VIDYASAGAR UNIVERSITY

Syllabus for M.Sc. Program (NEP 2020)

In

BIOTECHNOLOGY

Program Code: OISTPBT
Level 6.0

New Education Policy 2020
(Effective from 2025- 2026 session)

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The Preamble:

Biotechnology is a rapidly growing field of science where biological systems are used in diverse applications in the areas of fermentation, environment, diagnosis, treatment, agriculture, food industry etc. It is the most recent branches of biological sciences thriving on the latest technological advancements in engineering technology, recombinant DNA technology, computer sciences and many more. Biotechnology is an interdisciplinary field that brings together knowledge from diverse fields such as physics, statistics, mathematics, chemistry, microbiology, biological sciences, information technology, as well the most current technological advancements such as Artificial Intelligence and Machine Learning.

Biotechnology encompasses the study of all living beings including bacteria, archaebacteria, fungi, algae, protozoa, helminths, plants, animals and viruses. It includes the basic understanding of each type of cell - prokaryotic, eukaryotic, viral particles along with their intracellular architecture, their anatomical features, their physiological and biochemical process and their molecular mechanisms of inheritance right from chromosomes, genes to the nucleic acids. Biotechnology as a field of science is the most application-oriented field where the knowledge gained in this course has direct and immediate application in the real world, be it pharmaceutical industry, food industry, diagnostics, personalized medicine, genetically modified crops and animals, bioprinting of organs, bioinformatics or clinical research.

Why Biotechnology in OIST: Oriental Institute was established in the year 2006 under the affiliation of Vidyasagar University and recognized by Department of Higher Education Govt. of India. OIST has started PhD programs in the year 2010 in Biotechnology and Biochemistry under the affiliation of Vidyasagar University, more than 30 students have awarded their PhD in the Department of Biotechnology and Biochemistry.

The educational approach at OIST focuses on nurturing students' intellectual and personal strengths in a holistic manner. The OIST experience goes beyond the confines of the classroom, fostering creativity and innovation through engaging project work and interactive learning. Recognizing the uniqueness of each individual and their diverse approaches to life, we empower students to select their own pathways according to their interests. OIST has established partnerships with leading companies to offer students valuable industry exposure and immersion. The pedagogical approach at OIST is distinctive, emphasizing experiential learning and guidance from industry practitioners. This approach ensures that our students have hands-on experiences throughout their education. At OIST, we provide dedicated success specialists who mentor and support students in achieving their educational goals, offering a wealth of information and resources. Join the Institute with a research-oriented and industry-driven program. Our state-of-the-art facilities, including laboratories and libraries, are designed to facilitate effective learning and help students achieve their planned learning objectives. Creating a seamless, enjoyable, and productive teaching and learning environment requires the right aids, facilities, and infrastructure. At OIST, we prioritize providing our students, scholars, and faculty members with the best resources and infrastructure available. We take pride in our commendable infrastructure facilities, including a computer laboratory with over 60 computers,

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a Biotech lab equipped with sophisticated instruments, these facilities are accessible to students across disciplines. OIST offers a uniquely productive learning atmosphere for our students and scholars. With access to diverse and interdisciplinary learning and research facilities and infrastructure, they can enjoy an integrated educational experience.

OIST is one of the best options for students who want to establish and build their carrier in the field of Biotechnology and Biochemistry. OIST is a leading choice for students aspiring to establish and advance their careers in the field of modern Biological Sciences. We provide exceptional teaching, professional training, and research/development opportunities that are rapidly expanding to meet the demands of our diverse student community. With expertise and experience in LIFE SCIENCES, we encourage students from all backgrounds to apply. Whether you're interested in pursuing a UG-Honors degree in Microbiology or Biotechnology or seeking opportunities in Biochemistry and Biotechnology for a two-year PG course, we invite you to submit your application and join us on this exciting journey.

• Provide quality education in flexible mode to fulfil the aim of establishing an equitable knowledge society.

• Strive for upgradation of Science and Technology

• Highly qualified, bright and meritorious teaching faculties

• Well-equipped student laboratory for Biochemistry, Biotechnology, Microbiology, Botany, Tissue culture, Bioinformatics, Chemistry, Physics, and other related biological subjects.

• Very enriched library with multidisciplinary subjects.

• Internal assessment, weekly seminar, group discussion, symposia/ conference.

Placements: Regular Job fair and campus interview are organised by OIST. Many of our students have qualified national Level tests like NET, GATE(IIT), ICMR and JNU and Ph.D. entrance tests conducted by different Universities and are placed in various lucrative assignments. Many of our students are conducted PhD and post-Doctoral research in reputed Institutes/ organisation in Country and abroad. Our students are engaging as faculty position ion allied Health Science colleges, **some of the important Company and organisation where our students are well placed:** Cipla, Alkem, Lupin, Torrent, Mankind, Dabur, Morries, Ajanta Pharma, Biocon, TCS, Wipro. Cord Life India, Biological Evans, Sun Pharma, PCG Life Sciences Private Limited, Tata Medical Center. Pallishree Limited. Health Tek Private Limited. Vocis – LLc, etc. and many more. West Bengal Health department.

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Vidyasagar University

Syllabus of M.Sc. Course in Biotechnology

Two-year P.G. Program as per NEP-2020 (Effective from 2025-26)

Distribution of Marks: -

M.Sc. PG 1st year

SEMESTER – I

- Theoretical -200 marks
- Practical -75 marks

Paper Code	Paper name	Type of Paper	IA	EA	Maximum marks	Credits
BITC401X1	Biochemistry and Metabolism	Theory (Core)	5	20	25	2
BITC401X8	Biochemistry	Practical (Core)	-	25	25	2
BITC402X1	Cell Biology and Genetics	Theory (Core)	5	20	25	2
BITC402X8	Cell Biology and Genetics	Practical (Core)	-	25	25	2
BITC403X0	Research Methodology and Ethics	Theory (Core)	10	40	50	4
	One Elective must be Chosen:					
BITE404A0 BITE404B0	Elective I: Microbial Biotechnology Elective II: Biofuels and Biopolymers	Theory (Elective)	10	40	50	4
BITC405X1	Molecular Biology	Theory (Core)	5	20	25	2
BITC405X8	Molecular Biology	Practical (Core)	-	25	25	2
BITO406VC	Indian Knowledge System (IKS)	Theory Paper	5	20	25	2
BITO407NC	Vidyasagar: Life and Philosophy	Compulsory Non-Credit Course	-	-	25	-
Total marks and Credits					**275 +25**	**22**

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Vidyasagar University
Syllabus of M.Sc. Course in Biotechnology
Two-year P.G. Program as per NEP-2020 (Effective from 2025-26)

