (8L)

Module2: Genome Sequencing: Overview of conventional and new sequencing technologies, Strategies used in whole genome sequencing, NGS technologies, RNAseq, Genome annotation, Candidate gene discover and data mining, Transcription factor, Development of databases and their uses, Genome mapping by genetic and physical technique, Comparative genomics and SNP analysis. (8L)

Module-3: Techniques for Genomics: Restriction and modifying enzymes, Various blotting techniques, PCR techniques, RT-PCR, qPCR, Digital PCR, Site directed mutagenesis, Genomic and cDNA libraries, Screening of libraries, DNA microarray, Antisense RNA, RNA interference, TALEN, CRISPR-Cas9. (8L)

Module 4: Genome Initiatives: Structural and functional genomics, Advances in human genome, Advances in buffalo genome, Advances in arabidopsis genome, Advances in rice genome, Advances in wheat genome, Advances in tomato genome, Advances in sorghum genome, Advances in peanut genome etc. (8L)

Module 5:
Application of Genomics: Genomics in gene function analysis, Genomics in plant and animal breeding and improvement, Genomics in drug discovery, Genomics in valued added crops, Genomics in recombinant protein etc. (8L)

Book Recommended:

TEXT BOOK

1. Principles of Genome analysis and Genomics, 3rd Edition, By S. B. Primrose and R. L. Twyman, Blackwell publishing (2003), ISBN: 1405101202
2. Bioinformatics and Functional Genomics, 3rd Edition, By Jonathan Pevsner, Wiley-Blackwell (2015), ISBN: 978-1-118-58178-0.

REFERENCE BOOK

1. Principles and Practices of Plant Genomics (Volume 3), By Chittaranjan Kole and Albert G. Abbott. CRC Press (2017): ISBN 9781138116498
2. Genome Analysis: Current Procedures and Applications by Maria S. Poptsova. Caister Academic Press (2014) ISBN: 978-1-908230-29-4.

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time industrial projects.

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Design optimization for industrial projects.

POs met through topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	2	2	-
CO2	1	-	1	3	1
CO3	3	2	2	3	2
CO4	2	3	3	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD4, CD6
CO4	CD1, CD3, CD6

COURSE INFORMATION SHEET

Course code: BT408
Course title: Genomics Lab
Pre-requisite(s): NIL
Co- requisite(s):BT 407
Credits: 2 L:0 T:0 P:4
Class schedule per week: 04
Class: M.Sc.
Semester / Level: 1/4
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students:

1.	To recapitulate the previous knowledge of Molecular Biology and biochemistry to design experiments.
2.	To use the techniques and skills necessary for estimation and quantification of DNA and their further analysis.
3.	To use the techniques and skills necessary for estimation and quantification of RNA and their further analysis.
4.	Use of modern tools for analysis of Nucleic acids and their further analysis.
5.	Independently execute a laboratory experiment using the standard methods and techniques in molecular biology, with the appropriate analysis and interpretation of results obtained.

Course Outcomes:

At the end of the course, a student should be able :

CO1	To handle DNA and its manipulation
CO2	To handle DNA and its manipulation
CO3	Hands on and gain expertise in handling routine laboratory equipment used in Genomics lab
CO4	To use modern tools for analysis of Nucleic acids and their further analysis. Independently execute a laboratory experiment using the standard methods and techniques in molecular biology, with the appropriate analysis and interpretation of results obtained.

Syllabus

List of Experiments

1. Isolation and purification of DNA.
2. Separation of DNA by agarose gel electrophoresis.
3. Isolation and purification of RNA.
4. Electrophoresis of RNA on denaturing gels.
5. Spectrophotometric estimation of DNA and RNA.
6. Preparation cDNA.
7. PCR amplification of gene of interest.
8. Real Time PCR/ PCR based comparative gene expression analysis of different tissue samples.
9. Visualization/analysis of data.

Text book

1. 3rd Edition, By S. B. Primrose and R. L. Twyman, Blackwell publishing (2003), ISBN: 1405101202
2. Bioinformatics and Functional Genomics, 3rd Edition, By Jonathan Pevsner, Wiley-Blackwell (2015), ISBN: 978-1-118-58178-0.

Reference book

1. Principles and Practices of Plant Genomics (Volume 3), By Chittaranjan Kole and Albert G. Abbott. CRC Press (2017): ISBN 9781138116498
2. Genome Analysis: Current Procedures and Applications by Maria S. Poptsova. Caister Academic Press (2014) ISBN: 978-1-908230-29-4.

Course Evaluation:
Lab (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through topics beyond syllabus/Advanced topics/Design

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	2	1
CO2	3	2	2	2	1
CO3	3	1	2	2	1
CO4	2	3	3	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2, CD3

COURSE INFORMATION SHEET

Course code: BT409
Course title: INDUSTRIAL BIOTECHNOLOGY
Pre-requisite(s):
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc
Semester / Level: I/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Know about principle of growth, importance of maintaining the cultures, techniques used for enhancing the yield and role of various factors on the growth of biological strains, significance of medium constituents on production process in liquid cultivation
2.	Design criteria for fermenter and operation of bioreactor, solid state fermentation and calculation of yield
3.	Learn the processes of primary and secondary metabolite production with certain examples and case study, production of enzymes and therapeutics from biological systems
4.	Gain knowledge about the application of living systems for energy production, in bioremediation and biotransformation with certain examples

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Understand the growth kinetics, Monod equation and explain the role of various factors affecting the process of growth. They will also be able to define the media for submerged and solid-state fermentation process
CO2	State the significance of application of fermentation in production of primary and secondary metabolites, production of important enzymes, solve the mass balance of production process
CO3	Collect the proficient knowledge of living systems in the energy production, utilization of waste to commercially important compounds and bioremediation process

Syllabus

Module 1: Technology of Microbial growth and Maintenance: Principles of Microbial growth, Methods to increase yield of microbes, Strain preservation, maintenance and improvement, Microbial culture selection for high yield potential, Physico-chemical parameters for microbial growth

[8 L]

Module 2: Bioreactor / Fermenter: Types & operation of Bioreactors, Introduction to Batch, Fed-batch and Continuous culture systems, s, Limitations of bioreactors, Stages of fermentation processes, Media design for fermentation processes, Solid substrate fermentation, advantages & disadvantages of solid substrate & liquid fermentations.

[8 L]

Module 3: Production of Primary and Secondary Metabolites: A brief outline of processes for the production of some commercially important primary metabolites (e.g. citric acid, lactic acid, acetic acid etc., glutamic acid, aspartic acid etc.,) and alcohols (ethanol, butanol), Production processes for various classes of secondary metabolites such as beta-lactams (penicillin, cephalosporin etc.), aminoglycosides (streptomycin) macrolides (erythromycin), and Vitamins [8 L]

Module 4: Production of Enzymes and other Bioproducts**:** Production of industrial enzymes such as proteases, amylases, lipases, Production of biopesticides, biofertilisers, biopreservatives (Nisin), Single cell protein, Production of recombinant proteins with therapeutic and diagnostic applications, Production of vaccines and monoclonal antibodies, Products of bioproducts from plant and animal cell culture. [8 L]

Module 5: Bioconversions and Bioremediation: Biomining and bioleaching of ores, Ethanol, methane and Hydrogen from biomass, Production of Biodiesel, Algal Biofuel, Bioremediation of oil spills, Wastewater treatment, Removal of heavy Metals, Microbial degradation of pesticides and aromatics compound.

[8 L]

Text Books:

1. Industrial Biotechnology, Isha Book, India (2006)
2. Biotechnology for Agro-Industrial Residues Utilisation, Springer, Netherland (2009)
3. Basic Industrial Biotechnology, New Age International Pvt Ltd, India (2012)

Reference Books:

1. Industrial Biotechnology: Sustainable Production and Bioresource Utilization, CRC Presss, Taylor and Francis (2017)
2. Industrial Biotechnology: Microorganisms, John Wiley and Sons (2017)

Course Evaluation:

Individual assignment, Presentation, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

Design of real-time industrial projects: NA

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Design optimization for industrial projects: NA

POs met through topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5
CO1	1	-	2	3	-
CO2	1	1	3	2	3
CO3	3	2	-	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD3
CO2	CD1, CD2, CD3,CD4
CO3	CD1, CD2, CD3,CD4, CD6

COURSE INFORMATION SHEET

Course code: BT410
Course title: INDUSTRIAL BIOTECHNOLOGY LAB
Pre-requisite(s):
Co- requisite(s): None
Credits: 2 L:0 T:0 P:4
Class schedule per week: 04
Class: M.Sc
Semester / Level: I/04
Branch: Biotechnology
Name of Teacher:
Course Objectives:

This course enables the students to:

1.	Know about principle of growth, importance of maintaining the cultures, techniques used for enhancing the yield and role of various factors on the growth of biological strains, significance of medium constituents on production process in liquid cultivation
2.	Design criteria for fermenter and operation of bioreactor, solid state fermentation and calculation of yield
3.	Learn the processes of primary and secondary metabolite production with certain examples and case study, production of enzymes and therapeutics from biological systems
4.	Gain knowledge about the application of living systems for energy production, in bioremediation and biotransformation with certain examples

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Understand the growth kinetics, Monod equation and explain the role of various factors affecting the process of growth. They will also be able to define the media for submerged and solid-state fermentation process
CO2	State the significance of application of fermentation in production of primary and secondary metabolites, production of important enzymes, solve the mass balance of production process
CO3	Collect the proficient knowledge of living systems in the energy production, utilization of waste to commercially important compounds and bioremediation process

Syllabus

List of Experiments

1. Isolation of proteolytic enzymes from soil sample
2. Production of baker's yeast and inoculums preparation
3. Production of citric acid by SSF
4. Preparation of standard plot of protein
5. Preparation of standard plot of sugar
6. Growth of microorganism and yield caculation
7. Immobilization of whole cell by entrapment
8. Kinetic study of enzyme

Books Recommended:

TEXT BOOKS:

1. Doran, Bioprocess Engineering Principles, Academic Press, 1995
2. Bailey and Ollis, Biochemical Engineering Fundamentals, 1986

Reference Books:

1. Shuler and Kargi, Bioprocess Engineering – Basic Concepts. Prentice Hall PTR
2. Industrial Biotechnology: Microorganisms, John Wiley and Sons (2017)

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time industrial projects: NA
POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects: NA
POs met through topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5
CO1	1	-	2	3	-
CO2	1	1	3	2	3
CO3	3	2	-	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD3
CO2	CD1, CD2, CD3,CD4
CO3	CD1, CD2, CD3,CD4, CD6

COURSE INFORMATION SHEET

Course code: BT411
Course title: MOLECULAR PLANT PHYSIOLOGY
Pre-requisite(s):
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc
Semester / Level: I/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To understand about photosynthesis and detailed mechanism involved in the CO2 fixation by plants
2.	To learn about techniques used in genetic modification for increased plant biomass
3.	To impart knowledge about the structure and functionality of chloroplast protein and their encoding genes as well as plant hormones
4.	To develop novel protein using various recent approaches and increase crop production under adverse condition

Course Outcomes:

At the end of the course, a student should be able to:

CO1	explain the detailed characteristics of chloroplast and mechanism of photosynthesis
CO2	engineer photorespiration as well as apply other approaches to increase plant biomass
CO3	gain the proficient knowledge about structure and functionality chloroplast protein and encoding genes as well as hormonal response on plants
CO4	develop capacity to pin point the suitable strategies in developing stress resistance plants and increasing crop productivity

Syllabus

Module 1: Photosynthesis**:** Anatomy of chloroplasts, photosynthetic pigments, Structure of photosystems I and II and their coding genes, Molecular oxygen evolving complex, Photolysis of water; mechanisms of electron transport; Calvin cycle and its light/dark regulation. RuBisCO activities, C3, C4 and CAM pathways. (8L)

Module 2: Photorespiration and Respiration: Photorespiration, Gross and net photosynthesis, Glycolysis, Citric acid cycle; Electron transport and ATP synthesis; Pentose phosphate pathway, Mitochondrial ATP synthase, Engineering or genetic modification of photorespiration (8L)

Module 3: Photomorphogenesis: Molecular structure of phytochrome, Photoconversion, Nuclear translocation of Pfr and modification of gene expression, Family of PHY genes and multiplicity of responses. Structure and function of Cryptochromes. Photoperiodism and biological clocks.

