PRAVARA INSTITUTE OF MEDICAL SCIENCES

(DEEMED TO BE UNIVERSITY)

College of Biosciences and Technology

Loni- 413736, Dist. Ahmednagar, Maharashtra, India

NAAC Reaccredited with 'A' Grade (CGPA 3.17)

TWO-YEAR M.Sc. MEDICAL BIOTECHNOLOGY

SYLLABUS

AS PER

THE NATIONAL EDUCATION POLICY (NEP) - 2020

NCrF Level	Two-Year Programme	Duration	Credits Earned in that year	Total Credits Earned
6.0	PG Diploma Medical Biotechnology	**1st year** (I-II Sem)	44	44
6.5	M. Sc. Medical Biotechnology	**2nd year** (III-IV Sem)	44	88

Approved by Academic Council Resolution No: AC/2024(2)/D-16(iii); Dated: 12/08/2024

IMPLEMENTED FROM 2025-2026 A.Y.

Pravara Institute of Medical Sciences
(Deemed to be University)
University Established under section (3) of UGC Act,1956.
NAAC Acreditated with 'A' Grade (CGPA 3.17)

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- Dr. Balasaheb Vikhe Patil Rural Medical College
- Rural Dental College
- Dr. APJ Abdul Kalam College of Physiotherapy
- Smt. Sindhutai Eknathrao Vikhe Patil College of Nursing
- Centre for Bio-Technology
- School of Public Health and Social Medicine
- Dr. Vitthalrao Vikhe Patil Pravara Rural Hospital

Ref. No.
Ref. No.: PIMS/R/2024/2011

Date :
Date: 18/10/2024

NOTIFICATION No.: 86 / 2024

Subject: **Notification regarding Conversion of curriculum and credit framework for M. Sc. Medical Biotechnology.**

Reference: Academic Council Meeting dated 12th August, 2024.

Pursuant to the Academic Council Resolution No. AC/2024(2)/D-16(iii), dated 12th August, 2024; it is to bring to the notice of all the concerned that the M.Sc. Medical Biotechnology Curriculum and Credit framework has been transformed as per National Education Policy (NEP)– 2020 from the AY 2025-2026.

The Director, College of Biosciences & Technology, Loni and Dean, Faculty of Allied Health Sciences are authorised to follow & implement the said revised Curriculum from the Academic Year 2025-26.

Registrar
Registrar
Pravara Institute of Medical Sciences
(Deemed to be University)
Loni-413736,Tal. Rahata
Dist. Ahmednagar (M.S. India)

Copy for information:
1. Hon'ble President, PIMS (DU), Loni.
2. Hon'ble Dy. Director Administration, PIMS (DU), Loni.
3. Hon'ble Vice-Chancellor, PIMS (DU), Loni.

Copy for information & necessary action to:
4. Director, College of Biosciences & Technology, Loni.
5. Dean, Faculty of Allied Health Sciences, PIMS (DU), Loni.
6. Controller of Examinations, PIMS (DU), Loni.

PRAVARA INSTITUTE OF MEDICAL SCIENCES (Deemed to be University) Loni-413736 Tal. Rahata Dist. Ahmednagar (M.S. India)

PRAVARA INSTITUTE OF MEDICAL SCIENCES
(DEEMED TO BE UNIVERSITY)
Loni, Tal. Rahata, Dist. Ahmednagar 413736
NAAC Re-accrediated with 'A' Grade
COLLEGE OF BIOSCIENCES AND TECHNOLOGY

TWO-YEAR M. Sc. MEDICAL BIOTECHNOLOGY SYLLABUS

Sr. No.	Code	Name of the Course	Credit	Page No.
First Year: Semester I (Two-Year Programme)				
1.	MBT 25101DSC	Cellular and Molecular Biology	4	5-6
2.	MBT 25102DSC	Physiology and Biomolecular Sciences	4	7-8
3.	MBT 25101DSE-A	Fundamentals of Biotechnology	4	9-10
4.	MBT 25101DSE-B	Industrial Biotechnology		11-12
5.	MBT 25101DSE-C	Bioinstrumentation and Analytical Techniques		13-14
6.	MBT 25101DSE-D	Fundamentals of Computational Biology		15-16
7.	MBT 25101RM	Research Methodology	4	17-18
8.	MBT 25101DSP	Cellular and Molecular Biology (Practical)	2	19
9.	MBT 25102DSP	Physiology and Biomolecular Sciences (Practical)	4	20
First Year: Semester II (Two-Year Programme)				
10.	MBT 25111DSC	Introduction to Nanoscience and Nanotechnology	4	21-22
11.	MBT 25112DSC	Diagnostic Microbiology and Clinical Biochemistry	4	23-24
12.	MBT 25111DSE-A	Genetic Engineering and Its Recent Advancements	4	25
13.	MBT 25111DSE-B	Clinical Immunology and Vaccinology		26-27
14.	MBT 25111DSE-C	Molecular Enzymology and Enzyme Technology		28-29
15.	MBT 25111DSE-D	Artificial Intelligence (AI)		30-31
16.	MBT 25111OJT	On Job Training/Internship (External)	4	32-33
17.	MBT 25111DSP	Introduction to Nanoscience and Nanotechnology (Practical)	2	34-35
18.	MBT 25112DSP	Diagnostic Microbiology and Clinical Biochemistry (Practical)	4	36-37

Notification No: 86/ 2024 **Academic Council Meeting Dated: 12.08.2024**

Sr. No.	Code	Name of the Course	Credit	Page No.
Second Year: Semester III (Two-Year Programme)				
19.	MBT 25201DSC	Cell Culture Techniques	4	38-39
20.	MBT 25202DSC	Advanced Molecular Diagnostic Techniques	4	40-41
21.	MBT 25201DSE-A	Cancer Biotechnology and Oncogenomics	4	42-43
22.	MBT 25201DSE-B	Cyber Security		44-45
23.	MBT 25201DSE-C	Cytogenetics		46-47
24.	MBT 25201DSE-D	Marine Biotechnology		48-49
25.	MBT 25201RP	Research Project	4	50-52
26.	MBT 25201DSP	Cell Culture Techniques, Animal Biotechnology and Stem Cell Biology (Practical)	4	53-54
27.	MBT 25202DSP	Advanced Molecular Diagnostic Techniques (Practical)	2	55-56
Second Year: Semester IV (Two-Year Programme)				
28.	MBT 25211DSC	Bioinformatics: Tools and Techniques	4	57-58
29.	MBT 25212DSC	Animal Biotechnology and Stem Cell Biology	4	59-61
30.	MBT 25211DSE-A	Gene Therapy and RNA-Based Therapeutics	2	62-63
31.	MBT 25211DSE-B	Innovation Driven Entrepreneurship		64-65
32.	MBT 25211DSE-C	3D Bioprinting		66
33.	MBT 25212DSE-A	Clinical Research	2	67-68
34.	MBT 25212DSE-B	Omics Technologies		69-70
35.	MBT 25212DSE-C	Pharmacognosy and Metabolic Engineering		71-72
36.	MBT 25211DSP	Bioinformatics: Tools and Techniques (Practical)	4	73
37.	MBT 25211RP	Research Project	6	74-76

FIRST YEAR: SEMESTER-I

CELLULAR AND MOLECULAR BIOLOGY

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25101DSC	**Discipline Specific Core**	**Cellular and Molecular Biology**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

The objective of this course is to provide an understanding of the fundamental processes of cellular structure, function, and molecular mechanisms, including protein synthesis, cell signaling, and the cell cycle.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Gain an advanced understanding of the fundamental concepts of cellular and sub-cellular organization.

LO2: Develop an advanced understanding of the cellular transport and signaling.

LO3: Gain an advanced understanding of the cell cycle and cell death.

LO4: Understand the structure and functions of nucleic acids.

LO5: Understand mechanism of genetic damage caused by mutation and role of various repair systems.

LO6: Emphasize the molecular mechanism of DNA replication, repair, transcription, and translation in prokaryotes and eukaryotes.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Introduction to Cellular and Molecular Biology**	Basic principles of cell theory. Structure and function of prokaryotic and eukaryotic cells. Overview of biomolecules: carbohydrates, lipids, proteins, and nucleic acids. Central dogma of molecular biology.	5
Unit II	**Cell Structure and Function**	Cell membrane: structure and composition. Organelles: structure and function (nucleus, mitochondria, ER, Golgi apparatus, lysosomes, peroxisomes, etc.). Cytoskeleton: types, structure and functions of microfilaments, intermediate filaments and microtubules. Cell interaction: interaction between cell and extracellular matrix (ECM): ECM proteins (collagens, elastin, proteoglycans, fibronectins, and laminins). Interaction between cells: tight junction, anchoring junction and gap junction. Cell adhesion molecules: selectins, cadherins and immunoglobulins.	8
Unit III	**Cellular Transport and Protein Trafficking**	Transport of small molecules across membrane: passive and active transport (P, V, F, and ABC transporters). Transport of large molecules: endocytosis and exocytosis. Protein sorting and vesicular trafficking: transport of molecules into and out of the nucleus, structure and significance of Nuclear Pore Complex. Transport of proteins into mitochondria and chloroplasts. Transport of proteins from the ER through Golgi apparatus to lysosomes.	7
Unit IV	**Cell Cycle and Signaling**	Introduction and importance of cell cycle. Phases of the cell cycle (G1, S, G2 and M Phase). Regulation of the cell cycle: role of checkpoints, cyclins and Cyclin-dependent kinases (CDKs) and their role in regulating cell cycle progression. Molecular regulators of the cell cycle. Cyclins and CDKs: types, mechanisms of activation, regulation, and CDK inhibitors: p21, p27 and p57. Apoptosis and cell cycle arrest. Cell cycle checkpoints (G1/S, G2/M and spindle checkpoints). Oncogenes and tumor suppressors genes in cell cycle regulation. The role of p53 in cell cycle control. Apoptosis and cell cycle regulation. Principles of cell signaling, types of signaling: autocrine, paracrine, endocrine, and synaptic. Signal transduction	10

		pathways: G-protein-coupled receptors, receptor tyrosine kinases, and secondary messengers.	
Unit V	**Nucleic Acid- Structure and Function**	Definition and biological importance of nucleic acids. Types of nucleic acids: DNA and RNA. Historical discoveries: Griffith, Avery-MacLeod-McCarty, and Hershey-Chase experiments. Chemical composition of nucleic acids: Nucleotides: building blocks of nucleic acids, structure of a nucleotide, nitrogenous bases, phosphodiester bonds and the sugar-phosphate backbone. DNA structure: Watson and Crick's double-helix model, Chargaff's rules, structural forms of DNA, supercoiling and topological properties of DNA. DNA packaging in prokaryotes and eukaryotes. Differences between RNA and DNA, types of RNA: mRNA, tRNA, rRNA, and non-coding RNAs (miRNA, siRNA, lncRNA). Secondary and tertiary structures of RNA (e.g., hairpins, stem-loops and pseudoknots), tRNA cloverleaf structure and its significance in translation.	10
Unit VI	**Central Dogma of Molecular Biology**	The chemistry of DNA synthesis, modes and experimental proofs of DNA replication. Prokaryotic and eukaryotic DNA replication: mechanism- initiation, elongation and termination. Prokaryotic and eukaryotic transcription-initiation, elongation and termination. Post transcriptional modifications: RNA splicing and processing-spliceosome and alternative splicing. Regulation of transcription: RNA editing, mRNA transport and catalytic RNA. Genetic code and Wobble hypothesis. Prokaryotic and eukaryotic translation: steps and mechanism- initiation, elongation and termination. Inhibitors of protein synthesis. Post-translational modifications and its importance.	12
Unit VII	**DNA Repair Mechanisms**	DNA mutation: types (point mutations, insertions, deletions and frameshift mutations) and causes (spontaneous vs induced mutations and mutagens). DNA repair and recombination: pyrimidine dimer, nick and gap in DNA, AP sites, base mispairing; mismatch, base excision and nucleotide-excision repair mechanisms and SOS response. Non-homologous end joining (NHEJ), Homologous recombination, Holliday model, double strand break repair model, gene conversion, site specific recombination, FLP/FRT and Cre-Lox recombination. Transposable elements in prokaryotes and eukaryotes and mechanisms of transposition.	8

METHODOLOGY

The course will be delivered through well-structured lecture sessions.

BOOKS RECOMMENDED:

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (n.d.). Molecular biology of the cell (Indian ed.). Garland Science.
2. Karp, G. (n.d.). Cell and molecular biology (Indian ed.). Wiley India.
3. Devi, V. S. (n.d.). Cell biology and histology (Indian ed.). S. Chand & Company.
4. Krebs, J., Kilpatrick, S., & Goldstein, E. (2017). Lewin's genes XI (Int. ed.). Jones and Bartlett Learning.
5. Glick, B. R., and Pasternak, J. J. (2010). Molecular biotechnology: Principles and applications of recombinant DNA (4th ed.). ASM Press.
6. Weaver, R. F. (2003). Molecular biology (2nd ed.). Tata McGraw-Hill.
7. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., and Losick, R. (2008). Molecular biology of the gene (6th ed.). Cold Spring Harbor Laboratory Press; Pearson.

PHYSIOLOGICAL AND BIOMOLECULAR SCIENCES

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25102DSC	**Discipline Specific Core**	**Physiological and Biomolecular Sciences**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

The objective of this course is to provide an understanding of chemical and physiological foundations of life, focusing on metabolism, enzyme function, blood physiology, and how the body's systems work together to maintain health.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Understand the components and functions of blood and recognize common blood disorders like anemia and leukemia.

LO2: Understand the structure and function of the digestive and excretory systems and the role of kidneys in maintaining fluid and electrolyte balance.

LO3: Describe the structure and function of the heart, the process of blood circulation, and the mechanics of breathing, along with the regulation of heart rate and respiration.

LO4: Describe the role of endocrine hormone and explain the structure and function of the male and female reproductive systems.

LO5: Describe the chemical structures, functions, and classifications of carbohydrates, lipids, proteins, amino acids and their roles in cellular processes including enzyme activity and oxygen transport.

LO6: Describe the digestion, absorption, and metabolism of carbohydrates, lipids, and proteins along with related metabolic disorders.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Introduction to Physiology and Blood**	Introduction and scope of physiology. Homeostasis and Feedback mechanism. Composition and function of blood: WBC, RBC and platelets. Functions of plasma proteins. Principles of hemopoiesis. Regulation of erythropoiesis. RBC disorders: anemia, abnormal hemoglobin, polycythemia, thalassemia and leukemia. Regulation of WBC production. An overview of lymphoid tissue and lymph. Hemostasis and blood coagulation mechanisms. Disorders of hemostasis: hemophilia, thrombosis and embolism. Blood group: ABO and Rh. Erythroblastosis fetalis. Blood transfusion and its hazards.	7
Unit II	**Digestive and Excretory System**	Digestive system: structure and functions of alimentary canal. Composition, secretion and functions of bile, saliva, pancreatic, gastric, and intestinal juice. Gastrointestinal hormones and disorders. Excretory system: renal physiology, filtration, glomerular filtration rate (GFR), mechanisms of reabsorption, role of secretion in eliminating waste, acid-base balance, regulation of pH and electrolyte balance. Sodium, potassium, calcium regulation and role of kidneys in homeostasis.	7
Unit III	**Cardiovascular and Respiratory System**	Introduction to CVS. Structure and function of heart. Properties of cardiac muscle. Action potential and spread of impulse in the heart. Conduction system. Cardiac cycle: phases and events. Heart sounds. Cardiac output, and Starling's law of heart. Electrocardiogram. Respiratory system: overview, mechanism of breathing, respiratory muscles, mechanics of ventilation, lung volumes and capacities, gas exchange and control of respiration. Transport of oxygen and carbon dioxide. Bohr and Haldane effect. Chloride shift. Regulation of respiration.	9

Unit IV	**Endocrine and Reproductive Physiology**	Endocrine hormones: classification and mechanism of action. Signal transduction, secondary messengers and nuclear receptors. Posterior pituitary hormones and their actions. Anterior pituitary, thyroid and parathyroid hormones. Structure and function of male and female reproductive organ. Puberty, pregnancy, parturition and lactation. Reproductive ageing.	7
Unit V	**Chemistry and Function of Biomolecules**	Chemical basis of life. Function and classification of carbohydrates, lipids, amino acids and protein. Stereoisomerism and chemistry of monosaccharides, amino acids, and fatty acids. Structural organization and structure-function relationships of proteins. Nomenclature and classification of enzymes. Kinetics, mechanism and factors affecting enzymatic catalysis. Regulation of enzyme activity. Isoenzymes. Digestion, absorption and transport of carbohydrates, proteins and lipids.	10
Unit VI	**Metabolism of Carbohydrate and Lipids**	General concepts and characteristics of metabolic pathways. Carbohydrate metabolism: glycolysis, HMP shunt, Gluconeogenesis, Glycogenolysis and glycogenesis. Glycogen storage disease and regulation of glucose metabolism. Lipid metabolism: biosynthesis and degradation of fatty acids, phospholipids and triacylglycerols. Biosynthesis of cholesterol. Chemistry and metabolism of lipoproteins. Hyperlipoproteinemia. Lipid storage disorders. Synthesis and utilization of Ketone bodies. Ketoacidosis.	10
Unit VII	**Metabolism of Amino Acids and Biological Oxidation**	Amino acid metabolism: general reactions, transamination, its metabolic and diagnostic significance. Disposal of amino acid nitrogen and detoxification of urea. Metabolic fate of amino acid carbon skeleton. Sulphur containing amino acids. In born errors of amino acids metabolism. TCA cycle, Electron Transport Chain, oxidative phosphorylation and ATP synthase complex. Regulation of carbohydrate, lipid and amino acid metabolism. Integration of metabolic pathways.	10

METHODOLOGY

The course will be delivered through well-structured lecture sessions.

BOOKS RECOMMENDED:

1. Guyton, A.C., Hall, J.E. (2006). Textbook of medical physiology (11th ed.). Harcourt Asia Pte Ltd.; W. B. Saunders Company.
2. Tortora, G.J., Grabowski, S. (2006). Principles of anatomy and physiology (11th ed.). John Wiley & Sons Inc.
3. Ganong, W.F. (2003). Review of medical physiology (21st ed.). McGraw-Hill.
4. Strand, F.L. (1978). Physiology: A regulatory system approach. McMillan Publishing Co.
5. Shier, D., Butler, J., Lewis, R. (1996). Human anatomy and physiology. WCB.
6. Nelson, D.L., Cox, M.M. (2017). Lehninger principles of biochemistry (7th ed.). Macmillan; Worth Publishers; W. H. Freeman & Company.
7. Voet, D., Voet, J.G. (2004). Fundamentals of biochemistry (3rd ed.). John Wiley & Sons.
8. Murray, R.K., Hayes, P.A., Granner, D.K., Mayes, P.A., Rodwell, V.W. (2018). Harper's biochemistry (31st ed.). Prentice Hall International.

FUNDAMENTALS OF BIOTECHNOLOGY

Course Code	Category	Course Name	L	T	P	Total Hr.	Credits (T+P)
MBT 25101DSE-A	**Discipline Specific Elective**	**Fundamentals of Biotechnology**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

The objective of this course is to provide students with a comprehensive understanding of the fundamental principles, interdisciplinary applications, and technological advancements in biotechnology, with a focus on its roles in healthcare, agriculture, environment, pharmaceuticals, and artificial intelligence, fostering scientific knowledge and ethical awareness for societal and sustainable development.

Learning Outcomes:

Upon completion of this course, students will be able to:

LO1: Understand the historical evolution, scope, and interdisciplinary nature of biotechnology.

LO2: Explain key principles and techniques in animal biotechnology, including tissue culture and reproductive technologies.

LO3: Describe the role of microorganisms in industrial, environmental, and health-related applications.

LO4: Understand medical biotechnology tools and their application in diagnostics, therapeutics, and public health.

LO5: Analyze environmental biotechnology tools for pollution control, waste management, and sustainable development.

LO6: Apply biotechnology principles in the pharmaceutical industry, including bioproduct development and quality control.

LO7: Explore the applications and ethical dimensions of AI in biotechnology and healthcare.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Introduction to Biotechnology**	History and evolution of biotechnology. Key milestones and contributions in ancient, classical, and modern periods. Definition and scope of biotechnology. Comparison of traditional and modern biotechnology. Major domains and interdisciplinary aspects of biotechnology. Introduction to recombinant DNA technology, principles of gene cloning, vectors and host systems, and their applications. Role of biotechnology in achieving sustainable development goals: food security, healthcare, environmental conservation, bioenergy, and resource-efficient technologies.	4
Unit II	**Animal Biotechnology**	Animal models: types and applications. Concept of cell plasticity, types of stem cells and animal tissues. Introduction to animal tissue culture: media and growth conditions and types of cultures. Applications of animal tissue culture. Artificial reproductive technologies: artificial insemination and IVF. Introduction to transgenic animals: concept, basic methods and examples. Cloning techniques: somatic cell nuclear transfer and therapeutic cloning. Animal biotechnology in development of GMOs and improving maternal and child health.	8
Unit III	**Microbial Biotechnology**	Types, culturing and industrially important microorganisms. Microbes in production of antibiotics, enzymes, vitamins and organic acids. Microbes as insecticides, biopesticides and biofertilizers. Probiotics and their health benefits. Role of extremophiles in biotechnology. Microbial biosensors for soil and water quality monitoring. Microbial production of biogas and bioethanol. Development of microbial vaccines and microbial kits for disease diagnosis.	9
Unit IV	**Medical Biotechnology**	Applications of medical biotechnology in health care delivery. Genomics and genetic engineering: Human Genome Project, Gene Editing techniques and Gene therapy: types and delivery system.	10

		Diagnosis and biomarkers: Next Generation Sequencing and disease detection. Regenerative medicine and Stem Cell technology: tissue engineering, stem cell biology, tissue repair and regeneration. Monoclonal antibodies and therapeutic proteins. Development of DNA/mRNA vaccines for communicable diseases. Diagnostic kits for rural and resource-limited healthcare settings. Biomarkers for malnutrition and anemia detection. Public health biotechnology and disease surveillance tools.	
Unit V	**Environmental Biotechnology**	Pollution: introduction and its control. Pollution indicators. Bioremediation: fundamentals, methods and strategies. Applications of bacteria and fungi in bioremediation. Fundamentals and methods of phytoremediation. Biofuels, bioleaching of metals, biomining, bioplastics and bioemulsifiers. Biogas and bioenergy production from organic waste for sustainable rural development. Biosensors for pollution monitoring, environmental impact and biosafety concerns. Role of biotechnology in climate resilience and conservation. Microbial treatment of industrial and domestic wastewater. Role of green technology.	9
Unit VI	**Pharmaceutical Biotechnology**	Scope and applications of biotechnology in pharmaceutical industry. Introduction to biopharmaceutical production and quality control, upstream and downstream processing, fermentation and purification techniques. Enzyme Biotechnology: methods of enzyme immobilization and applications. Production of Penicillinase. Development and application of rDNA technology and genetic engineering in the production of vaccines (Hepatitis- B) and hormones (Insulin). Nutraceuticals as preventive healthcare agents. Biosimilars and affordable biotech-based drugs. Pharma biotech regulatory and ethical frameworks: GMO policy, biosafety and IPR.	10
Unit VII	**AI in Biotechnology**	Introduction to artificial intelligence. Applications of AI in drug discovery, drug repurposing, gene editing, genomics and gene expression profiling. AI in diagnostics and image analysis in pathology and radiology. AI in medical data management, electronic health records and patient data analysis. AI in epidemiology, disease surveillance and outbreak prediction. AI in vaccine development, epitope prediction and immune response modeling. AI in clinical trials. AI in biomanufacturing: automation and predictive analytics. Ethical considerations in AI applications, data privacy and algorithmic bias. Regulatory and policy frameworks related to AI in healthcare and biotechnology.	10

METHODOLOGY

The course will be delivered through well-structured lecture sessions.

BOOKS RECOMMENDED

1. Dubey, R.C. (2014). Advanced biotechnology. S. Chand Publishing.
2. Singh, B.D., and Singh, B. D. (2007). Biotechnology expanding horizons. Kalyani publishers.
3. Stanbury, P.F., Whitaker, A., and Hall, S.J. (2013). Principles of fermentation technology. Elsevier.
4. Casida, L.E. (1968). Industrial microbiology. Industrial microbiology.
5. Okafor, N. and Okeke, B. C. (2017). Modern industrial microbiology and biotechnology. CRC Press.
6. Gupta P.K., Biotechnology and Genomics, Rastogi Publications, Meerut.
7. Kumar H.D, Modern Concepts of Biotechnology, Vikas Publishing House, New Delhi.
8. Smith J.E, Biotechnology, Cambridge University Press.
9. Singh R.P., Introductory Biotechnology, Central Book Depot, Allahabad.
10. Trehan, K. Biotechnology, Wiley Eastern Ltd., Delhi.