Distribution of Marks: -
M.Sc. PG 1st year

SEMESTER – II
- Theoretical -175 marks
- Practical -100 marks

Paper Code	Paper name	Type of Paper	IA	EA	Maximum marks	Credits
BITC451X1	Recombinant DNA Technology	Theory (Core)	5	20	25	2
BITC451X8	Genetic Engineering	Practical (Core)		25	25	2
BITE452A1	Immunology	Theory (Elective)	5	20	25	2
BITE452A8	Immunology	(Practical)		25	25	2
BITE453A1	Biostatistics and Bioinformatics	Theory (Elective)	5	20	25	2
BITE453A8	Bioinformatics	Practical (Elective)		25	25	2
BITE454A1	Agriculture and Food Biotechnology	Theory (Elective)	5	20	25	2
BITE454A8	Review Work & Seminar	Practical (Elective)		25	25	2
BITE455A0	Quality Control in Food and Pharma Industry	Theory Paper	10	40	50	4
BITO456X9	Field /Industry Visit	Compulsory	-	-	25	2
Total marks and Credits					**275**	**22**

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Vidyasagar University
Syllabus of M.Sc. Course in Biotechnology
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Distribution of Marks: -
M.Sc. PG 2nd year

SEMESTER – III
- Theoretical -175 marks
- Practical -100 marks

Paper Code	Paper name	Type of Paper	IA	EA	Maximum marks	Credits
BITC501X1	Plant Biotechnology	Theory (Core)	5	20	25	2
BITC501X8	Plant Biotechnology	Practical (Core)		25	25	2
BITC502X1	Animal Biotechnology	Theory (Core)	5	20	25	2
BITC502X8	Animal Biotechnology	Practical (Core)		25	25	2
BITC503X1	Virology and Oncology	Theory (Core)	5	20	25	2
BITC503X8	Microbiology	Practical (Core)		25	25	2
BITC504X0	Analytical Instrumentation	Theory (Core)	10	40	50	4
BITO505X0	MOOCs	Theory Paper	10	40	50	4
BITO505X9	Social Service/Community Engagement	Compulsory Practical	-	-	25	2
Total marks and Credits					**275**	**22**

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Distribution of Marks: -
M.Sc. PG 2nd year

SEMESTER – IV
- Theoretical -75 marks
- Practical -200 marks

Paper Code	Paper name	Type of Paper	IA	EA	Maximum marks	Credits
BITC551X1	Nanobiotechnology	Theory (Core)	5	20	25	2
BITC551X8	Nanobiotechnology	Practical (Core)			25	2
BITC552X0	Genomics and Proteomics	Theory (Core)	5	20	25	2
BITC553X9	Grand Viva	Practical (Core)			25	2
BITC554X9	Research Project and Dissertation	Practical (Core)	20	80	100	8
BITC555X9	Internship/Applied field or Industry Project/ Entrepreneurship	Practical (Core)	10	40	50	4
BITC556X0	Intellectual Property Right and Bio-entrepreneurship	Theory (Core)	5	20	25	2
Total marks and Credits					**275**	**22**

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SEMESTER – I

*Paper-I (*BITC401X1*)*

(2 Credits, EA:20 +IA :5)
(20 Hours)

Biochemistry and Metabolism (*Theory*)

Course Objectives (COBs):

- To understand the structure, significance, and characteristics of the vital biomolecules—carbohydrates, proteins, and nucleic acids.
- To understand protein synthesis, folding, post-translational modification, and degradation.
- To understand, biosynthesis and degradation of fatty acids, purines and pyrimidines, amino acids, nucleotides.
- To understand the structure and function of different class of enzymes including ribozymes, their kinetics.

Course Outcomes (COs): On completing the course, the student will be able to:

- Comprehend understanding of the structure, function, and properties of carbohydrates, proteins, fats and nucleic acids, which are essential biomolecules in living organisms.
- Acquire a basic understanding of the biosynthesis and degradation of carbohydrates, proteins, fats and nucleic acids.
- Gain basic information of enzymes, exploring knowledge of application and kinetics of different enzymes.

Course Contents:

Unit – I: Overview of Carbohydrates: Classification, structure, and functions. Metabolic Pathway and regulation of glycolysis, gluconeogenesis, glycogenesis and glycogenolysis. Citric acid cycle and its regulation, electron transport chain and oxidative phosphorylation, pentose phosphate pathway. (5H)

Unit-II: Overview of Fatty acids: Classification and structure and function. β-oxidation, oxidation of unsaturated fatty acids and odd chain fatty acids, β-oxidation in peroxisomes. Fatty acid biosynthesis and regulation. (4H)

Unit-III: Overview of Nucleic acids: Structure and functions. Purine biosynthesis and its regulation, pyrimidine biosynthesis, and its regulation, Salvage pathway for purine and pyrimidine nucleotides, Oxidation of purines and pyrimidines. (4H)

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Unit-IV: Overview of Amino acids: Structure and functions. Protein: Classification, structure, and functions. Amino acid metabolism: overview of amino-acid biosynthesis and degradation, urea cycle (4H)

Unit-V: An overview of enzyme classification, Overview of enzyme-reaction kinetics, Multienzyme complexes, Allosteric enzymes, Ribozymes. (3H)

Reference Books:

1. Nelson, D.L., Cox, M.M. Lehninger. (2004). Principles of Biochemistry 8th edition Pub WH Freeman Co.
2. Elliott, W.H., Elliott, D.C. Biochemistry and Molecular Biology 3 rd Indian edition, Pub. Oxford.
3. Mathews, Van Holde and Ahern, Biochemistry by 3 rd edition, Pub Pearson education
4. Stryer, L. Biochemistry 4th Edn. W.H. Freeman and Co. NY.
5. Kuchel, P.W., Ralston Schaums, G.B. Outlines of Biochemistry 2 nd edition Pub: Tata.
6. Voet, D., Voet J.G. (2004). Biochemistry 2nd Edn.
7. Garrett R.H., Grisham C.M. Biochemistry. 2024. 7th ed. Cengage.
8. Devlin, T.M. (1997). Biochemistry with clinical correlations, Wiley-Liss Inc. NY
9. Zubey, G.L. Parson, W.W., Vance, D.E. (1994). Principles of Biochemistry WmC.Brown publishers. Oxford.

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Vidyasagar University
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SEMESTER – I

*Paper-II (*BITC401X8*)*

(2 Credits, 25 marks)

Biochemistry (*Practical*)

Course Objectives (COBs):

- To acquire hands on knowledge of quantitative estimation of sugar amino acid, protein, lipid, ascorbic acid from different sample.
- To know the different chromatographic techniques for separation of amino acids, sugars and lipids.
- To determine the iodine number, acid number and saponification of value of different essential oils.
- To gain practical knowledge for preparation of different buffer used in laboratory.
- To know the extraction process of different enzymes followed by their quantitative estimation using spectrophotometer.

Course Outcomes (COs): On completing the course, the student will be able to:

- Acquire knowledge regarding sample preparation and estimation of different biomolecules used to test in industry and diagnostic laboratory.
- Understand the qualitative estimation process of amino acids, sugars and lipids.
- Achieve ideas about rancidity of essential by determining iodine number, acid number and saponification value.
- Acquire the process of extraction of different enzymes followed by their quantitative estimation using spectrophotometer.