(8L)

Module 4: Stress Physiology: Biotic and abiotic stress responses in plants, Characteristic features of stress responsive genes, stomatal functions and transpiration, Physiological process affected by stresses and resistance mechanisms, Molecular responses to various stress perception, expression of regulatory genes and significance of gene products. Development of stress resistance plant.

(8L)

Module 5: Plant Hormones: Overview about various plant hormones, Molecular mechanism of plant hormones action, Hormone receptors and signal transduction, Gene expressions at developmental stages and stresses, Phytohormone signalling in plant defense mechanism, Cross-talk and molecular aspect of growth and development processes. (8L)

Book Recommended:

TEXT BOOK:

1. Plant Physiology, 5th Edition by Lincoln Taiz and Eduardo Zeiger, Sinauer Associate (2010). ISBN: 978-0878938667
2. Plant Physiology, 4th Edition, by Salisbury F. B. and Ross C. W. (2004), Wadsworth Publisher, ISBN: 9788131501658, 8131501655

REFERENCE BOOK:

1. The Molecular Life of Plants by Russell L. Jones, Helen Ougham, Howard Thomas, Susan Waaland (2012) Wiley-Blackwell. ISBN: 978-0-470-87011-2
2. Plant Hormones under Challenging Environmental Factors by Ahammed, Golam Jalal, Yu, Jing-Quan (2016) ISBN 978-94-017-7758-2

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time industrial projects.
POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects.
POs met through topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	-	3	3	1
CO2	1	-	3	3	1
CO3	2	1	3	2	-
CO4	2	2	3	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD3
CO2	CD1, CD2, CD3, CD4, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3,CD6

COURSE INFORMATION SHEET

Course code: BT412
Course title: MOLECULAR PLANT PHYSIOLOGY LAB
Pre-requisite(s):
Co- requisite(s): None
Credits: 2 L:0 T:0 P:4
Class schedule per week: 04
Class: M.Sc
Semester / Level: I/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To understand about photosynthesis and detailed mechanism involved in the CO2 fixation by plants
2.	To learn about techniques used in genetic modification for increased plant biomass
3.	To impart knowledge about the structure and functionality of chloroplast protein and their encoding genes as well as plant hormones
4.	To develop novel protein using various recent approaches and increase crop production under adverse condition

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Explain the detailed characteristics of chloroplast and mechanism of photosynthesis
CO2	Engineer photorespiration as well as apply other approaches to increase plant biomass
CO3	Gain the proficient knowledge about structure and functionality chloroplast protein and encoding genes as well as hormonal response on plants
CO4	Develop capacity to pin point the suitable strategies in developing stress resistance plants and increasing crop productivity

Syllabus

List of Experiments

1. Quantification of pigment content in leaves.
2. Comparison of photosynthetic pigment content under different stresses.
3. Observation of absorption spectra of photosynthetic pigment.
4. Isolation of chloroplast
5. Isolation and purification of RNA.
6. Quantification of RNA AND preparation cDNA.
7. PCR amplification of gene of interest.
8. Real Time PCR/ PCR based comparative gene expression analysis of different tissue samples.
9. Visualization/analysis of data.

Recommended Books:

Text Book

1. Experiments in Plant Physiology: A Laboratory Manual by Dayananda Bajracharya, Narosa Publishing House (1999), **ISBN:** 978-8173193101.
2. Research Experiences in Plant Physiology: A Laboratory Manual by Moore, T.C. (1974) ISBN 978-3-642-96168-7.

Reference book:

1. Plant Physiology, 5th Edition by Lincoln Taiz and Eduardo Zeiger, Sinauer Associate (2010). ISBN: 978-0878938667
2. Plant Physiology, 4th Edition, by Salisbury F. B. and Ross C. W. (2004), Wadsworth Publisher, ISBN: 9788131501658, 8131501655
3. The Molecular Life of Plants by Russell L. Jones, Helen Ougham, Howard Thomas, Susan Waaland (2012) Wiley-Blackwell. ISBN: 978-0-470-87011-2
4. Plant Hormones under Challenging Environmental Factors by Ahammed, Golam Jalal, Yu, Jing-Quan (2016) ISBN 978-94-017-7758-2
5. Shuler and Kargi, Bioprocess Engineering – Basic Concepts. Prentice Hall PTR

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

1. Conducting presentations in group and writing reports.
2. Giving assignments to the students on some relevant topics.

POs met through Gaps in the Syllabus: PO2, PO3

Topics beyond syllabus/Advanced topics/Design:

1. Lecture on specialized physiological sensing.
2. Lecture on human-machine interaction.

POs met through topics beyond syllabus/Advanced topics/Design: PO1, PO4

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	1	3	2	-
CO2	-	-	2	-	-
CO3	-	-	1	-	-
CO4	-	-	1	1	-
CO5	1	2	2	1	-

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2
CO2	CD2, CD3, CD6
CO3	CD2, CD7
CO4	CD3
CO5	CD3, CD7

COURSE INFORMATION SHEET

Course code: BT414
Course title: BIOSIGNAL ACQUISITION SYSTEM LAB.
Pre-requisite(s):
Co- requisite(s): BT413
Credits: 2 L:0 T:0 P:4
Class schedule per week: 04
Class: M.Sc
Semester / Level: I/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To impart knowledge for interdisciplinary and applied engineering and technology.
2.	To provide knowledge about different physiological parameters and associated measuring sensors.
3.	To impart practical knowledge about the application of biomedical equipment.
4.	To make them learn about the general processing tools for biomedical signal analysis.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Working with the biomedical equipment.
CO2	Fundamentals of the types of biomedical sensors and transducers for biomedical data acquisition.
CO3	Fundamentals of biosignals and their pattern analysis.
CO4	Work in an interdisciplinary team.

Syllabus

List of Experiments

1. To study and calculate body mass index and its correlation with human health.
2. To study different types of electrodes and sensors used in bio-potential recordings.
3. To study and measure non-invasive blood pressure using sphygmomanometer.
4. To analyse the characteristics of different types of electrolytic medium between electrode and body.
5. To record and analyse bipolar electrocardiogram.
6. To record and analyse surface electromyogram.
7. To record and analyse vertical and horizontal eye ball activity.
8. To study and analyse electrical and mechanical cardiac activities using phonocardiography.
9. To record biopolar and monopolar electroencephalogram and analyse delta, theta, alpha and beta bands.
10. To study and analyse haemodynamic activity using pulse plethysmography.
11. To record and analyse electrodermal activity or galvanic skin response.
12. To study and perform lie detector test.

Books Recommended:

TEXT BOOKS:

1. Introduction to Biomedical Technology by J. J. Karr & J. M. Brown, Pearson , 2001
2. Handbook of Biomedical Instrumentation by R. S. Khandpur, Tata McGraw-Hill Education, 1994
3. Biomedical Instrumentation and Measurement by L. Cromwell et al., Prentice Hall

REFERENCE BOOKS:

1. Biomedical Digital Signal Processing by W. J. Tompkins, Prentice Hall; Har/Dskt edition (March 2, 1993)
2. Biomedical Signal Processing: Principles and Techniques by D C Reddy., McGraw-Hill Education (India) Ltd.

Course Evaluation:
Written test, viva and performance examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

3. Conducting presentations in group and writing reports.
4. Giving assignments to the students on some relevant topics.

POs met through Gaps in the Syllabus: PO2, PO3

Topics beyond syllabus/Advanced topics/Design:

1. Lecture on specialized physiological sensing.
2. Lecture on human-machine interaction.

POs met through topics beyond syllabus/Advanced topics/Design: PO1, PO4

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4
CO1	1	1	3	2
CO2	-	-	2	2
CO3	-	-	2	2
CO4	1	2	3	-

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD3
CO2	CD1, CD3
CO3	CD1, CD3
CO4	CD3, CD7

COURSE INFORMATION SHEET

Course code: BT415
Course title: MOLECULAR BIOLOGY & rDNA TECHNOLOGY
Pre-requisite(s):
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc
Semester / Level: II/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Introduce knowledge on basic concepts of molecular biology techniques
2.	Exemplify different types of polymerase chain reactions and their applications
3.	Implement, organize and design different vectors for gene cloning and expression
4.	Generating contextual and conditional knowledge of gene function for various applications

Course Outcomes

After the completion of this course, students will be able to:

CO1	Apply the principles of molecular biology techniques
CO2	Analyze the experimental data to select a suitable PCR for a particular application
CO3	Evaluate selectivity and specificity of vectors for cloning genes and their expressions
CO4	Examine gene function, gene modulation and their effects on improvement of crops and animals.

Gaps in the syllabus (to meet Industry/Profession requirements) Nil

POs met through Gaps in the Syllabus: Nil

Topics beyond syllabus/Advanced topics/Design: Nil

POs met through Topics beyond syllabus/Advanced topics/Design: Nil

Syllabus

Module 1: Genetic Organization: Central dogma of molecular biology, structure of DNA, DNA replication, DNA damage and repair, repetitive DNA, kinetics of DNA renaturation. Discovery and salient features of genetic code, organellar genetic code. RNA synthesis, RNA processing and RNA editing, Protein synthesis and Posttranslational modifications of proteins, collinearity of genes and protein 8L

Module 2: Gene Regulation: difference in genetic organization of prokaryote and eukaryote, *lac* operon, regulation of bacteriophage λ life cycle, nucleic acid binding motifs in regulatory proteins, Small Double stranded RNAs and RNA interference, Epigenetics 8L

Module 3: Methods in Genetic Engineering: Polymerase Chain Reaction: Thermostable DNA Polymerases, PCR technique and its variants, Quantitative Real-Time PCR, Site directed mutagenesis, Restriction and modifying enzymes

8L

Module 4: Creation of Recombinant Molecules and Libraries**:** Characteristics of plasmid and other cloning vectors, artificial chromosomes, prokaryotic and eukaryotic expression vectors, Recombinant Protein purification by IMAC method. Genomic, cDNA, EST and Large insert genomic libraries, Strategies and approaches to genome sequencing, Overview of Enzymatic DNA sequencing, NGS, Assembly and annotation of DNA sequences. 8L

Module 5: Applications of Recombinant DNA Technology: Transgenic plants and animals, DNA vaccine, Gene therapy, PCR based diagnosis, Golden rice, Terminator technology, Safety guidelines of recombinant DNA research.