INDUSTRIAL BIOTECHNOLOGY

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25101DSE-B	**Discipline Specific Elective**	**Industrial Biotechnology**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

The objective of this course is to provide students with foundational knowledge and practical insights into the utilization of microbes and enzymes in biochemical processes for the sustainable production of industrially significant products across sectors such as chemicals, food, and bioenergy.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Understand and explain the role of industrially significant microbes and enzymes in the production of key bioproducts such as antibiotics, organic acids, alcoholic beverages, and biofuels.

LO2: Analyze and compare different types of bioreactors and apply principles of bioreactor design, microbial growth kinetics, and substrate utilization to optimize biochemical production processes.

LO3: Demonstrate knowledge of key industrial processes including upstream and downstream processing in a biochemical manufacturing setup.

LO4: Evaluate the production pathways for diverse industrial products and bio-based chemicals, and explain their economic and environmental significance.

LO5: Assess and apply microbial technologies for sustainable energy solutions and environmental management.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Introduction to Industrial Microbiology and Bioprocessing**	Overview of industrial biotechnology. Importance and applications of microbes and enzymes in industry. Classification and screening of industrially important microorganisms. Development and characteristics of industrial strains: stability, productivity, substrate and tolerance. Preservation techniques: freeze drying, subculturing, mineral oil, and cryopreservation. Microbial metabolism and bioenergetics. Medium formulation and characteristics: carbon/nitrogen sources, vitamins, minerals, precursors, buffering capacity, and foaming agents. Microbial growth kinetics (Monod model), substrate utilization, and product formation (growth-associated and non-growth-associated products).	8
Unit II	**Bioreactor Operations and Control**	Basic concepts of bioreactor. Types, design and operational principles of bioreactors: batch, fed-batch, and continuous. Online/offline monitoring: dissolved oxygen levels, pH, temperature, and agitation. Control strategies for bioprocesses. Sterilization techniques: air, medium, and vessel. Aseptic operation principles. Inoculum preparation and scale-up techniques. Upstream processing: sterilization, agitation, and aeration systems and flow diagrams: block flow diagram and process flow diagram. Pumps and valves in fermentation setups. Downstream processing: primary separation (centrifugation and filtration) and cell disruption methods. Purification techniques: extraction, evaporation, and crystallization. Product recovery and finishing steps. Importance of maintaining sterility in bioprocesses.	12
Unit III	**Industrial Production of Biochemicals**	Raw materials for fermentation: selection and pretreatment. Industrial production of ethanol from *Saccharomyces cerevisiae*: process, media and recovery. Brewing process: malting, mashing, fermentation, conditioning and packaging. Wine fermentation: red and white wine production. Vinegar production: *Acetobacter* species, surface and submerged processes. Citric acid production by *Aspergillus niger*:	12

		pathway control and aconitase inhibition. Lactic acid production using *Lactobacillus*. Metabolic pathways of product formation and downstream recovery techniques.	
Unit IV	**Antibiotics and Microbial Bioproducts**	Penicillin and streptomycin production processes: inoculum preparation, fermentation, and product recovery. High fructose corn syrup production: enzymatic starch conversion and isomerization. Cheese making using microbial rennin. Single cell protein production: Baker's yeast, fodder yeast, and *Spirulina*. Nutritional value and limitations of SCP. Microbial production of amino acids: lysine and glutamic acid. Industrial enzymes: production of α-amylase, proteases, and lipases. Applications of enzymes in food, detergent, textile, and pharmaceutical industries.	10
Unit V	**Vaccine Technology and Metal Bioprocessing**	Introduction to recombinant DNA technology. Hepatitis B vaccine: surface antigens, mode of action, and production. Recombinant human insulin production: *E. coli*-based production and downstream processing. Gene cloning and microbial host expression. Strain improvement: genetic engineering and metabolic pathway manipulation. Biopesticide development: *Bacillus thuringiensis* and its applications for agriculture. Biopolymer production: polylactic acid and polyhydroxyalkanoates. Microbial metal leaching (bioleaching) and its applications for low-grade ores (copper and gold). Environmental and economic benefits of bioprocessing.	8
Unit VI	**Bioenergy and Wastewater Treatment**	Bioethanol production: starch and lignocellulosic materials. Biodiesel production from microbial lipids: lipid accumulation and transesterification. Biobutanol production from *Clostridium acetobutylicum*. Biohydrogen production: dark fermentation and photolysis. Biomethane generation via anaerobic digestion and reactor design. Microbial fuel cells: principle, design, and electricity generation. Wastewater treatment: aerobic wastewater (activated sludge and trickling filters) and anaerobic wastewater (UASB and biomethanation) treatment. Integrated wastewater management for energy recovery and zero discharge. Pilot-scale biohydrogen production systems and challenges.	10

METHODOLOGY:

The course is offered via the SWAYAM platform or through lecture sessions. The course title and syllabus may remain the same or be subject to minor modifications, depending on the availability of equivalent courses on the SWAYAM platform during the respective semester.

Link to SWAYAM:

https://onlinecourses.nptel.ac.in/noc25_bt56/preview

BOOKS RECOMMENDED:

1. Prescott, S. C., and Dunn, C. G. (1982). Industrial microbiology (4th ed.). AVI Publishing Co.
2. Bailey, J. E., and Ollis, D. F. (1986). Biochemical engineering fundamentals (2nd ed.). McGraw-Hill.
3. Doran, P. M. (1995). Bioprocess engineering principles. Prentice Hall.
4. Shuler, M. L., and Kargi, F. (2002). Bioprocess engineering: Basic concepts (2nd ed.). Prentice Hall.
5. Blanch, H. W., and Clark, D. S. (1997). Biochemical engineering. Marcel Dekker.
6. Aiba, S., Humphrey, A. E., and Millis, N. F. (1973). Biochemical engineering. Academic Press.
7. Crueger, W., and Crueger, A. (1990). A textbook of industrial microbiology (2nd ed.). Benjamin/Cummings.

BIOINSTRUMENTATION AND ANALYTICAL TECHNIQUES

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25101DSE-C	**Discipline Specific Elective**	**Bioinstrumentation and Analytical Techniques**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

The objective of this course is to equip students with the skills to use and interpret various analytical methods and instruments for the precise measurement and analysis of biological samples.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Demonstrate proficiency in using key bioanalytical techniques, such as chromatography, mass spectrometry, and spectroscopy etc., for the separation, identification, and quantification of biomolecules.

LO2: Effectively operate and troubleshoot various laboratory instruments, including HPLC, GC, and spectrophotometers etc., to analyze biological samples.

LO3: Implement procedures for method validation and ensure the accuracy, precision, and reliability of results.

LO4: Interpret complex analytical data, including spectra and chromatograms, to make informed conclusions about the composition and concentration of biological substances.

LO5: Describe types of radiation, their effects, and the necessary occupational protection and safety measures, as well as the use of radioisotopes in fields like medicine and industry.

LO6: Recognize and apply relevant regulatory frameworks and quality control standards in bioanalytical testing, ensuring compliance and maintaining high-quality research and diagnostic practices.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Basics of Biophysical Techniques**	Definition and concept of molarity (M) and normality (N), calculation of molarity and normality, relationship between molarity and normality, applications of molarity and normality in biochemical analysis. Homogenization techniques for biological samples, Extraction methods for biomolecules (e.g., proteins, nucleic acids and lipids). pH and its calibration. Buffers and its importance. Titrations: interaction of an acid with a base. Viscosity: factors affecting viscosity, applications of viscometry, significance of viscosity in biological systems.	6
Unit II	**Basic Separation Techniques**	Separation techniques: based on size by micro, ultra and nano membrane filters and reverse osmosis. Filtration: principle and applications in sample preparation. Dialysis: principle and applications in biomolecule purification. Centrifugation: principle of sedimentation and principle and types (differential, analytical and density gradient).	6
Unit III	**Microscopy**	Overview and principle of microscopy. Basic principle and components of light and dark-field microscopy. Principle and applications of phase contrast and fluorescence microscopy in cellular imaging. Confocal Microscopy: principle and applications. Principle and applications of Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). Freeze fracture techniques and specific staining of biological materials.	10

Unit IV	**Spectroscopy**	Overview and types of spectroscopic techniques. Electromagnetic radiation and interactions with matter. Principles of molecular excitation, Jablonski diagram, fluorescence and phosphorescence mechanisms. Beer-Lambert's Law and its limitations. Principle, theory, instrumentation and applications: UV-Visible, Fluorescence, IR/Raman, X-ray diffraction, Mass and NMR Spectroscopy.	11
Unit V	**Chromatography**	Definition, classification and principle of chromatography. Principle, basic setup, operating characteristics and applications: paper chromatography, Thin-Layer Chromatography (TLC), HPTLC, Column chromatography, Ion Exchange chromatography, Size Exclusion chromatography, Affinity chromatography, Gas Chromatography (GC), High-Performance Liquid Chromatography (HPLC) and Fast Protein Liquid Chromatography (FPLC).	12
Unit VI	**Electrophoresis**	Definition, types and principle of electrophoresis. Principle, basic setup, operating characteristics, visualization methods and applications: Agarose gel electrophoresis, Native PAGE, SDS-PAGE, Capillary Electrophoresis (CE), Pulse-Field Gel Electrophoresis and Isoelectric focusing (IEF). Two- and three- dimensional (2 and 3D) gel electrophoresis.	10
Unit VII	**Radiolabeling Techniques**	Introduction and types of radioisotopes. Radioactive decay. Detection and measurement: Geiger-Muller Counters and Liquid Scintillation Counting. Counting efficiency and autoradiography. Safety aspects. Use of isotopes as tracers in biological sciences. Biotechnological applications of radioisotopes.	5

METHODOLOGY

The course will be delivered through well-structured lecture sessions.

BOOKS RECOMMENDED:

1. Campbell, I.D. (n.d.). Biological spectroscopy. Benjamin/Cummings Pub. Co.
2. Switzer, R.L. (n.d.). Experimental biochemistry. W. H. Freeman and Co.
3. Boyer, R.F. (n.d.). Modern experimental biochemistry. Benjamin Cummings.
4. Boyer, R.F. (n.d.). Biochemistry laboratory: Modern theory and techniques. Prentice Hall.
5. Katoch, R. (n.d.). Analytical techniques in biochemistry and molecular biology. Springer.
6. Harvey, D. (n.d.). Modern analytical chemistry. McGraw-Hill.
7. Spector, D. L., Goldman, R. D. (n.d.). Basic methods in microscopy: Protocols and concepts from Cells: A laboratory manual. Cold Spring Harbor Laboratory Press.
8. Wilson, K., Walker, J.M. (Eds.). (n.d.). Principles and techniques of biochemistry and molecular biology. Cambridge University Press.

FUNDAMENTALS OF COMPUTATIONAL BIOLOGY

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25101DSE-D	**Discipline Specific Elective**	**Fundamentals of Computational Biology (SWAYAM)**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

The objective of this course is to introduce the principles and applications of computational biology by integrating mathematical modeling, data analysis, and programming to simulate biological systems and processes, with hands-on experience using tools like MATLAB and Python.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Understand the fundamentals of computational biology, including the role of mathematical models and concepts such as vector algebra, matrix algebra, and ordinary differential equations (ODEs) in biological systems.

LO2: Develop and analyze biological models using ODEs, including bacterial growth kinetics, enzyme kinetics, population dynamics, and prey-predator models.

LO3: Apply graph theory and game theory concepts such as the prisoner's dilemma and snow drift model to model biological interactions and evolutionary processes.

LO4: Gain hands-on experience in data representation, function development, and solving ODEs using MATLAB and/or Python for biological applications.

LO5: Model complex biological systems such as the circulatory and respiratory systems, transcription and translation processes, and infectious disease spread using SIR and SI models.

LO6: Explore advanced computational techniques including Flux Balance Analysis (FBA) and molecular switch, and understand their applications in biotechnology.

Sr. No.	Topic		Hrs.
Unit I	**Overview and Mathematical Concepts in Biology**	Introduction to Computational Biology. What are models? Use of Mathematics in Biology. Concept of Vector algebra. Concept of Matrix algebra. Concept of Ordinary Differential Equations. Biological Models.	6
Unit II	**Basics and Application of Model Building**	Model building using ODE. Introduction to Bacterial growth kinetics. Different models of Bacterial growth kinetics. Introduction to Enzyme Kinetics. Fundamentals of population dynamics. Fundamentals of graph theory. Basics of Data Representation.	10
Unit III	**Data Representation and Model Simulations**	Data representation: MATLAB T1/Python and MATLAB T2/Python. Functions using MATLAB / Python. Solving ODE equations using MATLAB T1 / Python. Solving ODE equations using MATLAB T2/Python. Basics of prey-predator model and population-based model building.	12
Unit IV	**Modeling and Computational Approaches in Healthcare and Basic Sciences**	Infectious disease spread models, SIR and SI models. Introduction to Game theory and basic examples of game theories in biology. Modelling of game theories, prisoner's dilemma, and snow drift model. Basics of circulatory system in humans. Basics of Respiratory system in humans. Modelling of respiration at cellular level. Application of fluid mechanics principles in Biology. Basics of transcription and translation. Modelling of transcription and translation. Basics of mutations and its importance.	12
Unit V	**Basics of Evolutionary Processes**	Mathematical models of Mutations. Basics of evolution and evolutionary processes. Mathematical models of evolutionary processes.	10

Unit VI	**Applications of Computational Approach**	Basics of Flux Balance Analysis. Computational approach to solve FBA. Molecular Switch and its application in the field of Biotechnology. Revision of Data representation.	10

METHODOLOGY

The course is offered via the SWAYAM platform or through lecture sessions. The course title and syllabus may remain the same or be subject to minor modifications, depending on the availability of equivalent courses on the SWAYAM platform during the respective semester.

LINK TO SWAYAM:

https://onlinecourses.swayam2.ac.in/nou25_bt09/preview

BOOKS RECOMMENDED:

1. An Introduction to Computational Systems Biology, By Karthik Raman.
2. Alon, U. (2019). An introduction to systems biology: Design principles *of* biological circuits (2nd ed.). CRC Press.
3. Ingalls, B.P. (2013). Mathematical modeling in systems biology: An introduction. MIT Press.
4. de Jong, H. (2002). Modeling and simulation of genetic regulatory systems: A literature review. Journal of Computational Biology, 9(1), 67–103.
5. Otto, S.P., and Day, T. (2007). A biologist's guide to mathematical modeling in ecology and evolution. Princeton University Press.
6. Allman, E.S., and Rhodes, J.A. (2004). Mathematical models in biology: An introduction. Cambridge University Press.
7. Meerschaert, M.M. (2013). Mathematical modeling (4th ed.). Academic Press.
8. Kinser, J.M. (2008). MATLAB programming for biomedical engineers and scientists. McGraw-Hill.
9. Langtangen, H.P. (2016). A primer on scientific programming with Python (5th ed.). Springer.
10. Palsson, B.O. (2015). Systems biology: Constraint-based reconstruction and analysis (2nd ed.). Cambridge University Press.
11. Nowak, M.A. (2006). Evolutionary dynamics: Exploring the equations of life. Belknap Press of Harvard University Press.

RESEARCH METHODOLOGY

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25101RM	**Research Methodology (RM)**	**Research Methodology**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

The objective of this course is to equip students with essential skills in identifying problem, designing and conducting research, applying appropriate biostatistical methods for data analysis and understanding intellectual property rights relevant to biomedical sciences.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Develop the ability to identify various types of research, formulate relevant research problems, and design appropriate methodologies.

LO2: Conduct comprehensive literature reviews to define research gaps, set objectives, and outline the significance and approach of the study.

LO3: Construct clear purpose statements, formulate research questions and hypotheses, and establish measurable research objectives.

LO4: Plan and execute experimental designs based on research aims, incorporating statistically valid sampling techniques.

LO5: Collect, organize, and analyze research data using systematic methods, and interpret results accurately for meaningful insights.

LO6: Apply core biostatistical principles including probability, hypothesis testing and regression to support research findings.

LO7: Develop skills to write structured scientific documents with clarity, use proper referencing styles, ensure ethical writing, and prepare effective research presentations and protocols.

LO8: Understand the fundamentals of IPR, including types, laws, patentability criteria, filing processes, and their role in biotechnology, healthcare, and sustainable development.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Overview of Research Methodology**	Definition, objectives and significance of research. Types of research: basic, applied, and translational. Research process: steps and flowchart. Literature review: importance, types (systematic and narrative), sources, use of databases and techniques. Criteria for good research. Meaning and sources of research problem. Identification, formulation and justification of research problem. Setting research questions and objectives. Empiricism, deductive and inductive theory. Meaning, types and development of research hypotheses. Ethical approval processes. Ethical considerations: informed consent, confidentiality and anonymity.	7
Unit II	**Research Design and Sampling Techniques**	Concepts of research design. Conceptual vs. empirical research. Cross-sectional vs. longitudinal studies. Research design: definition, types (qualitative and quantitative), need, steps and validity. Features of good research design. Sampling and sampling methods: sampling frame, sampling vs. census, characteristics of good sample, types (probability, non-probability and mixed methods). Bias and errors. Sample size: factors influencing sample size and methods for calculating sample size.	11
Unit III	**Data Collection and Analysis**	Types and sources of data. Data collection methods: primary and secondary. Tools for data collection: questionnaires (open-ended, closed-ended, likert and semantic differential scales). Interviews and surveys. Pilot testing and refinement. Reliability and validity in research. Types of validity: construct, internal and external. Ensuring reliability: test-retest and inter-rater. Data collection methods: observations, surveys, interviews (structured, semi-structured, and unstructured), and case studies. Online	12

		data collection methods: e-surveys and web analytics. Levels of measurement: nominal, ordinal, interval and ratio. Classification, tabulation and interpretation of data. Graphical representation of data using graphs and charts: histograms, frequency polygon and frequency curves, bell shaped curve and their properties. Coding and categorization. Data cleaning and preparation. Qualitative data analysis: thematic and content analysis. Quantitative data analysis: descriptive and inferential statistics. Ensuring ethical data collection practices and data protection regulations. Research misconduct: data fabrication, falsification, and plagiarism.	
Unit IV	**Introduction to Biostatistics**	Definition and role of statistics in research. Principles of biostatistics in research. Descriptive statistics: measures of central tendency (mean, median, mode) and measures of deviation (standard deviation, variance, and coefficient of variation). Probability theory: basic concepts and rules. Probability distributions: normal, binomial and poisson. Inferential statistics: confidence intervals. Hypothesis testing: simple, composite, null and alternative. Two types of errors, critical region, significance level, size and power of the test. *P*-value and its interpretation.	6
Unit V	**Advanced Biostatistical Techniques**	Small sample tests for means and variances based on chi-square, t and F distributions. Test of significance for correlation coefficient ($\rho = 0$, $\rho = \rho$) (one and two sample test). Correlation and regression analysis. Analysis of Variance (ANOVA). Non-Parametric tests: Chi-Square, Mann-Whitney U, Kruskal-Wallis, etc. Survival analysis: Kaplan-Meier curve, Log-Rank test, etc. Meta-analysis and systematic reviews. Data interpretation and presentation. Statistical software: introduction to SPSS/R/GraphPad Prism.	10
Unit VI	**Writing and Reporting Research**	Manuscript and Research Reports: structure, elements, types and layout of research report and articles. Writing and interpreting research results, figures, and graphs. Referencing styles and bibliography: APA, Chicago, MLA, Vancouver, etc. Tools and software for reference management: EndNote and Mendeley. Common mistakes in research writing. Ensuring clarity and coherence. Writing thesis and dissertations. Quoting, paraphrasing, and plagiarism. Plagiarism software. Components of oral and poster presentations. Preparing a study protocol for research projects, publication ethics and grant proposal writing.	4
Unit VII	**Intellectual Property Rights and Patents**	Introduction and need for intellectual property rights. IPR in India and abroad. Types of IP: patents, trademarks, copyrights, and trade secrets. Geographical indication and plant varieties: genetic resources and traditional knowledge. Patent laws, WHO and TRIPS agreement. IP protection. Contemporary issues in IPR. Plant variety protection. IPR and sustainable development. Criteria for patentability. Patent drafting and filing process: national and international. Infringement and enforcement of IPR. Role of IPR in R&D. IPR in biotechnology and healthcare.	10

METHODOLOGY

This course is offered through lecture sessions or via the SWAYAM platform. The course title and syllabus may remain the same or be subject to minor modifications, depending on the availability of equivalent courses on the SWAYAM platform during the respective semester.

BOOKS RECOMMENDED:

1. McBurney, D.H. (2007). Research methods; New Delhi, India: Thomson Wadsworth.
2. Singh, A.K. (2012). Tests, measurements, and research methods in behavioral sciences. B.B. Printer.
3. Best and Kahn, Research Methodology, PHI Limited.
4. Neeraj, P and Khusdeep D. Intellectual Property Rights. India, IN: PHI Learning Private Ltd. 2014.
5. Nithyananda KV (2019). IPR: Protection and Management. India, IN: Cengage Learning India Pvt. Ltd.
6. Property Rights, Law and Practice, Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament, 2013.
7. C.R. Kothari (2004). Research methodology: methods and techniques
8. Gupta S.C and V.K. Kapoor (2001). Fundamentals of Applied Statistics, Sultan Chand & Sons, 3rd Ed.

CELLULAR AND MOLECULAR BIOLOGY PRACTICAL

Course Code	Category	Course Name	L	T	P	Total Hr	Credits (T+P)
MBT 25101DSP	**Discipline Specific Practical**	**Cellular and Molecular Biology**	**0**	**0**	**2**	**60**	**0+2=2**

Objective:

The objective of this course is to develop comprehensive practical skills by enabling students to observe cellular structures and chromosomal behavior, analyze cell division processes, isolate and characterize subcellular organelles and nucleic acids, and perform essential molecular techniques such as electrophoresis, DNA manipulation, and protein separation.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Understand cellular structure and chromatin organization by observing sex chromatin (Barr bodies).

LO2: Evaluate red blood cell membrane integrity and viability through osmotic fragility testing and viable RBC counting assays.

LO3: Analyse the stages of mitosis and meiosis, and to study mitotic inhibition using colchicine.

LO4: Isolate subcellular organelles such as nuclei and mitochondria from plant and animal tissues, and to observe plasmolysis and deplasmolysis in plant cells.

LO5: Isolate and quantify different types of nucleic acids (genomic DNA, plasmid DNA, and mRNA) from various biological sources, and to analyse them using agarose gel electrophoresis.

LO6: Apply molecular biology techniques such as preparing competent cells, maintaining *E. coli* strains, gel elution of DNA, determining DNA melting temperature and GC content, and performing SDS-PAGE for molecular analysis.

Sr.No.	List of Experiments
1.	To observe human sex chromatin (Barr's body) in the buccal epithelial cells by smear technique.
2.	To perform a viable RBC cell counting assay.
3.	To determine the osmotic fragility of red blood cells.
4.	To test the effect of temperature on the permeability of the plasma membrane using beetroot tissue by observing the leakage of betacyanin pigment.
5.	To study the different stages of mitosis in onion root tips.
6.	To observe the different stages of meiosis using permanent slides of grasshopper testes.
7.	To isolate nuclei and mitochondria from spinach leaves.
8.	To isolate nuclei and mitochondria from goat liver sample.
9.	To demonstrate plasmolysis and deplasmolysis in plant cell.
10.	To study the effects of colchicine on mitosis in onion root tips.
11.	To isolate and quantify genomic DNA from bacteria.
12.	To isolate and quantify genomic DNA from animal tissues.
13.	To isolate plasmid DNA from bacterial cells.
14.	To isolate and quantify mRNA from biological samples.
15.	To perform agarose gel electrophoresis of DNA and RNA.
16.	To separate DNA/RNA molecules by denaturing agarose gel electrophoresis.
17.	To perform gel elution of DNA fragments.
18.	To maintain and store DH5α *E. coli* cells.
19.	To determine the DNA melting point and GC content.
20.	To perform SDS-PAGE for molecular analysis.

TEXT/REFERENCE BOOKS

1. Day, A.G., and Roberts, R.K. (2008). Practical clinical cytogenetics (2nd ed.). Springer.
2. Sambrook, J., Russell, D.W. (2001). Molecular cloning: A laboratory manual (3rd ed.). Cold Spring Harbor Laboratory Press.
3. Wilson, K., and Walker, J. (2005). Practical biochemistry: Principles and techniques (5th ed.). Cambridge University Press.
4. White, M.J. D. (2013). Experimental plant biology (1st ed.). Oxford University Press.

PHYSIOLOGY AND BIOMOLECULAR SCIENCES PRACTICAL

Course Code	Category	Course Name	L	T	P	Total Hr	Credits (T+P)
MBT 25102DSP	**Discipline Specific Practical**	**Physiology and Biomolecular Sciences**	**0**	**0**	**4**	**120**	**0+4=4**

Objective:

The objective of this course is to develop practical skills and conceptual understanding of biochemical and hematological techniques through the estimation, isolation, separation, and analysis of key physiological parameters and biomolecules.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Understand and perform basic hematological techniques including blood smear preparation, platelet count estimation, and detection of abnormal red blood cells.