Course Contents:

1) Quantitative estimation of
   i) Total sugar/ Glycogen ii) Reducing sugar iii) Amino acids iv) Total protein
   v) Total lipid vi) Cholesterol vii) Ascorbic acid
2) Separation of amino acids sugar and phospholipids by TLC/Column Chromatography
3) Analysis of oils- iodine number, saponification value and acid number
4) Preparation of buffer- a) phosphate buffer (b) citrate buffer (c) Tris HCI
5) Extraction and spectrophotometric estimation of following enzyme

a) α Amylase b) Protease c) Alkaline Phosphatase

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SEMESTER – I

*Paper-III (*BITC402X1*)*

(2 Credits, EA:20 +IA :5)
(20 Hours)

Cell Biology and Genetics (*Theory*)

Course Objectives (COBs):

- To provide fundamental knowledge of cell structure, cell membranes, cell motility, organelles, in prokaryotes and eukaryotes, transport across membranes.
- To understand the genetic development and control of different genes, their expression in Plant and Animal model system.
- To develop an understanding of the Mendelian Genetics, Human genetics and Population genetics, molecular basis of Chromosome, Gene mapping and genetic mapping, counselling and regulation.

Course Outcomes (COs): On completing the course, the student will be able to:

- Acquire the knowledge about the structure-function relationship of cells, organelles, cell motility and transport of molecules across membranes.
- Develop the concept genetic development and their control in human, animal and plant.
- Understand the concept of Mendelian, Human and population genetics, Law, inheritance, gene mapping

Course Contents:

Unit – I: Cell types: Overview of prokaryotic and eukaryotic cells, ultra structure of animal and plant cell. (2H)

Unit – II: Biological membranes: structure and properties, membrane constituents- phospholipids, glycolipid, cholesterol, membrane proteins. Transport of nutrients- ions and macromolecules across membrane – passive; diffusion, osmosis, ionophores, reverse osmosis and active transport, permease, Na Pump, Ca Pump, Co-transport, symport, antiport, endocytosis and exocytosis. (4H)

Unit – III: Cell motility: Cilia and flagella of eukaryotes and prokaryotes, cyto- skeleton – Microtubules, microfilaments and intermediate filaments. (2H)

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Unit – IV: Genetic Control of development: Zygotic genes (eg. gap genes, segmental polarity genes and homeotic genes) in pattern formation, anterio-posterior embryogenesis; gene expression in animals (Drosophila) and plants (Arabidopsis). (3H)

Unit – V: Overview of Mendelian Genetics, molecular organization of chromosomes Linkage and Crossing over, Maternal inheritance, Polygenic inheritance, in situ hybridization and its applications. (3H)

Unit – VI: Human Genetics: - Pedigree analysis, inheritance of sex linked and autosomal traits, chromosome aberrations, Biochemical genetics, mapping of human genome, genetic counseling. (3H)

Unit – VII: Population Genetics: - Genetic variation, random mating, genetic, frequency and Hardy-Weinberg law, natural selection, genetic drift, inbreeding, genetic equilibrium, DNA polymorphism. (3H)

Reference Books:

1. Alberts, B., Bray, D., Lewis, J., Raf, M., Roberts, K., Watson, J.D. (1994). Molecular Biology of the Cell.
2. Cooper, G.M. (1997).The Cell: A molecular approach, ASM Press, USA.
3. Watson J.E. Molecular Biology of the Gene. 2014. 7thed. Pearson Publishers
4. Karp, G. (1996). Cell and Molecular Biology concepts and experiments, John Wiley and Sons Inc. NY.
5. Lodish, H., Baltimore, D., Berk, A., Zipursky, B.L., Mastsydaira, P., Darnell, J. (2004). Molecular Cell Biology, Scientific American Books Inc. NY.
6. Gardner/Simmons/Snustad. (2006). Principal of Genetics. 8th Edn. John Wiley & sons.
7. Klug, W.S.,Cummings. (2003). Concepts of genetics, 7th Edn. Pearson Education.
8. Dale, J.W. (1994). Molecular Genetics of bacteria, John Wiley & Sons.
9. Streips and Yasbin. (2001). Modern microbial Genetics. Niley Ltd.
10. John Ringo (2004). Fundamental Genetics. Cambridge University Press.

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Two-year P.G. Program as per NEP-2020 (Effective from 2025-26)
SEMESTER – I

*Paper-IV(*BITC402X8*)*

(2 Credits, 25 marks)

Cell Biology and Genetics (*Practical*)

Course Objectives (COBs):

- To achieve practical knowledge about some basic aspects of cell biology, cytology.
- To stain and visualize and identify the chromosomes in somatic and reproductive cell of both plant and animals.
- To stain, visualize and identify the different conductive cells in human blood sample.

Course Outcomes (COs): On completing the course, the student will be able to:

- Acquire hands on ideas about some basic aspects of cell biology, cytology.
- Acquire knowledge to identify the chromosomes in somatic and reproductive cell of both plant and animals.
- Understand the techniques to identify the different conductive cells in human blood sample.

Course Contents:

1. Cell fractionation (nucleus and mitochondria).
2. Localization of Barr bodies
3. Mitosis – onion root tips
4. Meiosis – Grasshopper testis, flower buds
5. Study of chromosome aberration on mitosis in *Allium cepa / Allium sativum*.
6. Polytene chromosome – Salivary gland of Drosophila / Chironomus
7. Blood smear – differential staining and identification of different types of cells.

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Vidyasagar University
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SEMESTER – I

*Paper-V (*BITC403X0*)*

(4 Credits, EA:40 +IA :10)
(40 Hours)

Research Methodology and Ethics (T*heory*)

Course Objectives (COBs):

- To understand the fundamental concepts of research, including types of research, research problems, hypothesis formulation, and the research process.
- To apply research design principles, data collection methods, and sampling techniques to conduct effective and systematic research.
- To develop skills to review literature, write research proposals, and integrate research findings into coherent reports or projects.
- To demonstrate knowledge of research ethics, publication ethics, privacy and confidentiality, and evaluate research impact using appropriate metrics.

Course Outcomes (COs): On completing the course, the student will be able to:

- Comprehend understanding the concept of basics of research, research problem, literature review.
- Acquire the knowledge of research hypothesis, process design and plan of research., sampling methods.
- Understanding the writing of research title, abstract, problem statement, literature review, methodology, outcomes, references.
- Understanding the research ethics, ethical judgment, privacy and confidentiality.