8L

Books recommended:

1. Old and Primorose- Gene Manupulation, Wiley, 2002
2. Alberts et al, Molecular Biology of the Cell, W. W. Norton & Company; Sixth edition (November 18, 2014)
3. Watson, Recombinant DNA., Scientific American Books
4. Lodish et al, Molecular Cell Biology., Freeman and Co., 2013

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and SWAYAM

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	-	3	3	1
CO2	1	-	3	3	1
CO3	2	1	3	2	-
CO4	2	2	3	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD3
CO2	CD1, CD2, CD3,CD4
CO3	CD1, CD2, CD3,CD4, CD6
CO4	CD1, CD3,CD6

COURSE INFORMATION SHEET

Course code: BT416
Course title: ENZYME AND BIOPROCESS TECHNOLOGY
Pre-requisite(s): BT 409
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc
Semester / Level: II/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Understand the process of microbial growth and synthesis of bioproducts, methods of measurements of growth and mass balance of the bioprocess, kinetics of product formation
2.	Aware about significance of enzyme catalysis, production of enzyme at large scale and stability related issues, media constituents, formulations and sterilization, types of sterilizes and role of filers on sterilization
3.	Expand the knowledge on agitation of media, stirring mechanism, kinetics of oxygen supply, and requirement of power during the process
4.	Identify the reactors applicability as per the process requirement, understand mode of reactor operation and significance of solid state fermentation

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Understand the growth kinetics, Monod equation and explain the role of various factors affecting the process of growth. They will also be able to define the media for submerged and solid-state fermentation process and sterilization
CO2	State the significance of application of process technology on enzyme production, enzyme kinetics, solve the mass balance of production process, learn the process of oxygen transfer rate, agitation systems
CO3	Collect the proficient knowledge of design of fermenter and operation of fermentation process, methods of translation of laboratory data to pilot scale process

Syllabus

Module 1: Cell growth and bio-product formation kinetics**:** Growth patterns and kinetics in batch culture, quantification of cell growth, effect of environmental factors on microbial growth, kinetics of product formation, growth, non-growth associated products, yield concepts and mass balance. 8L

Module 2: Enzyme kinetics: Introduction to enzymes, mechanistic models for simple enzyme kinetics, rate parameters, effect of pH, temperature, concentration of substrate on enzyme catalysis, stability of enzymes, methods of immobilization, immobilized enzyme reactors, diffusional limitations in immobilized enzyme systems, large scale enzyme production, case study for manufacture of commercial enzymes and applications. 8L

Module 3: Media and air sterilization: Importance of media on growth, introduction and the kinetics of death, batch and continuous sterilization of media, air sterilization, various type of sterilization equipments, sterilization of media by membrane filters. 8L

Module 4: Agitation and aeration: types of impellors and sparger, oxygen transfer rate, oxygen uptake rate, volumetric oxygen transfer rate (k_La), measurement of k_La, power requirement for agitation in gaseous and non gaseous systems. 8L

Module 5: Bioreactor Selection and Design: Selection criteria for bioreactor, body construction of fermenter and its components, solid state and submerged fermentation, design aspects of bubble column bioreactor, air-lift fermenter, plug-flow and packed bed bioreactor, scaling up of bioreactor, Choosing the cultivation methods, Batch, fed-batch and continuous bioreactors. 8L

Books Recommended:

TEXT BOOKS:

1: Shuler and Kargi, Bioprocess Engineering – Basic Concepts. Prentice Hall PTR
2: Aiba and Humphary. Biochemical Engineering, Academic Press (1965)
3: Doran, Bioprocess Engineering Principles, Academic Press, 2012
4: Enzyme by Palmer (2001); Horwood publishing series, Elsevier

REFERENCE BOOKS:

1: Bailey and Ollis, Biochemical Engineering Fundamentals, TATA-McGraw Hill, 2nd ed.
2: Lee, Biochemical Engineering, Prentice Hall, 1992.

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time industrial projects: NA
POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects: NA

POs met through topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5
CO1	1	-	2	3	-
CO2	1	1	3	2	3
CO3	3	2	-	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD3
CO2	CD1, CD2, CD3,CD4
CO3	CD1, CD2, CD3,CD4, CD6

COURSE INFORMATION SHEET

Course code: BT417
Course title: BIOINFORMATICS
Pre-requisite(s):
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc
Semester / Level: II/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	State and comprehend the fundamental concepts of database system and its architecture, importance of biological database in the current time
2.	Extend comprehensive knowledge about data mining and Big data analysis and its complexity.
3.	Demonstrate concept about Biological problem solving, regarding to sequence alignment and Genome editing, motif finding with the help of specific algorithms
4.	Gain knowledge about the techniques for molecular modelling and drug designing

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Explain the theoretical knowledge of database system and algorithms.
CO2	Analyze and discuss the results in light of molecular biological knowledge (sequence alignment and phylogenetic tree plot)
CO3	Collect the proficient knowledge to solve biological system- a multi-disciplinary problem
CO4	Develop the key skills of molecular modeling techniques currently practiced in any pharmaceutical research and development unit.

Syllabus

Module I: Major Information Resources & Databases in Bioinformatics: Information Resources: NCBI, EBI, ExPasy, Entrez, Derived (Secondary) Databases of Sequences, Different Bio-sequence File Formats.

(8L)

Module II: Sequence Analysis: Homology, Gap Penalty, Scoring matrices (PAM, BLOSUM), Dot matrix method, Dynamic programming using Needleman-Wunsch algorithm, Scoring methods of MSA (Sum of Pair), BLAST and FASTA.

(8L)

Module III: Phylogenetic Analysis: Molecular Phylogenetics: Basics, molecular clock, Substitution Models of evolution, Tree reconstruction methods (Distance based).

(8L)

Module IV: Molecular Modeling and Molecular Docking: Structure alignment: superimposition and RMSD calculations, DALI, Classification of 3-D structures of proteins, SCOP, CATH, Structure Prediction of Protein Structure (Chou-Fasman), Homology modelling. (8L)

Module V: Applications of Bioinformatics: Cheminformatics, Bigdata analysis, Microarray - Data analysis, Theory and Algorithms, motif analysis and presentation.

(8L)

Books recommended:

TEXT BOOK

1. Bioinformatics: Sequence and Genome Analysis, David W Mount, Cold Spring Harbor Laboratory Press, New York.
2. Binformatics: a practical guide to the analysis of genes and proteins, Baxevanis A., Ouellette F.B.F., John Wiley and Sons, New York.

REFERENCE BOOK

1. Guidebook on Molecular Modeling In Drug Design, J. G. Vinter, Mark Gardner (Editor), J. G. Vinter (Editor), CRC Press (May 1994) ISBN: 0849377722
2. Fundamental Concepts of Bioinformatics, Dan E Krane, Michael L Raymer, Benjamin- Cummings Pub Co (ISBN 0805346333)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

Design of real-time industrial projects.

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Design optimization for industrial projects.

POs met through topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	2	2	2
CO2	1	-	2	3	3
CO3	3	1	2	2	-
CO4	4	2	-	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD3
CO2	CD1, CD2, CD3,CD4
CO3	CD1, CD2, CD3,CD4, CD6
CO4	CD1, CD3,CD6,CD7

COURSE INFORMATION SHEET

Course code: BT418
Course title: ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY
Pre-requisite(s):
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc
Semester / Level: II/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	The primary objectives of this course are to develop the skills to understand the theory and practice of bioanalytical techniques
2.	Additionally, an overview of the instruments used in isolation and separation of molecules will also be provided.
3.	To provide scientific understanding of analytical techniques and detail interpretation of results.
4.	This will enable the students to understand all subjects of Biotechnology as these tools and techniques will be used therein.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Familiarity with working principals, tools and techniques of analytical techniques.
CO2	Apprehend the functioning, maintenance and safety aspects of the apparatus used in a Biotechnology lab.
CO3	Assimilate the principles and applications of centrifuge, electrophoresis, chromatography and spectroscopy in research and related experiments.
CO4	To understand the strengths, limitations and creative use of techniques for problem solving.

Syllabus

Module 1: Centrifugation Techniques and Imaging: Principle, instrument and application of steady state sedimentation, density gradient centrifugation, ultracentrifugation, Atomic Force Microscopy, Scanning & Transmission Electron Microscopy. 8L

Module 2: Electro-kinetics: Electro-osmosis and electrophoresis, Helmholtz-Smoluchowski equation, Zeta potential, Principle, design and application of Gel electrophoresis; SDS-PAGE, gradient gels, Two dimensional gels, isoelectric focusing. 8L

Module 3: Chromatographic Techniques: Principles, design and application of column chromatography, partition and adsorption chromatography, Affinity Chromatography; Ion Exchange Chromatography, Gas Chromatography, HPLC. 8L

Module 4: Spectroscopy -I**:** Beers Lamberts law, Principles, Instrumentation and applications of Visible and UV Spectrophotometry; Spectroflourimetry (FRET); FTIR, NMR spectroscopy. 8L

Module 5: Spectroscopy – II and Thermal Analysis: Principles, Instrumentation & applications for flame emission / atomic absorption spectrophotometry and their comparative study; ICP (b) Mass spectrometry; Principles, Instrumentation and applications. Instrumentation and application of Differential scanning calorimetry and Thermogravimetry. 8L

Books Recommended:

TEXT BOOK

1. K. Wilson & K.H. Goulding, A biologist's guide to Principles and Techniques of Practical Biochemistry. Cambridge University Press, 1994

REFERENCE BOOK

1. Willard and Merrit, Instrumental Methods and Analysis, CBS Publishers & Distributors; 7th edition (December 1, 2004)
2. Ewing GW, Instrumental Methods of Chemical analysis. "McGraw-Hill Inc.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets

CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	1	1	1	1
CO2	1	-	3	3	1
CO3	-	1	3	2	-
CO4	2	2	3	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3,CD6
CO4	CD1, CD3,CD6,

Course code: BT419
Course title: ENZYME AND BIOPROCESS TECHNOLOGY LAB
Pre-requisite(s):
Co- requisite(s): None
Credits: 2 L:3 T:0 P:4
Class schedule per week: 04
Class: M.Sc
Semester / Level: II/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Understand the process of microbial growth and synthesis of bioproducts, methods of measurements of growth and mass balance of the bioprocess, kinetics of product formation
2.	Aware about significance of enzyme catalysis, production of enzyme at large scale and stability related issues, media constituents, formulations and sterilization, types of sterilizes and role of filers on sterilization
3.	Expand the knowledge on agitation of media, stirring mechanism, kinetics of oxygen supply, and requirement of power during the process
4.	Identify the reactors applicability as per the process requirement, understand mode of reactor operation and significance of solid state fermentation

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Understand the growth kinetics, Monod equation and explain the role of various factors affecting the process of growth. They will also be able to define the media for submerged and solid-state fermentation process and sterilization
CO2	State the significance of application of process technology on enzyme production, enzyme kinetics, solve the mass balance of production process, learn the process of oxygen transfer rate, agitation systems
CO3	Collect the proficient knowledge of design of fermenter and operation of fermentation process, methods of translation of laboratory data to pilot scale process

Syllabus

List of Experiments

1. Bacterial growth kinetics.
2. Calculation of specific growth rate.
3. Sterilization of inlet and outlet air filters by steam.
4. *In situ* Sterilization of empty bioreactor.
5. Medium preparation and sterilization of medium.
6. Designing of fermentation process for enzyme production
7. Designing of fermentation process for ethanol production
8. Designing of fermentation process for organic acid production.
9. K_{La} determination using non-fermentative and fermentative methods
10. effect of mixing and agitation rate on KLa,
11. Screening of enzyme producing microorganism viz. cellulase, hemicellulase, asparaginase, lipase etc.
12. Determination of kinetic parameters in enzyme catalysed reactions.
13. Sterilization of inlet and outlet air filters by steam.

Books Recommended:

TEXT BOOKS:

1: Shuler and Kargi, Bioprocess Engineering – Basic Concepts. Prentice Hall PTR
2: Aiba and Humphary. Biochemical Engineering, Academic Press, New York
3: Doran, Bioprocess Engineering Principles, Academic Press, 2013.
4: Enzyme by Palmer (2001); Horwood publishing series

REFERENCE BOOKS:

1: Bailey and Ollis, Biochemical Engineering Fundamentals, McGraw-Hill, 1986.
2: Lee, Biochemical Engineering, Prentice Hall, 1992

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

Design of real-time industrial projects: NA
POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Design optimization for industrial projects: NA
POs met through topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5
CO1	1	-	2	3	-
CO2	1	1	3	2	3
CO3	3	2	-	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD3
CO2	CD1, CD2, CD3,CD4
CO3	CD1, CD2, CD3,CD4, CD6

Course code: BT420
Course title: GENOMICS & rDNA TECHNOLOGY LAB
Pre-requisite(s):
Co- requisite(s): None
Credits: 2 L:0 T:0 P:4
Class schedule per week: 04
Class: M.Sc
Semester / Level: II/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Introduce knowledge on basic concepts of molecular biology techniques
2.	Exemplify different types of polymerase chain reactions and their applications
3.	Implement, organize and design different vectors for gene cloning and expression
4.	Generating contextual and conditional knowledge of gene function for various applications

Course Outcomes

After the completion of this course, students will be able to:

CO1	Apply the principles of molecular biology techniques
CO2	Analyze the experimental data to select a suitable PCR for a particular application
CO3	Evaluate selectivity and specificity of vectors for cloning genes and their expressions
CO4	Examine gene function, gene modulation and their effects on improvement of crops and animals.