LO2: Apply biochemical assays for the estimation of blood glucose, assess body mass index (BMI), and evaluate anti-inflammatory activity *in vitro*.

LO3: Quantify carbohydrates, reducing sugars, proteins, and amino acids using colorimetric methods such as Anthrone, DNSA, Bradford, and Ninhydrin assays.

LO4: Separate and identify amino acids and lipids using paper and thin-layer chromatography.

LO5: Isolate and analyze biological macromolecules such as albumin, cholesterol, lecithin, casein, and starch from natural sources.

LO6: To determine the physicochemical properties of lipids by estimating their saponification value and iodine number.

Sr. No.	List of Experiments
1.	To study different methods of sampling blood.
2.	To prepare and examine a peripheral blood smear and study the morphology of WBCs and RBCs.
3.	To detect the presence of toxic granulation & Döhle bodies in neutrophils on a peripheral blood smear
4.	To estimate the platelet count from blood using smear preparation.
5.	To screen blood samples for sickle cell anemia.
6.	To detect Heinz bodies in red blood cells using supravital staining.
7.	To detect the presence of Plasmodium species in a stained peripheral blood smear using microscopy.
8.	To determine the fibrinogen activity.
9.	To estimate blood glucose level by GOD-POD assay.
10.	To determine the body mass index (BMI).
11.	To evaluate *in vitro* anti-inflammatory activity of test sample using egg albumin denaturation assay.
12.	To evaluate the antioxidant activity of a natural compound by testing its ability to protect red blood cells from oxidative hemolysis.
13.	To estimate total carbohydrate content in a sample using the Anthrone method.
14.	To estimate the concentration of reducing sugars using the DNSA (3, 5-dinitrosalicylic acid) method.
15.	To estimate protein concentration by the Bradford dye-binding method.
16.	To estimate free amino acids using the Ninhydrin assay.
17.	To separate and identify amino acids by Paper chromatography.
18.	To separate and identify lipids by Thin Layer chromatography.
19.	To isolate and analyze albumin, cholesterol, and lecithin from egg.
20.	To determine saponification value and iodine number of a fat/oil sample.
21.	To isolate casein from milk by isoelectric precipitation using acidification.
22.	To extract starch from potato tuber and confirm its presence using iodine test.

TEXT / REFERENCE BOOKS

1. Day, A.G., and Roberts, R.K. (2008). Practical clinical cytogenetics (2nd ed.). Springer.
2. Sambrook J., Russell, D.W (2001). Molecular cloning: A laboratory manual (3rd ed.). CSHL Press.
3. Wilson K., Walker J. (2005). Practical Biochemistry: Principles & Techniques (5th ed.). Cambridge Press.
4. White, M.J.D. (2013). Experimental plant biology (1st ed.). Oxford University Press.

FIRST YEAR: SEMESTER-II

INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25212DSC	**Discipline Specific Core**	**Introduction to Nanoscience and Nanotechnology**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

The aim of this course is to provide a comprehensive understanding of nanoscience and nanotechnology, covering the synthesis, classification, and characterization of nanomaterials, their unique quantum properties, and their applications in medicine, and nanofabrication techniques.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Understand the origin and evolution of nanoscience and nanotechnology, including key discoveries such as fullerenes and carbon nanotubes.

LO2: Classify nanomaterials based on dimensionality (0D, 1D and 2D) and explain the concept of quantum confinement and its influence on material properties.

LO3: Demonstrate knowledge of top-down and bottom-up synthesis techniques for nanomaterials, including methods for producing quantum dots, nanowires, and thin films.

LO4: Gain practical understanding of characterization techniques and their applications in studying nanomaterials.

LO5: Explore biomedical applications of nanotechnology, including drug and gene delivery, bioimaging, and hyperthermia treatment using nanomagnetic materials.

LO6: Analyze various nanofabrication techniques and understand their applications in thin-film devices and nanoelectromechanical systems (NEMS).

Sr. No.	Topic	Detail Syllabus	Hrs.
Unit I	**Introduction and Dimensional Classification of Nanomaterials**	Introduction to the term “nano”. Evolution of nanoscience and nanotechnology. Discovery of fullerenes. Introduction to carbon nanotubes. Zero-dimensional nanomaterials: quantum dots. One-dimensional nanomaterials: nanowires, nanorods, nanotubes and nanofibres.	8
Unit II	**Confinement Effects and Fabrication Approaches**	Two Dimensional: 2D layered materials and thin films. Quantum confinement definition. Confinement in 0D, 1D and 2D confined materials. Effect of quantum size on magnetic, optical, electrical, catalytic and other properties. Surface to volume ratio and its effects on properties. Top-down and Bottom-up procedures.	12
Unit III	**Synthesis of Nanomaterials and Thin Films**	Synthesis: Quantum Dots, 1D materials and 2D layered materials. Synthesis of thin films by bottom-up and physical methods. Electrical Characterisation.	10
Unit IV	**Advanced Characterisation Techniques**	Optical characterisation. Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy and Scanning Tunnelling Microscopy. Magnetic characterisation (VSM, SQUID). Bio-imaging.	12
Unit V	**Biomedical Applications and Lithography**	Drug/gene delivery using nano vehicles. Nanodrug formulations: Objectives. Hyperthermia using nanomagnetic materials and other medicinal applications. Lithography: Optical, E-Beam, Direct laser write, Nano imprint, and Dip pen.	12

Unit VI	**Lithography, Nano Devices, and Systems**	Fountain Pen lithography. Thin film solar cells, LEDs, FET and MOSFET. Memory/storage devices and nano-electromechanical systems.	6

METHODOLOGY

The course is offered via the SWAYAM platform or through lecture sessions. The course title and syllabus may remain the same or be subject to minor modifications, depending on the availability of equivalent courses on the SWAYAM platform during the respective semester.

Link to SWAYAM:

https://onlinecourses.swayam2.ac.in/cec25_cy03/preview

BOOKS RECOMMENDED:

1. McNeil, S.E., (2011) Characterization of Nanoparticles Intended for Drug Delivery, Humana press.
2. Xian, W. (2009). A laboratory course in biomaterials. CRC Press.
3. Micou, Melissa Kurtis, and Dawn Kilkenny. (2016). A Laboratory Course in Tissue Engineering. CRC Press.
4. Bisen, P.S., (2014). Laboratory Protocols in Applied Life Sciences. Taylor & Francis Group, LLC Holtzhauer, M., (2006). Basic Methods for the Biochemical Lab. Springer-Verlag Berlin Heidelberg
5. Malsch, N.H., "Biomedical Nanotechnology", CRC Press. (2005).
6. Mirkin, C.A. and Niemeyer, C.M., "Nanobiotechnology II: More Concepts and Applications", Wiley-VCH. (2007).
7. Kumar, C. S. S. R., Hormes, J. and Leuschner C., "Nanofabrication Towards Biomedical Applications: Techniques, Tools, Applications, and Impact", WILEY -VCH Verlag GmbH & Co. (2005).
8. Lamprecht, A., "Nanotherapeutics: Drug Delivery Concepts in Nanoscience", Pan Stanford Publishing. Pte. Ltd. (2009).
9. Jain, K.K., "The Handbook of Nanomedicine", Humana press. (2008).

DIAGNOSTIC MICROBIOLOGY AND CLINICAL BIOCHEMISTRY

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25112DSC	**Discipline Specific Core**	**Diagnostic Microbiology and Clinical Biochemistry**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

The objective of this course is to provide students with essential knowledge and practical skills in microbiology and clinical biochemistry, focusing on diagnostic lab practices, immunodiagnostic techniques, and disease diagnosis, while helping them understand the biochemical processes and clinical significance of microorganisms that impact human health and disease.

Learning Outcomes:

Upon successful completion of the course, students will be able to:

LO1: Gain proficiency in specimen collection, handling, transportation, processing, and identification techniques, ensuring accurate and reliable diagnostic results.

LO2: Demonstrate the use of antigen-antibody reactions and various immunoassays for the detection and diagnosis of infectious diseases.

LO3: Critically evaluate the development and mechanisms of antimicrobial resistance and their clinical implications.

LO4: Analyze specimen considerations in clinical biochemistry, including factors affecting sample quality and appropriate handling, alongside laboratory safety and regulations.

LO5: Develop competence in performing diagnostic tests related to liver, cardiac, renal, and pancreatic functions, and interpreting test results to diagnose related diseases.

LO6: Evaluate risk factors, diagnostic methods, and management strategies for lifestyle diseases with an emphasis on prevention and early detection.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Principles of Clinical Microbiology and Diagnostic Laboratory**	Role of the microbiologist in diagnostic laboratories. Specimen collection: importance of correct specimen collection, types of specimens: blood, urine, stool, swabs, tissues, and bodily fluids and factors affecting specimen quality (e.g., timing, method, and container type). Specimen handling, transportation and processing. Specimen cultivation and identification techniques: primary cultivation, media and identification of bacterial morphology, growth patterns and biochemical characteristics. Microscopic examination for infectious diseases. Laboratory safety: Biosafety levels (BSL-1 to BSL-4), proper use of personal protective equipment (PPE) and handling of infectious materials and sharps. Infection control in the laboratory: sterilization, disinfection, waste management and disposal.	6
Unit II	**Immuno-diagnostic Techniques and Vaccination**	Immunodiagnostic techniques: antigen-antibody reactions *in vitro*, agglutination, complement fixation, ELISA, Western blotting, immunodiffusion, immunoelectrophoresis, immunofluorescence, immunoprecipitation, Radioimmunoassay (RIA) and serotyping. Vaccines and vaccination: definition, types of vaccines (live attenuated, inactivated, subunit, toxoid and conjugate), antigens used as vaccines, effectiveness of vaccines, vaccine safety, adjuvants in vaccines, active immunization and passive immunization.	8
Unit III	**Antimicrobial Chemotherapy and Drug Resistance**	Antimicrobial chemotherapy: development of chemotherapy, general characteristics of antimicrobial drugs and mechanisms of action. Antibacterial, antifungal, antiviral and antiprotozoan drugs: classes, types, mechanisms of action and clinical applications. Antibiotic sensitivity testing: methods (disk diffusion, E-test and broth dilution) and MIC determination. Drug resistance: intrinsic vs. acquired, mechanisms (enzyme production, target modification, efflux pumps and biofilm	10

Sr. No.	Topic	Detail of Syllabus	Hrs.
		formation), multi-drug resistance (MDR) and strategies (combination therapy, new drug development and antimicrobial stewardship).	
Unit IV	**Foundations of Clinical Biochemistry**	Clinical specimen considerations: processing, sample variables, chain of custody, infection control. Composition and types of blood specimens, preservation, influence of nutrition, drugs, posture, anticoagulants, care of specimens, identification, transport, storage, influence of temperature and freezing/thawing. Laboratory safety and regulations: biological, chemical, fire and radiation safety. Method of evaluation and quality management: basic concepts, reference interval study, diagnostic efficiency, method evaluation, quality control and quality management.	8
Unit V	**Enzymes and Biomarkers in Clinical Diagnosis**	Enzymes of clinical significance: creatine kinase, lactate dehydrogenase, aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase, acid phosphatase, glutamyl transferase, amylase, lipase, glucose-6-phosphate dehydrogenase and drug-metabolizing enzymes. Tumor, bone, cardiac and liver markers.	6
Unit VI	**Organ Function Tests and Disease Diagnostics**	Introduction to hormones and pituitary function: hypophysiotropic, hypothalamic, anterior pituitary hormones and pituitary function tests. Liver functions: liver dysfunction disorders (jaundice, cirrhosis, tumors, hepatitis, drug- and alcohol-related disorders) and assessment of liver function (bilirubin test and liver enzyme analysis). Cardiac function: cardiovascular disease, diagnosis of heart disease, laboratory diagnosis of myocardial infarction and markers of congestive heart failure. Renal function: glomerular and tubular diseases, urinary tract infection/obstruction, renal calculi and renal failure. Pancreatic and gastrointestinal function: diseases of the pancreas, tests of pancreatic function, secretin/cholecystokinin test and tests of intestinal function (lactose intolerance test).	12
Unit VII	**Lifestyle Diseases: Diagnosis and Prevention**	Lifestyle diseases: definition, risk factors and public health impact. Cardiovascular diseases: hypertension, atherosclerosis, coronary artery disease and diagnostic tests (ECG, cholesterol and echocardiogram). Diabetes mellitus: type 1 and type 2, risk factors and diagnostic tests (fasting blood glucose, HbA1c and OGTT). Obesity: causes, risk factors and diagnostic tests (BMI, waist circumference and body fat). Chronic respiratory diseases: COPD, asthma and diagnostic tests (spirometry and chest x-ray). Cancer: risk factors (lung, colorectal and breast) and screening tests (mammography, colonoscopy and pap smear). Prevention and management: lifestyle modifications (diet, exercise and smoking cessation), screening and early detection.	10

METHODOLOGY

The course will be delivered through well-structured lecture sessions.

BOOKS RECOMMENDED:

1. Prescott, L.M., Harley, J.P. and Klein, D.A. 1999. Microbiology. 4th Edition, McGraw-Hill.
2. Ananthanarayan and Paniker, Textbook of Microbiology. Orient Blackswan, 2006.
3. Mims, Medical Microbiology, 5th Ed, Elsevier.
4. Michael L. Bishop, Edward P. Fody and Larry E. Schoeff; (2013). Basic Principles and Practice of Clinical Chemistry, (7th Ed). Lippincott Williams and Wilkins.
5. D.M. Vasudevan and Sreekumari, S, (2010). Textbook of Biochemistry for Medical Students, (6th Ed). Jaypee Brothers Medical Publishers, New Delhi.
6. Sucheta Dandekar; (2010). Concise Medical Biochemistry, (3rd ed), Elsevier Health.
7. Satyanarayana and Chakrapani, (2013), Biochemistry; (4th Ed). Elsevier.
8. Clinical Biochemistry- Metabolic and Clinical aspects by William J. Marshall et al.– 3rd Edition Churchill Lirigstone- Elsevier
9. Textbook of Clinical Biotechnology- Ramnik Sood, CBS publications.

GENETIC ENGINEERING AND ITS RECENT ADVANCEMENTS

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25112DSE-A	**Discipline Specific Elective**	**Genetic Engineering and Its Recent Advancements (SWAYAM)**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

This course aims to equip the students with a comprehensive understanding of genetic engineering principles and techniques, including gene cloning, expression analysis, genome editing, and transgenic technologies, with an emphasis on their applications in research, agriculture, and medicine.

Learning Objectives:

Upon completion of this course, students will be able to:

LO1: Understand the fundamental principles and tools of genetic engineering, including cloning techniques, vector systems, and DNA replication models.

LO2: Demonstrate the ability to describe the steps involved in gene manipulation, including the construction and screening of genomic and cDNA libraries, and the use of bacterial, yeast, and mammalian artificial chromosomes.

LO3: Analyze and compare methods of gene delivery and genetic manipulation in both prokaryotic and eukaryotic systems, development of transgenic plants and animals, and the use of reporter genes.

LO4: Evaluate gene silencing mechanisms such as RNA interference (RNAi), siRNA, and mRNA degradation, and understand the applications of knock-out technologies in functional genomics.

LO5: Explain gene expression and its regulation at transcriptional and translational levels in prokaryotes, incorporating the roles of transcription factors, operon systems, and regulatory sequences.

LO6: Explore advanced techniques in genome editing, DNA footprinting, microarrays and gene therapy, with insights into emerging applications in transgenic biotechnology.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Fundamentals of Genetic Engineering**	Introduction to Genetic Engineering. Tools of Genetic Engineering. Steps involved in Genetic Engineering.	6
Unit II	**Cloning, Types of Vectors and Genetic Libraries**	Principles and applications of cloning. Different types of libraries. Library Screening. Cloning and expression vectors. DNA replication: Rolling circle and Theta replication model. Bacterial Artificial Chromosome, Yeast Artificial Chromosome, and Mammalian Artificial Chromosome.	10
Unit III	**Introduction of DNA into Host**	Genetic manipulation of cells. Types of transfections. Genetic manipulation in plants. Transgenic plants and transgenic animals	10
Unit IV	**Gene Silencing and Regulation of Gene Expression**	Gene silencing. mRNA, siRNA and RNAi. Knock out technology. Gene Expression. Regulation of gene expression in prokaryotes. Transcription, translation and its regulation in prokaryotes.	12
Unit V	**Restriction Modification and Applications of GE**	Restriction Endonucleases and its types. Restriction modification system. Reporter genes. Microarrays. DNA foot printing. Gene Therapy. Future trends in transgenic plants and animals. Pharm animals.	12
Unit VI	**Genome Editing**	Genome editing. CRISPR-Cas technology. Mechanism of CRISPR-Cas. Case studies of CRISPR-Cas. Basic instrumentations in genetic engineering. Sequence analysis.	10

METHODOLOGY

The course is offered via the SWAYAM platform or through lecture sessions. The course title and syllabus may remain the same or be subject to minor modifications, depending on the availability of equivalent courses on the SWAYAM platform during the respective semester.

Link to SWAYAM:

https://onlinecourses.swayam2.ac.in/nou25_bt04/preview

BOOKS RECOMMENDED:

1. Primrose SB., Twyman RM., Old RW. (2001). Principles of gene manipulation & genomics (6th ed.). Blackwell.
2. Lewin, B. (2004). Genes VIII. Pearson Prentice Hall.
3. Nicholl, D. S. T. (2008). An introduction to genetic engineering (3rd ed.). Cambridge University Press.

CLINICAL IMMUNOLOGY AND VACCINOLOGY

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25112DSE-B	**Discipline Specific Elective**	**Clinical Immunology and Vaccinology**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

This course aims to provide students with knowledge of immune system function, antigen-antibody interactions, immune responses, vaccine types and mechanisms, production methods, regulatory and safety guidelines, and therapeutic antisera production.

Learning Objectives:

Upon completion of this course, students should be able to:

LO1: Understand the structure and function of the immune system and the roles of innate and adaptive immunity in defense mechanisms.

LO2: Explain antigen-antibody interactions and describe the mechanisms involved in immune responses.

LO3: Identify the different types of vaccines and understand their mechanisms of action, including live attenuated, inactivated, mRNA, and recombinant vaccines.

LO4: Analyze the process of therapeutic antisera production, including immunization of equines, plasma collection, and aseptic filtration for therapeutic use.

LO5: Comprehend the methods of vaccine production, including traditional and modern techniques such as cell culture-based, egg-based, recombinant DNA, mRNA, and viral vector vaccines.

LO6: Understand vaccine production regulations and safety guidelines and evaluate factors affecting vaccine efficacy, safety, monitoring, and quality control.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Introduction to the Immune System**	Introduction to immunology, Innate and adaptive immunity and their relationship. Humoral and cell-mediated immune responses. Overview of primary and secondary immune responses.	4
Unit II	**Cells and Organs of Immune System**	Haematopoiesis. Structure and functions: macrophages, granulocytes and NK cells. T and B lymphocytes: origin, development and differentiation. Immune organs: primary and secondary.	5
Unit III	**Antigen and Antibody Structure and Diversity**	Antigen: definition and types. Properties: antigenicity, immunogen and immunogenicity, epitope, hapten and adjuvants. Antibody: structure, types and functions. Clonal selection theory. Antibody diversity generation. Somatic gene rearrangements during B-lymphocyte differentiation, allelic exclusion and class switching.	9
Unit IV	**Immune Responses**	Major Histocompatibility Complexes: class I and class II MHC molecules, antigen processing and presentation. Complement system: structure/pathways, properties, and functions. Immuno-tolerance: central and peripheral. Role of cytokines, lymphokines and chemokines. Transplantation immunology: autograft, isograft, allograft and xenograft. Immunological basis of transplantation reactions.	8
Unit V	**Allergic Responses and Immunodeficiencies**	Allergic responses in host defense: Gell and Coombs classification. Hypersensitivity: types and related disorders. Anaphylaxis and autoimmune diseases. Primary immunodeficiency disorders: defects in lymphoid, myeloid and complement system. Secondary immunodeficiencies: AIDS and other acquired immunodeficiencies.	9
Unit VI	**Introduction to Vaccinology**	Historical background and vaccine preventable infectious diseases. Bacterial and viral vaccines. Epidemiology and pathophysiology	9

		of vaccine preventable diseases: Diphtheria, Tetanus and Pertussis. Types of vaccines: Live attenuated vaccines, inactivated (Killed) vaccines, subunit, recombinant, polysaccharide, conjugate vaccines, DNA and mRNA vaccines and toxoid vaccines. Vaccine antigenic components: role of antigens in vaccines, pathogen-associated molecular patterns (PAMPs), adjuvants, immunogenicity and factors influencing it. Immunological mechanisms of vaccination: mechanisms of action of live attenuated, inactivated, mRNA and DNA vaccines. Specificity and cross-protection in vaccines. Vaccine safety and efficacy. Factors affecting Host-Virus interaction in vaccine efficacy.	
Unit VII	**Antisera Production**	Therapeutic antisera and its importance. Antigens and adjuvants for immunizations of equines. Dose preparation and immunization of equines for production of antisera. Bleeding of equines for production of therapeutic antisera, collection and separation of plasma. Reinfusion of RBCs in equines. Steps involved in processing of plasma for the production of therapeutic antisera. Aseptic filtration of serum (0.22µM): importance and quality control	5
Unit VIII	**Vaccine Production and Quality Control**	Traditional methods- cell culture-based production: use of mammalian, avian, and insect cells for virus growth for Polio and Hepatitis B vaccines. Egg-based production: role of chicken eggs, process for influenza vaccines, advantages and limitations. Animal-based production: Tetanus and Anthrax. Modern methods- Recombinant DNA technology: production of subunit vaccines (Hepatitis B and HPV) using genetically engineered bacteria, yeast, or mammalian cells. mRNA and plasmid DNA vaccine production: development, advantages, and challenges. Viral vector vaccine: role of Adenovirus in vaccine production, process of antigen insertion (Oxford-AstraZeneca COVID-19 vaccine). Quality control: testing for sterility, potency, purity and stability. WHO, FDA, EMA and GMP regulations in production.	11

METHODOLOGY

The course will be delivered through well-structured lecture sessions.

BOOKS RECOMMENDED:

1. Gupta, S.K. (2017). Essentials of Immunology (2nd ed.). Arya Publications.
2. Ashim K. Chakravarty (2006). Immunology and immunotechnology (1st ed.). Oxford University Press.
3. Rastogi, S.C. (2006). Elements of immunology (1st ed.). CBS Publishers and Distributors.
4. Sinha, B.K. (2022). Principles of immunology (2nd ed.). CBS Publishers and Distributors Pvt. Ltd.
5. Murphy, K., and Weaver, C. (2016). Janeway's immunobiology (9th ed.). Garland Science.
6. Abbas, A.K., Lichtman, A.H., and Pillai, S. (2019). Cellular and molecular immunology (9th ed.). Elsevier.
7. Coico, R., and Sunshine, G. (2015). Immunology: A short course (8th ed.). Wiley.
8. Paul, W.E. (2013). Fundamentals of immunology: A textbook (1st ed.). Elsevier.
9. Tarlinton, D.J., and Gommerman, J.L. (2015). Molecular immunology (1st ed.). Wiley-Blackwell.
10. Parham, P. (2014). The immune system (4th ed.). Garland Science.
11. Kuby, J. (2018). Immunology (8th ed.). W. H. Freeman and Company.

MOLECULAR ENZYMOLOGY AND ENZYME TECHNOLOGY

Course Code	Category	Course Name	L	T	P	Total Hr.	Credits (T+P)
MBT 25111DSE-C	**Discipline Specific Elective**	**Molecular Enzymology and Enzyme Technology**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

The objective of this course is to understand the structure, function, and catalytic mechanisms of enzymes at the molecular level, and to apply this knowledge in designing, modifying, and utilizing enzymes for industrial, medical, and environmental applications.

Learning Outcomes:

Upon successful completion of this course, students will be able to:

LO1: Define and classify enzymes based on their structure, catalytic properties, and functions.

LO2: Explain enzyme specificity, catalytic mechanisms, and the action of enzymes, including the concept of the transition state, and analyze the mechanisms of key enzymes and multi-enzyme complexes.

LO3: Demonstrate a strong understanding of enzyme kinetics, types of inhibition, and the use of various kinetic plots, and apply appropriate methods to study enzyme-substrate interactions.

LO4: Describe techniques for enzyme extraction, purification, immobilization, and characterization, along with mass transfer and reactor design in industrial applications.