Course Contents:

Unit-I: Basics of Research, Definition, importance, and characteristics of research; distinction between method and methodology; types of research – basic, applied, qualitative, quantitative, descriptive, analytical, experimental. (5H)

Unit-II: Research Problem and Literature Review Identification and formulation of research problem; research questions and objectives; survey of literature – importance, sources, and research gaps. (4H)

Unit III: Hypothesis and Research Process Hypothesis – meaning, role, and types (null, alternative, simple, complex, directional, causal); research process – steps of problem identification to report writing. (4H)

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Unit-IV: Research Design and Plan, Research design – meaning, significance, and types (exploratory, descriptive, analytical, experimental); developing a research plan – statement of problem, objectives, methodology, data plan, timeline, budget. (6H)

Unit-V: Sampling Methods, Concept of sampling; probability sampling – simple random, stratified, cluster, systematic; non-probability sampling – purposive, convenience, quota, snowball. (4H)

Unit-VI: Reviewing and Proposal Writing, reviewing articles – analysis of objectives, methodology, findings; writing a research proposal – title, abstract, problem statement, literature review, methodology, outcomes, references. (4H)

Unit-VII: Introduction to Research Ethics Definition, nature, and scope of ethics; different branches of ethics; importance of ethics in research and academic life. Meaning and significance; responsibilities of researchers towards fellow researchers, public, and academic community; concept of academic integrity. (5H)

Unit-VIII: Ethical Judgments and Scientific Misconduct Ethical judgments in research: scientific misconduct – falsification, fabrication, plagiarism; redundant, duplicate, and overlapping publications; salami slicing; selective reporting; misrepresentation of data. (4H)

Unit-IX: Privacy and Confidentiality, Concepts of privacy, autonomy, confidentiality, and anonymity in research; ethical handling of sensitive data. (4H)

Reference Books:

1. Kothari, C. R., & Garg, G. (2019). *Research Methodology: Methods and Techniques* (4th ed.). New Age International Publishers.
2. Kumar, R. (2019). *Research Methodology: A Step-by-Step Guide for Beginners* (5th ed.). Sage Publications.
3. Creswell, J. W., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th ed.). Sage Publications.
4. Saunders, M., Lewis, P., & Thornhill, A. (2019). *Research Methods for Business Students* (8th ed.). Pearson Education.
5. Sekaran, U., & Bougie, R. (2019). *Research Methods for Business: A Skill-Building approach* (8th ed.). Wiley.
6. Resnik, D. B. (2020). *The Ethics of Research with Human Subjects: Protecting People,Advancing Science, Promoting Trust*. Springer.
7. Shamoo, A. E., & Resnik, D. B. (2015). *Responsible Conduct of Research* (3rd ed.). Oxford University Press.

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SEMESTER – I

*Paper-VI (*BITE404A0*)*

(4 Credits, EA:40 +IA :10)
(40 Hours)

Microbial Biotechnology (*Theory*)

Course Objectives (COBs):

- To understand the types, structure, features, culture methods, growth requirement and growth factors of microorganism.
- To gather knowledge about production and application of alcoholic beverages, antibiotics, proteins, toxins, nanoparticles at industrial level.
- To acquire concepts about bioprocess engineering, downstream processing.
- To know the techniques of genome analysis of unculturable microbes, their similarity dissimilarity study.

Course Outcomes (COs): On completing the course, the student will be able to:

- Gain ideas about classification, structure, function, growth, growth nutrients of microbes.
- Acquire knowledge about industrial production and purification of some commercial beverages, proteins, toxins, antibiotics at large scale.
- Understand know how techniques of bioprocess engineering.
- Understand the knowledge of metagenomics, library construction, genome sequencing and microbial diversity study.

Course Contents:

Unit – I: Microorganisms: General structure, characteristic features. Laboratory culture and methods to study microbes: classification and importance of microorganisms. (4H)

Unit – II: Growth requirements, growth factors, mathematical expression of growth, synchronous growth, continuous culture, Factors affecting bacterial growth, modes of bacterial nutrition, methods to control microbial growth. (4H)

Unit – III: Antibiotics and antimicrobial agents, Sulfa drugs, Mode of action of important antibiotics, Mechanism of resistance to antibiotics. (4H)

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Unit– IV : ***Industrial Production and their application:***

I. alcoholic beverages (Wine, Beer, Rum, Whiskey)
II. antibiotics (Penicillin, Streptomycin)
III. toxin (β -exotoxin)
IV. enzymes including purification and immobilization
V. probiotics
VI. Single Cell Protein (SCP).
VII. Microbial production of nanoparticles (12H)

Unit – V: ***Bioprocess engineering:*** Introduction to bioprocess engineering, design and operation of conventional fermenters, Downstream processing – Cell disruption, Precipitation methods, solid-liquid separation, liquid- liquid extraction, filtration, centrifugation, chromatography, drying devices (Lyophilization and spray dry technology), crystallization, biosensors – construction and applications, bioleaching. (10H)

Unit –VI: Metagenomics: Definition and concept, applications in studying unculturable microorganisms, metagenomic library construction and functional screening in suitable hosts, amplicon and genome sequencing to study microbial diversity and functions, (6H)

Reference Books:

1. Willey, J., Sherwood, L., Woolverton, C.J. Prescott's Microbiology. 2023. 10th ed. New York, McGraw Hill Education.
2. Wood, D., Joanne, W., Sandman, K. Prescotts Microbiology. 2023.McGraw Hill Education.
3. Madigan, M.T., Bender, K.S., Buckley, D.H., Sattley, W.M., Stahl, D.A. Brock Biology of Microorganisms. 2021. 16th ed. Pearson Education Ltd.
4. Tortora, G.J., Funke, B.ll R., Case, C.L. Microbiology: An Introduction. 2019. 13th ed. Chicago, Pearson.
5. Pelczar, M.J., Chan, E.C.S., Krieg, N.R. 2001. Microbiology, McGraw Hill Education.
6. Atlas R.M. (1998) Microbiology, Fundamentals and applications 2nd Edition, Milan Publishing Co.
7. Holt J.S. Kreig N.R., Sneath P.H.A and Williams S.T (1994) Bergey‟s Manual of Systemic Bacteriology 9th Edn. William and Wilkins, Baltimore.
8. Prescott L.M, Harley T.P and Klein D.A. (1996) Microbiology WMC. Brown publishers
9. Brock T.D. and Madigan M.T (1992) Biology of Microorganisms 6th Edn. Prentice Hall, Eagle wood cliffs N.j.

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SEMESTER – I

*Paper-VI (*BITE404B0*)*

(4 Credits, EA:40 +IA :10)
(40 Hours)

Biofuels and Biopolymers (*Theory)*

Course Objectives (COBs):

- To understand the basic concepts of different generation of biofuels, their properties and microbial production, application.
- To develop concepts about anaerobic digestion of wastes, production and genetic engineering of biofuels.
- To acquire knowledge about Bioplastics, their microbial production, application, advantages over synthetic plastics.

Course Outcomes (COs): On completing the course, the student will be able to:

- Acquire concepts regarding the types, production application of several generation of biofuels.
- Develop ideas of biofuels production from wastes and genetic engineering technology to improve the process.
- Acquaintance with natural polymers from microbes, their synthesis, application and merits over synthetic plastics.