Gaps in the syllabus (to meet Industry/Profession requirements) Nil

POs met through Gaps in the Syllabus: Nil

Topics beyond syllabus/Advanced topics/Design: Nil

POs met through Topics beyond syllabus/Advanced topics/Design: Nil

Syllabus

List of Experiments

1. Isolation and purification of DNA.
2. Isolation and purification of RNA.
3. Isolation and purification of plasmid DNA.
4. Spectrophotometric estimation of DNA and RNA.
5. Separation of DNA by agarose gel electrophoresis.
6. Electrophoresis of RNA on denaturing gels.
7. PCR Amplification, Agarose gel electrophoresis and elution of DNA bands from gel.
8. T/A cloning of eluted DNA in plasmids.
9. Bacterial transformation and selection of transformants.
10. Validation of transformants using PCR technique.

Books recommended:

TEXT BOOK

1. Old and Primorose- Gene Manupulation, Oxford; Seventh edition (2006)
2. Alberts et al, Molecular Biology of the Cell, Garland Science; 5 edition (2008)

REFERENCE BOOK

1. Watson, Recombinant DNA. W. H. Freeman; Second Edition edition (1992)
2. Lodish et al, Molecular Cell Biology. W. H. Freeman; 6th edition (2007)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and SWAYAM

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	-	3	3	1
CO2	1	-	3	3	1
CO3	2	1	3	2	-
CO4	2	2	3	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD3
CO2	CD1, CD2, CD3,CD4
CO3	CD1, CD2, CD3,CD4, CD6
CO4	CD1, CD3,CD6

COURSE INFORMATION SHEET

Course code: BT421
Course title: PROTEOMICS
Pre-requisite(s):
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc
Semester / Level: II/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To organize protein in four structural levels: Primary, Secondary, Tertiary and Quaternary, study on post translational modifications, structural determination and folding.
2.	Extend comprehensive knowledge about characterization, tools and techniques in determination of abundance of protein in particular tissue and its quantification.
3.	Obtain information about atomic mass, amino acid sequence and basic physical and chemical properties of protein, the technology used in determining these informations.
4.	Gain knowledge about the production of industrial important proteins and enzymes, designing new proteins with special functions and storage and use of proteomics database.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Handle a proteins and its characterization.
CO2	Know the principles of proteome quantification.
CO3	Demonstrate how various types of mass spectrometers (e.g. Orbitrap, triple-quad, Q-TOF) can be used for proteome quantification, structure determination of proteins by various methods.
CO4	Use software tools to analyse various quantitative proteomic data types, Principles of statistical analysis of proteomic data, how quantitative proteomics can be applied in biology, clinical research and drug discovery and designing novel proteins.

Syllabus

Module I: Protein Basics: Proteomics basics, Forces that determine protein structure and physicochemical properties, Mechanisms of protein folding, Molten globule structure, Characterization of folding pathways. 8L

Module II: Protein isolation and profiling: Method for protein isolation and purification, Profiling by Native-PAGE, SDS-PAGE, 2-D/IEF SDS-PAGE, staining and de-staining, imaging and analysis of 1-D and 2-D gels.

8L

Module III: Protein characterization:Protein sequencing using various methods, Protein identification by mass spectrometry, Determination of post translation modification, Proteomics tools and databases, Thermal, enzymatic, physical, pressure, solvents, interactions effect on protein, Application of DSC, Protein denaturation, aggregation and gelation.

8L

Module IV: Protein structure: Background and basic principles of various spectroscopic techniques used for protein structure determination, Absorption and fluorescence, Circular dichroism, FT-Raman, FT-IR, NMR, Protein crystallization and X-ray crystallography, MALLS. 8L

Module V: Development of novel proteins**:** Basic concepts for design of a new protein, Site directed mutagenesis for specific protein function, Specific examples of novel engineered proteins. 8L

Book Recommended:

TEXT BOOK

1. Carl, Branden and Tooze, John. Introduction to Protein Structure, Garland Publishing
2. (Taylor and Francis Group). New York.
3. Yada, R. Y.; Jackman, R. L.; Smith, J. L. Protein Structure-Function Relationships Blakie Academic and Professional: London

REFERENCE BOOKS:

1. Clark, R. J. H and Hester, R. E. Spectroscopy of Biological Systems, John Wiley and Sons, New York
2. Nakai, S. and Modler, H. W. Food Proteins: Properties and Characterization, VCH Publishers, New York.

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time industrial projects.
POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects.
POs met through topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	1	3	3	1
CO2	1	1	3	3	1
CO3	2	1	3	2	1
CO4	2	2	3	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD3
CO2	CD1, CD2, CD3,CD4
CO3	CD1, CD2, CD3,CD4, CD6
CO4	CD1, CD3,CD6,CD7

COURSE INFORMATION SHEET

Course code: BT422
Course title: PROTEOMICS LAB
Pre-requisite(s): NIL
Co- requisite(s):BT 421
Credits: 2 L:0 T:0 P:4
Class schedule per week: 04
Class: M.Sc.
Semester / Level: 1/4
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students:

1.	To recapitulate the previous knowledge of Molecular Biology and biochemistry to design experiments.
2.	To use the techniques and skills necessary for Isolation and estimation of Protein and their further analysis.
3.	To use the techniques and skills necessary for quantification of Proteins and their further analysis.
4.	Use of modern tools for analysis of Proteins.
5.	Independently execute a laboratory experiment using the standard methods and techniques in molecular biology, with the appropriate analysis and interpretation of results obtained.

Course Outcomes:

At the end of the course, a student should be able :

CO1	To handle Protein and its Estimation
CO2	To quantify the protein
CO3	Hands on and gain expertise in handling routine laboratory equipment used in Proteomics lab
CO4	To use modern tools for analysis of Protein and their further analysis. Independently execute a laboratory experiment using the standard methods and techniques in molecular biology, with the appropriate analysis and interpretation of results obtained.

Syllabus

List of the Experiments

1. Introduction about various instruments used in the lab.
2. Solution preparation given normality/concentration and its standardization.
3. Buffer preparation of different pH capacity.
4. Extraction of protein from the given plant sample.
5. Estimation of protein concentration of the protein extract by suitable method.
6. Enzyme assays.
7. Partial purification of protein by precipitation and subsequent dissolving in the buffer.
8. Assay of a suitable/selected enzyme using spectrophotometer.
9. Separation of protein using SDS-PAGE.
10. Protein profiling using 2-D IEF/ SDS-PAGE.
11. Visualization of protein spot and analysis.

Book Recommended:

TEXT BOOK

1. Proteins and Proteomics: A Laboratory Manual by Richard Simpson, Cold Spring Harbor laboratory Press,U.S.; Lab Manual edition (13 December 2002) ISBN-10: 0879695544
2. Plant Proteomics: Jozef Samaj (Author), Jay J Thelen (Author) Springer India Private Limited (2007) ISBN-10: 8132205162

REFERENCE BOOK

1. Principles of Proteomics 14 Oct 2013 by Richard Twyman Garland Science; 2 edition (14 October 2013)ISBN-10: 0815344724

Course Evaluation:
Lab (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through topics beyond syllabus/Advanced topics/Design

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	2	1
CO2	3	2	2	2	2
CO3	3	1	2	2	3
CO4	2	3	3	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2, CD3

COURSE INFORMATION SHEET

Course code: **BT423**
Course title: **ANIMAL BIOTECHNOLOGY**
Pre-requisite(s):
Co- requisite(s):
Credits: L:3 T:0 P:0
Class schedule per week: **03**
Class: **M.Sc.**
Semester / Level: **II/04**
Branch: **Biotechnology**
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To impart the knowledge on basic tissue culture techniques;
2.	to apply the state of art knowledge of subject for the production of transgenic animals and production modern drug delivery or vaccination methods.
3.	To become familiarize with the ethical practices in animal biotechnology

Course Outcomes:
At the end of the course, a student should be able to:

CO1	To demonstrate foundational knowledge of Cell culture techniques and competence in laboratory techniques. Student can set up a tissue culture lab to carry out research.
CO2	To acquire knowledge in animal cloning and its applications by various methods.
CO3	To acquire adequate knowledge in the use of genetically modified organisms and its beneficial uses.
CO4	To gain more insights into the ethical issues and regulatory affairs.

Syllabus

Module 1: Techniques in Animal Tissue Culture**:** Primary and secondary cell culture and maintenance; Embryonic fibroblast isolation and culture; measurement of cell viability/ toxicity, cell separation, development, cryopreservation and transport of germplasm; Embryonic and pluripotent stem cell culture and sorting. 8L

Module 2: Organ and Histotypic Cultures: cell synchronization, characterization and recent development; In Vitro fertilization and embryo transfer; Tissue engineering; Organ Culture. 8L

Module 3:

Transgenesis: Gene propagation methods; Use of cloning and expression vectors, Adeno viral vectors and Baculoviruses; Genetically engineered proteins, vaccines, hormones etc. produced in the host; newly emerging transgenic tools.

8L

Module 4:

Medical Molecular Biology: Designer/transgenic animals as different disease models comparable to human system; Gene therapy and its utilization; Cloning and xenotransplantation.

8L

Module 5:

Animal Genetic Engineering: Chemical and electrochemical gene transfection methods - microinjection, viral and other methods of gene transfection; application of transgenic animals for pharmaceutical and therapeutic purposes; Ethical issues related to animal biotechnology.

8L

Books Recommended:

TEXT BOOKS:

1: Animal Cell biotechnology: R.E. Spier and J.B. Griffiths (1988), Academic press.
2: Animal Biotechnology: Murray Moo-Young (1989), Pergamon Press, Oxford.

REFERENCE BOOKS:

1: Masters, J. R.W., Animal Cell Culture, Oxford (2000) 3rd ed.
2: Srivatsa AK, Singh RK, Yadhav MP. Animal biotechnology

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	3	-
CO2	3	1	1	1	3
CO3	2	3	2	3	-
CO4	3	2	2	2	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2
CO2	CD1, CD2
CO3	CD1, CD2
CO4	CD1, CD2

COURSE INFORMATION SHEET

Course code: **BT424**
Course title: **ANIMAL CELL TECHNOLOGY LAB**
Pre-requisite(s):
Co- requisite(s):
Credits: 2 L:0 T:0 P:4
Class schedule per week: **4**
Class: **M.Sc.**
Semester / Level: **II/04**
Branch: **Biotechnology**
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To familiarized with the basic components of animal cell culture lab.
2.	To impart the hands on experience on basic tissue culture techniques;

Course Outcomes:

At the end of the course, a student should be able to:

CO1	To demonstrate experimental skill of Cell culture techniques and competence in laboratory techniques.
CO2	To develop proficiency in establishing and maintaining of cell lines.
CO3	To conduct the independent research in the animal cel culture and its further application.

Syllabus

List of Experiments

1.	Laboratory Design & Instrumentation in ACT.
2.	Quality Assurance in Animal tissue culture facility.
3.	Sterilization Techniques used in ACTL.
4.	Preparation of animal cell culture media.
5.	Isolation and Culturing Peripheral Blood Lymphocytes.
6.	Cell counting, Viability assay, Cryopreservation technique.
7.	Sub-culturing and maintenance of Cell line.
8.	In vitro anticancer assay (MTT Assay).
9.	DPPH radical scavenging assay.
10.	Genomic DNA Isolation from animal tissue.

Books Recommended:

TEXT BOOKS:

1: Freshney, Animal cell culture – a practical approach
2: N. Jenkins, Animal Cell Biotechnology: methods and protocols.

REFERENCE BOOKS:

1: Masters, J. R.W., Animal Cell Culture, Oxford (2000) 3rd ed.
2: Ranga, M.M., Animal Biotechnology, Agrobios (2007) 2nd ed.

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	3	
CO2	3	1	3	1	2
CO3	2	2	2	3	

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD3
CO2	CD1, CD3
CO3	CD1, CD3

COURSE INFORMATION SHEET

Course code: BT425
Course title: PLANT BIOTECHNOLOGY

Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M.Sc
Semester / Level: II/4
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Acquire knowledge about layout of plant tissue culture lab, culture environment, learn varied sterilization techniques.
2.	Learn the fundamentals of plant totipotency nature, culturing plant cells and tissues, designing of culture environment.
3.	Gain knowledge about protoplast isolation , purification and culture techniques.
4.	Acquire knowledge about molecular markers and their use in development of stress resistant crop plants.
5.	Get knowledge about plant transgenic development, varied methods of gene transfer, and get exposure about gene editing and methods involved.