LO5: Evaluate the diverse applications of enzymes in pharmaceutical, clinical, food, agricultural, textile, and environmental industries, including their role in biosensors, diagnostics and as therapeutic agents.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Introduction to Enzymes**	Definition, nomenclature and classification of enzymes. Properties of enzymes, units, enzyme activity and specific activity. Protein nature of enzymes and non-protein enzymes: Ribozymes and DNAzymes. Metalloenzymes and metal activated enzymes. Coenzymes and Cofactors: prosthetic groups and coenzymes involved in metabolic pathways. Classification of coenzymes. Isozymes, Abzymes, and Synzymes. Role of enzymes in pharma, textile, food and beverages industry. Clinical and agricultural applications of enzymes.	6
Unit II	**Enzyme Catalysis and Mechanism**	Enzyme specificity: absolute, group, linkage and stereochemical. Active site: salient features and determination. Catalysis: acid-base, covalent, metal ion, nucleophilic and electrophilic catalysis. Mechanism of enzyme action: lock and key model, induced fit theory and transition state hypotheses. Mechanism of serine proteases: trypsin and chymotrypsin. Mechanism of action and regulation: lysozyme, carboxypeptidase A, ribonuclease and DNA polymerase. Mechanism of action and regulation: pyruvate dehydrogenase and fatty acid synthase complex. Analysis of substrate specificity and affinity. Design and optimization of enzyme assay methods: continuous vs. discontinuous methods.	12
Unit III	**Enzyme Kinetics and Inhibition**	Enzyme Kinetics: single-substrate and bisubstrate reactions. Factors affecting the velocity of enzyme-catalyzed reactions. Michaelis-Menten assumptions. Michaelis-Menten equation: Km, Vmax, L.B plot, Hanes-Woolf equation, Eadie-Hofstee equation, and turnover number (kcat). Kinetics and factors affecting the enzyme activity: substrate, pH, temperature, and enzyme concentration. Types of enzyme inhibition: reversible (competitive, non-competitive, uncompetitive and mixed substrate inhibition), irreversible, allosteric, and product inhibition. Allosteric enzymes. Examples and mechanisms of enzyme inhibition: penicillin, iodoacetamide, and diisopropyl	10

		fluorophosphate (DIPF). Techniques for studying enzyme-substrate binding and kinetics: spectrophotometry, chromatography, isothermal titration calorimetry (ITC), and surface plasmon resonance (SPR).	
Unit IV	**Enzyme Regulation**	Organization of enzymes in the cell: cell localization, compartmentalization of metabolic pathways and membrane-associated enzymes. Mechanisms of enzyme degradation: lysosomal and non-lysosomal pathways. Enzyme regulation: feedback and allosteric regulation. Sigmoidal kinetics and their physiological significance. Symmetric (Monod–Wyman–Changeux, MWC) and the sequential (Koshland–Némethy–Filmer) models of allosterism. Reversible and irreversible covalent modification of enzymes.	8
Unit V	**Extraction, Purification and Characterization of Enzymes**	Choice of sources. Sources of enzymes: microbial, plant, and animal. Enzyme extraction: preparation of crude extracts. Cell disruption methods: mechanical, enzymatic, and chemical lysis. Factors affecting enzyme stability during extraction. Enzyme purification: salting out, organic solvents, and isoelectric precipitation. Dialysis and ultrafiltration. Chromatographic techniques: Ion-exchange chromatography, Gel filtration (size-exclusion) chromatography, Affinity chromatography, and Hydrophobic interaction chromatography. Electrophoretic methods for enzyme purification and analysis. Enzyme characterization: determination of enzyme activity and specific activity, protein estimation, Km and Vmax determination, optimal pH, temperature and inhibition studies, determination of molecular weight and purity (SDS-PAGE, gel filtration). Enzyme stability: thermal, pH, and storage stability.	6
Unit VI	**Immobilization of Enzymes**	Enzyme immobilization. Methods of immobilization of enzymes: physical and chemical techniques (adsorption, matrix entrapment, encapsulation, cross-linking and covalent bonding). Properties and kinetics of immobilized enzymes. Application of immobilized enzymes. Mass transfer effect on immobilization and intra-particle diffusion. Limitations of immobilized enzymes.	6
Unit VII	**Production of Industrial Enzymes and Clinical Applications**	Types of reactors for enzymatic processing and steady state analysis. Production of enzymes: glucose isomerase, proteases, amylase, pectinase, cellulases and lipases. Applications of industrial enzymes: reverse transcriptase, amylase, lipases and proteolytic enzymes in meat and leather industry. Cellulose and metals degrading enzymes. Applications of clinically important enzymes: streptokinase, asparaginase, LDH, transaminases (ALT and AST), amylases, phosphatases and cholinesterases. Enzyme-based biosensors: components, principles and working mechanisms. Glucose biosensors: first, second and third generation.	12

METHODOLOGY:

The course will be delivered through well-structured lecture sessions.

BOOKS RECOMMENDED:

1. Palmer, T. (2007). Enzymes: Biochemistry, Biotechnology, and Clinical Chemistry (2nd ed.). Woodhead Publishing.
2. Price, N. C., Stevens, L. (1999). Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins (3rd ed.). Oxford University Press.
3. Pandey, A., Webb, C., Soccol, C. R., Larroche, C. (2006). Enzyme Technology (1st ed.). Springer.
4. Buchanan, B. B., Gruissem, W., Jones, R. L. (2015). Biochemistry and Molecular Biology of Plants (2nd ed.). Wiley-Blackwell.
5. Devasena, T. (2012). Enzymology (1st ed.). Oxford University Press.

ARTIFICIAL INTELLIGENCE (AI)

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25111DSE-D	**Discipline Specific Elective**	**Artificial Intelligence (AI)**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

This course offers a comprehensive introduction to Artificial Intelligence, covering core concepts, machine learning, Python programming, data handling, CNNs, reinforcement learning, and ethical aspects, with emphasis on real-world applications and future prospects.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Understand the fundamental concepts of Artificial Intelligence and trace its historical development and evolving applications across various industries.

LO2: Analyze real-world case studies to evaluate the impact, challenges, and success factors of AI implementations.

LO3: Develop practical skills in applying supervised, unsupervised, and reinforcement learning algorithms to solve domain-specific problems.

LO4: Gain proficiency in data preprocessing, model evaluation, and Python programming for implementing machine learning workflows.

LO5: Demonstrate the ability to design data-driven AI solutions using Python libraries and frameworks through hands-on projects.

LO6: Identify ethical challenges in AI, assess societal impacts, and apply principles of responsible and transparent AI development in compliance with regulatory standards.

Sr. No.	Topic	Detail of syllabus	Hrs.
Unit I	**Fundamentals and Historical Context of Artificial Intelligence**	Introduction to AI. AI definitions, scope, and goals. Historical evolution of AI. Key milestones and contributors. Overview of AI subfields: machine learning, natural language processing, and robotics. Case studies of AI applications: healthcare, finance, and autonomous systems. Role of AI in future technological advancements.	8
Unit II	**Supervised and Unsupervised Machine Learning**	Machine learning fundamentals. Supervised learning: classification tasks and regression tasks. Unsupervised learning: clustering techniques. Dimensionality reduction methods. Evaluation metrics and confusion matrix. Precision, recall, F1-score, and model selection strategies.	8
Unit III	**Reinforcement Learning and Advanced AI Applications**	Reinforcement learning concepts. Agent-environment interaction. Reward and policy. Q-Learning, SARSA, and applications of reinforcement learning: game playing, robotics, and recommender systems. Comparative analysis of ML techniques. Model deployment challenges.	11
Unit IV	**Data Understanding and Preprocessing for AI**	Data understanding. Data types and sources. Data quality assessment. Data visualization techniques: histograms and scatter plots. Data preprocessing: data cleaning, normalization and standardization. Feature extraction, feature selection, and dataset preparation workflows.	10
Unit V	**Python Programming for Artificial Intelligence**	Python programming for AI. Python syntax and control structures. Data structures: lists, tuples, and dictionaries. NumPy for numerical operations. Pandas for data manipulation. Matplotlib and seaborn for visualization. Hands-on exercises: building classifiers, clustering algorithms, and reinforcement learning agents.	12

Unit VI	**Ethics, Human-AI Interaction, and Governance**	Ethics in AI: bias and fairness, transparency, and accountability. Societal impacts of AI. Workforce transformation and human-AI collaboration. Regulatory frameworks, privacy, and security. Legal implications. Ethical AI design principles. Bias mitigation strategies and responsible AI practices.	11

METHODOLOGY

The course is offered via the SWAYAM platform or through lecture sessions. The course title and syllabus may remain the same or be subject to minor modifications, depending on the availability of equivalent courses on the SWAYAM platform during the respective semester.

Link to SWAYAM:

https://swayam-plus.swayam2.ac.in/courses/course-details?id=P_SkillD_01

BOOKS RECOMMENDED:

1. Thomas, J.A., Fuchs, R.L. (2002). Safety assessment. Academic Press.
2. Fleming, D.A., Hunt, D.L. (2000). Biological safety: Principles and practices (3rd ed.). ASM Press.
3. Mepham, B. (2005). Bioethics: An introduction for the biosciences. Oxford University Press.
4. Rallapalli, R., Bali, G. (2007). Bioethics and biosafety. APH Publishing Corporation.
5. Sateesh, M.K. (2008). Bioethics and biosafety. I K International Publishing House.
6. Joshi, R. (2006). Biosafety and bioethics. Gyan Publishing House.
7. Richmond, J.Y. (2005). Anthology of biosafety (Vols. 1–4). American Biological Safety Association.
8. Murray, T. H., Mehlman, M. J. (2003). Encyclopedia of ethical, legal, and policy issues in biotechnology. John Wiley and Sons.
9. Rehm, H.J., Reed, G., Brauer, D., Pühler, A., Stadler, P. (2008). Biotechnology, a multi-volume comprehensive treatise, Volume 12: Legal, economic and ethical dimensions (2nd completely revised ed.). Wiley-Blackwell.

ON JOB TRAINING

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25111OJT	**OJT**	**On Job Training (External)**	**0**	**0**	**4**	**180**	**0+4=4**

Overview

On-Job training (OJT) is a practical approach to acquiring new competencies and skills needed for a job in a real, or close to real, working environment. It is often used to learn how to use particular tools or equipment in a live-work practice, simulated, or training environment. OJT exposes students to real-world biotechnology applications and offers invaluable practical experience and effective professionals by bridging the knowledge gap between theory and practice. It enables students to apply the biotechnological skills they have acquired in the classroom to practical scenarios, like carrying out laboratory experiments, making use of specialized tools, and analysing data. Students will gain practical experience in the biotech sector in settings such as research labs, bioprocessing plants, pharmaceutical firms, or healthcare facilities. Interaction between OJT students and seasoned scientists, researchers, and professionals, as well as mentors and supervisors, will improve the students' learning experience by offering advice, their knowledge, and insights into industry best practices. Their exposure not only provides students with the chance to learn about the latest developments in the biotech sector and contribute to practical research, but it also allows them to network with specialists in the industry, which may lead to future partnerships or career prospects.

Following are the intended objectives of engaging the students in On Job Training program:

- To provide experience of real work environment with faculty guidance over a specific period.
- To familiarize students with research methods, analytical tools and techniques along with their appropriate usage and troubleshooting.
- To provide exposure to emerging technologies/ automation and how it can support, facilitate, improve, and reinforce work processes/ culture/ job roles/art and craft.
- To promote academic and professional developments.
- To help students identify the career paths.
- To provide an opportunity to jumpstart their professional careers and supplement their courses with hands-on experience making them employment ready.
- To enhance their research potential.
- To improve the professional network.

Guidelines for On Job Training in Biotechnology-based Industry for M.Sc. Medical Biotechnology

1. OJT Program Structure:

1. The duration of the OJT must be one month or more or as per regulation.
2. Students are allowed to choose any bio-based/pharmaceutical industry, research/academic institute/ health care hospitals or any other related facility covering different aspects of research and development, production, quality control, and regulatory compliances in the field of life sciences.

2. How to identify OJT?

Students with specific objectives and with the help of teachers and alumni need to identify reputable organizations offering OJT opportunities and must ensure their availability. Once after ensuring the availability the student shall apply through proper channel.

1. **Assigning Mentors and Supervisors:** The college need to appoint experienced professionals as mentors/supervisors for the students during the OJT period. They should provide guidance, monitor progress, and facilitate learning experiences.

2. **Regular Progress Review and Record Keeping:** Mentor/Mentors should conduct periodic evaluations to track the students' progress during the OJT and should maintain a detailed record of the tasks performed, skills learned, and achievements during the OJT.

INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY PRACTICAL

Course Code	Category	Course Name	L	T	P	Total Hr	Credits (T+P)
MBT 25112DSP	**Discipline Specific Practical**	**Introduction to Nanoscience and Nanotechnology**	**0**	**0**	**2**	**60**	**0+2=2**

Objective:

The objective of this course is to synthesize, characterize, and evaluate various types of nanoparticles using chemical, physical, and biological methods, and to assess their physicochemical properties, biocompatibility, and potential applications in drug delivery and biomedical fields.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Demonstrate the ability to synthesize various types of nanoparticles (metallic, metal oxide, carbon quantum dots, lipid-based, and polymer-based) using physical, chemical, and green synthesis methods.

LO2: Characterize synthesized nanoparticles using UV-visible spectroscopy, and interpret absorption spectra to confirm nanoparticle formation and evaluate optical properties.

LO3: Identify surface functional groups and stabilization mechanisms in nanoparticles using Fourier Transform Infrared (FTIR) Spectroscopy.

LO4: Assess the surface charge, colloidal stability, and particle interaction behaviour of nanoparticles using zeta potential analysis.

LO5: Analyse crystalline structure, phase, and morphology of nanoparticles using advanced techniques such as XRD, SEM, and TEM, and interpret the data for structural confirmation.

LO6: Evaluate the biocompatibility, drug loading efficiency, and formulation potential of synthesized nanoparticles for biomedical applications, including drug delivery and oral thin film development.

Sr.No.	List of Experiments
1.	To synthesize silver nanoparticles using chemical reduction with sodium borohydride and characterize them by UV-visible spectroscopy.
2.	To synthesize zinc oxide nanoparticles using chemical precipitation method and characterize them by UV-visible spectroscopy.
3.	To synthesize iron nanoparticles using hydrothermal method and characterize them by UV-visible spectroscopy.
4.	To synthesize silver/copper nanoparticles using plant extract and characterize them by UV-visible spectroscopy.
5.	To synthesize silver nanoparticles using fungal culture of *Aspergillus niger* and characterize them by UV-visible spectroscopy.
6.	To synthesize silver nanoparticles using extracellular metabolites from *Pseudomonas aeruginosa* and characterize them by UV-visible spectroscopy.
7.	To synthesize silver-zinc oxide nanocomposites using plant-mediated green synthesis and characterize them by UV-visible spectroscopy.
8.	To synthesize ultrasonic assisted copper nanoparticles using plant extract and characterize them by UV-visible spectroscopy.
9.	To synthesize iron nanoparticles using microwave irradiation of ferric salts and reducing agents and characterize them by UV-visible spectroscopy.
10.	To formulate chitosan-based nanoparticles for drug delivery applications.
11.	To synthesize curcuminoids loaded solid lipid nanoparticles.
12.	To synthesise and characterize carbon quantum dots from plant materials using hydrothermal autoclave.

13.	To synthesise and characterize carbon quantum dots from plant materials using ultrasonicator.
14.	To synthesise and characterize microwave assisted carbon quantum dots from plant materials.
15.	To load a model drug into synthesized nanoparticles and estimate loading efficiency.
16.	To assess the biocompatibility of nanoparticles on cell lines using trypan blue exclusion method.
17.	To prepare oral thin films using biopolymer.
18.	To identify functional groups involved in nanoparticle stabilization using Fourier Transform Infrared (FTIR) Spectroscopy (Demonstration).
19.	To measure surface charge and colloidal stability of nanoparticles using Zeta potential.
20.	To determine crystalline structure, phase, and crystallite size of nanoparticles using XRD.
21.	To understand surface morphology, particle shape and size using Scanning and Transmission Electron Microscopy (SEM and TEM) (Demonstration).

TEXT / REFERENCE BOOKS

1. Khan, I., Saeed, K., and Khan, I. (2019). Nanoparticles: Properties, applications and toxicities. Arabian Journal of Chemistry, 12(7), 908–931
2. Mohan, Y. M., and Rao, K. S. (2017). Nanoparticles synthesis, characterization and applications (1st ed.). CRC Press.
3. Jain, K.K. (2015). The handbook of nanoparticle technology (2nd ed.). Springer. https://doi.org/10.1007/978-1-4939-3094-6
4. Singh, P., and Pandey, A. (Eds.). (2020). Green synthesis, characterization and applications of nanoparticles. Elsevier. https://doi.org/10.1016/B978-0-12-820636-3.00001-7
5. Kumar, A., and Yadav, S. (2016). Nanobiotechnology: Synthesis and applications of nanoparticles. Springer.
6. Bhattacharya, P., and Mukherjee, P. (Eds.). (2012). Nanotechnology and nanomedicine: Introduction to nanomedicine and nanobiotechnology. CRC Press.
7. Baruah, S., and Dutta, J. (2013). Nanotechnology for biologists: An introduction to synthesis and characterization. Wiley.
8. Narayanan, K.B., and Sakthivel, N. (Eds.). (2016). Microbial nanobiotechnology: Principles and applications. Springer. https://doi.org/10.1007/978-81-322-2694-5
9. Vijayaraghavan, K., and Rahman, P.K.S.M. (2017). Green synthesis of metallic nanoparticles: Advances in eco-friendly nanomaterials. CRC Press.
10. Kumar, R., and Jena, H.M. (2021). Laboratory manual of nanoparticle synthesis and characterization techniques. Springer.

DIAGNOSTIC MEDICAL MICROBIOLOGY AND BIOCHEMISTRY PRACTICAL

Course Code	Category	Course Name	L	T	P	Total Hr	Credits (T+P)
MBT 25111DSP	**Discipline Specific Practical**	**Diagnostic Medical Microbiology and Biochemistry**	**0**	**0**	**4**	**120**	**0+4=4**

Objective:

The objective of this course is to equip the students with hands-on experience in operating a microscope, performing bacterial identification, antibiotic resistance profiling, water quality testing and estimating key biochemical markers in biological samples, preparing them for future careers in clinical diagnostics, microbiology, and biomedical research.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Demonstrate proficiency in operating compound microscope and develop the skills to perform bacterial identification using selective media, biochemical tests, and staining techniques.

LO2: Acquire proficiency in isolating and identifying pathogenic microorganisms (e.g., *E. coli*, *S. aureus* etc.) and determine their antibiotic resistance profiles.

LO3: Gain experience in performing bacteriological water quality tests to detect coliform bacteria and assess contamination levels.

LO4: Estimate and interpret various biochemical markers (e.g., blood glucose, protein, cholesterol, urea and creatinine) in biological samples using standard laboratory methods.

LO5: Acquire the skills to perform clinical tests such as the estimation of serum albumin and the albumin-globulin ratio, contributing to understanding protein levels and their clinical implications.

Sr. No.	List of Experiments
1.	To study the functioning and proper handling of compound microscope.
2.	To perform sterilization of glassware and media.
3.	To perform staining techniques (Gram, Acid Fast and Leishman's stain) for identification of bacteria.
4.	To isolate and identify pathogenic bacteria (e.g., *Escherichia coli*, *Staphylococcus aureus* etc.) using selective media and biochemical tests.
5.	To determine the antibiotic resistance profile of bacterial isolates using the Kirby-Bauer disk diffusion method.
6.	To perform the bacteriological examination of water.
7.	To identify bacterial species or strains using serological testing.
8.	To isolate and identify clinically important bacteria from urine.
9.	To diagnose streptococcal infections in humans by detecting Anti-Streptolysin O (ASO) antibodies.
10.	To identify bacteria using 16S-rRNA sequencing (Demonstration).
11.	To isolate fungi from clinical samples (e.g., skin scrapings, sputum) and identify them using morphological and biochemical characteristics.
12.	To estimate blood glucose by O-Toluidine method.
13.	To estimate protein in a given biological sample by biuret/Lowry's method.
14.	To estimate serum albumin by BCG Method.
15.	To determine serum proteins and the albumin-globulin ratio.

16.	To estimate cholesterol levels in a biological sample.
17.	To estimate urea concentration in a biological sample.
18.	To estimate serum/urine creatinine by Jaffe's method
19.	To detect the presence of ketone bodies in a given urine sample using Rothera's test.
20.	To quantitatively estimate uric acid in a given serum sample.
21.	To estimate ammonia in a biological sample by Nessler's reagent / Berthelot's reaction.
22.	To detect C-Reactive Protein concentration in a serum.

TEXT / REFERENCE BOOKS

1. Prince, C.P. (2009). Practical manual of medical microbiology (1st ed.). Jaypee Publication.
2. Thimmaiah, S. K. (2016). Standard methods of biochemical analysis (2nd ed.). Kalyani Publishers.
3. Bergey, D.H., Holt, J.G., Krieg, N.R. (2009). Bergey's manual of systematic bacteriology (2nd ed., Vol. 1). Springer.
4. Vasudevan, D.M. (2015). Biochemistry textbook for medical students (10th ed.). Jaypee Brothers Medical Publishers.

SECOND YEAR: SEMESTER-III

CELL CULTURE TECHNIQUES

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25111DSC	**Discipline Specific Core**	**Cell Culture Techniques**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

This course aims to equip students with essential knowledge and practical skills in laboratory setup and cell culture techniques involving plant, animal, and microbial cells, while also preparing them for advanced research and professional careers in biotechnology, pharmaceuticals, agriculture, and related disciplines.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Set up and manage cell culture laboratories, including sterile handling, environmental controls, and essential equipment for plant, animal, and microbial systems.

LO2: Apply aseptic techniques and sterilization methods for media preparation, culture maintenance, and contamination control.

LO3: Understand the composition and properties of culture media, and the role of nutrients, supplements, and antibiotics in cell growth.

LO4: Differentiate tissue and cell culture techniques, including primary and secondary cultures, organ cultures, and cryopreservation.

LO5: Evaluate biotechnological methods in plant and microbial systems, such as micropropagation, secondary metabolite production, and protoplast fusion.

LO6: Recognize applications of cell culture in biopharma and therapy, including vaccine production, stem cells, and emerging technologies like organ-on-a-chip.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Design and Sterile Techniques for Cell Culture Laboratory**	Laboratory setup and layout: plant and animal cell culture laboratory design, sterile handling area, incubation conditions and hot room setup. Air circulation and laminar flow: airflow principles, laminar flow systems and service bench design. Sterilization and incubation equipments: sterilizers (autoclave and hot air oven), incubator and CO_2 incubator. Storage and culture monitoring: refrigerator, deep freezer, liquid nitrogen freezer, controlled rate freezer, culture rack and colony counter. Laboratory instruments: centrifuge, inverted microscope, magnetic stirrer and water bath. Cryopreservation and cooling systems: slow cooling systems for cell freezing and liquid nitrogen storage. Washing, packing, and sterilization: materials for plant, animal, and microbial cultures. Aseptic condition, maintenance of sterility and types of culture vessels.	11
Unit II	**Cell Culture Media: Composition and Physiochemical Requirements**	Types of cell culture media for plants, animals, and microbial cells. Ingredients of media: essential nutrients, vitamins, amino acids, glucose, pH indicators, trace elements and salts. Physiochemical properties of media: pH, osmolarity and temperature. Temperature requirements and control in cell culture. Role of balanced salt solutions and antibiotics. Growth supplements: serum, growth factors, hormones and plant growth regulators. Conditioned media: definition and applications. Preparation and sterilization of cell culture media and reagents.	9
Unit III	**Animal Tissue Culture Techniques**	History and types of tissue culture techniques. Cell separation: mechanical vs. enzymatic. Disaggregation of tissues: mechanical and enzymatic. Continuous cell lines: characteristics, development, and	12

	and Applications	maintenance. Organ culture: techniques, applications, advantages and disadvantages. Cell culture systems: monolayer and suspension culture. Primary cell culture: establishment and characteristics. Secondary cell culture: development and maintenance. Characterization and maintenance of cell lines. Cryopreservation: techniques and applications. Commercial scale production of animal cells: bioreactors and scale-up techniques. Stem cells applications in research and therapy.	
Unit IV	**Plant Tissue Culture Techniques and Applications**	Cellular totipotency and applications. Types of plant tissue culture. Organogenesis: processes and influencing factors. Micropropagation: stages, advantages, and applications. Somatic embryogenesis and synthetic seeds. Haploid Production: methods, diploidization, double haploids and applications. Triploid production and endosperm culture. Secondary metabolite production: factors, selection of high-yielding lines, elicitation, immobilization of cultures, hairy root culture and biotransformation. Secondary metabolites: production and applications. Protoplast isolation, culture, fusion and applications. Molecular Farming: applications in bio-based products.	11
Unit V	**Microbial Cell Culture Techniques**	Auxotroph isolation: principles and methods. Replica plating technique: process and applications. Screening and preservation of microbial products. Production of antibiotics: microbial sources, fermentation process, and optimization of antibiotic yield. Enumeration and screening of novel microbial secondary metabolites. Microbial Biosensors: concept, construction and its applications in diagnostics, and food safety. Microbial Fuel Cells: principles, working mechanism, role of electrochemically active microbes (exoelectrogens) and Electron transfer mechanisms (direct and mediated).	9
Unit VI	**Advances and Applications in Cell Culture Technology**	Applications of cell culture in gene expression studies and protein production. *In vitro* drug and toxicity testing. Stem cell culture and regenerative medicine. Industrial applications of cell culture: production of monoclonal antibodies, recombinant proteins, vaccines and biologics. Regulatory considerations in biopharmaceutical production. Future trends in cell culture technology: 3D cell cultures, organ-on-a-chip, and personalized medicine.	8

METHODOLOGY:

The course will be delivered through well-structured lecture sessions.