Course Contents:

Unit- I: Introduction to biofuels: Generation of biofuels -first, second, third and fourth generation and their historical development, various types of biofuels and their properties and characteristics. (6H)

Unit- II: Microbial metabolism to produce biofuels: Producers of key biofuels such as biohydrogen, biomethane, bio methanol, bioethanol, biodiesel, and biobutanol, and their metabolism. (8H)

Unit- III: Anaerobic digestion and waste management: Biotechnological aspects in biofuels production from biowaste(s). Genetic engineering of biofuel producers: Bioprocess management in major biofuels production such as biohydrogen and bioethanol, present status and future development in dark- fermentative, and photo-fermentative biohydrogen production technology. (10H)

Unit- IV: Natural biopolymers: Types of natural biopolymers and their benefits over synthetic plastics. Polyhydroxyalkanoates (PHA): Microbial biodiversity of PHA-producers, and their

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metabolism, microbial production of PHA co-polymers and their physicochemical characteristics. (8H)

Unit- V: PHA application: Biotechnological advancement in application of PHA as biocontrol agents, drug carriers, medical implants, and tissue engineering. Commercialization of PHA: Updates on commercial production of microbial PHA. (8H)

Reference Books:

1. Soccol, C.R., Brar, S.K., Permaul, K., Pakshirajan, K., de Carvalho, J.C. Biohydrogen - Advances and Processes. 2024. 1st ed. Springer Cham.
2. Rena, Kumar S. Biofuels – Technologies, Policies and Opportunities. 2023. 1st ed. CRC Press.
3. Koller, M. The Handbook of Polyhydroxyalkanoates. 2023. 1st ed. CRC Press.
4. Sahay, S. Handbook of Biofuels. 2021.1st ed. Academic Press.
5. Kalia, V.C. Biotechnological Applications of Polyhydroxyalkanoates. 2019. 1st ed. Springer Singapore.

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SEMESTER – I

Paper-VII (BITC405X1)

(2 Credits, EA:20 +IA :5)
(20 Hours)

Molecular Biology (*Theory*)

Course Objectives (COBs):

- To give an overall insight about de novo synthesis of DNA, their damage by different exogenous and endogenous agent, different mutagen resulting mutation, DNA repair mechanism.
- To familiarize students with the central dogma processes, and mechanisms of gene expression.
- To understanding the process of biosignaling, factors effecting the regulation of cellular mechanism.
- To understand the molecular basis of cancer, role of different tumor suppressor protein.

Course Outcomes (COs): On completing the course, the student will be able to:

- Understand DNA replication, transcription, translation, and gene regulation in prokaryotes and eukaryotes.
- Acquire knowledge about signaling pathways, their controlling factors, cellular regulation mechanism.
- Acquainted with cause of formation of cancer, their molecular basis, different tumor suppressive protein factors.

Course Contents:

Unit- I: Biosynthesis of DNA – DNA replication, helicases, nucleases, DNA binding and unwinding proteins, topoisomerases, Mechanism of DNA replications in Prokaryotes and Eukaryotes. (3H)

Unit- II: Mutation and DNA damage and repair: - Types of mutation, molecular basis of mutation, normal and induced mutation. Photo reactivation, excision, mismatch, recombination, SOS, double strand break repair. (3H)

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Unit- III: Transcription – RNA polymerases in prokaryotes and Eukaryotes – its molecular composition, different sigma factors – related to stress, viral infection etc. Mechanism of transcription, RNA Processing enzymes, RNA editing, splicing. (3H)

Unit- IV: Translation: Prokaryotic and eukaryotic translation – Mechanism of initiation, elongation and termination. Amino acid activation, inhibitors. (2H)

Unit- V: Bio signaling - Over view of extra cellular signaling, G- Protein linked receptor and activity of G-Proteins, role of c-AMP in the regulation of cellular metabolism, Receptor tyrosine kinase, Ca++, IP3, DAG as second messengers. (3H)

Unit- VI: Molecular biology of cancer – Characteristics of tumor cells, viral and cellular oncogenes, structure, function and mechanism of actions of p53 and RB tumor suppressor protein. The multicausal, multistep nature of carcinogenesis. (3H)

Unit- VII: Regulation of gene expression in prokaryotes and eukaryotes: Positive and negative regulation, lac operon, and trp operon, regulatory proteins and DNA binding, chromatin modifications associated with gene expression, and regulatory modules for eukaryotic promoters. (3H)

Reference Books:

1. Principles of gene manipulation - An introduction to genetic engineering, Old R.W., Primrose S.B., Blackwell Scientific Publications, 1993.
2. Nelson, D.L., Cox, M.M. Lehninger Principles of Biochemistry (2005). 4th edition Pub WH Freeman Co.
3. Elliott, W.H., Elliott, D.C. Biochemistry and Molecular Biology 3rd Indian edition, Pub. Oxford.
4. Mathews, Van Holde, Ahern, Biochemistry by 3rd edition, Pub Pearson education.
5. Alberts, B., Bray, D., Lewis, J., Raf, M., Roberts, K. and Watson, J.D. (1994). Molecular Biology of the Cell.
6. Cooper, G.M. (1997).The Cell: A molecular approach, ASM Press, USA.
7. Darnell, J. Lodish, H., Baltimore, D. (1990). Molecular Cell Biology. Scientific American Books Inc. NY.
8. Garrett, R.H. and Gresham, C.M. (1995). Molecular aspects of Cell Biology, International edition, Saunders College Pub.
9. Karp, G. (1996). Cell and Molecular Biology concepts and experiments, John Wiley and Sons Inc. NY.
10. Lodish, H., Baltimore, D., Berk, A., Zipursky, B.L., Mastsydaira, P., Darnell, J. (2004). Molecular Cell Biology, Scientific American Books Inc. NY.

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SEMESTER – I

*Paper-VIII (*BITC405X8*)*

(2 Credits, Marks 25)

Molecular Biology (*Practical*)

Course Objectives (COBs):

- To develop fundamental knowledge in molecular biology techniques such as DNA isolation and visualization DNA from bacteria, plant and animal cells.
- To develop skills in quantification, and characterization of nucleic acids.
- To give hands on knowledge regarding Tm of DNA, UV visible spectroscopic methods to estimate DNA contents in different sample.

Course Outcomes (COs): On completing the course, the student will be able to:

- Acquire knowledge of some fundamental molecular biology techniques such as DNA isolation and visualization DNA from bacteria, plant and animal cells.
- Develop skills in quantification, and characterization of nucleic acids.
- Achieve hands on training regarding Tm of DNA, UV visible spectroscopic methods to estimate DNA contents in different sample.

Course Contents:

1. Isolation of plasmid DNA from *E. coli* by adopting two methods – (A) Alkaline SDS method
2. (B) Boiling lysis, Agarose Gel electrophoresis
3. Isolation of genomic DNA from bacteria
4. Isolation of genomic DNA from plant cell/animal cell
5. Quantitative estimation of DNA and RNA.
6. Determination of the melting temperature of DNA.
7. Preparation of the absorption spectra of DNA.