Course Outcomes

After the completion of this course, students will be able to:

1.	Demonstrate the knowledge about the techniques of Plant Tissue Culture technoiques, Lab organization & measures adopted for aseptic manipulation and nutritional requirements of cultured tissues.
2.	Apply knowledge for large scale clonal propagation of plants through various micropropagation techniques and Production of secondary metabolites under *in vitro* conditions .
3.	Develop skill in raising transgenics resistant to biotic & abiotic stresses & quality characteristics and their role in crop improvement.
4.	Design and implement experimental procedures using relevant techniques

Syllabus

Module-1: Practical aspects of plant tissue culture**:** Design and layout of laboratory, various components of culture media and types, sources of contaminants and various sterilization techniques, advantages and applications.

8L

Module-2: Micropropagation: Maintenance and growth of callus and suspension culture, Production of secondary metabolites, Various stages of micropropagation, Organogenesis, Embryogenesis, Artificial Seeds, Somaclonal variation, Production and use of haploids.

8L

Module-3: Protoplast Technology: Protoplast isolation and regeneration, Protoplast fusion and Somatic hybridization, Cytoplasmic hybridization, Uptake of foreign cellular components, Gene transfer with the use of protoplast, Identification, selection and characterization somatic hybrid cells.

8L

Module-4: Molecular Markers: Different molecular markers, DNA Microarray; Construction of Molecular Maps, Marker Assisted Selection**,** Use of Molecular Markers in the development of crops adaptable to stresses.

8L

Module-5: Transgenic Technology: Vectors and *Agrobacterium* mediated gene transfer, Direct gene transfer, Genetically modified value added crops and social issues, Molecular farming for biopharmaceuticals, Engineering of chloroplast genome, Gene editing with TALEN and CRISPER technology, Resistance against biotic and abiotic stresses.

8L

Books Recommended:

TEXT BOOKS:

1. M. K. Razdan: An introduction to plant tissue culture. Science Publishers (2003) 2nd ed.
2. Timir Baran Jha and Biswajit Ghosh: Plant Tissue Culture: Basic and Applied
3. Slater, A., Scott, N.W., and Fowler, M.R., Plant Biotechnology, Oxford University Press (2008) 2nd ed.

REFERENCE BOOKS:

1. A. Mizrahi, Biotechnology in agriculture , Wiley-Blackwell; Volume 9 edition (1988)
2. S. Natesh, Biotechnology in agriculture, South Asia Books (November 1, 1987)
3. Dixon and Gonzales, Plant cell culture – a practical approach. IRL Press; 2 edition (1995)
4. Primrose, S.B. and Twyman, R.M., Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell Publishing (2006) 7th ed.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	3	-	-
CO2	3	1	3	-	-
CO3	3	1	3	-	-
CO4	2	2	2	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2,CD6
CO5	CD2, CD2, CD6

COURSE INFORMATION SHEET

Course code: BT426
Course title: PLANT BIOTECHNOLOGY LAB
Pre-requisite(s):
Co- requisite(s): BT425
Credits: L: 0 T: 0 P: 4
Class schedule per week: 04
Class: M.Sc
Semester / Level: II/4
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Acquire knowledge about layout of plant tissue culture lab, culture environment, learn varied sterilization techniques.
2.	Learn the fundamentals of plant totipotency nature, culturing plant cells and tissues, designing of culture environment.
3.	Gain knowledge about protoplast isolation , purification and culture techniques.
4.	Acquire knowledge about molecular markers and their use in development of stress resistant crop plants.
5.	Get knowledge about plant transgenic development, varied methods of gene transfer, and get exposure about gene editing and methods involved.

Course outcomes:

1.	Demonstrate the knowledge about the techniques of Plant Tissue Culture techniques, Lab organization & measures adopted for aseptic manipulation and nutritional requirements of cultured tissues.
2.	Apply knowledge for large scale clonal propagation of plants through various micropropagation techniques
3.	Develop skill in raising transgenics resistant to biotic & abiotic stresses & quality characteristics and their role in crop improvement.
4.	Design and implement experimental procedures using relevant techniques
5.	Production of secondary metabolites under *in vitro* conditions .

Syllabus

List of Experiment

1. Demonstration of about various instruments/equipment used in the said lab.
2. Preparation of and sterilization of Culture Media.
3. Inoculation of explant in solid culture media.
4. Growth pattern analysis of inoculated explant.
5. Subculture of callus for the development of cell suspension culture.
6. Artificial seed preparation by encapsulation of somatic embryos.
7. Development of anther culture for the haploid production.
8. Agrobacterium mediated transformation for hairy root culture.
9. Protoplast isolation and its regeneration.

Books Recommended:

TEXT BOOKS

1. O.L. Gamborg and G. C. Phillips (Eds.): Plant Cell, Tissue and organ Culture: Fundamental methods. A Springer Lab Manual.
2. M. K. Razdan: An introduction to plant tissue culture. Science Publishers (2003) 2nd ed.
3. Timir Baran Jha and Biswajit Ghosh: Plant Tissue Culture: Basic and Applied

REFERENCE BOOKS:

5. Dixon and Gonzales, Plant cell culture – a practical approach.
6. Primrose, S.B. and Twyman, R.M., Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell Publishing (2006) 7th ed.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	3	-	-
CO2	3	1	3	-	-
CO3	1	1	3	-	-
CO4	2	1	2	1	-
CO5	2	1	2	-	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2,CD3
CO5	CD2, CD2, CD3

COURSE INFORMATION SHEET

Course code: BT427
Course title: BIOMEDICAL EQUIPMENT & DEVICES
Pre-requisite(s): Nil
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc
Semester / Level: II/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To impart knowledge for interdisciplinary, applied engineering and technology.
2.	With respect to design consideration, to understand the standard structure of biomedical instrumentation systems.
3.	To learn the technicality associated with instrumentation and design of basic biosignal and imaging equipment.
4.	To understand the engineering aspects for safety and hazards associated with biomedical instruments.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Understand the general physiology for man-machine interaction in medical environment.
CO2	Understand the fundamentals of the concept and design of biomedical equipment.
CO3	Understand the importance of medical data transmission for better healthcare.
CO4	Analyse the electrical hazards associated with medical equipment so that the safety equipment can be devised or suggested.
CO5	Work in an interdisciplinary team.

Syllabus

Module-I: Bioelectric Recorder: Factors in making measurement, Electrocardiography (ECG), Electromyography (EMG), electroencephalography (EEG), evoked potentials analysis. Electroretinograghy (ERG), Electro-Oculography (EOG).

(8L)

Module-II: Cardiopulmonary Devices: Holter recorder, patient monitoring system, phonocardiography, blood pressure measurement, pulse plethysmography, Blood flow and cardiac output measurement, Ventilators, Anesthesia machine, Capnograph, Spirometry, Pulmonary function analyzers, Pneumotachometers.

(8L)

Module-III: Therapeutic Devices: Pacemakers, Defibrillators, Physiotherapic diathermies, nerve and muscle stimulator, electroshock therapy. Medical linear accelerator, Co60 Machine.

(8L)

Module-IV: Surgical Devices: Surgical diathermy, Heart lung machine, extra corporeal membrane oxygenator, intra-aortic balloon pump, surgical laparoscopy, lithotripsy, Sterilization equipment.

(8L)

Module-V: Analytical Instruments: Principle and applications of Blood Cell counter and Biochemical analysers.

(8L)

Books Recommended:

TEXT BOOKS:

1. Textbook of Medical Physiology by A. C. Guyton, 8th edition, Prism Indian Publication, Bangalore, 1991.
2. Handbook for Biomedical instrumentation by R. S. Khandpur, 3rd edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 2014.
3. Medical instrumentation, Application &Design by J. G. Webstar, 4th edition, Wiley Student Edition, New Delhi, 2009.
4. Introduction to Biomedical Equipment Technology by J. J. Kar and J. M. Brown, 4th edition, Pearson India Education Services Pvt. Ltd., Noida, 2016.

REFERENCE BOOKS:

1. Biomedical Engineering and Instrumentation, Basic Concepts and Applications by J. D. Bronzino, 1st Edison, PWS Publishers, Boston, 1986.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

1. Conducting presentations in group and writing reports
2. Giving assignments to the students on some relevant topics
3. Industrial visits

POs met through Gaps in the Syllabus: PO1, PO2, PO3

Topics beyond syllabus/Advanced topics/Design:

1. Lecture on human-computer interaction
2. Lecture on specialized imaging devices

POs met through topics beyond syllabus/Advanced topics/Design: PO4

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	-	3	-	-
CO2	1	-	3	1	-
CO3	-	2	2	-	-
CO4	-	-	2	1	1
CO5	2	2	2	-	-

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD3
CO2	CD1, CD3, CD5
CO3	CD2, CD4
CO4	CD4
CO5	CD3, CD4, CD5, CD7

COURSE INFORMATION SHEET

Course code: BT428
Course title: BIOMEDICAL INSTRUMENTATION LAB
Pre-requisite(s):
Co- requisite(s): BT427
Credits: 2 L:0 T:0 P:4
Class schedule per week: 04
Class: M.Sc
Semester / Level: II/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To impart knowledge on biomedical signal acquisition.
2.	To learn the technicality associated with instrumentation and design of basic biosignal equipment.
3.	To record and analyse the engineering aspects for safety and hazards associated with biosignal recording.
4.	To record and interpret the characteristics of different biosignals.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Understand the components of man-machine interaction.
CO2	Understand the fundamentals of the concept and design of biosignal recorder.
CO3	Identify the electrical hazards associated with biosignal recording so that the safety equipment can be devised or suggested.
CO4	Analysing a biosignal recorder.
CO5	Work in an interdisciplinary team.

Syllabus

List of Experiments

1. To Study of electrical and electronics components and instruments.
2. To study different types of electrodes and sensors used in bio-potential recordings.
3. To record and analyse different types of noises in biosignals.
4. To apply and analyse the effect of different digital filters in removing noises from electrocardiogram.
5. To apply and analyse the effect of different digital filters in removing noises from electromyogram.
6. To apply and analyse the effect of different digital filters in removing noises from electroencephalogram.
7. To distinguish different bands of electroencephalogram using application of different filters.
8. To analyse the characteristics of different types of electrolytic medium between electrode and body.
9. To separate out different heart sounds from phonocardiogram.
10. To perform an experiment in evaluating FFT of different recorded biosignals.
11. To perform an experiment in evaluating PSD of different recorded biosignals.
12. To correlate the different body activities with variable assigned task.

Books Recommended:

Text Books:

1. Introduction to Biomedical Technology by J. J. Karr & J. M. Brown, Pearson; 4 edition (2000)
2. Handbook of Biomedical Instrumentation by R. S. Khandpur, McGraw Hill Education; Third edition (2014)
3. Biomedical Instrumentation and Measurement by L. Cromwell et al. Prentice Hall India Learning Private Limited; 2 edition

Reference Books:

1. Biomedical Digital Signal Processing by W. J. Tompkins. Prentice Hall; Har/Dskt edition (1993)
2. Biomedical Signal Processing: Principles and Techniques by D C Reddy. Tata McGraw-Hill Education, 2005.

Course Evaluation:

Written test, viva and performance examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

1. Conducting presentations in group and writing reports
2. Giving assignments to the students on some relevant topics

POs met through Gaps in the Syllabus: PO1, PO2, PO3

Topics beyond syllabus/Advanced topics/Design:

1. Lecture on specialized physiological sensing
2. Lecture on human-machine interaction

POs met through topics beyond syllabus/Advanced topics/Design: PO4

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	-	1	2	2	-
CO2	1	-	3	2	-
CO3	-	-	2	2	1
CO4	2	2	2	2	-
CO5	2	2	3	-	-

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2
CO2	CD1, CD3
CO3	CD1, CD3, CD4
CO4	CD3, CD7
CO5	CD3, CD5, CD7

COURSE INFORMATION SHEET

Course code: BT429
Course title: CONCEPTS IN NANOBIOTECHNOLOGY
Pre-requisite(s):
Co- requisite(s):
Credits: 3 L:03 T: P:
Class schedule per week: 03
Class: M.Sc
Semester / Level: II/04
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

1.	To understand the concept & phenomena of nanotechnology in biological and biomedical research
2.	To guide the students to comprehend how nanomaterials can be used for a diversity of analytical and medicinal rationales.