BOOKS RECOMMENDED:

1. Freshney, R.I. (2016). Culture of animal cells: A manual of basic technique and specialized applications (7th ed.). Wiley-Blackwell.
2. Mather, J.P., Roberts, S.C. (2009). Cell culture: A practical approach (2nd ed.). Oxford University Press.
3. Ranga, R., Sato, M. (2019). Stem cell culture: Methods and protocols (2nd ed.). Humana Press.
4. Wiemann, S. (2018). Cell and tissue culture: Laboratory procedures (3rd ed.). Springer.
5. Pirt, S. J. (2012). Principles of microbe and cell culture (4th ed.). Blackwell Scientific.
6. Trumbull, D.L., Russell, D.E. (2020). Bioreactor design: Principles and applications. Springer.
7. McLellan, J. (2018). Handbook of cell and tissue culture for biotechnology (2nd ed.). Wiley.
8. Zimmermann, T. (2019). Biotechnology in plant tissue culture. Springer.
9. Doyle, A., Griffith, J.B. (n.d.). Cell and tissue culture: Lab procedures in biotechnology.
10. Singh, B.D. (2001). Plant biotechnology (1st ed.). Kalyani Publishers.
11. Chawla, H.S. (2002). Plant biotechnology (1st ed.). Oxford and IBH Publishing.
12. Bhojwani, S.S., Razdan, M.K. (1996). Plant tissue culture: Theory and practice (1st ed.). Elsevier.

ADVANCED MOLECULAR DIAGNOSTIC TECHNIQUES

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25202DSC	**Discipline Specific Core**	**Advanced Molecular Diagnostic Techniques**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

The objective of this course is to provide students with an in-depth understanding of advanced molecular diagnostic technologies with an emphasis on nucleic acid and protein-based assays, sequencing technologies, bioinformatics, and regulatory frameworks for disease detection, monitoring, and personalized medicine.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Understand the principles and performance characteristics of diagnostic tests and factors influencing test accuracy and reliability in clinical settings.

LO2: Demonstrate knowledge of molecular techniques such as nucleic acid extraction, PCR, blotting techniques, and CRISPR-based diagnostics, and explain their applications in disease detection.

LO3: Analyze sequencing data and bioinformatics outputs, including NGS workflows, variant calling, and mutation interpretation, using relevant databases and tools in molecular diagnostics.

LO4: Evaluate and apply protein-based diagnostic methods such as ELISA, Western blotting, and mass spectrometry, and understand integrated diagnostic platforms and their relevance to point-of-care testing.

LO5: Assess the clinical, ethical, and regulatory aspects of molecular diagnostics in areas such as infectious diseases, oncology, pharmacogenomics, and prenatal screening.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Fundamentals of Molecular Diagnostics**	Overview of molecular diagnostics and its role in healthcare. Principles of diagnostic testing: sensitivity and specificity, predictive values, and factors influencing test performance. Introduction to point-of-care testing and its applications. Types of diagnostic tests: screening, diagnostic, prognostic, and monitoring. Role of diagnostics in disease prevention, early detection, and treatment. Clinical specimens: types, methods of collection, handling, transport, processing of samples, personal and laboratory safety. Types of molecular diagnostics. Diagnostic biomarkers and their classification. Overview of laboratory workflow in molecular diagnostics. Biosafety and regulatory considerations. Quality control and assurance in diagnostic laboratories.	6
Unit II	**Nucleic Acid Extraction, Quantification and Amplification**	DNA and RNA extraction methods: manual and automated. Sample-specific protocols: blood, tissues, FFPE and swabs. RNA integrity and DNase treatment. Nucleic acid quantification methods: UV spectrophotometry and fluorometry. Gel electrophoresis for quality analysis. PCR: principles, components and types: Endpoint PCR, qPCR and RT-qPCR, Digital PCR and Multiplex PCR. Isothermal amplification: LAMP, NASBA, and RPA. PCR troubleshooting and controls.	10
Unit III	**Nucleic Acid Detection and Hybridization Technologies**	Southern and Northern blotting. Dot blot and slot blot techniques. Fluorescence *in situ* hybridization (FISH). Comparative Genomic Hybridization (CGH). Microarrays and gene chips. SNP genotyping and analysis. CRISPR-based diagnostics: SHERLOCK and DETECTR. Nucleic acid biosensors and point-of-care devices.	10
Unit IV	**Sequencing and Genomic**	Sanger sequencing: principle and applications. Next-Generation Sequencing (NGS) platforms: illumina, ion torrent and nanopore.	10

	Technologies in Diagnostics	Targeted vs whole-genome sequencing. Exome sequencing. RNA sequencing. Metagenomics and microbial diagnostics. Bioinformatics in sequence analysis. Variant calling and interpretation. Clinical reporting of sequencing data.	
Unit V	**Protein-based and Integrated Diagnostic Platforms**	Immunodiagnostics: ELISA, Western blot, and lateral flow assays. Flow cytometry in diagnostics. Mass spectrometry in proteomics. Biomarker validation techniques. Lab-on-a-chip and microfluidics. Integrated diagnostic platforms: GeneXpert and FilmArray. Automation in diagnostics. Companion diagnostics and personalized therapy.	10
Unit VI	**Bioinformatics and Data Analysis in Molecular Diagnostics**	Introduction to diagnostic bioinformatics. Sequence data analysis: FASTQ to VCF. Quality control tools: FastQC and Trimmomatic. Genome alignment tools: BWA and Bowtie. Variant calling: GATK and SAM tools. Interpretation of mutations: ClinVar and dbSNP). Databases for molecular diagnostics: OMIM, COSMIC and HGMD. Basics of gene expression analysis. Introduction to machine learning in diagnostics.	8
Unit VII	**Applications of Molecular Diagnostics**	Infectious diseases: COVID-19, TB and HIV. Oncology diagnostics: liquid biopsy, ctDNA and CTCs. Prenatal and neonatal screening. Pharmacogenomics and drug response prediction. Autoimmune and metabolic disorder diagnostics. Ethical and legal aspects. Regulatory guidelines: FDA, CE-IVD and ICMR. Emerging trends in diagnostics: AI integration, digital health, and wearable diagnostics.	6

METHODOLOGY:

The course will be delivered through well-structured lecture sessions.

BOOKS RECOMMENDED:

1. Bruns, D.E. (2007). Fundamentals of molecular diagnostics. Philadelphia: W. B. Saunders Company.
2. Debnath, M. (2015). Tools and techniques of biotechnology (1st ed.). Jaipur: Pointer Publishers.
3. Kauffman, S.A. (1993). The origins of order: Self-organization and selection in evolution. New York: Oxford University Press.
4. Buckingham, L., Flaws, M.L. (2016). Molecular diagnostics: Fundamentals, methods and clinical applications (2nd ed.). Philadelphia: F.A. Davis Company.
5. Strachan, T., Goodship, J., Chinnery, P. (2021). Genetics and genomics in medicine (2nd ed.). London: Garland Science.
6. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., Walter, P. (2015). Molecular biology of the cell (6th ed.). New York: Garland Science.
7. Glick, B. R., Patten, C.L. (2017). Molecular biotechnology: Principles and applications of recombinant DNA (5th ed.). Washington, DC: ASM Press.
8. Campbell, M.A., Heyer, L.J. (2006). Discovering genomics, proteomics, and bioinformatics (2nd ed.). San Francisco: Benjamin Cummings.
9. Wilson, K., Walker, J. (2018). Principles and techniques of biochemistry and molecular biology (8th ed.). Cambridge: Cambridge University Press.

CANCER BIOTECHNOLOGY AND ONCOGENOMICS

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25201DSE-A	**Discipline Specific Elective**	**Cancer Biotechnology and Oncogenomics**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

The objective of this course is to provide students with a comprehensive understanding of cancer biology, including its epidemiology, pathogenesis, molecular mechanisms, diagnostic approaches, treatment strategies, prevention, and research methodologies.

Learning outcomes:

Upon completion of the course, students will be able to:

LO1: Explain the global and regional trends in cancer incidence, mortality, and associated risk factors, and classify tumors based on tissue origin, grading, and staging systems.

LO2: Describe the key biological characteristics of cancer cells and the multistep process of carcinogenesis, including the roles of physical, chemical, and biological causative agents.

LO3: Differentiate between major models of carcinogenesis and analyze the molecular mechanisms of tumor angiogenesis, metastasis, and tumor microenvironment interactions.

LO4: Identify and explain the roles of oncogenes, tumor suppressor genes, cell cycle regulators, and DNA repair mechanisms in cancer development and progression.

LO5: Apply knowledge of modern diagnostic techniques such as histopathology, immunohistochemistry, molecular profiling, and liquid biopsy in cancer detection and classification.

LO6: Evaluate current therapeutic approaches, including chemotherapy, targeted therapy, immunotherapy, and preventive strategies, as well as emerging trends in cancer research using advanced experimental models and technologies.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Introduction to Cancer Biology and Carcinogenesis**	Epidemiology of cancer: global and regional statistics, incidence, mortality and risk factors. Classification based on tissue origin (carcinoma, sarcoma, leukemia, and lymphoma), with grading and staging systems. Characteristics of cancer cells: loss of contact inhibition, altered metabolism, and immortality. Multistep carcinogenesis: initiation, promotion, progression, and termination. Causative factors: physical (radiation), chemical (carcinogens), and biological agents (oncogenic viruses, bacteria, and parasites). Models of carcinogenesis (somatic mutation theory, clonal evolution, cancer stem cell model, and multistage models).	8
Unit II	**Molecular Mechanisms of Tumor Development**	Tumor angiogenesis (VEGF, FGF, HIFs, angiogenic switch, and invasion). Metastasis: local invasion, intravasation, circulation, extravasation, colonization, and metastatic niche formation. Cell-cell and tumor-stromal interactions. Alterations in adhesion molecules (e.g., E-cadherin and integrins). ECM remodeling and degradation by MMPs. Introduction to oncogenes. Activation via gene amplification (e.g., HER2/neu) and chromosomal translocations (e.g., BCR-ABL and MYC). Dominant negative effects. Tumor suppressor genes (two-hit hypothesis) and examples like p53, Rb, BRCA1/2, and APC.	10
Unit III	**Hallmarks and Molecular Basis of Cancer**	Hallmarks of Cancer: Sustained cell proliferation, resistance to apoptosis, induction of angiogenesis, activation of invasion and metastasis. Oncogenes and Tumor Suppressor Genes: mechanisms of activation/inactivation, examples (e.g., Ras, Myc, p53, and Rb). Cell Cycle Regulation in Cancer: role of cyclins, CDKs, checkpoints, and dysregulation in malignancy. DNA Damage and Repair Mechanisms: overview of repair pathways (NER, BER, MMR) and failure of repair mechanisms in carcinogenesis. Key Signaling Pathways in Cancer: PI3K/Akt, MAPK, Wnt/β-catenin, Notch, and Hedgehog pathways and their roles in tumorigenesis	10

Unit IV	**Cancer Diagnosis and Early Detection**	Cancer Screening and Early Detection Strategies: importance and methods for population-level screening. Biopsy Techniques: types of biopsy (incisional, excisional, and needle) and sample processing. Histopathology and Immunohistochemistry (IHC): identification of cancer subtypes using morphology and protein markers. Biochemical Detection Methods: use of tumor markers (e.g., PSA, CA-125, AFP) in early detection and monitoring. Molecular Diagnostic Tools: PCR, FISH, qPCR, NGS in mutation and gene expression profiling. Liquid Biopsy and Circulating Tumor Cells (CTCs): concepts, advantages, and applications.	12
Unit V	**Cancer Therapeutics and Drug Development**	Chemotherapy, radiation and hormonal therapy. Molecularly targeted therapies: TKIs and PARP inhibitors. Monoclonal antibodies and antibody-drug conjugates. Immunotherapy: immune checkpoint inhibitors (CTLA-4, PD-1/PD-L1) and CAR-T cells. Cancer vaccines (preventive and therapeutic). RNA-based therapies: siRNA and mRNA vaccines. Drug resistance mechanisms and overcoming resistance.	8
Unit VI	**Integrative Approaches to Cancer Prevention**	Primary Prevention: tobacco cessation and its impact on cancer incidence. HPV and HBV vaccination in cancer prevention. Lifestyle Modifications: diet, exercise, and avoidance of carcinogens. Integrative and Supportive Therapies: acupuncture, music therapy, hypnosis, meditation in pain and stress management. Role of palliative care in terminal cancers.	6
Unit VII	**Advanced Tools in Cancer Biotechnology and Oncogenomics**	Animal models for cancer research: xenografts, PDX and transgenic mice. 3D cell culture, organoids, and tumor-on-a-chip models. CRISPR and genome editing in cancer research. Biomarker discovery pipelines. Clinical trials in oncology: phases, design, and endpoints. Regulatory and ethical issues in cancer biotechnology. Introduction to oncogenomics. Genomic technologies in cancer. Single-cell genomics and tumor heterogeneity. Cancer genomics databases and tools. The Cancer Genome Atlas (TCGA), International Cancer Genome Consortium (ICGC) and COSMIC. cBioPortal and UCSC Xena: data visualization and interpretation. Clinical applications of oncogenomics. Ethical issues in genomic data usage and regulatory frameworks for clinical genomics.	6

METHODOLOGY

The course will be delivered through well-structured lecture sessions.

BOOKS RECOMMENDED:

1. Weinberg RA. The Biology of Cancer. 2nd ed. New York: Garland Science; 2013.
2. Hanahan D, Weinberg RA. Hallmarks of Cancer: The Next Generation. Cell. 2011;144(5):646-674.
3. DeVita VT, Lawrence TS, Rosenberg SA. DeVita, Hellman, and Rosenberg's Cancer: Principles and Practice of Oncology. 11th ed. Philadelphia: Wolters Kluwer; 2019.
4. Vogelstein B, Kinzler KW. The Genetic Basis of Human Cancer. 2nd ed. New York: McGraw-Hill; 2002.
5. Abbas AK, Lichtman AH, Pillai S. Basic Immunology: Functions and Disorders of the Immune System. 6th ed. Philadelphia: Elsevier; 2020.
6. Knowles MA, Selby PJ. Introduction to the Cellular and Molecular Biology of Cancer. 4th ed. Oxford: Oxford University Press; 2005.
7. Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P. Molecular Biology of the Cell. 6th ed. New York: Garland Science; 2014.
8. Tannock IF, Hill RP, Bristow RG, Harrington L. The Basic Science of Oncology. 5th ed. New York: McGraw-Hill Education; 2016.
9. Allison JP, Honjo T. Immunotherapy of Cancer. New York: Springer; 2016.
10. Masters JRW, Palsson B. Human Cancer Biology. Cambridge: Cambridge University Press; 2006.

CYBER SECURITY

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25201DSE-B	**Discipline Specific Elective**	**Cyber Security**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

The objective of this course is to provide students with an understanding of cybersecurity and the threat landscape, equip them with technical skills to protect IT assets, and develop their ability to plan, implement, and monitor security measures while fostering awareness of governance, legal, ethical, social, and environmental aspects, promoting responsible online behavior, understanding the global impact of cybercrimes, and committing to professional ethics and societal values.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Understand and critically analyze the cyber security threat landscape, including types of cyberattacks, cybercrimes, vulnerabilities, and their countermeasures.

LO2: Evaluate the existing legal and regulatory frameworks related to cybersecurity, data privacy, and digital payment systems, and apply this knowledge to prevent and respond to digital fraud.

LO3: Assess the security challenges and ethical considerations associated with social media platforms and personal data, emphasizing privacy and responsible digital behavior.

LO4: Perform cyber risk assessments and propose suitable security controls, audits, and compliance measures to mitigate identified risks.

LO5: Examine the human factors in cyber security, including ethical responsibilities, susceptibility to social engineering, and the role of awareness and training in strengthening cyber defense.

LO6: Demonstrate the ability to implement personal and community-level cyber protection strategies, enhancing overall awareness of cyber-attack vectors and safe online practices.

Sr. No.	Topic	Detail Syllabus	Hrs.
Unit I	**Overview of Cyber Security**	Cyber security increasing threat landscape. Cyber security terminologies: cyberspace, attack, attack vector, attack surface, threat, risk, vulnerability, exploit, exploitation, and hacker. Non-state actors and cyber terrorism. Protection of end-user machines, critical IT, and national critical infrastructure. Cyberwarfare and case studies.	6
Unit II	**Cyber crimes**	Cyber-crimes targeting computer systems and mobiles: data diddling attacks, spyware, logic bombs, DoS, DDoS, APTs, viruses, Trojans, ransomware, and data breaches. Online scams and frauds: e-mail scams, phishing, vishing, smishing, online job fraud, online sextortion, debit/credit card fraud, online payment fraud, cyberbullying, website defacement, cyber-squatting, pharming, cyber espionage, and cryptojacking. Darknet: illegal trades, drug trafficking, and human trafficking. Social media scams and frauds: impersonation, identity theft, job scams, misinformation, and fake news. Cybercrime against persons: cyber grooming, child pornography, and cyber stalking. Social engineering attacks. Cyber police stations. Crime reporting procedure. Case studies.	12
Unit III	**Cyber Law**	Cybercrime and legal landscape around the world. IT Act, 2000 and its amendments. Limitations of IT Act, 2000. Cybercrime and punishments. Cyber laws and legal and ethical aspects related to new technologies: AI/ML, IoT, Blockchain, Darknet, and social media. Cyber laws of other countries. Case studies.	10

Unit IV	**Data Privacy and Data Security**	Defining data, metadata, big data, and non-personal data. Data protection, data privacy and data security. Personal Data Protection Bill and its compliance. Data protection principles. Big data security issues and challenges. Data protection regulations of other countries: general Data Protection Regulations (GDPR), 2016, Personal Information Protection and Electronic Documents Act (PIPEDA). Social media: data privacy and security issues.	12
Unit V	**Cyber Security Management, Compliance & Governance**	Cyber security plan: cyber security policy and cyber crisis management plan. Business continuity. Risk assessment. Types of security controls and their goals. Cybersecurity audit and compliance. National cyber security policy and strategy.	8
Unit VI	**Demonstration**	Platforms for reporting cybercrimes. Checklist for reporting cybercrimes online. Setting privacy settings on social media platforms. Dos and don'ts for posting content on social media platforms. Registering complaints on a social media platform. Prepare a password policy for computers and mobile devices. List out security controls for: computers and mobile phones, and implement technical security controls. Log in to the computer system as an administrator and check the security policies in the system.	12

METHODOLOGY

The course is offered through lecture sessions or via the SWAYAM platform. The course title and syllabus may remain the same or be subject to minor modifications, depending on the availability of equivalent courses on the SWAYAM platform during the respective semester.

BOOKS RECOMMENDED:

1. Belapure, S., and Godbole, N. (n.d.). Cyber security: Understanding cyber-crimes, computer forensics and legal perspectives. Wiley India Pvt. Ltd.
2. Denning, D.F. (1999). Information warfare and security. Addison-Wesley.
3. Oliver, H.A. (2015). Security in the digital age: Social media security threats and vulnerabilities. CreateSpace Independent Publishing Platform.
4. Venkataramanan, N., and Shriram, A. (2016). Data privacy: Principles and practice. CRC Press.
5. Brody, W.K. (2005). Information security governance: Guidance for information security managers (1st ed.). Wiley.
6. Weiss, M., and Solomon, M. G. (2015). Auditing IT infrastructures for compliance (2nd ed.). Jones & Bartlett Learning.

CYTOGENETICS

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25201DSE-C	**Discipline Specific Elective**	**Cytogenetics (SWAYAM)**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

The objective of this course is to provide an understanding of cell structure, function, and organization, genetic and chromosomal mechanisms, cellular and molecular techniques, immune system components, and the role of cellular processes in health, disease, and development.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Explain the historical development of cell theory, classify different cell types, and describe the levels of biological organization from cells to organisms.

LO2: Describe the structure, properties, and functions of immune cells and organs, and understand the processes of mitosis, meiosis, and genetic recombination.

LO3: Analyze chromosomal and gene mutations, mechanisms of sex determination, and the molecular basis and detection methods of mutations.

LO4: Understand the principles and applications of various microscopy and biochemical techniques used in cell biology and cytogenetics.

LO5: Illustrate membrane composition, transport mechanisms, cellular organelles structure and function, and processes like phagocytosis and exocytosis.

LO6: Discuss cell cycle regulation, cytoskeleton dynamics, signal transduction, extra-chromosomal inheritance, and the cellular basis of carcinogenesis and chromosomal abnormalities in cancer.

Sr. No.	Topic	Detail Syllabus	Hrs.
Unit I	**Cell Structure, Classification, and Microbial World**	Historical perspective of cells. Cell theory and exceptions to cell theory. Classification of cell types within an organism. Levels of organization: cell, tissue, organ and organism. Overview of prokaryotic and eukaryotic (plant and animal) cells. Structure of viruses, properties of viral envelopes, and enzymes. Principles of virus taxonomy. Overview of phages, viroids, mycoplasma, and *Escherichia coli*.	8
Unit II	**Immune System and Cell Division Mechanisms**	Structure, properties, and functions of immune cells. Hematopoiesis, T and B lymphocytes, NK cells, Monocytes, Macrophages, Neutrophils, Eosinophils, Basophils, Mast cells, and Dendritic cells. Structure and function of immune organs: thymus, bone marrow, lymph nodes, spleen, MALT, GALT, and SALT. Mitosis and Meiosis: relation to cell structure and genetic function. Linkage, crossing over and chromosomal mapping. Cytological basis and molecular mechanism of crossing over, recombination frequency, two-factor and three-factor crosses. Interference, coincidence, and somatic cell genetics.	9
Unit III	**Sex Determination, Mutations and Microscopy**	Chromosomal and environmental factors in sex determination: Barr bodies and dosage compensation. Gametogenesis and fertilization: structure and production of gametes and zygote formation. Organization of the nucleus: chromatin movements, nuclear bodies, and significance. Chromosomal mutations: deletion, duplication, inversion, translocation, aneuploidy, and polyploidy. Gene mutations: induced vs. spontaneous, back vs. suppressor mutations. Mutation detection methods: CLB and Attached X method. Molecular basis of mutations: UV and chemical mutagens. Principles and types of microscopy: light microscopy, phase contrast, confocal microscopy, electron microscopy (SEM and STEM), and fluorescence microscopy.	12
Unit IV	**Experimental Techniques**	Biochemical techniques: Part I and II. Sub-cellular fractionation: differential and density gradient centrifugation. Sample preparation and histological analysis: cell fixation, freeze-drying, free-substitution,	10

	and Cytogenetics	microtomes, embedding and staining. Chemical basis of staining and metachromasia. Human karyotype. Human cytogenetics: Fluorescence *In Situ* Hybridization (FISH), advanced chromatography techniques and applications. General characteristics of cell differentiation. Molecular mechanisms of cell differentiation.	
Unit V	**Membranes, Nucleus, Genome and Chromatin Organization**	Membrane composition and properties. Selective permeability and membrane transport mechanisms. Cell wall and extracellular matrix. Plasma membrane structure and transport: phagocytosis, pinocytosis, and exocytosis. Nuclear structure and function, nuclear lamina, and transport across the nuclear envelope. Chromatin: molecular organization, nucleolus, and rRNA processing. Genome sequencing and chromosome diversity. Chromosome duplication and segregation, nucleosome structure, chromatin structure and regulation, nucleosome assembly, and chromosome organization. Human chromosomal abnormalities: aneuploidy, reciprocal translocations, sex and autosomal abnormalities.	11
Unit VI	**Organelles, Cytoskeleton, Signalling, Cell Cycle, and Cancer Biology**	Cell biology overview. Endoplasmic reticulum, Golgi apparatus and vesicular transport, lysosomes, mitochondria, and chloroplast DNA. Extra-chromosomal inheritance, mitochondrial mutations, maternal effects, and ineffective heredity. Cytoskeleton and cell movement: intermediate filaments and microtubules. Signalling molecules and receptors. Functions of cell surface receptors. Cell cycle and its regulations. Carcinogenesis: characteristics of cancer cells and mechanisms. Common chromosomal abnormalities in cancer.	10

METHODOLOGY

The course is offered via the SWAYAM platform or through lecture sessions. The course title and syllabus may remain the same or be subject to minor modifications, depending on the availability of equivalent courses on the SWAYAM platform during the respective semester.