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SEMESTER – I

*Paper-IX (*BITO406VC*)*

(2 Credits, EA:20 +IA :5)
(20 Hours)

Indian Knowledge System (IKS) (*Theory*)

Course Objectives (COBs):

- To provide a comprehensive and interdisciplinary overview of ancient Indian knowledge systems.
- To explore the genesis of Indian civilization, from the Indus Valley to the Vedic period, and examine the development of its intellectual and philosophical frameworks.
- To delve into the structure of ancient Indian society, astronomy, science and technology.
- To highlight significant contributions of Plants, Anatomy, Physiology, Agriculture, Ecology and Environment, Ayurveda, Integrated Approach to Healthcare, Medicine, Microbiology, Medicine, Surgery, and Yoga

Course Outcomes (COs): On completing the course, the student will be able to:

- Learn about a comprehensive and interdisciplinary overview of ancient Indian knowledge systems.
- Explore the genesis of Indian civilization, from the Indus Valley to the Vedic period.
- Gain ideas about the structure of ancient Indian society, astronomy, science and technology.
- Gather knowledge regarding the role of Plants, Anatomy, Physiology, Agriculture, Ecology and Environment, Ayurveda, Integrated Approach to Healthcare, Medicine, Microbiology, Medicine, Surgery, and Yoga in society.

Course Contents:

Unit -I: Bharatiya Civilization and Development of Knowledge System

Genesis of the land, Antiquity of civilization, On the Trail of the Lost River, Discovery of the Saraswati River, the Saraswati-Sindhu Civilization, Traditional Knowledge System, The Vedas, Main Schools of Philosophy, Ancient Education System - the Takṣasila University, the Nalanda University. (6H)

Unit-II: Science, Astronomy, and Mathematics

Concept of Matter, Life and Universe. Development of Science and Technology in ancient India, Astronomy - History and Culture of Astronomy, Sun, Earth, Moon, and Eclipses, Earth is

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Spherical and Rotation of Earth. Key Contributions: Aryabhatta and Varahmihir. Mathematics- Shulvasutra and Baksali manuscript, Formulation of Arithmetic, Algebra and trigonometry. (5H)

Unit-III: Life Science, Environment, Medicine and Health

Ethnic Studies, Life Science in Plants, Anatomy, Physiology, Agriculture, Ecology and Environment, Ayurveda, Integrated Approach to Healthcare, Medicine, Microbiology, Medicine, Surgery, and Yoga, etc. (9H)

Reference Books:

1. Textbook on The Knowledge System of Bhārata by Bhag Chand Chauhan,
2. Histrory of Science in India Volume-1, Part-I, Part-II, Volume VIII, by Sibaji Raha, et al.
3. National Academy of Sciences, India and The Ramkrishan Mission Institute of Culture, Kolkata (2014).
4. Pride of India- A Glimpse of India's Scientific Heritage edited by Pradeep Kohle et al. Samskrit Bharati (2006).
5. Vedic Physics by Keshav Dev Verma, Motilal Banarsidass Publishers (2012).
6. India's Glorious Scientific Tradition by Suresh Soni, Ocean Books Pvt. Ltd. (2010).

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SEMESTER – I

*Paper-X (*BITO407NC)

(25 marks)
(25 Hours)

Vidyasagar: Life and Philosophy (*Theory*)

Course Objectives (COBs):

- Aims to provide a comprehensive understanding of the life and philosophy of Ishwar Chandra Vidyasagar, a key figure of the Bengal Renaissance.
- To trace his journey from birth and lineage to his transformation into "Vidyasagar" (ocean of learning).
- To delve into his pivotal role in Indian education, examining his reforms as a teacher, writer, and planner, as well as his efforts to modernize the system.
- To explore his relentless work in women's emancipation, focusing on his campaigns for widow remarriage and his opposition to child marriage.
- To highlight his immense philanthropy and analyze his unique position as a figure who bridged tradition and modernity.
- To discuss the enduring relevance of his thoughts and values for contemporary society.

Course Outcomes (COs): On completing the course, the student will be able to:

- Acquire the knowledge regarding the life and philosophy of Ishwar Chandra Vidyasagar, a key figure of the Bengal Renaissance.
- Understanding his journey from birth and lineage to his transformation into "Vidyasagar" (ocean of learning).
- Gather knowledge regarding contribution of his thoughts and values for contemporary society.

Course Contents:

Unit-I: Early Life and Education: (4 H)

1.Birth and Lineage

2. Journey from Iswar Chandra Bandyopadhyay to Iswar Chandra Vidyasagar.

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Unit-II: Vidyasagar and Indian Education: (5 H)

1. The then Indian education system
2. Vidyasagarian plan for reformation of Indian education- Vidyasagar as teacher, Vidyasagar as writer, planner and reformer of Indian education.

Unit-III: Vidyasagar and Women Emancipation: (5 H)

1.Introduction of widow remarriage
2. Struggle to stop child marriage

Unit-IV: Philanthropist Vidyasagar (3 H)

Vidyasagar's philanthropy as narrated by others

Unit-V: Vidyasagar: Traditions and modernity (5 H)

1. Tradition
2. Modernity
3. Vidyasagara as Traditional modernizer

Unit-VI: Relevance of Vidyasagarian thoughts and values (3 H)

1. Vidyasagar and the then Society of Bengal
2. Lesson for future generations.

Further Readings:

Online course. Available on the University website.

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Vidyasagar University
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SEMESTER – II

*Paper-I (*BITC451X1)

(2 Credits, EA:20 +IA :5)
(20 Hours)

Recombinant DNA Technology (*Theory*)

Course Objectives (COBs):

- To give an overall insight about synthesis recombinant DNA, their modification by different exogenous agent, their introduction and stabilization into another host cell/ tissue/organism
- To familiarize students with the different carrier of DNA to be carried the recombinant product to host cell.
- To understanding the process of selection screening, identification and analysis of recombinant products.
- To understand the techniques of nucleic acid hybridization, labelling of DNA by radio, non-radioactive agent.
- To gather fundamental knowledge about different types of gene editing technology.

Course Outcomes (COs):
On completing the course, the student will be able to:

- Understand gene cloning technology to generate Genetically modified (GM)_crop plant/ animal.
- Student will acquire knowledge about the different process of foreign delivery to another host organism.
- Acquainted with the process of selection screening, identification and analysis of recombinant products.
- Student can understand the Gene editing technology to produce different gene/ protein product by using single set of gene.