Course Outcomes

After the completion of this course, students will be:

CO 1	Understand the fundamentals of nanoscience, nanotechnology and biology with in detail knowledge of different nanomaterial types and properties
CO 2	Acquire the knowledge on different nanofabarication methods. Skilled in various characterization techniques.
CO 3	Recognize and relate to the structural and functional principles of biomolecular interactions to nanomaterials, factors involved and their significance in designing nanomaterials and nanodevices.
CO 4	Familiarize themselves with nanobiotechnology potentialities and concerns associated with nanomaterials usage and handling. Able to apprehend and explain use of nanomaterials in different medical/environmental applications. Analyse the possible impact of this technology on society, industry and environment

Syllabus

Module 1: Introduction to Nanoworld:The world of small dimensions: Introduction and scientific revolutions, Dimensionality and size dependent phenomena, Properties at nanoscale, Nanomaterials synthesis techniques (Top-Down, Bottom-Up, Biological).

8L

Module 2: Introduction to Nanostructures: Classification & Types: Classification based on dimensionality, (synthesis, properties and applications of Fullerens, Carbon nanotube, Metal nanoparticles, Quantum dots, Dendrimers, Biological nanomaterials

8L

Module 3: Nanoscale visualization & Characterization techniques: Electron microscopy: FESEM, HRTEM, Scanning probe microscopy: AFM, STM, Diffraction techniques (XRD), UV-Vis & FTIR, light scattering

8L

Module 4: Bionanotechnology: Biomolecular Structure and Stability, Protein Folding, Self-assembly, self-organization, molecular recognition, Flexibility, Information-Driven Nanoassembly, Energetics, Chemical Transformation, Biomolecular Motors, Traffic Across Membranes, Machine-Phase Bionanotechnology

8L

Module 5: Biomedical applications of nanomaterials & Challenges: Drug delivery, Tissue engineering, cancer nanotechnology, nano labels, Biosensors, Nanobiosensors nanomedicine, bioimaging, Nanotoxicology challenges, Impact of nanotechnology on society and industry

8L

Books Recommended:

TEXT BOOKS:

1. Niemeyer and Mirkin ed. Nanobiotechnology: concepts, applications & perspectives,
2. Jain, KK. Nanobiotechnology in molecular diagnostics: current techniques and applications

REFERENCE BOOKS:

1. T. Pradeep, "A Textbook of Nanoscience and Nanotechnology", Tata McGraw Hill Education Pvt. Ltd., 2012
2. David S Goodsell, "Bionanotechnology", John Wiley & Sons, 2004

Gaps in the syllabus (to meet Industry/Profession requirements): Nil

POs met through Gaps in the Syllabus: NA

Topics beyond syllabus/Advanced topics/Design: NA

POs met through Topics beyond syllabus/Advanced topics/Design: NA

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Individual assignment, Theory (Quiz and End semester) examinations

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	1	2	-	-
CO2	2	2	2	3	2
CO3	2	-	3	3	-
CO4	2	2	3	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD5
CO2	CD1,CD3, CD4, CD5
CO3	CD1, CD2, CD5
CO4	CD1,CD3, CD4, CD5, CD6, CD8

COURSE INFORMATION SHEET

Course code: BT430
Course title: BASIC NANOBIOTECHNOLOGY LAB
Pre-requisite(s):
Co- requisite(s): BT 429
Credits: 2 L: T: P:04
Class schedule per week: 04
Class: M.Sc
Semester / Level: II/4
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

1.	To understand the concept & phenomena of nanotechnology in biological and biomedical research
2.	To guide the students to comprehend how nanomaterials can be used for a diversity of analytical and medicinal rationales.

Course Outcomes

After the completion of this course, students will be:

CO 1	Acquire the knowledge on different nanofabarication methods. Skilled in various characterization techniques.
CO 2	Employ nanomaterials for analysis and sensing technique
CO 3	Recognize and relate to the structural and functional principles of biomolecular interactions to nanomaterials, factors involved and their significance in designing nanomaterials.
CO 4	Familiarize themselves with nanobiotechnology potentialities and concerns associated with nanomaterials usage and handling.

Syllabus

List of Experiments

1. To study various instruments used for nanoscale characterization
2. Synthesis and characterization of nanomaterial by physical method
3. Synthesis and characterization of nanomaterial by wet chemical method
4. Biological synthesis and characterization of nanoparticles
5. Synthesis and characterization of polymeric carrier for nanoparticle delivery
6. Bioconjugation & characterization of biomolecules/drug with nanomaterial
7. Study of dispersity and stability profile of nanoparticles

Books Recommended:

TEXT BOOKS:

1. Gerrard Eddy Jai Poinern, Nanobiotechnology Laboratory course material, CRC Press (2014)

REFERENCE BOOKS:

1. Challa, "Nanofabrication Towards Biomedical Applications, Techniques, Tools, Applications and Impact", Wiley – VCH, 2005
2. Andrew Collins, "Nanotechnology Cookbook: Practical, Reliable and Jargon-free Experimental Procedures", Elsevier, 2012

Gaps in the syllabus (to meet Industry/Profession requirements)

Nil

POs met through Gaps in the Syllabus

NA

Topics beyond syllabus/Advanced topics/Design

NA

POs met through Topics beyond syllabus/Advanced topics/Design

NA

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Individual assignment, Theory (Quiz and End semester) examinations

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	-	-
CO2	3	-	3	3	-
CO3	3	2	3	3	-
CO4	3	3	2	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD5
CO2	CD1, CD5
CO3	CD1, CD5
CO4	CD1, CD5

COURSE INFORMATION SHEET

Course code: BT501
Course title: IMMUNOTECHNOLOGY
Pre-requisite(s):
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc
Semester / Level: III/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To recapitulate the previous knowledge of immunology and to establish thorough understanding of various structure & function at cellular and molecular level.
2.	To provide a thorough understanding of the various immunology concepts in study of cell biology and to study the different tools and techniques used to study the immunology at molecular level.
3.	To provide students with a deep insight about the immunological reactions with emphasis on the effector mechanisms, rationale behind the immunological interactions leading to successful reactions.
4.	To teach our students to have a concrete knowledge about immunology human system to study about the basis of the interaction as well as the genes involved in it.
5.	To acquire in-depth knowledge of the molecular events involved in immunological processes and their regulation. To provide wider and global perspective of techniques involved as well as the genetic basis of the immunological diseases and their cure, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

Course Outcomes:
At the end of the course, a student should be able to:

CO1	to apply knowledge of immunology in various cellular functions, inculcate a knowledge of various issues related to immunological reactions eg the application of and research involved in functioning of the different molecules and moieties in the reactions.
CO2	to design and analyze the experiments related with the different molecules involved in immunology and use of the various techniques in the immunology to study the kinetics and rationale behind each phenomenon.
CO3	to identify, formulate, and solve problems arisen due to the inefficient functioning of the various immunological phenomenon leading to various immunological dieases.
CO4	to use the techniques, skills, and modern tools necessary for imbalances in various life processes, design a molecular cell biology research project, collect and analyze data, and interpret results

Syllabus

Module 1: Introduction: brief history of Immunotechnology, immune system, components of immune system, Innate and adaptive immune system, external and internal barriers, phagocytosis. Antigen clearance mechanism.

(8L)

Module 2: The antigens and antibodies, immunogenicity, MHC, cell-mediated and humoral immunity, effector mechanism. Kinetics of Antigen antibody interaction, thermodynamics, different mathematical, Models of antigen antibody interaction with single and multiple binding sites.

(8L)

Module 3: Techniques in Immunotechnology, Blood groups: AB, Rh system, Precipitin curve, Immuno diffusion, Immuno electrophoresis, Agglutination, Widal test, Radioimmunoassay: ELISA, Immuno fluorescence, comet assay, FACS. ELISPOT assay, immunofluorescence, Surface plasmon resonance, Biosensor assays for assessing ligand – receptor interaction, Staining techniques for live cell imaging and fixed cells; Flow cytometry, Instrumentation, Applications; Cell Functional Assays – lymphoproliferation, Cell Cytotoxicity, mixed lymphocyte reaction, Apoptosis, Cytokine expression; Cell cloning, Reporter Assays, In–situ gene expression techniques; Cell imaging Techniques- In vitro and In vivo; Immuno-electron microscopy; In vivo cell tracking techniques; Microarrays; Transgenic mice, gene knock outs

(8L)

Module 4: Immunodeficiency, animal models of immunodeficiency, Diagnosis, therapeutic approaches. Antibody engineering, antigen engineering, Rationale of vaccine design, types of vaccines (live, killed, attenuated, Sub unit vaccines; Recombinant DNA and protein based vaccines, plant-based vaccines and reverse vaccinology; Peptide vaccines, conjugate vaccines), Passive Immunization; Antibody, Transfusion of immuno-competent cells, Stem cell therapy; Cell based vaccines vaccine production, Catalytic antibodies, antibody immunotherapy, productions of drugs to allergies. Hybridoma technology.

(8L)

Module 5: Reactor system for Production of Polyclonal antibodies , antigen preparation and modification, adjuvants, dose and route of antigen administration, collection of sera, purification of antibodies Production of cellular chemicals like Interferons, Interleukin etc.

(8L)

Books recommended:

TEXT BOOK

1. Kuby J, Immunology, WH Freeman & Co., 2000.
2. Tizard, Immunology, fourth edition, Thomson Asia pvt. Ltd, 2004.
3. Talwar G.P., and Gupta S.K., "A hand book of practical and clinical immunology", Vol. 1 & 2, CBS Publications, 1992.

REFERENCE BOOK

1. Textbook of Basic and Clinical Immunology" by Sudha Gangal
2. Immunology" by Roitt I and Male Brostoff

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time research projects.
POs met through Gaps in the Syllabus: PO2, PO3, PO5

Topics beyond syllabus/Advanced topics/Design:
Design optimization for molecular cell biology projects.
POs met through topics beyond syllabus/Advanced topics/Design: PO1, PO2, PO3, PO4, PO5.

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	-	2	2	1
CO2	1	2	3	3	2
CO3	1	3	2	3	3
CO4	1	3	3	2	-

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD3, CD6
CO2	CD1, CD2, CD3,CD4, CD6
CO3	CD1, CD2, CD3,CD4, CD6
CO4	CD1, CD3,CD6,CD7

COURSE INFORMATION SHEET

Course code: BT502
Course title: ENVIRONMENTAL BIOTECHNOLOGY
Pre-requisite(s):
Co- requisite(s):
Credits: 2 L:0 T:0 P4
Class schedule per week: 04
Class: M. Sc.
Semester / Level: III/05
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Identify and explain the environmental factors responsible for the pollution
2.	Provide solutions for environmental problems and understand legal aspects related with environmental issues and environmental protection
3.	Select the appropriate method for the treatment of wastewater and solid waste management
4.	Select and apply Suitable bioremediation methods for the treatment
5.	Expose to significance of biofuels and organic farming

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Identify the problems related to environment and the Environment Protection Acts and Legislations
CO2	Apply advanced knowledge on environmental waste management (waste water and solid waste)
CO3	Design techniques for bioremediation process
CO4	Identify and evaluate the importance of biofuels and organic farming
CO5	Apply the scientific method by stating a question; researching the topic; determining appropriate tests; performing tests; collecting, analyzing, and presenting data and effective communicate with both specialist and non-specialist audiences/community

Syllabus

Module I: Introduction: Ecosystem, Concept of biosphere, Biodiversity and its conservation strategies, Natural resources, Environmental Protection Acts and Legislations, National and international status, Environmental Planning for sustainable development 8L

Module II: Environmental pollutants and waste water: Sources of pollutants for Air, Water, Noise, Land; Pollution control and management- Environmental monitoring & sampling, Physical, chemical and biological methods and analysis of different pollutants, Microbial treatment of waste water (sewage or industrial effluent)- aerobic and anaerobic methods 8L

Module III: Solid waste management**:** Solid waste-types and characteristics. Effects of solid waste generation on quality of air, water and public health; Technical approach for solid waste management; Disposal of organic and medical waste; Recovery and recycling of metallic waste; Disposal of plastic and hazardous waste. 8L