Link to SWAYAM:

https://onlinecourses.swayam2.ac.in/cec25_bt13/preview

BOOKS RECOMMENDED:

1. Karp, G. (2018). Cell and molecular biology: Concepts and experiments (8th ed.). Wiley. ISBN: 9781119644057
2. Nelson, D. L., and Cox, M. M. (2017). Lehninger principles of biochemistry (7th ed.). W.H. Freeman and Company. ISBN: 9781464126109
3. Weaver, R. F. (2011). Molecular biology (5th ed.). McGraw-Hill Education. ISBN: 9780073525327
4. Lodish, H., Berk, A., Matsudaira, P., Kaiser, C. A., Krieger, M., Scott, M. P., Zipursky, S. L., & Darnell, J. (2016). Molecular cell biology (8th ed.). W.H. Freeman and Company. ISBN: 9781464183393
5. Margulis, L., and Chapman, M. J. (2009). Kingdoms and domains: An illustrated guide to the phyla of life on Earth (4th ed.). Academic Press/Elsevier. ISBN: 9780123736215
6. De Robertis, E. D. P., and De Robertis, E. M. F. (2001). Cell and molecular biology (8th ed.). Lippincott Williams & Wilkins. ISBN: 9780781734936
7. Odum, E. P., and Barrett, G. W. (2005). Fundamentals of ecology (5th ed.). Cengage Learning. ISBN: 9788131500200
8. Taylor, D. J., Green, N. P. O., and Stout, G. W. (2004). Biological science (3rd ed.). Cambridge University Press. ISBN: 9780521684170
9. Jordan, F., and Jørgensen, S. E. (2013). Models of the ecological hierarchy: From molecules to the ecosphere (1st ed.). Elsevier. ISBN: 9780444593962
10. Kumar, P., and Mina, U. (2018). Life sciences: Fundamentals and practices – Volume II (5th ed.). Pathfinder Publication. ISBN: 9788190642774
11. OpenStax College. (2013). Anatomy and physiology. Rice University. ISBN: 9781938168130
12. Solomon, E.P., Berg, L.R., and Martin, D.W. (2002). Biology (6th ed.). Brooks/Cole. ISBN: 0534391753.

MARINE BIOTECHNOLOGY

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25201DSE-E	**Discipline Specific Elective**	**Marine Biotechnology**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:
This course aims to equip life science students with knowledge of the traditional culture of marine organisms such as fish, shrimp, lobsters, mollusks, microalgae, and seaweeds and to introduce them to marine-derived drugs used in treating cancer and neurological disorders.

Learning Outcomes:
Upon completion of the course, students will be able to:
LO1: Explain the biological and ecological characteristics of key marine organisms including fish, shrimp, lobsters, mollusks, microalgae, and seaweeds.
LO2: Describe traditional and modern aquaculture practices used in the cultivation of marine species for food and commercial purposes.
LO3: Analyze the economic and environmental significance of marine bioresources in the life sciences and biotechnology sectors.
LO4: Evaluate the processes involved in the extraction and development of marine-derived compounds for pharmaceutical use, particularly in cancer and neurological disorder treatments.
LO5: Apply theoretical knowledge to identify potential marine organisms with biomedical applications and understand their role in drug discovery and development.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Introduction to Marine Biotechnology and Ecosystems**	Marine Biotechnology: introduction, marine ecosystem and its functions. Values of marine biodiversity, mariculture, and mangroves. Induced breeding in fish.	6
Unit II	**Aquaculture of Marine Species**	Eel and Asian sea bass culture. Culture of brackish water fishes: mullet, milkfish and etroplus. Culture of shrimps, edible oysters, pearl oyster, and edible mussels.	8
Unit III	**Aquaculture of Crustaceans and Live Feed Organisms**	Culture of crab and lobster. Culture of live feed organisms: artemia and rotifer. Diseases and diagnosis of fish and shrimp.	10
Unit IV	**Marine Algae and Genetic Manipulations**	Culture of marine microalgae: seaweeds and marine hydrocolloids. Hormonal manipulation of sex in fish. Chromosomal manipulation: transgenic Fish.	10
Unit V	**Advanced Marine Biotechnology Applications**	Probiotics in aquaculture. Cryopreservation in fishery sciences. Marine pharmaceuticals. Sea snakes. Biofouling. Extremophiles.	13
Unit VI	**Marine Environmental Biotechnology and Products**	Marine bioremediation. Aquatic vaccines. Marine by-products, marine natural products, and their applications. Marine protein.	13

METHODOLOGY

The course is offered via the SWAYAM platform or through lecture sessions. The course title and syllabus may remain the same or be subject to minor modifications, depending on the availability of equivalent courses on the SWAYAM platform during the respective semester.

Link to SWAYAM:
https://onlinecourses.swayam2.ac.in/cec25_bt08/preview

BOOKS RECOMMENDED:

1. Pillay, T. V. R. (1990). Aquaculture – principles and practices. Fishing Nets Books.
2. Fletcher, G. L., Rise, M. L. (Eds.). (2012). Aquaculture biotechnology (1st ed.). Wiley-Blackwell.
3. Ramachandran, V. (2013). Aquaculture biotechnology. Black Prints.

4. Nybakken, J. W. (1988). Marine biology – an ecological approach. Harper Collins.
5. Bhakuni, D. S., Rawat, D. S. (Eds.). (2005). Bioactive marine natural products. Springer, Anamya Publications.
6. Jefford, R., Rinehart, K., Sheld, R. (1988). Pharmaceuticals and the sea. Technomic Publishing Co.
7. Central Institute of Fisheries Technology. (2000). Fishery by-products (CIFT manual). CIFT Publications.
8. Edwards, C. (Ed.). (1990). Microbiology of extreme environments. McGraw-Hill.
9. Oren, A. (1998). Microbiology and biogeochemistry of hypersaline environments. CRC Press.
10. Colegate, S. M., Molyneux, R. J. (2008). Bioactive natural products (2nd ed.). CRC Press.
11. Bardach, J., Ryther, J., McLarney, W. (1972). Aquaculture: The farming and husbandry of freshwater and marine organisms. Wiley-Interscience.
12. Voigt, M. N., Botta, J. R. (Eds.). (1990). Advances in fisheries technology and biotechnology for increased profitability. Technomic Publishing Co.
13. Colwell, R. R. (Ed.). (1982). Biotechnology in the marine science: Proceedings of the first annual MIT Sea Grant lecture and seminar. MIT Sea Grant Program.
14. Le Gal, Y., Halvorson, H.O. (Eds.). (1998). New developments in marine biotechnology. Plenum Press.
15. Jadhav, U. (2009). Aquaculture technology and environment. PHI Learning Private Ltd.

RESEARCH PROJECT

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25201RP	**Research Project**	**Project/Dissertation (Internal/External)**	**0**	**0**	**4**	**120**	**0+4=4**

Objective:

The objective of this course is to engage students in systematic investigation and analysis of a specific topic or problem, enabling them to develop critical thinking, research methodologies, and data interpretation skills while contributing original insights and solutions to their field of study.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Design and conduct scientific experiments, analyze data, interpret results, and formulate evidence-based recommendations, thereby developing essential research and practical skills relevant to medical biotechnology.

LO2: Critically evaluate scientific literature, data, and arguments to draw logical and well-supported conclusions.

LO3: Address complex biomedical research questions using innovative methodologies and evidence-based problem-solving approaches.

LO4: Analyze and interpret experimental data to identify patterns, trends, and correlations relevant to the research hypothesis or objectives.

LO5: Demonstrate proficiency in writing clear, coherent, and well-structured research reports or scientific papers that adhere to academic and professional standards.

LO6: Effectively review and synthesize existing scientific literature to contextualize and support the objectives, methodology, and findings of the research project.

LO7: Understand and apply ethical principles in research, including research integrity, data confidentiality, responsible conduct, and proper citation and referencing practices.

RESEARCH PROJECT (INTERNAL/EXTERNAL)

In the 3rd semester, a student must undertake a research project in the area of their major subject. The entire process shall be carried out under the supervision of an approved PG teacher of the concerned subject, and must be approved by the Institutional Research and Review Board (IRRB) through the proper channel.

The title and synopsis must be presented before the Institutional Research and Review Board (IRRB) of CBT and finalized based on the comments provided. If necessary, depending on the proposed study, it may also require further approval from the Institutional Ethics Committee (IEC) and/or the Committee for the Control and Supervision of Experiments on Animals (CCSEA) of CBT/PIMS (DU). Thereafter, students shall finalize their synopsis as per the prescribed guidelines. Timeline for research work to be carried out shall be as follows:

No.	Work to be carried out	Timeline
1.	Finalization of title of the research work and Synopsis presentation	In the last week of the 2nd semester/first week of the 3rd semester
2.	Research Work	Next 2 -3 months
3.	Compilation of Dissertation and Corrections	Fourth month of the semester
4.	Presentation (CIA)	Fourth month of the semester
5.	Final Presentation and Viva voce	Semester-End Exam (date shall be notified separately by the University)

Synopsis Format for the Research Project/Dissertation

1. Title:
2. Background/Introduction
3. Review of the Literature
4. Statement of the Problem
5. Significance of the Study
6. Objectives of the Study
7. Scientific Hypothesis/ Research Questions
8. Expected Outputs of the Research Projects
9. Relevance of the Project in Relation to Local and Regional Environmental and Socio-Economic Conditions
10. Methodology or Materials and Methods
11. Ethical Considerations (If any)
12. Dissemination of the Results
13. Time Schedule for Research Project or Work Plan
14. Detailed Plan of Activities (Gantt chart)
15. References: APA style

References

Ensure that every reference cited in the text is also present in the reference list (and vice versa). Citation of a reference as "in press" implies that the item has been accepted for publication. Format for Citing the references in text:

1. Single author: Author's name (without initials, unless there is ambiguity) and the year of publication.
2. Two authors: Both authors' names without initials and the year of publication;
3. Three or more authors: First author's name without initial followed by "et al.," and the year of publication.

Format for References in Reference Section All references should be mentioned in Alphabetical order.

Journal Articles:

Yogesh, H.S., Chandrashekhar, V.M., Katti, H.R., Ganapaty, S., Raghavendra, H.L., Muchchandi, I.S., Goplakhrishna, B. (2011). Anti-osteoporotic activity of aqueous-methanol extract of Berberis aristata in ovariectomized rats. Journal of Ethnopharmacology 134: 334-338.

Organization as Author:

Diabetes Prevention Program Research Group (2015). Hypertension, insulin, and proinsulin in participants with impaired glucose tolerance. Hypertension 679-86.

Paper or Chapter in a Book:

Osawa, T. (1994). Novel natural antioxidants for utilization in food and biological systems. In: Uritani, I., Garcia, V.V. and Mendoza, E.M. (Eds.), Postharvest biochemistry of plant food materials in the tropics. Tokyo, Japan: Japan Scientific Societies Press. pp. 241-251.

Book by Authors:

Atta-ur-Rahman., Choudhary, M.I., Thomsen, W.J. (2001). Bioassay Techniques for Drug Development. Harwood Academic Publishers, The Netherlands. pp. 142.143.

Thesis / Dissertation:

Srichuanchuenskul, W. (1994). Modern Chromatography of Metal Chelates, PhD Thesis, Chiang Mai University, Thailand.

Patents:

Haga, T. (1976). Japan Patent No: 50-54628. iii Web Pages Include author, date, title, availability information, and accession date, if needed. URL of the site should be mentioned.

In-text

Among many recognized styles, we recommend the author-year style of in-text referencing, where you indicate in the text itself not only the name of the source author but also the year in which the source was published. The author's name may appear in the sentence itself or in parentheses; the year of publication always appears in parentheses.

The following example illustrates the style:

A key role of the state is said to be to regulate the conflicts between them in order to realise 'national interest' (Miliband 1977).

OR

Miliband (1977) argues that a key role of the state is to regulate the conflicts between them in order to realise 'national interest'.

In case of citing from a specific page or page range, use one of the following formats (example):

Mattoo and Subramanian expressed India's position at Doha to be 'characteristically but perhaps not unjustifiably defensive', and recommended a proactive stance at future negotiations (Mattoo and Subramanian 2003: 328).

Once again, in a reverse manner, ethnic conflicts broke out in Bhutan in 1990 as a result of exclusivist Drukpa ethno-nationalism, bent on turning Bhutan into a mono-ethnic polity (Baral 1996; Phadnis 1990: 39-40, 79-80, 125-129).

The synopsis should be written using Times New Roman with a font size of 12, line spacing with 1.5, and margins as "normal".

CELL CULTURE, ANIMAL BIOTECHNOLOGY AND STEM CELL BIOLOGY PRACTICAL

Course Code	Category	Course Name	L	T	P	Total Hr	Credits (T+P)
MBT 25201DSP	**Discipline Specific Practical**	**Cell Culture, Animal Biotechnology and Stem Cell Biology**	**0**	**0**	**4**	**120**	**0+4=4**

Objective:

The objective of this course is to provide hands-on training in animal and plant cell culture, molecular cloning, stem cell characterization, and nucleic acid analysis, enabling students to develop practical competencies in cell maintenance, genetic manipulation, and cellular analysis for applications in biomedical research and biotechnology.

Learning Outcomes:

Upon completion of the course, student will be able to:

LO1: Demonstrate the ability to establish and maintain primary and continuous animal cell cultures, including subculturing, cryopreservation, and revival using aseptic techniques.

LO2: Evaluate cell viability, morphology, proliferation, and response to cytotoxic and stress conditions using techniques such as trypan blue exclusion, MTT assay, and flow cytometry.

LO3: Establish and manage plant tissue cultures by preparing MS medium, inducing callus and shoot regeneration, and performing advanced techniques such as anther, embryo, and protoplast culture.

LO4: Apply molecular biology techniques such as restriction digestion, ligation, transformation, and recombinant selection using Blue-White Screening for gene manipulation studies.

LO5: Isolate and characterize stem cells and splenocytes from biological tissues, and assess their adherence, colony-forming ability, confluency, and chromosomal integrity using cytological stains and metaphase analysis.

LO6: Isolate RNA from cultured cells and evaluate its quality and integrity, while understanding the preparation of coated surfaces for optimized cell culture conditions in research and therapeutic applications.

Sr. No.	List of Experiments
1.	To prepare primary cell culture from animal tissue.
2.	To perform the passaging (subculturing) of adherent animal cells using trypsinization.
3.	To quantify animal cells and assess viability using a hemocytometer and trypan blue exclusion method.
4.	To perform cryopreservation and revival of animal cells using DMSO as a cryoprotectant.
5.	To detect contamination in cell cultures.
6.	To characterize the various cell lines and determine their morphological growth pattern, assessment of cell adherence properties and doubling rate.
7.	To investigate the cell response to stress conditions.
8.	To determine cytotoxicity of given sample using MTT assay.
9.	To demonstrate the analysis of cell cycle phases, apoptosis, and necrosis using flow cytometry.
10.	To study the essential infrastructure, equipment, and aseptic practices required for setting up a plant tissue culture laboratory.
11.	To prepare and sterilize Murashige and Skoog (MS) medium with appropriate plant growth regulators.
12.	To induce callus formation from leaf explants using different concentrations of auxins.
13.	To establish shoot regeneration from nodal explants and meristem culture.
14.	To perform anther culture for haploid production.

15.	To perform embryo and endosperm culture.
16.	To perform the isolation and fusion of protoplast from the leaf samples.
17.	To perform the production of synthetic seeds.
18.	To increase secondary metabolite production in plant cell suspension culture using elicitors.
19.	To isolate splenocytes from goat spleens and culture them *in vitro.*
20.	To isolate mesenchymal stem cells from umbilical cord.
21.	To perform restriction digestion of DNA with a restriction endonuclease.
22.	To perform ligation of restriction-digested fragments using the ligase enzyme.
23.	To prepare and transform competent cells.
24.	To perform the selection of recombinants using Blue-White Screening.
25.	To observe the general morphology of stem cells (e.g., MSCs or ESCs) using Giemsa stain.
26.	To evaluate the adherence and confluency of cultured stem cells by crystal violet.
27.	To assess the adherence ability and colony-forming efficiency of stem cells *in vitro*.
28.	To perform hypotonic treatment, fixation, and metaphase spread preparation for analyzing chromosomes in dividing stem cells.
29.	To prepare culture surfaces (e.g., plates, flasks, coverslips) with biological or synthetic coatings that support stem cell adherence, spreading, and survival.
30.	To isolate RNA from cultured cells and assess its purity and integrity using spectrophotometry and gel electrophoresis.

TEXT / REFERENCE BOOKS

1. Freshney RI. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. 7th ed. Hoboken: Wiley-Blackwell; 2016.
2. Sambrook J, Russell DW. Molecular Cloning: A Laboratory Manual. 3rd ed. Cold Spring Harbor: Cold Spring Harbor Laboratory Press; 2001.
3. Freshney, R.I. (2016). Culture of animal cells: A manual of basic technique and specialized applications (7th ed.). Wiley-Blackwell.
4. Davis, J.M. (2002). Basic cell culture: A practical approach (2nd ed.). Oxford University Press.
5. Masters, J.R. (2000). Animal cell culture: A practical approach (3rd ed.). Oxford University Press.
6. Doyle, A., and Griffiths, J.B. (2000). Cell and tissue culture: Laboratory procedures. Wiley.
7. Pattnaik, B.R. (2015). A laboratory guide to cell culture. Springer.
8. Maheshwari SC. Plant Tissue Culture: Theory and Practice. New Delhi: McGraw-Hill Education; 2011.
9. Bhojwani, S.S., and Razdan, M.K. (2005). Plant tissue culture: Theory and practice. (Rev. ed.). Elsevier.
10. George, E. F., Hall, M. A., and De Klerk, G.-J. (2008). Plant propagation by tissue culture: Volume 1. The background (3rd ed.). Springer.
11. Loyola-Vargas, V.M., and Ochoa-Alejo, N. (Eds.). (2012). Plant cell culture protocols (2nd ed.). Humana Press.
12. Smith, R.H. (2013). Plant tissue culture: Techniques and experiments (3rd ed.). Academic Press.
13. Trigiano, R.N., and Gray, D.J. (2011). Plant tissue culture, development, and biotechnology. CRC Press.

ADVANCED MOLECULAR DIAGNOSTIC TECHNIQUES PRACTICAL

Course Code	Category	Course Name	L	T	P	Total Hr	Credits (T+P)
MBT 25202DSP	**Discipline Specific Practical**	**Advanced Molecular Diagnostic Techniques**	**0**	**0**	**2**	**60**	**0+2=2**

Objective:

The objective of this course is to develop practical skills in advanced molecular diagnostic techniques by performing nucleic acid and protein extraction, blotting methods, immunoassays, gene expression analysis, and PCR-based applications for the detection and analysis of biomolecules.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Perform nucleic acid extraction and assess DNA/RNA quality and quantity using gel electrophoresis and spectrophotometry.

LO2: Apply blotting techniques such as Southern, Northern, and Western blotting for the detection and analysis of DNA, RNA, and proteins.

LO3: Execute immunodiffusion assays including Ouchterlony and Rocket Immunodiffusion to analyze antigen-antibody interactions.

LO4: Perform Dot ELISA, Sandwich ELISA, and cytokine-specific ELISA techniques for protein detection and quantification.

LO5: Demonstrate gene expression analysis using methods like dot blotting, gene reporter assays, and mRNA isolation.

LO6: Amplify specific DNA targets using PCR and perform DNA fingerprinting using RFLP for genetic analysis and disease diagnostics.

Sr. No.	List of Experiments
1.	To detect dengue NS1 antigen and differential detection of IgM and IgG antibodies in human serum or plasma.
2.	To detect infection with *P. falciparum* and *Plasmodium* species in whole blood.
3.	To detect chikungunya specific IgM antibodies in human serum/plasma.
4.	To diagnose syphilis using Rapid Plasma Reagin (RPR) test.
5.	To detect Rickettsia specific Proteus OX antigens (Weil Felix Test).
6.	To detect cardiac troponin I in whole blood/serum/plasma.
7.	To detect Rheumatoid factors in a serum sample.
8.	To diagnose enteric fever using Widal agglutination test.
9.	To perform extraction of genomic DNA from biological samples such as blood or saliva.
10.	To separate DNA or RNA fragments based on size using agarose gel electrophoresis.
11.	To quantify and assess the purity of extracted DNA using spectrophotometry.
12.	To perform the Ouchterlony Double Diffusion Assay for detecting disease-specific antigen-antibody interactions.
13.	To perform the Rocket Immunodiffusion Assay for quantifying disease-associated antigens.
14.	To perform Western blotting for protein identification in the diagnosis.
15.	To perform Northern Blotting for mRNA detection of disease-related gene expression.
16.	To perform Southern blotting for DNA hybridization analysis.
17.	To perform DNA Fingerprinting using RFLP for genetic profiling.

18.	To perform the DOT ELISA technique for the rapid detection of pathogen-specific antigens or antibodies.
19.	To perform the isolation of mRNA from mammalian cells for analysis of gene expression.
20.	To perform RNA quantification using spectrophotometry for evaluating sample integrity.
21.	To perform Sandwich ELISA for the detection and quantification of disease biomarkers.
22.	To perform gene expression analysis using a dot blot method to assess differential expression of disease-related genes.
23.	To perform a colorimetric or fluorometric gene reporter assay to evaluate promoter activity or gene regulation.
24.	To perform an ELISA to detect and quantify a specific protein (e.g., IL-6, TNF-α) as an indirect measure of gene expression.
25.	To amplify a target gene using Polymerase Chain Reaction (PCR) for disease-specific diagnostics.

TEXT / REFERENCE BOOKS

1. Sambrook, J., Russell, D.W. (2001). Molecular cloning: A laboratory manual (3rd ed.). Cold Spring Harbor: Cold Spring Harbor Laboratory Press.
2. Ausubel, F.M., Brent, R., Kingston, R.E., Moore, D.D., Seidman, J.G., Smith, J.A., et al. (2003). Current protocols in molecular biology. New York: Wiley-Interscience.
3. Wilson, K., Walker, J. (2018). Principles and techniques of biochemistry and molecular biology (8th ed.). Cambridge: Cambridge University Press.
4. Harlow, E., Lane, D. (1988). Antibodies: A laboratory manual. Cold Spring Harbor: Cold Spring Harbor Laboratory Press.
5. Walker, J.M. (2009). The protein protocols handbook (3rd ed.). Totowa: Humana Press.
6. Roe, B.A., Crabtree, J.S., Khan, A.S. (1996). DNA and RNA isolation: The basics. Hoboken: Wiley-Liss.
7. Reece, R.J. (2004). Analysis of genes and genomes. Chichester: Wiley-Blackwell.

SECOND YEAR: SEMESTER-IV

BIOINFORMATICS: TOOLS AND TECHNIQUES

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25211DSC	**Discipline Specific Core**	**Bioinformatics: Tools and Techniques**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

The objective of this course is to provide a comprehensive understanding of bioinformatics tools, techniques and applications for analyzing biological data, including sequence alignment, structural analysis, gene and protein prediction along with essential programming skills.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Explain the fundamentals of bioinformatics, including biological databases, data formats, and database search engines.

LO2: Demonstrate basic programming skills and understand the use of programming languages and Linux in bioinformatics applications.

LO3: Perform sequence alignment techniques such as pairwise and multiple sequence alignments and interpret homology, similarity, and phylogenetic relationships.

LO4: Identify motifs, domains, and regulatory elements using bioinformatics tools, and apply gene and promoter prediction methods for prokaryotic and eukaryotic genomes.

LO5: Utilize structural bioinformatics tools to analyze protein structures, secondary structure predictions, and protein-ligand interactions relevant to drug discovery.