Course Contents:

Unit-I: Introduction to Recombinant DNA technology, Nucleic acid modifying enzymes, Cloning vectors (Plasmid and phage-based vectors, cosmid, phagemid, yeast cloning vectors, animal, plant and viruses as vectors. BAC, PAC, YAC, HAC). Marker genes (reporter genes, selectable markers). [5H]

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Unit II: Transformation techniques: Preparation of competent cells, Physical and chemical methods of gene transfer- Electroporation, Microinjection, Gene gun, PEG, DEAE, CaCl2, calcium phosphate precipitation method, liposome-mediated method. [5H]

Unit III: Selection, screening, and analysis of recombinants, PCR amplified DNA. Genomic DNA libraries, cDNA library identification and analysis of cloned DNA. Approaches for identification of genes (colony and plaque hybridization, Southern blot analysis) Radioactive labelling, non-radioactive labelling. [5H]

Unit IV: Gene editing Technology**:** *Site* directed mutagenesis, Antisense and ribozyme technology, Gene Knock Out, Gene Knock in, Zinc Finger Nucleases (ZFNs), Transcription activator-like effector nucleases (TALENs), CRISPR-Cas9 Technology. [5H]

Reference Books:

1. Nicholl D.S.T. Introduction to Genetic Engineering Cambridge (3rd Ed.) University press.UK. 2008
2. Old R.W., Primrose S.B. Principles of gene manipulation and Genomics- An introduction to genetic engineering (7th Ed.), Blackwell Scientific Publications, UK. 2023.
3. Benjamin Lewis, Genes XII (12 th Ed.) Oxford University & Cell Press, NY.2017
4. Robert Williamson. Genetic Engineering (1st Ed.) Academic Press.1981.USA
5. Rodriguez. R.L (Author), Denhardt D.T. Vectors: A Survey of Molecular Cloning Vectors and Their Uses (1st Ed.) Butterworth-Heinemann publisher.UK. 1987
6. Ansubel F.M., Brent R., Kingston R.E., Moore D.D. et al. short protocols in molecular biology (4th Ed), Wiley publishers. India. 1999.
7. Sambrook J et al. Molecular cloning Volumes I, II and III. Cold Spring Harbor laboratory Press, New York, USA. (1989, 2000)
8. S. B. Primrose, Richard M. Twyman. Principles of gene manipulation and genomics (7th Ed.) John Wiley & Sons publishers.2006

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SEMESTER – II

Paper-II (*BITC*451X8)

(2 Credits,25 Marks)

Genetic Engineering (*Practical*)

Course Objectives (COBs):

- To give an overall insight about isolation and *in vitro* synthesis of DNA, their polymorphic pattern by digestion with different enzymes.
- To familiarize with the isolation of digested DNA from Agarose gel.
- To understanding the process of foreign DNA cloning into carrier DNA.
- To understand the how the cloned DNA transferred to host cell chromosome.

Course Outcomes (COs): On completing the course, the student will be able to:

- Understand DNA isolation replication, digestion and analysis of polymorphic pattern.
- Acquire knowledge about the isolation of digested DNA from Agarose gel.
- Acquainted with process of foreign DNA cloning into carrier DNA.
- Understand how the cloned DNA transferred and integrated into host cell chromosome.

Course Contents:

1. Isolation of Bacterial genomic DNA
2. Restriction enzyme digestion of DNA
3. Elution of digested DNA from Agarose gel
4. Ligation of DNA fragment with cloning vector
5. Preparation of Competent cells
6. Transformation in *E.coli* with recombinant vector
7. Polymerase Chain Reaction

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SEMESTER – II

*Paper-III (*BITE452A1)

*(*2 Credits, EA:20 +IA :5)
(20 Hours)

Immunology (*Theory*)

Course Objectives (COBs):

- To give an overall insight about the initiation and development of immune system, their types structure and functions.
- To familiarize students with the organization and expression of genes responsible for immunity development.
- To understanding the process of antibody and cell mediated effector, complement system.
- To understand the hypersensitivity reactions and their types, different types of autoimmunity and immunodeficiency.
- To acquire knowledge regarding antibody production and application, types of vaccines and process of develop immunity by vaccination.

Course Outcomes (COs): On completing the course, the student will be able to:

- Understand the initiation and development of immune system, their type's structure and functions, the organization and expression of genes responsible for immunity development.
- Understand the process of antibody and cell mediated effector, complement system.
- Acquire knowledge hypersensitivity reactions and their types, different types of autoimmunity and immunodeficiency.
- Acquainted with antibody production and application, types of vaccines and process of develop immunity by vaccination.

Course Contents:

Unit-I: Historical development in Immunology. Overview of the immune system: Innate and adaptive immunity, Cells and organs of the immune, system, Antigens, antigenicity and immunogenicity, haptens and epitopes, Immunoglobulins: Structure and function. [3H]

Unit-II: Organization and expression of immunoglobulin genes, Major histocompatibility complex (MHC) – Structure and functions of MHC and the HLA system. Generation, maturation, activation and differentiation of T and B Lymphocytes. [4H]

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Unit-III: Antibody and Cell mediated effector mechanism, Complement components, activations, pathways and regulations, Cytokines. [4H]

Unit-IV: General features of hypersensitivity reactions, overview of Type – I, Type – II, Type – III and Type – IV hypersensitivity, Autoimmunity and their types, Immunodeficiency. [3H]

Unit-V: Monoclonal antibody Production and Application. Chimeric antibody, Humanized antibody, Reshaped antibody. Vaccines – Different types of vaccines. Active and Passive immunization. Production of toxoids, production of Recombinant vaccines. [6H]

Reference Books:

1. Abdul, K., Abbas, Andrew K. L., Jordan, S. P. (1998). Cellular and Molecular Immunology. Sanders College Pub.
2. Benjamine, E., Coico., Sunshine. (2000). Immunology 4 th edition- Wiley- Liss. Publ.NY.
3. *Textbook of Basic and Clinical Immunology* · Sudha Gangal; Shubhangi Sontakke · (2013).
4. Hyde, R.M. (1992). Immunology, 2nd edition, Williams and Wilkins, Baltimore.
5. Kuby, J. (2018). Immunology 8th Edition. WH. Freeman and Company, NY.
6. Klaus D. Elgert (1996). Immunology. ELBS, Blackwell Scientific Publishers, London.
7. Roitt, I.M. (2016). Essential Immunology, ELBS, Blackwell Scientific Publishers, London.
8. Tizard I.R. (1995). Immunology, 4th edition, Saunder College Pub.

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SEMESTER – II

*Paper-IV (BITE*452A8)

(2 Credits, 25 marks)

Immunology (*Practical*)

Course Objectives (COBs):

- To give an overall insight about the immunization of model mice.
- To familiarize students with the basic techniques of serum separation from blood sample.
- To understanding the process of some common immune techniques to disease diagnosis.
- To understand the techniques of protein hybridization.

Course Outcomes (COs): On completing the course, the student will be able to:

- Understand the overall insight about the immunization of model mice.
- Acquire students with the basic techniques of serum separation from blood sample and several similar techniques clinical laboratory.
- Acquainted with the process of some common immune techniques to disease diagnosis and protein hybridization.

Course Contents:

1. Immunization of mice
2. Serum separation from whole blood and Precipitation of immunoglobulins (Igs) from serum by ammonium sulphate precipitation followed by dialysis of ammonium sulphate precipitated Immunoglobulins.
3. Electrophoresis of the immunoglobulin preparation
4. Separation of Lymphocytes from blood
5. Single radial immune diffusion and determination of Ig concentration, Ochterlony double diffusion method
6. Blood group testing
7. ELISA
8. Western Blot

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SEMESTER – II

Paper-V (BITE453A1)

(2 Credits, EA:20 +IA :5)
(20 Hours)

Biostatistics and Bioinformatics (*Theory*)

Course Objectives (COBs):

- To give an overall idea about basic statistical tools and techniques used in biological sciences.
- To familiarize students with the basic concepts of hypothesis testing and use of some recently used statistical software for statistical analysis study.
- To understanding basic computer and biological databases.
- To understand the concept of computational sequence analysis.
- To give an overall idea about primer designing, comparative genomics proteomics and their application.
- To acquainted with molecular structure analysis and tools and techniques used for analysis.