Module IV: Bioremediation: Types, microbial degradation and its mechanism, Bioaugmentation, Biosorption, Bioleaching, Phytoremediation, GMOs in waste management, Nanoscience in environmental management, Biosensors in pollution monitoring, Superbug 8L

Module V: Biofuels and organic farming: Alternate Source of Energy, Biomass as a source of energy, Biomineralization, Liquid and gaseous biofuels, Microbial fuel cell, Biocomposting, Vermiculture, Biofertilizers, biopesticides. 8L

Books recommended:

TEXT BOOK

1. Dash and Dash, Fundamentals of ecology, 3rd Ed., TMH Education, 2009 (**T1**)
2. Mohapatra, Text Book of Environmental Biotechnology, 1st Ed., I K International Publishing House Pvt. Ltd, 2007 (**T2**)

REFERENCE BOOK

1. Odum, Fundamentals of Ecology, 5th Ed., Brooks/Cole, 2004 (**R1**)
2. Metcalf and Reddy Inc et al, Wastewater Engineering: Treatment and Reuse, 4th Ed., McGrawHill Higher Education, 2002 (**R2**)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	3	3	2	1
CO2	2	2	3	2	1
CO3	2	2	3	2	2
CO4	2	2	3	2	2
CO5	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD4, CD5 and CD6
CO2	CD1, CD2, CD3, CD5 and CD6
CO3	CD1, CD2, CD3, CD4, CD5 and CD6
CO4	CD1, CD2, CD4, CD5 and CD6
CO5	CD1, CD2, CD3, CD4, CD5 and CD6

COURSE INFORMATION SHEET

Course code: **BT503**
Course title: **BIOSAFETY, BIOETHICS & IPR**
Pre-requisite(s):
Co- requisite(s):
Credits: L:3 T:0 P:0
Class schedule per week: **03**
Class: **M.Sc.**
Semester / Level: **III/05**
Branch: **Biotechnology**
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To create awareness on IPR issues and need for knowledge in patents in biotechnology
2.	To understand the biosafety regulations and ethical practices in biotechnology
3.	To become familiarize with the ethical practices in biotechnology

Course Outcomes:

At the end of the course, a student should be able to:

CO1	To understand and follow the regulatory framework important for the product safety and benefit for the society.
CO2	To devise business strategies by taking account of IPRs
CO3	To acquire adequate knowledge in the use of genetically modified organisms and its effect on human health
CO4	To gain more insights into the regulatory affairs.

Syllabus

Module-1: Intellectual Property: Patents, Trademarks, Copyright, Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs,IPs of relevance to Biotechnology and Case Studies; Agreements and Treaties, Indian Patent Act 1970 & recent amendments.

8L

Module-2: Patents and Concept of Prior Art: Types of patent applications, Ordinary, PCT, Conventional, Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees, Invention in context of "prior art". 8L

Module-3: Patent Filing Procedures: National & PCT filing procedure; Time frame and cost; Status of the patent applications filed; Precautions while patenting–disclosure/non-disclosure; Patent licensing and agreement Patent infringement. 8L

Module-4: Biosafety: Introduction to Biological Safety Cabinets; Biosafety Levels of Specific Microorganisms; Biosafety guidelines:Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, applications in food and agriculture; Environmental release of GMOs; Risk Analysis, Risk management and communication; National Regulations and relevant International Agreements,Cartegana Protocol. 8L

Module-5: Bioethics: Ethical implications of biotechnological products and techniques, Social and ethical implications of biological weapons. 8L

Books Recommended:

Text books:

1: Deepa Goel &Shomini Parashar IPR, Biosafety and Bioethics, Pearson Education India, (2013)

2: Anupam Singh Intellectual Property Rights and Bio-Technology Biosafety and Bioethics, Narendra Publishing House, (2012)

Reference books:

1: BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., (2007)

2: Kankanala C., Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd., (2007)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training

CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	3	2	-
CO2	2	3	1	1	3
CO3	2	1	2	2	-
CO4	3	2	1	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2
CO2	CD1, CD2
CO3	CD1, CD2
CO4	CD1, CD2

COURSE INFORMATION SHEET

Course code: BT504
Course title: MOLECULAR GENETICS & PHARMACOGENOMICS
Pre-requisite(s):
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc
Semester / Level: III/05
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Learn the aspects of molecular genetics pharmacogenetics & pharmacogenomics;
2.	Gain comprehensive knowledge about pharmacogenetic and pharmacogenomic aspects of multi drug resistance associated protein, organic anion transporter peptide family media constituents. They will also learn about pharmacogenomics of asthma, chemo therapeutic agents in cancer, alcoholism and neurodegenerative diseases;
3.	Identify, locate, analyse frequencies and SNPs;
4.	Process comparative genomic data, proteome and related genetic information.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Discuss various aspects of molecular genetics pharmacogenetics & pharmacogenomics;
CO2	Interpret comprehensive knowledge about pharmacogenetic and pharmacogenomic aspects of multi drug resistance associated protein, organic anion transporter peptide family media constituents, asthma, chemo therapeutic agents in cancer, alcoholism and neurodegenerative diseases;
CO3	Distinguish SNPs as genetic marker;
CO4	Analyse comparative genomic data, proteome and genetic information.

Syllabus

Module-1: Organisation of eukaryotic and prokaryotic genome, Methods of gene analysis, Comparative genome analysis, Analysis of proteome, concepts of genetics, pharmacogenetics and pharmacogenomics. (8L)

Module-2: SNPs as genetic marker: Identification, location, frequency and analysis of SNPs; SNPs based pharmacogenomic markers. (8L)

Module-3: Pharmacogenomics and Drug design: In silico design of small molecules, Automated drug design methods, Structure based drug design methods, Ligand based drug design methods. (8L)

Module-4: Pharmacogenomics of human P- glycol protein and drug transporters (Multi drug resistance associated Protein, Organic anion transporter peptide family). (8L)

Module-5: Pharmacogenomics aspects in Asthma, Chemo therapeutic agents in cancer, Alcoholism, Neurodegenerative diseases. (8L)

Books recommended:

TEXT BOOK

1. Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications, Oliver Kayser, Rainer H. Miller, Wiley Interscience, 2004
2. Pharmaceutical Biotechnology by S.P. Vyas, V.K.Dixit, 1st ed,CBS Publishers & Distributors, New Delhi, 1998
3. Pharmaceutical Biotechnology by Daan J.A. Crommilin & Robert D. Sindelar (edts.) Routledge, Taylor & Francis group, London 2002

REFERENCE BOOK

1. Pharmacogenomics: The search of Individual Therapies, Julio Licinio and Ma-li Wong, Wiley-Blackwell; 2002

Course Evaluation:
Individual assignment, Presentation, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time industrial projects.
POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects.
POs met through topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	1	1	-
CO2	3	2	2	-	1
CO3	3	2	3	-	1
CO4	3	2	3	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2
CO2	CD1, CD2, CD4
CO3	CD1, CD2, CD4
CO4	CD1, CD2, CD4

COURSE INFORMATION SHEET

Course code: BT505
Course title: IMMUNOTECHNOLOGY LAB
Pre-requisite(s): **Basics of immunology**
Co- requisite(s): None
Credits: 2 L: T:0 P:4
Class schedule per week: 4
Class: M.Sc.
Semester / Level: IV/05
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To provide a thorough understanding of various Immunological phenomenon occurring in the body to fight the entry of the antigen.
2.	To provide a thorough understanding of diversity of the antibodies and the different antigen and antibody reactions used for diagnosis of the various diseases.
3.	To provide students with a deep insight about the different immunological diseases.
4.	To teach our students to have a concrete knowledge about the types of vaccines and how are they made.
5.	To acquire in-depth knowledge of immunology, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Apply knowledge of immunology, inculcate a knowledge of various issues related to immunology eg vaccines etc. and immunological techniques.
CO2	Design and conduct experiments, as well as to analyze and interpret data of different immunological methods. To identify, formulate, and solve problems arisen due to the inefficient functioning of the immune system.
CO3	Use the techniques, skills, and modern tools necessary for detection of the immunological diseases, design a immunology research project, collect and analyze data, and interpret results.
CO4	Demonstrate knowledge and understanding of the engineering principles and apply these to manage projects work a recognition of the need for and an ability to engage in life-long learning.

Syllabus

List of Experiments

1. To detect the blood group of the given sample.
2. To perform differential count (DLC) of given sample.
3. To perform the Technique of Radial immunodiffusion
4. To learn and perform the technique of Ouchterlony Double Diffusion Technique
5. To perform the pregnancy test with the help of Pregnancy Kit
6. To learn the technique of Immunoelectrophoresis
7. To study the technique of Rocket Immunoelectrophoresis for determination of concentration of antigen in unknown sample
8. To perform widal test for detection of typhoid.
9. To study the different immunoinformatics tools.
10. To perform the sandwich Dot ELISA Test for antigen detection
11. To perform Affinity chromatography for antibody purification.
12. To identify cells in a blood smear
13. To isolate monocytes from blood
14. To Isolate peripheral blood mononuclear cells
15. Identification of t cells by T-cell rossetting using sheep RBC

Books recommended:

1. Immunology: Theoretical and practical concepts in Laboratory Medicine. Hannah D. Zane, Saunders; 1 edition (2001)
2. Clinical Immunology and Serology: A Laboratory Perspective By Christine Dorresteyn Stevens, F.A. Davis Company; 2nd Revised edition edition (2009)

Course Evaluation:
Lab (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time research projects.
POs met through Gaps in the Syllabus: PO2, PO3, and PO5

Topics beyond syllabus/Advanced topics/Design:
Design optimization for molecular cell biology projects.
POs met through topics beyond syllabus/Advanced topics/Design: PO1, PO2, PO3, PO4, and PO5.

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	3	3	1
CO2	3	2	2	2	-
CO3	2	1	3	3	1
CO4	3	2	3	3	-

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD3, CD6
CO2	CD1, CD3, CD6
CO3	CD1, CD3, CD6
CO4	CD1, CD3,CD6

COURSE INFORMATION SHEET

Course code: BT506
Course title: ENVIRONMENTAL BIOTECHNOLOGY LAB
Pre-requisite(s):
Co- requisite(s):
Credits: 2 L:0 T:0 P:4
Class schedule per week: 04
Class: M. Sc.
Semester / Level: II/05
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Identify and explain the environmental factors responsible for the pollution
2.	Select the appropriate method for the treatment of wastewater and solid waste management
3.	Select and apply Suitable bioremediation methods for the treatment
4.	Expose to significance of biofuels and organic farming

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Apply knowledge on wastewater management
CO2	Design techniques for bioremediation of xenobiotics
CO3	Identify and evaluate the importance of biofuels and organic farming
CO4	Apply the scientific method by stating a question; researching the topic; determining appropriate tests; performing tests; collecting, analyzing, and presenting data and effective communicate with both specialist and non-specialist audiences/community

Syllabus

List of Experiments

1. Estimation of biological oxygen demand in sewage samples
2. Estimation of chemical oxygen demand in sewage samples
3. Determination of total dissolved solids in water samples
4. Determination of coliforms to estimate quality of water samples
5. Isolation of xenobiotic degrading bacteria by selective enrichment technique
6. Estimation of heavy metals in water/soil by atomic absorption spectrophotometry
7. Production of microbial fertilizers
8. Preparation of formulations of microbial biopesticide

Books Recommended:

TEXT BOOK

1. James G. Cappuccino and Natalie Sherman: Microbiology: A Laboratory Manual, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., 2005

REFERENCE BOOK

2. Metcalf and Reddy Inc et al, Wastewater Engineering: Treatment and Reuse, 4th Ed., McGrawHill Higher Education, 2002

Course Evaluation:

Progressive Evaluation (Viva Voce), Practical (End semester) examination

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	2	2
CO2	3	3	2	2	2
CO3	2	2	3	2	2
CO4	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD3, CD4 and CD6
CO2	CD1, CD3, CD4 and CD6
CO3	CD1, CD3, CD4 and CD6
CO4	CD1, CD2, CD3, CD4 and CD6