LO6: Analyze gene expression data, understand pharmacogenomics concepts, and address ethical considerations in bioinformatics research.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Essentials of Bioinformatics**	Introduction, overview and applications of bioinformatics. Biological databases and data formats. Database search engines: Text-based search engines (Entrez, DBGET/Link DB) and sequence file formats. File formats for bio-molecular sequences: GenBank, FASTA, GCG, MSF etc. Conversion between formats. Basics of object-oriented programming: C^{++}/JAVA, JavaScript, R programming, Python/Perl and Linux.	07
Unit II	**Biological Databases**	Definition, goals, scope, types, applications and limitations of databases. Genomic Sequencing. Sequence assembly. Submission of sequences. Sequence accuracy. Sequence databases. Introduction to CORBA architecture. Applications of NCBI and EMBL databases. Protein sequence databank: NBRF, PIR and SWISSPROT. Structural databases: Protein Data Bank (PDB). Metabolic pathway data bank: Pub gene, microbial genomic database (MBGD), cell line database (ATCC), virus data bank (UICTVdb), EST databases and SNP databases. Annotation and Archival. Cloud concept of data warehousing.	10
Unit III	**Sequence Alignment**	Sequence alignment: uses, choice to be made for alignment, definitions of homologues, orthologues and paralogues. Gap penalties and scoring matrices. Pairwise sequence alignment: dot matrix. Sequence homology vs. similarity vs. identity. Dynamic programming alignment: Needleman-Wunsch algorithm, Smith-Waterman algorithm, BLAST and FASTA. Multiple sequence alignment: uses and methods (Iterative Heuristic alignment and progressive alignment (ClustalW and T-Coffee)). Profile methods: Gribskov profile, PSI-BLAST, PHI-BLAST, HMM, Clustering and Phylogeny. Phylogenetics basics: principles of molecular evolution and phylogenetics, terminology and types of phylogenetic trees and challenges in tree reconstruction. Phylogenetic tree construction methods	12

		and programs: distance-based and character-based methods. Tree evaluation programs.	
Unit IV	**Motifs and Domains**	Motif and domain databases. Identification of Motifs and domains in multiple sequence alignment. Motif and domain databases statistical models. Protein family databases. Motif and Domain analysis tools. Motif discovery in unaligned sequences. Sequence logos. Gene and promoter prediction: promoter and regulatory elements in prokaryotes and eukaryotes. Algorithms for promoter and regulatory element prediction. Gene prediction in prokaryotes and eukaryotes. Categories of gene prediction programs. Prediction algorithms.	7
Unit V	**Predictive Methods**	Predicting DNA framework and masking of repetitive DNA. Predicting RNA secondary structure: reading frames, codon usage analysis, transcriptional, translational signals and splice site identification. Gene prediction methods: RNA fold analysis and compositional analysis. Prediction of scalar parameters: composition, molecular weight, charge, iso-electric point, molar extinction co-efficient, hydrophobicity and amphiphilicity detection using Kyte-Dolittle plot. Secondary structure prediction methods: helical wheel, helical net and moment analysis. Protein secondary structure prediction using Chou-Fassman method. Programs (J Pred and Garnier) for protein secondary structure prediction: antigenic sites, active sites, folding classes, specialized and tertiary structures. *In silico* primer designing and developing Restriction Maps. Gene expression analysis: gene expression data analysis, pre-processing and normalization of gene expression data.	13
Unit VI	**Structural Bioinformatics, Molecular Modelling and Drug Designing**	Introduction to structural bioinformatics. Protein structure conformation and visualization tools: RASMOL, PYMOL and Swiss PDB Viewer. Domain databases: CDD, SMART and ProDom. Introduction to protein-ligand interactions and drug discovery. Analysing molecular surfaces, cavities, and intermolecular interactions. Target identification and validation, identifying the lead compound, optimization of lead compound and chemical libraries. Pharma informatics, pharmacogenomics and population genomics. Ethical considerations in bioinformatics research.	11

METHODOLOGY:

The course will be delivered through well-structured lecture sessions.

BOOKS RECOMMENDED:

1. Attwood, T. A., Parry-Smith, D. J. (2001). Introduction of bioinformatics. Pearson Education.
2. Mount, D. W. (2005). Bioinformatics: Sequence and genome analysis (2nd ed.). CBS Publishers.
3. Pevsner, J. (2003). Bioinformatics and functional genomics. John Wiley and Sons.
4. Baxevanis, A. D. (2004). Bioinformatics – A practical guide to the analysis of genes and proteins. Wiley-Interscience.
5. Westhead, D. R. (2003). Instant notes: Bioinformatics. BIOS Scientific Publishers.
6. Xiong, J. (2006). Essential bioinformatics. Cambridge University Press.
7. Buehler, L. K., Rashidi, H. H. (2005). Bioinformatics basics: Applications in biological science and medicine. Taylor and Francis (CRC).
8. Baxevanis, A. D. (2003). Current protocols in bioinformatics. Wiley.
9. Higgs, P. G., Attwood, T. K. (2005). Bioinformatics and molecular evolution. Blackwell Publishing.
10. Mount, D. (2004). Bioinformatics: Sequence and genome analysis. Cold Spring Harbor Laboratory Press.
11. Ahmad, Z., Jain, S. M. (Eds.). (2012). Bioinformatics: Concepts, skills, and applications. Springer.
12. Bateman, S., Rawlings, J. A. (Eds.). (1998). Bioinformatics: A practical approach. Oxford University Press.

ANIMAL BIOTECHNOLOGY AND STEM CELL BIOLOGY

Course Code	Category	Course Name	L	T	P	Total Hr.	Credits (T+P)
MBT 25201DSC	**Discipline Specific Core**	**Animal Biotechnology and Stem Cell Biology**	**4**	**0**	**0**	**60**	**4+0=4**

Objective:

The objective of this course is to provide an in-depth understanding of the principles, techniques, and applications of genetic engineering, animal biotechnology and stem cell research with the goal of advancing biomedical research, therapeutic interventions and industrial applications, while critically evaluating the ethical, legal, and regulatory frameworks.

Learning Outcomes:

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

LO1: Define and describe the scope, historical milestones, and diverse applications of stem cells and genetic engineering techniques in research, medicine, and biotechnology.

LO2: Demonstrate proficiency in the culture, authentication, contamination control, and characterization of stem cells, using techniques such as STR profiling, karyotyping, and functional assays.

LO3: Understand and apply various cloning and expression vectors, alongside molecular tools like restriction endonucleases, DNA ligases, and polymerases, for genetic manipulation and cloning.

LO4: Examine the use of stem cell-based models for disease research, regenerative medicine, and organ transplantation.

LO5: Critically evaluate the ethical, legal, and biosafety considerations in stem cell research, including the use of transgenic animals, gene-editing and their implications for clinical and industrial applications.

LO6: Apply advanced stem cell technologies in biopharming, gene therapy, xenotransplantation, and understanding the challenges involved in translating stem cell therapies into clinical practice.

No.	Topic	Detail of syllabus	Hrs.
Unit I	**Introduction to Animal Biotechnology**	Definition and scope, historical milestones, ethical and legal considerations. Genetic engineering of mammalian cell lines: an overview, types, characteristics, and applications. Culture media types, supplements, and sterilization. Cell line authentication and contamination, STR profiling and karyotyping. Embryo sexing techniques. Animal tissue engineering: basics, biocompatible scaffolds and biomaterials. Cell seeding, proliferation & differentiation.	6
Unit II	**Genetic Manipulation in Animals**	Cloning vectors: plasmids, cosmids, phagemids, lambda bacteriophage, M13, BAC, YAC, and MAC. Expression vectors: design, features, and expression in prokaryotic and eukaryotic hosts. Restriction endonucleases: types (Type I, II, III), recognition sequences, sticky vs blunt ends and applications in cloning. DNA ligases: mechanism and T4 DNA Ligase. DNA Polymerases: *Taq* polymerase and Pfu. Nucleases and Exonucleases: Exonuclease III and Dnase I. Other modifying enzymes: alkaline phosphatase, polynucleotide kinase and reverse transcriptase. Transformation techniques: physical (electroporation, microinjection, and gene gun), chemical (calcium phosphate precipitation, PEG-mediated transformation, and liposome-mediated delivery), and biological methods (bacterial and viral). Genomic and cDNA libraries: construction and screening (colony and plaque hybridization).	8
Unit III	**Animal Transgenesis**	Transgenic animal production: techniques and methods for transgenic mice, rabbits, pigs, and goats. Production of pharmaceuticals, donor organs, Knockout and Knock-in models. Gene targeting in embryonic stem cells. Cre-LoxP, Tet-inducible systems and CRISPR-Cas9 technology. Assisted Reproductive Technologies (ART): *in vitro* fertilization (IVF), embryo transfer, artificial insemination, and	10

		superovulation. Animal cloning techniques: somatic cell nuclear transfer (SCNT), embryo splitting, and therapeutic cloning. Study of gene function and regulation. Types of animal models: homologous, isomorphic, predictive, and exploratory models. Humanized mouse models. Model organisms: mouse, rat, zebrafish, *Drosophila* and *C. elegans*.	
Unit IV	**Applications of Animal Biotechnology**	Production of regulatory proteins, blood products, vaccines, and hormones in transgenic animals. Biopharming: production of recombinant proteins and antibodies. Transgenic animals as bioreactors: transgenic fish, poultry, and insects. Xenotransplantation: genetically modified pigs as organ donors. Applications of transgenic and animal models of diabetes, acute and chronic liver diseases and animal model systems for anticancer therapies. Ethical basis for the use of transgenic animals in research and biosafety issues.	8
Unit V	**Biology of Stem Cells**	Stem cell evolution. Historical perspective with model systems and stemness basics. Immortal DNA strand hypothesis. Asymmetric vs symmetric cell division. Cellular potency, lineage commitment, cellular development, differentiation, dedifferentiation and trans differentiation. Germline stem cells, germ-derived pluripotent cells and stem cell niche. Tissue specific stem cells: epithelial, mesenchymal, neural, hematopoietic, cardiac and cancer. Stem cell markers, identification and detection: surface markers and transcription factors (e.g., Oct4, Nanog and Sox2), flow cytometry and immunocytochemistry.	8
Unit VI	**Stem Cell Potency and Organoids**	Molecular regulation of stem cell fate: signaling pathways (Wnt, Notch, Hedgehog, BMP and FGF), transcriptional regulation and epigenetics. Embryonic Stem Cells (ESCs): derived from blastocysts and inner cell mass cells, primitive endoderm implantation, culture methods, and pluripotency maintenance. Germ layer differentiation: formation of ectoderm, mesoderm, and endoderm, developmental signaling and lineage tracing. Organogenesis and organoid models: *in vitro* modeling of organ development using stem cell-derived organoids.	8
Unit VII	**Isolation, Derivation and Characterization of Pluripotent Stem Cells**	Isolation and maintenance of embryonic stem cells: mouse, primate, human, avian, and *Xenopus*. Serum and feeder-free culture methods for embryonic stem cells. Alternate methods for isolating embryonic stem cell lines. Trophoblast stem cells: isolation, maintenance, and characterization of embryonic stem cells. Derivation of induced pluripotent stem cells: reprogramming methods and their comparison with embryonic stem cells (ESCs). Characterization of pluripotent stem cells: morphological and functional characteristics, surface antigen markers (SSEA-1, SSEA-4, TRA-1-60 and TRA-1-81), transcription factors and functional assays (teratoma formation, embryoid bodies and chimera contribution).	8
Unit VIII	**Clinical Applications of Stem Cells**	Regenerative medicine, tissue engineering and organ transplantation. Stem cells in the treatment of neurological, cardiovascular, diabetes, and genetic disorders. Induced pluripotent stem cells (iPSCs) for disease modeling, personalized medicine, and gene therapy. Stem cell applications in cancer treatment and immunotherapy. Use of organoids and 3D cell culture in drug discovery and organ-on-a-chip models for toxicity testing. Ethical considerations in stem cell research, legal and regulatory frameworks governing clinical stem cell applications. Challenges in translating stem cell therapies to clinical practice.	4

METHODOLOGY

The course will be delivered through well-structured lecture sessions.

BOOKS RECOMMENDED:

1. Brown, TA. (1998). Molecular Biology Labfax II: Gene Cloning and DNA Analysis. II Edi, Academic Press, USA.
2. Glick, B.R., Pasternak, J.J. (2009). Molecular Biotechnology – Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA.
3. Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009).
4. An Introduction to Genetic Analysis. IX Edition. Freeman and Co., N.Y., USA.
5. Snustard, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edi, John Wiley & Sons Inc.
6. Verma, A., and Singh, A. (2013). Animal Biotechnology. Elsevier. ISBN: 978-0124160026.
7. Ranga M.M. Animal Biotechnology. Agrobios India Limited, 2002
8. Freshney, I. (2016). Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (8^{th} ed.). Wiley-Blackwell.
9. Pörtner, R. (Ed.). (2007). Animal Cell Biotechnology: Methods and Protocols. Humana Press.
10. Singh, B., and Gautam, S.K. (2013). Textbook of Animal Biotechnology. The Energy and Resources Institute.
11. Gupta, P.K. (2018). Animal Biotechnology. Rastogi Publications.
12. Singh, B.D. (2006). Biotechnology: Expanding Horizons (3^{rd} ed.). Kalyani Publishers.
13. Srivastava A.K. Animal Biotechnology. (2018). Oxford & IBH Publishing Co Pvt. Ltd.
14. Lanza R, Gaerhart J, Hogan B, Melton R, Thomas D, Thomas J, and Wilmut S. Essentials of Stem Cell Biology. Elsevier Inc.
15. Stillman B, Stewart D and Grodzicker T, Control and Regulation of Stem Cells.
16. Tursen Kursad, Stem Cell Biology and Regenerative Medicine, Humana Press.

GENE THERAPY AND RNA-BASED THERAPEUTICS

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25211DSE-A	**Discipline Specific Elective**	**Gene Therapy and RNA-Based Therapeutics**	**2**	**0**	**0**	**30**	**2+0=2**

Objective:

The objective of this course is to provide students with understanding of gene therapy and RNA-based therapeutics, covering molecular mechanisms, delivery systems, clinical applications, and ethical considerations, enabling them to critically evaluate current advancements and future directions.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Demonstrate understanding of fundamental principles, types, and historical milestones of gene therapy and RNA-based therapeutics.

LO2: Evaluate and contrast viral/non-viral vectors and gene-editing tools based on efficiency, safety, and clinical applicability.

LO3: Describe mechanisms of RNA-based drugs, their design modifications, and strategies to enhance both stability and delivery.

LO4: Examine FDA-approved therapies for genetic/acquired diseases, including trial design and ethical-regulatory challenges.

LO5: Relate RNA structure/modifications to functional roles in gene regulation and disease, using common analytical techniques.

LO6: Identify limitations and debate ethical/safety concerns in gene editing and RNA therapeutics.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Introduction to Gene Therapy**	History and evolution of gene therapy. Types of gene therapy: somatic vs. germline, *in vivo* vs. *ex vivo*, gene augmentation, and gene silencing. Clinical Trials: phases (I-IV), ethical considerations, and regulatory approvals for gene therapy (FDA, EMA and ICMR).	3
Unit II	**Vectors and Delivery Systems for Gene Therapy**	Definition and role of vectors in gene therapy. Characteristics of ideal vectors used in gene therapy. Mechanisms, advantages, and limitations of viral vectors: Adenovirus, Adeno Associated Virus (AAV), lentivirus and retrovirus. Non-viral methods: lipid nanoparticles (LNPs), electroporation, gene gun, and hydrodynamic injection. Clinical applications and examples of vector-based therapies. Strategies to improve delivery efficiency and specificity. Regulatory concerns for vector use.	6
Unit III	**Functional and Structural Analysis of RNA**	RNA structure and function: primary, secondary, and tertiary. Methods to study RNA structure: X-ray crystallography, NMR spectroscopy, Cryo-electron microscopy and Computational modeling of RNA structures. Structure-function relationship of RNA. Functional diversity of RNA molecules. Coding and non-coding RNAs. Long non-coding RNAs (lncRNAs) in gene regulation and disease. RNA localization in cells. RNA metabolism and turnover. RNA stability and decay pathways. RNA modification and epitranscriptomics. Types of RNA modifications: m6A, pseudouridine and 5-methylcytosine. Role of RNA modifications in health and disease.	7
Unit IV	**Gene Editing Tools and RNA-Targeting Systems**	Introduction to gene editing technologies. Overview of targeted genome modification. CRISPR-Cas9, ZFNs, and TALENs: design, mechanisms, and comparative analysis. Off-target effects, delivery hurdles, and ethical concerns.	4

Unit V	**RNA-Based Therapeutics**	Introduction to RNA therapeutics. Evolution of RNA as a therapeutic molecule. Mechanism of RNA-based drugs. Functional diversity of RNA molecules. Therapeutic RNA classes: ASOs (Spinraza), siRNAs (Onpattro), miRNAs and mRNA vaccines (COVID-19). Delivery systems: LNPs, targeted delivery and immune evasion strategies. Stability and efficacy: nucleotide modifications (pseudouridine) and degradation pathways.	7
Unit VI	**Applications of Gene Therapy and RNA-Based Therapeutics**	Gene therapy for monogenic disorders: cystic fibrosis, hemophilia, Duchenne muscular dystrophy, sickle cell anemia, and thalassemia. Gene therapy for cancer, HIV/AIDS, cardiovascular diseases, and neurodegenerative disorders. RNA-based therapy for infectious diseases and cancer. mRNA vaccines for COVID-19, Zika and Ebola.	3

METHODOLOGY

The course will be delivered through well-structured lecture sessions.

BOOKS RECOMMENDED:

1. Karp, G. (2019). Cell and molecular biology: Concepts and experiments (8th ed.). Hoboken: Wiley.
2. Crooke, S. T. (2007). Antisense drug technology: Principles, strategies, and applications (2nd ed.). Boca Raton: CRC Press.
3. Brown, T. A. (2020). Gene cloning and DNA analysis: An introduction (7th ed.). Hoboken: Wiley-Blackwell.
4. Burnett, J.C., Rossi, J.J., Tiemann, K. (2012). RNA-based therapeutics: Current progress and future prospects. Chemistry and Biology, 19(1), 60–71.
5. Lewis, R. (2020). Human genetics: Concepts and applications (12th ed.). New York: McGraw-Hill.

INNOVATION DRIVEN ENTREPRENEURSHIP

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25211DSE-B	**Discipline Specific Elective**	**Innovation Driven Entrepreneurship (SWAYAM)**	**2**	**0**	**0**	**30**	**2+0=2**

Objective:

The objective of this course is to develop the ability to drive innovation and entrepreneurship through creative thinking, idea validation, business model development, use of emerging technologies, and protection of innovations with intellectual property rights.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Define innovation and explain its role in entrepreneurship, including types and global and Indian innovation landscapes.
LO2: Apply creative thinking techniques and identify sources to generate innovative business ideas.
LO3: Use validation tools like SWOT, MVP, and market research to assess feasibility and mitigate risks.
LO4: Apply design thinking principles to identify user needs and develop creative, user-centered solutions.
LO5: Develop and analyze business models using tools like Business Model Canvas and lean start-up methodology.
LO6: Identify the role of technology, funding sources, and IPR in supporting and scaling innovative ventures.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Introduction to Innovation in Entrepreneurship**	Definition and importance of innovation in entrepreneurship. Types of innovation: product, process, and business model. Disruptive vs. incremental innovation. Role of innovation in start-up and business success. Global and Indian innovation landscape. Innovation ecosystems and entrepreneurial hubs. Introduction to innovation frameworks. Innovation vs. invention. Barriers to innovation. Role of government and policy in promoting innovation.	4
Unit II	**Idea Generation and Validation**	Creative thinking techniques: brainstorming, SCAMPER, mind mapping, and Blue Ocean Strategy. Sources of new ideas: customers, competitors, research, trends, and markets. Tools and methods for idea validation: market research, surveys, and SWOT analysis. Proof of concept and prototype development. Minimum Viable Product (MVP). Customer discovery and feedback loop. Feasibility analysis: technical, financial, and market. Risk analysis and mitigation.	4
Unit III	**Design Thinking in Entrepreneurship**	Introduction to design thinking. Principles of human-centered design. Empathy and problem identification. Defining user needs and framing problems. Ideation and creative solution generation. Prototyping and iterative design. User testing and feedback. Design thinking process in start-up development. Case studies of design thinking in real-world ventures. Integrating design thinking with innovation strategies.	5
Unit IV	**Business Model Innovation**	Understanding business models: traditional vs. innovative models. Business Model Canvas: components and applications. Value proposition design. Revenue models and cost structures. Identifying customer segments and channels. Key resources and partnerships. Case studies of disruptive business models. Lean start-up methodology. Pivoting in business models. Digital business models and platform-based innovation.	4

Unit V	**Emerging Technologies and Innovation Strategy**	Role of technology in driving innovation. Emerging technologies: AI, IoT, blockchain, biotech, etc. Technology readiness levels and adoption. Innovation in product lifecycle. Sourcing and managing technology in start-ups.	3
Unit VI	**Funding Innovation**	Innovation funding lifecycle: bootstrapping, angel investors, venture capital, and crowdfunding. Government grants and innovation funds. Preparing for investor pitch: pitch deck essentials. Valuation basics and investment negotiation.	3
Unit VII	**Entrepreneurial Mindset, Leadership and IP**	Developing an entrepreneurial mindset: risk-taking, resilience, and adaptability. Leadership skills for innovation-driven entrepreneurs. Team building and strategic decision-making. Introduction to Intellectual Property Rights: patents, copyrights, trademarks, and trade secrets. Importance of IPR in protecting innovation.	4
Unit VIII	**Scaling and Growth Strategies, Sustainability**	Scaling and growth strategies: operational, market, and product scaling. Sustainable entrepreneurship practices. Social innovation and inclusive growth. Case studies of scalable social enterprises and sustainable innovations.	3

METHODOLOGY

The course is offered via the SWAYAM platform or through lecture sessions. The course title and syllabus may remain the same or be subject to minor modifications, depending on the availability of equivalent courses on the SWAYAM platform during the respective semester.

Link to SWAYAM:

https://onlinecourses.swayam2.ac.in/ntr25_ed85/preview

BOOKS RECOMMENDED:

1. Drucker, P.F. (1985). Innovation and Entrepreneurship. Harper & Row.
2. Ries, E. (2011). The Lean Startup: How Today Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Crown Business.
3. Osterwalder, A., and Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. Wiley.
4. Christensen, C.M. (1997). The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. Harvard Business Review Press.
5. Kim, W.C., and Mauborgne, R. (2005). Blue Ocean Strategy: How to Create Uncontested Market Space and Make the Competition Irrelevant. Harvard Business Review Press.
6. Kelley, T. (2001). The Art of Innovation: Lessons in Creativity from IDEO, America & Leading Design Firm. Currency.
7. Mootee, I. (2013). Design Thinking for Strategic Innovation: What They Can & Teach You at Business or Design School. Wiley.
8. Aulet, B. (2013). Disciplined Entrepreneurship: 24 Steps to a Successful Startup. Wiley.
9. Osterwalder, A., Pigneur, Y., Bernarda, G., and Smith, A. (2014). Value Proposition Design: How to Create Products and Services Customers Want. Wiley.
10. Moore, G.A. (1991). Crossing the Chasm: Marketing and Selling High-Tech Products to Mainstream Customers. Harper Business.

3D BIOPRINTING

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25211DSE-C	**Discipline Specific Elective**	**3D Bioprinting**	**2**	**0**	**0**	**30**	**2+0=2**

Objective:
The objective of this course is to introduce students to the principles, techniques, and applications of 3D bioprinting for fabricating functional tissues and organs using biomaterials, living cells, and advanced biofabrication technologies.

Learning Outcomes:
Upon completion of the course, students will be able to:

LO1: Explain the principles of bioprinting and compare different bioprinting techniques, analyzing their advantages and disadvantages, as well as their suitability for specific tissue engineering applications.

LO2: Demonstrate an understanding of 3D tissue/organ design and the bioprinting process by identifying and evaluating key process parameters that influence print fidelity and biological function.

LO3: Identify various biomaterials used in bioink development and understand how bioink properties can be modulated to match specific bioprinting requirements and biological outcomes.

LO4: Apply *in vitro*, *in vivo*, and *ex vivo* bioprinting concepts to develop tissue models for regenerative medicine and drug testing, and explore *in situ* and 4D bioprinting through recent research examples.

LO5: Examine the current challenges in bioprinting, discuss future directions, and critically evaluate the ethical, legal, and social implications of bioprinting technologies in clinical and commercial contexts.

Sr. No.	Topic	Detail Syllabus	Hrs.
Unit I	**Fundamentals of Bioprinting**	Introduction to bioprinting. Types of bioprinting techniques, their advantages and disadvantages.	2
Unit II	**3D Tissue and Organ Printing**	3D tissue designing. 3D tissue/organ printing. Process parameters and their role in bioprinting.	4
Unit III	**Bioinks and Biomaterials**	Introduction to bioinks. Biomaterials used for bioink development with their merits and demerits. Critical parameters of bioink formulations for bioprinting. Modulation of bioink properties to control different processing conditions.	8
Unit IV	**Bioprinted Models and Applications**	3D bioprinted *in vitro*, *in vivo*, and *ex vivo* models and techniques. *In vitro* manipulation of cells and biomaterials by bioprinter to engineer tissues for regenerative medicine or tissue/organ models.	8
Unit V	**Advanced Bioprinting Strategies**	*In situ* bioprinting. 4D bioprinting with examples from recent literature. Biofabrication-based strategies from bench to bed to address specific clinical problems.	5
Unit VI	**Challenges and Future Directions**	Next step in bioprinting: challenges and future directions. Ethical issues related to bioprinting.	3

METHODOLOGY

The course is offered via the SWAYAM platform or through lecture sessions. The course title and syllabus may remain the same or be subject to minor modifications, depending on the availability of equivalent courses on the SWAYAM platform during the respective semester.

Link to SWAYAM:
https://onlinecourses.nptel.ac.in/noc25_bt68/preview

BOOKS RECOMMENDED:

1. Atala, A., Yoo, J. J., Rizk, E., Atala, A. (Eds.). (2015). Essentials of 3D biofabrication and translation (1st ed.). San Diego: Academic Press.
2. Zhang, L. G., Fisher, J. P., Leong, K. W. (Eds.). (2016). 3D bioprinting and nanotechnology in tissue engineering and regenerative medicine (1st ed.). Amsterdam: Elsevier.
3. Forgacs, G., Sun, W. (Eds.). (2013). Biofabrication: Micro- and nano-fabrication, printing, patterning and assemblies (1st ed.). Amsterdam: Elsevier.
4. Derby, B. (2012). Printing and prototyping of tissues and scaffolds. Science, 338, 921–926.
5. Murphy, S.V., Atala, A. (2014). 3D bioprinting of tissues and organs. Nature Biotechnology, 32, 773–85.

CLINICAL RESEARCH

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25212DSE-A	**Discipline Specific Elective**	**Clinical Research**	**2**	**0**	**0**	**30**	**2+0=2**

Objective:

The objective of this course is to provide an understanding of the drug discovery and development process, preclinical and clinical research methodologies, ethical and regulatory frameworks, and clinical data management, enabling learners to design, conduct, and oversee clinical trials responsibly and effectively.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Explain the drug discovery process, including target identification, validation, and key development stages.

LO2: Describe preclinical screening methods, pharmacokinetics, pharmacodynamics, and various toxicology assessments.

LO3: Understand clinical trial phases, design principles, regulatory requirements, and ethical considerations.

LO4: Develop skills in clinical trial protocol preparation, participant recruitment, trial conduct, and quality assurance.

LO5: Apply ethical guidelines, regulatory frameworks, and understand the role of ethics committees in clinical research.

LO6: Demonstrate knowledge of national and international regulatory authorities and clinical data management systems and processes.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Introduction to Drug Discovery and Development**	Definition and scope of drug discovery, historical perspective and milestones. Stages of drug discovery and development: drug targets and pathways, combinatorial chemistry, and target-centered drug design. Lipinski's Rule of Five: identification and validation of drug targets. Role of biomarkers in drug development. Strategies for target-based drug discovery.	2
Unit II	**Screening, Preclinical Development and Toxicology**	High Throughput Screening (HTS): principles, methodologies, screening libraries, and assay development. Hit-to-lead optimization process. Pharmacokinetics and pharmacodynamics in preclinical development: *in vitro*, *in vivo*, and cell-based models. Safety assessment in preclinical testing: acute, sub-acute and chronic toxicity. Organ-specific toxicity, mutagenicity, teratogenicity, carcinogenicity, and reproductive toxicity. Problems in extrapolating data from animals to humans.	4
Unit III	**Clinical Research and Trial Design**	Clinical research: definition, objectives, and scope of clinical research. Clinical research vs clinical trials. Roles and responsibilities of key players in clinical trials. Phases of clinical trials. Phase I: design, safety, dose escalation, and ethical considerations. Phase II: sample size, efficacy testing, and regulatory pathways. Phase III: randomized controlled trial and adaptive designs. Study designs: overview of observational, experimental, cohort, case-control and cross-sectional studies. Randomized and non-randomized trials. Meta-analyses, and systematic reviews. Trial methodology: inclusion and exclusion criteria, randomization, blinding, screening, recruitment, placebo response, and role of biomarkers.	8
Unit IV	**Protocol Development**	Components and structure of protocol development: feasibility assessment, study planning, and site selection. Recruitment strategies, informed consent process, and participant enrolment.	5

	and Clinical Trial Conduct	Special populations in clinical trials. Data collection, monitoring, and quality assurance. Multicentre clinical trials: regulatory and logistical requirements. Types of bias in clinical research.	
Unit V	**Ethics and Regulatory Framework in Clinical Research**	Definition and importance of ethics in clinical research: Tuskegee experiment, Nuremberg Code, Declaration of Helsinki, Belmont Report, and Thalidomide tragedy. Drugs and Cosmetics Act 1945 and Schedule Y, ICH, ICH-GCP, and WHO guidelines. Ethical considerations in placebo use. CIOMS, NIH, and ICMR guidelines. Negligence and liability in clinical research. Role and functions of IRB/IEC/ERB. Challenges in obtaining informed consent from vulnerable populations. Fraud and ethical violations in clinical research.	6
Unit VI	**Regulatory Authorities and Clinical Data Management**	National regulatory bodies: CDSCO and ICMR. International regulatory bodies: USFDA, EMEA, MHRA, and TGA. Regulatory toxicology and OECD guidelines. GxP regulations: GMP, GLP, GDP and GCP. GAMP® 5 principles. Types of audits and inspections: FDA, MHRA, PMDA, TGA, and DCGI. Indian GMP, Schedule M, and WHO-CoPP. Regulatory requirements for traditional medicine: AYUSH, USFDA, Health Canada, EMEA, TCM and TGA. Clinical Data Management (CDM): objectives and tools, CDM process, data management plan (DMP), case report form (CRF), investigator's brochure, clinical study report, electronic data capture (EDC), user acceptance testing (UAT), design and verification of CRF/IXRS. Paper CRF vs electronic CRF: data entry, tracking and processing, data validation, discrepancy management, data storage, and archival.	5

METHODOLOGY

The course will be delivered through well-structured lecture sessions.

BOOKS RECOMMENDED:

1. Edwards, L.D., Fletcher, A.J., Fos, A.W., and Sloaier, P.D. (Eds.). (n.d.). Principles and practice of pharmaceutical medicine (2nd ed.). Wiley.
2. Lloyd, J., and Raven, A. (Eds.). (n.d.). Handbook of clinical research. Churchill Livingstone.
3. Di Ignazio, G., Di Giovanna, K., and Haynes, B. (Eds.). (n.d.). Principles of clinical research.
4. Central Drugs Standard Control Organization. (n.d.). Good clinical practices: Guidelines for clinical trials on pharmaceutical products in India. Ministry of Health, Government of India.
5. International Conference on Harmonisation. (1996). ICH harmonised tripartite guideline: Guideline for good clinical practice E6. https://database.ich.org/sites/default/files/E6_R1_Guideline.pdf
6. Indian Council of Medical Research. (n.d.). Ethical guidelines for biomedical research on human subjects. ICMR.
7. Machin, D., Day, S., and Green, S. (Eds.). (n.d.). Textbook of clinical trials. John Wiley and Sons.
8. Rondels, R.K., Varley, S.A., and Webbs, C. F. (Eds.). (2000). Clinical data management (2nd ed.). Wiley.
9. Hardman, J.G., and Limbard, L.E. (Eds.). (n.d.). Goodman and Gilman's the pharmacological basis of therapeutics. McGraw-Hill.
10. Various authors. (n.d.). Relevant review articles from recent medical and pharmaceutical literature.
11. Tripathi, P. C., and Reddy, P. N. (n.d.). Principles of management. Tata McGraw-Hill.
12. Desai, V. (n.d.). Dynamics of entrepreneurial development and management. Himalaya Publishing House.

OMICS TECHNOLOGIES

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25212DSE-B	**Discipline Specific Elective**	**Omics Technologies**	**2**	**0**	**0**	**30**	**2+0=2**

Objective:

The objective of this course is to equip students with a comprehensive understanding of omics technologies, including genomics, transcriptomics, proteomics, and metabolomics, and their applications in analyzing biological data, advancing personalized medicine, and exploring disease mechanisms through high-throughput techniques.

Learning Outcomes:

Upon completion of the course, students will be able to:

LO1: Understand the concepts, history, and scope of omes and omics, including principles of genomics, transcriptomics, proteomics, and metabolomics.
LO2: Explain genome structure, sequencing techniques, genome assembly, annotation, and major genome projects.
LO3: Apply transcriptomics techniques such as microarrays and RNA-Seq to analyze gene expression, alternative splicing, and non-coding RNAs.
LO4: Demonstrate knowledge of proteomics techniques for protein separation, identification, and quantification using electrophoresis, chromatography, and mass spectrometry**.**
LO5: Describe methods for metabolite extraction, separation, identification, and analyze metabolic pathways using databases and profiling approaches.
LO6: Evaluate the applications of omics in personalized medicine, diagnostics, biomarker discovery, disease profiling, and environmental studies.

Sr. No.	Topic	Detail of Syllabus	Hrs.
Unit I	**Introduction to Omics Technologies**	Introduction, history and concept of omes and omics. Overview and principles of genomics, transcriptomics, proteomics and metabolomics. High-throughput screening techniques in omics.	3
Unit II	**Genomics**	Genome structure and organization: chromosome structure and packaging, genome size and complexity and repetitive DNA elements (transposons and satellite DNA). Major genome sequencing projects. Genome sequencing techniques: Sanger sequencing, Next-generation sequencing (NGS) (e.g., Illumina sequencing, and Ion Torrent sequencing) and Third-generation sequencing (TGS) (e.g., PacBio sequencing and Oxford Nanopore sequencing). Genome assembly and annotation. Overview of functional genomics, medical genomics and evolutionary genomics.	6
Unit III	**Transcriptomics**	Gene expression profiling: microarray technology and RNA-Seq (RNA sequencing). Detection and analysis of alternative splicing events. Transcript quantification: differential gene expression analysis, microRNAs (miRNAs) and long non-coding RNAs (lncRNAs). Functional annotation: gene ontology analysis and single-cell transcriptomics.	6
Unit IV	**Proteomics**	Protein separation and characterization techniques: gel electrophoresis (SDS-PAGE and 2D-PAGE), liquid chromatography, mass spectrometry (MALDI and ESI), mass analyzers (TOF and Orbitrap) and fragmentation techniques (CID and HCD). Protein identification: database searching and *de novo* sequencing. Quantitative proteomics: label-based methods (SILAC and iTRAQ) and label-free methods.	5
Unit V	**Metabolomics**	Metabolite extraction, separation and identification techniques. Metabolite identification: database searching and structural elucidation.	5

		Metabolic pathway analysis: pathway databases (KEGG and MetaCyc) and flux balance analysis. Metabolomics profiling: targeted and untargeted metabolomics. Metabolomics data analysis.	
Unit VI	**Applications of Omics Technologies**	Genomics: genome-wide association studies (GWAS), personalized medicine, pharmacogenomics, genetic screening and diagnostics. Proteomics: biomarker discovery and validation, drug target identification and validation and disease mechanism elucidation. Transcriptomics: gene expression profiling in health and disease, single-cell transcriptomics and RNA-based therapeutics. Metabolomics: metabolic profiling in disease diagnosis and nutrigenomics. Metabolomics in environmental and microbial studies.	5

METHODOLOGY

The course will be delivered through well-structured lecture sessions.

BOOKS RECOMMENDED:

1. Isaacson, R. D., and Wu, T. (n.d.). Introduction to proteomics: Principles and applications (Indian edition). CRC Press.
2. Snyder, M. (n.d.). Genomics and personalized medicine: What everyone needs to know (Indian edition). Oxford University Press.
3. Kole, C., and Abbott, A. G. (n.d.). Transcriptomics and gene regulation (Indian edition). CRC Press.
4. Roessner, U. (n.d.). Metabolomics: From fundamentals to clinical applications (Indian edition). Springer.
5. Gupta, R.K., Kaur, A. (n.d). Omics technologies: Tools for food science (Indian edition). Academic Press.
6. Alberts, B., Johnson, A., and Lewis, J. (2022). Molecular biology of the cell (7th ed.). Garland Science.
7. Pevsner, J. (2021). Bioinformatics and functional genomics (4th ed.). Wiley-Blackwell.
8. Liebler, D. C. (2020). Introduction to proteomics (3rd ed.). Humana Press.
9. Lindon, J.C., Nicholson, J.K. (2019). Metabolomics and metabolic profiling (2nd ed.). Academic Press.
10. Karczewski, K. J., and Snyder, M. P. (2023). Integrative omics for health and disease (1st ed.). MIT Press.

PHARMACOGNOSY AND METABOLIC ENGINEERING

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25212DSE-C	**Discipline Specific Elective**	**Pharmacognosy and Metabolic Engineering**	**2**	**0**	**0**	**30**	**2+0=2**

Objective:
The objective of this course is to provide an in-depth understanding of plant specialized metabolism and its biotechnological applications, focusing on the biosynthesis, genetic manipulation, and metabolic engineering of key secondary metabolites with an emphasis on pathway discovery, enhancement strategies, and production of high-value bioactive compounds.

Learning Outcomes:
Upon completion of the course, students will be able to:

LO1: Understand the origin, evolution, and significance of specialized metabolism in medicinal and aromatic plants, and explore strategies to elicit metabolite production in plant cell and organ cultures.

LO2: Explain the principles and techniques of metabolic engineering and genetic transformation for manipulating plant secondary metabolite pathways.

LO3: Analyze the biosynthesis and engineering of tropane, morphine, purine, and indole alkaloids pathways, and explore methods for producing non-natural alkaloids in plants.

LO4: Evaluate genetic and biochemical strategies used to manipulate terpenoid and carotenoid pathways, including floral volatile emission and production of complex terpenes like hyperforin and taxol.

LO5: Examine phenylpropanoid and benzenoid metabolism, with emphasis on lignin modification, anthocyanin pathway manipulation, and polyphenol biosynthesis in plants such as tea.

LO6: Apply metabolic engineering approaches for the biosynthesis of high-value compounds such as vanillin, shikonin, phenolic esters, and recombinant pharmaceuticals like human somatotropin in transplastomic plants.

Sr. No.	Topic	Detail Syllabus	Hrs.
Unit I	**Fundamentals of Plant Specialized Metabolism**	Medicinal and aromatic plants. Origin and evolution of plant specialized metabolism. Eliciting specialized metabolism in plant cell and organ culture. Different strategies of metabolic engineering. Genetic transformation for manipulation of plant specialized metabolism.	4
Unit II	**Alkaloid Pathways and Their Engineering**	Introduction to alkaloids. Engineering tropane alkaloid pathways in plants. Engineering morphine and purine alkaloid pathways. Biosynthesis and genetic manipulation of indole alkaloid pathways. Metabolic reprogramming for non-natural indole alkaloids in plants.	6
Unit III	**Advanced Alkaloid Pathway Discoveries**	Discovery of new alkaloid pathways in plants (strychnine and colchicine). Terpenoid metabolism and pathway manipulation. Genetic manipulation of carotenoid pathway. Emission biology of terpenoid floral volatiles.	6
Unit IV	**Terpenoids and Complex Metabolites**	Biotechnological intervention for production of complex terpenes viz., hyperforin and taxol. Biochemistry of phenylpropanoid/ benzenoid metabolism. Pathway manipulation for reduction of lignin content and composition.	6
Unit V	**Anthocyanins and Polyphenols**	Biochemistry and cell biology of anthocyanin formation in flowers. Manipulation of anthocyanin pathways and creation of blue rose. Biochemistry of tea polyphenols. Biosynthesis of phenolic alcohols and esters. Pathway manipulation for production of phenolic esters.	5
Unit VI	**Engineering for High-Value Products and Molecular Pharming**	Metabolic engineering for vanillin biosynthesis. Genetic engineering of shikonin pathway. Molecular pharming for human somatotropin production in transplastomic plants.	3

METHODOLOGY

The course is offered via the SWAYAM platform or through lecture sessions. The course title and syllabus may remain the same or be subject to minor modifications, depending on the availability of equivalent courses on the SWAYAM platform during the respective semester.

Link to SWAYAM:

https://onlinecourses.nptel.ac.in/noc24_bt08/preview

BOOKS RECOMMENDED:

1. Evans, W.C., and Trease, G.E. (2009). Trease and Evans' Pharmacognosy (16th ed.). Saunders Elsevier.
2. Buchanan, B.B., Gruissem, W., and Jones, R.L. (2015). Biochemistry and molecular biology of plants (2nd ed.). Wiley Blackwell.
3. Walton, N.J., and Brown, D.E. (Eds.). (1999). Chemicals from plants: Perspectives on plant secondary products (1st ed.). Imperial College Press.
4. Lea, P.J., and Leegood, R.C. (Eds.). (1999). Plant biochemistry and molecular biology (2nd ed.). Wiley-Blackwell.
5. Bowsher, C and Tobin, A. (2nd Eds.) (2021). Plant Biochemistry. CRC Press.

BIOINFORMATICS: TOOLS AND TECHNIQUES PRACTICAL

Course Code	Category	Course Name	L	T	P	Total Hr	Credits (T+P)
MBT 25211DSP	**Discipline Specific Practical**	**Bioinformatics: Tools and Techniques**	**0**	**0**	**4**	**120**	**0+4=4**

Objectives:

This course aims to develop skills in querying, extracting, visualizing, analyzing, and interpreting biological data from complex biological datasets using high-throughput technologies, as well as applying bioinformatics tools for protein structure prediction and computer-based drug design.

Learning Outcomes:

On completion of the course, students will be able to:

LO1: Understand commonly used biological databases and how to retrieve relevant information from them.

LO2: Learn methods for text- and sequence-based searches, and how to retrieve, store, and secure molecular data.

LO3: Describe pairwise and multiple sequence alignment techniques and perform alignments using dynamic programming to compare biological macromolecules.

LO4: Build phylogenetic trees to analyze evolutionary relationships and population lineages.

LO5: Gain proficiency in using structural bioinformatics tools to predict, modify, and visualize secondary and tertiary structures of biomolecules.

LO6: Understand and apply molecular modeling techniques for developing structural models in drug design.

Sr.No.	List of Experiments
1	To use of different biological databases and bioinformatics search engines (e.g., NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt).
2	To retrieve DNA and protein sequences from various online databases.
3	To analyze biomacromolecule sequence length, GC content and amino acid composition.
4	To perform sequence similarity searches using BLAST.
5	To perform multiple sequence alignment of DNA and protein sequences using ClustalW/MUSCLE.
6	To analyze gene structure using ORFfinder and GenScan.
7	To identify conserved regions or motifs within the alignment.
8	To analyze molecular interactions, intra and inter molecular interactions, salt bridges and crystal contacts in secondary and tertiary structure of protein.
9	To predict genes within a DNA sequence using GeneMark/Glimmer/ GRAIL/Genscan.
10	To evaluate and visualize 3D structure of biomolecules.
11	To construct, interpret and visualize phylogenetic trees using neighbor-joining/maximum likelihood to understand evolutionary patterns.
12	To understand Kyto Encyclopedia of Genes and Genome (KEGG) database for biological pathways, metabolism, cellular process and genetic information processing.
13	To visualize gene expression patterns by heatmap.
14	To perform RNA structure prediction by SQUARNA.
15	To perform various primer designing and restriction site prediction.
16	To perform protein structure prediction using PDB, SCOP and CATH.
17	To construct, visualize and study the protein structures using Deepview/PyMol.
18	To perform homology modelling of proteins.
19	To use mutation tools and analyze the energy minimization of protein structures.
20	To perform miRNA prediction, designing and target prediction using various tools.

TEXT / REFERENCE BOOKS

1. Baxevanis, A.D., Ouellette, B.F.F. (2009). Bioinformatics: A practical guide to the analysis of genes and proteins. Wiley-Blackwell.
2. Harisha, S. (2013). Fundamentals of bioinformatics. I. K. International Pvt. Ltd.

RESEARCH PROJECT

Course Code	Category	Course Name	L	T	P	Total Hrs.	Credits (T+P)
MBT 25211RP	**Research Project**	**Project/Dissertation**	**0**	**0**	**6**	**180**	**0+6=6**

Objective:

The objective of this course is to engage students in systematic investigation and analysis of a specific topic or problem, enabling them to develop critical thinking, research methodologies, and data interpretation skills while contributing original insights and solutions to their field of study.

Learning Outcomes:

Upon completion of the course, students will be able to:

- **LO1:** Design and conduct scientific experiments, analyze data, interpret results, and formulate evidence-based recommendations, thereby developing essential research and practical skills relevant to medical biotechnology.
- **LO2:** Critically evaluate scientific literature, data, and arguments to draw logical and well-supported conclusions.
- **LO3:** Address complex biomedical research questions using innovative methodologies and evidence-based problem-solving approaches.
- **LO4:** Analyze and interpret experimental data to identify patterns, trends, and correlations relevant to the research hypothesis or objectives.
- **LO5:** Demonstrate proficiency in writing clear, coherent, and well-structured research reports or scientific papers that adhere to academic and professional standards.
- **LO6:** Effectively review and synthesize existing scientific literature to contextualize and support the objectives, methodology, and findings of the research project.
- **LO7:** Understand and apply ethical principles in research, including research integrity, data confidentiality, responsible conduct, and proper citation and referencing practices.

RESEARCH PROJECT (INTERNAL/EXTERNAL)

In the 4th semester, a student must undertake a research project in the area of their major subject. The entire process shall be carried out under the supervision of an approved PG teacher of the concerned subject, and must be approved by the Institutional Research and Review Board (IRRB) through the proper channel.

The title and synopsis must be presented before the Institutional Research and Review Board (IRRB) of CBT and finalized based on the comments provided. If necessary, depending on the proposed study, it may also require further approval from the Institutional Ethics Committee (IEC) and/or the Committee for the Control and Supervision of Experiments on Animals (CCSEA) of CBT/PIMS (DU). Thereafter, students shall finalize their synopsis as per the prescribed guidelines. Timeline for research work to be carried out shall be as follows:

No.	Work to be carried out	Timeline
1.	Finalization of title of the research work and Synopsis presentation	In the last week of the 3rd semester/first week of the 4th semester
2.	Research Work	Next 2 -3 months
3.	Compilation of Dissertation and Corrections	Fourth month of the semester
4.	Presentation (CIA)	Fourth month of the semester
5.	Final Presentation and Viva voce	Semester-End Exam (date shall be notified separately by the University)

Synopsis Format for the Research Project/Dissertation

1. Title:
2. Background/Introduction
3. Review of the Literature
4. Statement of the Problem
5. Significance of the Study
6. Objectives of the Study
7. Scientific Hypothesis/ Research Questions
8. Expected Outputs of the Research Projects
9. Relevance of the Project in Relation to Local and Regional Environmental and Socio-Economic Conditions
10. Methodology or Materials and Methods
11. Ethical Considerations (If any)
12. Dissemination of the Results
13. Time Schedule for Research Project or Work Plan
14. Detailed Plan of Activities (Gantt chart)
15. References: APA style

References

Ensure that every reference cited in the text is also present in the reference list (and vice versa). Citation of a reference as "in press" implies that the item has been accepted for publication. Format for Citing the references in text:

1. Single author: Author's name (without initials, unless there is ambiguity) and the year of publication.
2. Two authors: Both authors' names without initials and the year of publication;
3. Three or more authors: First author's name without initial followed by "et al.," and the year of publication.

Format for References in Reference Section All references should be mentioned in Alphabetical order.

Journal Articles:

Yogesh, H.S., Chandrashekhar, V.M., Katti, H.R., Ganapaty, S., Raghavendra, H.L., Muchchandi, I.S., Goplakhrishna, B. (2011). Anti-osteoporotic activity of aqueous-methanol extract of Berberis aristata in ovariectomized rats. Journal of Ethnopharmacology 134: 334-338.

Organization as Author:

Diabetes Prevention Program Research Group (2015). Hypertension, insulin, and proinsulin in participants with impaired glucose tolerance. Hypertension 679-86.

Paper or Chapter in a Book:

Osawa, T. (1994). Novel natural antioxidants for utilization in food and biological systems. In: Uritani, I., Garcia, V.V. and Mendoza, E.M. (Eds.), Postharvest biochemistry of plant food materials in the tropics. Tokyo, Japan: Japan Scientific Societies Press. pp. 241-251.

Book by Authors:

Atta-ur-Rahman., Choudhary, M.I., Thomsen, W.J. (2001). Bioassay Techniques for Drug Development. Harwood Academic Publishers, The Netherlands. pp. 142.143.

Thesis / Dissertation:

Srichuanchuenskul, W. (1994). Modern Chromatography of Metal Chelates, PhD Thesis, Chiang Mai University, Thailand.

Patents:

Haga, T. (1976). Japan Patent No: 50-54628. iii Web Pages Include author, date, title, availability information, and accession date, if needed. URL of the site should be mentioned.

In-text

Among many recognized styles, we recommend the author-year style of in-text referencing, where you indicate in the text itself not only the name of the source author but also the year in which the source was published. The author's name may appear in the sentence itself or in parentheses; the year of publication always appears in parentheses.

The following example illustrates the style:

A key role of the state is said to be to regulate the conflicts between them in order to realise 'national interest' (Miliband 1977).

OR

Miliband (1977) argues that a key role of the state is to regulate the conflicts between them in order to realise 'national interest'.

In case of citing from a specific page or page range, use one of the following formats (example):

Mattoo and Subramanian expressed India's position at Doha to be 'characteristically but perhaps not unjustifiably defensive', and recommended a proactive stance at future negotiations (Mattoo and Subramanian 2003: 328).

Once again, in a reverse manner, ethnic conflicts broke out in Bhutan in 1990 as a result of exclusivist Drukpa ethno-nationalism, bent on turning Bhutan into a mono-ethnic polity (Baral 1996; Phadnis 1990: 39-40, 79-80, 125-129).

The synopsis should be written using Times New Roman with a font size of 12, line spacing with 1.5, and margins as "normal".

Registrar
Pravara Institute of Medical Sciences
(Deemed to be University)
Loni-413736, Tal Rahata, Dist.Ahmednagar
(M.S.India)