COURSE INFORMATION SHEET

Course code: BT508
Course title: METABOLOMICS
Pre-requisite(s):
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc
Semester / Level: III/05
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	State and comprehend the fundamental concepts of metabolism and metabolic regulation network at different label
2.	Extend comprehensive knowledge about analysis of metabolic control and metabolic networks
3.	Demonstrate concept about Metabolic flux analysis and its applications with the help of specific algorithms
4.	Gain knowledge about the techniques for Metabolic Control Analysis with different programming and its application in biological systems

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Elucidate the theoretical knowledge of metabolism and metabolic regulation network
CO2	Analyze and design the metabolic control and metabolic networks with programming/algorithms
CO3	Collect the proficient knowledge to solve metabolic flux balance analysis
CO4	Develop the key skills of metabolic control analysis in different systems

Syllabus

Module I: Metabolism Basics: Overview of cellular metabolism, Different models for cellular reactions, Metabolic regulation network at enzyme level and whole cell level, Jacob Monod model and its regulation, Differential regulation by isoenzymes, Feedback regulation. (8L)

Module II: Metabolic Flux Analysis**:** Linear programming, Cell capability analysis, Genome scale, isotope labeling, Integration of anabolism and catabolism, Experimental determination method of flux distribution, Metabolic flux analysis and its applications, Thermodynamics of cellular processes. (8L)

Module III: Metabolic Networks: Stoichiometry, kinetics, mass balances for the steady state, mass balances for the transient case, Metabolic pathway modeling, Analysis of metabolic control and the structure, metabolic networks, Metabolic pathway synthesis algorithms. (8L)

Module IV: Metabolic Control Analysis: Nonlinear programming, Synthesis and design of metabolic networks, Integer programming, Mixed-integer nonlinear programming, Case studies about ethanol production, amino acid biosynthesis, metabolism in bacteria and yeast. (8L)

Module V: Metabolomics Applications: Application in pharmaceuticals, Chemical bioprocess, Food technology, Agriculture, Environmental bioremediation, Biomass conversion, Secondary metabolites production. (8L)

Books recommended:

TEXT BOOK

1. Metabolic Engineering: Principles and Methodologies. Edited by G. Stephanopoulos, A.A. Aristidou, J. sNeilson. (1998) Academic Press, San Diego, CA.
2. Metabolic Engineering Edited by S. Y. Lee & E.T. Papoutsakis (1999) Marcel Dekker, New York, pp.423.

REFERENCE BOOK

1. Biochemistry by J. M. Berg, J. L. Tymoczko and Lubert Stryer (2002) Fifth Edition, W.H. Freeman, New York.
2. Understanding the Control of Metabolism by David Fell (1997) Portland Press, London
3. Metabolism at a Glance by J. G Salway (1994) Blackwell Scientific Publications, Oxford
4. Systems Biology: Properties of Reconstructed Networks. B. O. Palsson, Cambridge University Press, 2006.
5. Modeling Metabolism with Mathematica. P. J. Mulquiney and P. W. Kuchel, CRC Press, 2003.
6. Pathway Analysis and Optimization in Metabolic Engineering. N. V. Torres and E. O. Voit, Cambridge University Press, 2002.
7. The Regulation of Cellular Systems. R. Heinrich and S. Schuster, Chapman & Hall, 1996.
8. Metabolic network reconstruction: Nature Reviews Genetics (2006) 7:130-141.

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time industrial projects.
POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects.
POs met through topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	2	2	1
CO2	1	-	2	3	1
CO3	2	1	1	1	-
CO4	3	3	2	2	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD3
CO2	CD1, CD2, CD3,CD4
CO3	CD1, CD2, CD3,CD4, CD6
CO4	CD1, CD3,CD6,CD7

COURSE INFORMATION SHEET

Course code: BT 509
Course title: DOWNSTREAM PROCESSING
Pre-requisite(s): BT 416
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M. Sc
Semester / Level: III/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Analyze the basic principles in Downstream process
2.	Decide among different chromatography method for protein purification
3.	Separate a protein from a mixture
4.	Apply their knowledge to make crystals or dry powder of a bio-molecule

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Extract intra-cellular materials and separate bio-molecules
CO2	Isolate a bio-molecule by adsorption, precipitation and extraction method
CO3	Purify a protein using different chromatography techniques
CO4	Separate molecules by various membrane based filtrations
CO5	Perform crystallization and drying of a bio-molecule

Syllabus

Module I: Removal of insoluble**:** An overview of Recovery processes, Removal of microbial cells and other solid matters from fermentation broth, Coagulation and Flocculation. Cell disruption techniques: Mechanical and non-mechanical methods, Filtration and Centrifugation. (8L)

Module II: Isolation of Bio molecules**:** Protein precipitation and separation; Aqueous-two-phase extraction; Supercritical extraction, Reverse micelles extraction; Adsorption-desorption process: isotherms. (8L)

Module III: Chromatographic techniques: Principles and practice of liquid chromatography, gradient elution chromatography, ion-exchange chromatography, size exclusion chromatography, reversed phase chromatography, hydrophobic interaction chromatography, affinity chromatography; HPLC and its applications. (8L)

Module IV: Membrane separation: Membrane materials and organization; Filter modules; Micro filtration, Ultra filtration; Reverse Osmosis, Electrophoresis Dialysis, Electrodialysis; Advance membrane based separation process, e.g. Pervaporation, membrane bioreactor, membrane distillation etc. (8L)

Module V: Crystallization and Drying: Crystallization: properties of a crystal, crystal growth and purity; Drying: different moisture content, drying kinetics, relative humidity, Industrial driers. (8L)

Books recommended:

TEXT BOOKS:

1. Nooralabettu Krishna Prasad, Downstream Process Technology, 1st Ed., Phi learning Pvt. Ltd, New Delhi, 2010
2. B. Sivasankar, Bioseparations: Principles and Techniques, 1st Ed., Prentice Hall, 2005
3. Michael L. Shuler, Fikret Kargi, Bioprocess Engineering – Basic Concepts, 2nd Ed., Pearson Education India, 2015

REFERENCE BOOKS:

1. Paul A. Belter, E. L. Cussler Wei-Shou Hu, Bioseparations: Downstream Processing for Biotechnology, Wiley India, Pvt Ltd., 1st Ed., 2011
2. James Bailey, David Ollis, Biochemical Engineering Fundamentals, 2nd Ed., McGraw Hill Education, 2017

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time industrial projects.
POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects.

POs met through topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	1	3	-	-
CO2	1	-	3	-	1
CO3	3	1	2	2	-
CO4	3	1	2	2	-

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD3, CD4
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD3, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: BT510
Course title: BIOTECHNOLOGY ENTREPRENEURSHIP
Pre-requisite(s): Nil
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc
Semester / Level: III/05
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Develop awareness about the biotechnology enterprise.
2.	Exposure of management principles and the global scenario of biotechnology industries.
3.	Develop skills to work in interdisciplinary team.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Prepare project report for biotechnology entrepreneurship.
CO2	Address the market challenges for a new enterprise.
CO3	Setup enterprise for new biotechnology product.
CO4	Assess the global market scenario of their product.

Syllabus

Module-I: Introduction: Concept of entrepreneurship, Fundamentals of Marketing.

8L

Module-II: Entrepreneurship Traits & Motivation: Growth of entrepreneurship, The marketing and selling of Biotechnology, Establishment and marketing of biotechnology company, Effective advertising.

8L

Module-III: Entrepreneurial Development: Training, Institution in aid of entrepreneur, Power and importance of Positioning of a company name and product.

8L

Module-IV: Start-up: Setting of a small industry, location of an enterprise, steps of starting small industry, Incentive & subsidies for industry, Problems of entrepreneurship, The Art of Negotiation, Workable marketing and the strength of distribution. Opportunities and lessons in international marketing.

8L

Module-V: Problem and Solution of Entrepreneurship: Risk and benefit, Steps involved in commercialization of a biotechnological product, Case studies.

8L

Books Recommended:

TEXT BOOKS:

1. Dynamics of Entrepreneurial development & management; Vasant Desai, Himalay. Publications.
2. Entrepreneurship reflection & investigation; M.S. Bisht & R.C. Mishra, Chugh Publication.
3. Entrepreneurship development in India; Samiuddin, Mittal Publication.

REFERENCE BOOKS:

1. Innovation, Product Development and Commercialization: Case Studies and Key Practices for Market.
2. Science Business: The Promise, the Reality, and the Future of Biotech by Gary P. Pisano Harvard Business School Press: 2006.
3. Design and Marketing of New Products by Urban and Hauser, ISBN 0-13-201567-6.
4. Putting Biotechnology to Work: Bioprocess Engineering (1992) Commission on Life Sciences, The National Academy Press.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

1. Conducting presentations in group and writing reports
2. Giving assignments to the students on some relevant topics
3. Industrial visits

POs met through Gaps in the Syllabus: PO4, PO5

Topics beyond syllabus/Advanced topics/Design:

1. Lecture on entrepreneurship development
2. Lecture on processes to develop new biotechnology product(s)

POs met through topics beyond syllabus/Advanced topics/Design: PO4

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	3	-	-	-
CO2	1	-	-	3	3
CO3	1	2	3	-	3
CO4	1	1	1	1	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2
CO2	CD1, CD4, CD5
CO3	CD4, CD5
CO4	CD3, CD6

COURSE INFORMATION SHEET

Course code: BT511
Course title: IMAGING CONCEPT AND DEVICES
Pre-requisite(s): BT413, BT427
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc
Semester / Level: III/05
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Impart knowledge for interdisciplinary science and technology.
2.	Understand the physics of medical imaging systems.
3.	Learn the technicality associated with imaging instrumentation.
4.	Understand the aspects of applications of different imaging modalities.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Understand the general physics in imaging systems.
CO2	Learn and understand the instrumentation of different image acquisition systems.
CO3	Process and analyse the anatomical and physiological images.
CO4	Analyse the radiation hazards and its prevention.

Syllabus

Module-I: Fundamental of X-Ray: X-Ray Generation and Generators, control, Interaction between X-Rays and matter, Intensity of an X-Ray, Attenuation, Beam Restrictors and Grids, Intensifying screens, X-Ray detectors. 8L

Module-II: Applications of X-Ray: X-Ray radiography, Fluoroscopy, Digital radiography, Angiography, Cardiac catheterization lab., Computed tomography, X-Ray image characteristics, darkroom accessories and film processing. 8L

Module-III: Ultrasound Imaging: Acoustic propagation, Attenuation, Absorption and Scattering, Ultrasonic transducers, Transducer Arrays, A mode, B mode, M mode and TM mode scanners, Tissue characterization, Color Doppler flow imaging, Echocardiography. 8L

Module-IV: Radio Nuclide Imaging: Interaction of nuclear particles and matter, Nuclear sources, Radionuclide generators, Nuclear radiation detectors, Rectilinear scanner, scintillation camera, SPECT, PET. 8L

Module-V: Magnetic Resonance Imaging: Angular momentum, Magnetic dipole moment, Magnetization, Larmor frequency, Rotating frame of reference, Free induction decay, Relaxation times, Pulse sequences, Generation and Detection of NMR Imager. Slice selection, Frequency encoding, Phase encoding, Spin-Echo imaging, Gradient-Echo imaging, Imaging safety: Biological effects of ionizing and non-ionizing radiations.

8L

BOOKS RECOMMENDED

TEXT BOOKS

1. Hand Book of Biomedical Instrumentation by R S Khandpur, Tata McGraw Hill Publication, Second Edition
2. Principles of Medical Imaging by K Kirk Shung, Michael B Smith & Benjamim M W Tsui, Academic Press Inc.

REFERENCE BOOK

1. Medical Imaging Signals and Systems by Jerry L Prince & Jonathan M Links, Pearson Prentice Hall.

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

1. Conducting presentations in group and writing reports.
2. Giving assignments to the students on some relevant topics.

POs met through Gaps in the Syllabus: PO2, PO3

Topics beyond syllabus/Advanced topics/Design:

1. Lecture on advance imaging modalities.

POs met through topics beyond syllabus/Advanced topics/Design: PO1, PO4

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	-	1	2	2	-
CO2	-	-	2	2	-
CO3	2	-	2	-	-
CO4	-	2	2	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD4
CO2	CD1, CD2, CD6
CO3	CD1, CD4
CO4	CD1, CD4, CD6