Course Outcomes (COs): On completing the course, the student will be able to:

- Understand the overall idea about basic statistical tools and techniques used in biological sciences.
- Acquired knowledge about the basic concepts of hypothesis testing and use of some recently used statistical software for statistical analysis study, basic computer and biological databases, concept of computational sequence analysis.
- Acquainted with the overall idea about primer designing, comparative genomics proteomics and their application.
- Familiarize students with molecular structure analysis and tools and techniques used for analysis.

Course Contents:

Unit-I: Statistical methods – Collection tabulation and graphical representation of data, Measures of central tendency – Arithmetic mean, median, mode, range, standard deviation, Standard error and co-efficient of variation, Concept of correlation and regression method of least squares. [3H]

Unit-II: Hypothesis testing – Basic idea about sample distribution, tests based on normal, student t test, Chi square test for goodness of fit, Analysis of Variance. Concept of ORIGIN, SPSS and AI based statistical software. [4H]

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Unit-III: Basic computer and biological databases: Concept on basic computers, Accession codes and identifiers, major tools and contents of the biological database. [3H]

Unit-IV: Computational sequence analysis: Sequence analysis – sequence reading, sequence alignment – Global local sequence alignment, Pair-wise sequence alignment, Multiple sequence alignment, phylogenetic analysis, coding region identification. Protein analysis, secondary structure prediction. [4H]

Unit-V: Primer designing, comparative genomics - Gene Prediction, Gene Counting and SNPs, potentiality of Proteomics, Application of Proteomics technology. [3H]

Unit-VI: Molecular structure analysis: Toxicity analysis tools, Molecular dynamics, molecular modeling and simulation, Homology modeling, Computer aided drug designing, Molecular docking. [3H]

Reference Books:

1. Daniel (1999). Biostatistics (3rd edition) Panima Publishing Corporation.
2. Khan (1999). Fundamentals of Biostatistics, Panima Publishing Corporation
3. Swardlaw, A.C. (1985). Practical Statistics for Experimental Biologists, Joh
4. Campbell, R.C. (1974). Statistics for Biologists, Cambridge Univ. Press, Cambridge
5. Bliss, C.I.K. (1967). Statistics in Biology, Vol.1 Mc Graw Hill, New York.
6. Dhananjaya (2002). Introduction to Bioinformatics, www.sd-bio.com series 2. Jan (2001). Nucleic acid research, Genome Database issue
7. Higgins & Taylor (2000). Bioinformatics, OUP.
8. Baxavanis (2014). Bioinformatics: A practical guide 9. Fry, J.C. (1993). Biological Data Analysis. A practical Approach. IRL Press, Oxford.

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SEMESTER – II

Paper-VI(BITE453A8)

(2 Credits, 25 marks)

Biostatistics and Bioinformatics (*Practical*)

Course Objectives (COBs):

- To give an overview of computational analysis of biological sequences, use of statistical software.
- To familiarize students with the sequence analysis, analysis tools for sequence data bank, pairwise and multiple sequence alignment.
- To give an insight about the process of phylogenetic tree analysis, BLAST database, BLAST and genome annotation
- To acquainted with the prediction of bimolecular structure and analysis, molecular docking analysis.

Course Outcomes (COs): On completing the course, the student will be able to:

- Understand the overview of computational analysis of biological sequences and use of statistical software.
- Acquire knowledge about the sequence analysis, analysis tools for sequence data bank, pairwise and multiple sequence alignment.
- Acquainted with the process of phylogenetic tree analysis, BLAST database, BLAST and genome annotation
- Understand the prediction of bimolecular structure and analysis, molecular docking analysis.

Course Contents:

1. Application of statistical software (EXCEL/ORIGIN/SPSS/AI based software)
2. An overview of computational analysis of biological sequences
3. Sequence analysis, Analysis Tools for Sequence Data Bank
4. Pairwise and Multiple sequence alignment
5. Phylogenetic tree analysis
6. BLAST database, BLAST and genome annotation
7. Prediction of bimolecular structure and analysis
8. Molecular docking analysis.

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SEMESTER – II

Paper-VII(BITE454A1)

(2 Credits, EA:20 +IA :5)
(20 Hours)

Agriculture and Food Biotechnology (*Theory*)

Course Objectives (COBs):

- To give an overall insight about the modern agricultural techniques for crop improvement and methodology to assess the genetic diversity by using molecular tools and techniques.
- To familiarize students with the alternative approaches to develop bio and organic fertilizer to restore soil fertility.
- To understanding the strategies to search alternative approaches to combat plant pathogen by biological control mechanisms.
- To acquainted with the modern techniques for food preservation, spoilage their canning and packaging
- To familiarize students with the process of production and uses of fermented food.

Course Outcomes (COs): On completing the course, the student will be able to:

- Understand the modern agricultural techniques to crop improvement and methodology to assess the genetic diversity by using molecular tools and techniques.
- Acquire knowledge with the alternative approaches to develop bio and organic fertilizer to restore soil fertility.
- Acquainted with the strategies to search alternative approaches to combat plant pathogen by biological control mechanisms.
- Acquainted with the modern techniques for food preservation, spoilage their canning and packaging
- Familiarize students with the process of production and uses of fermented food.

Course Contents:

Unit-I: Introduction to Agriculture biotechnology- Principles of plant breeding: conventional, Mutation, MAS and MAB, Integrated, Transgenic. Advanced methods of genotyping, Methods of assessing genetic diversity and germplasm characterization, DNA fingerprinting and its application, Allele mining by TILLING and Eco-TILLING. (5H)

Unit-II: Biofertilizers and Biopesticides: Mass cultivation of *Rhizobium* sp, *Azotobacter*, *Azospirillum*, Blue green algae, Azolla, phosphate solubilizing microorganisms. Benefits from

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biofertilizers. Vermicomposting. Biocontrol of bacteria and phytopathogenic fungi. Terminator and Traitor technology (cotton). Biotechnology of weed control. (6H)

Unit-III: Food processing: Food preservation and spoilage, sterilization and pasteurization, Food irradiation, Food additives (Preservatives, color, emulsifiers and stabilizers). canning and packing of foods. (5 H)

Unit-IV: Production and uses of fermented foods, Soya foods, Food fads, Organic foods, Edible films. Probiotic bacteria and their importance, Marine food analysis- preservation, spoilage, quality control. Concept of nutrigenomics. (4H)

Reference Books:

1. Handbook of Agricultural Biotechnology: Editor(s): Charles Oluwaseun Adetunji, Chukwuebuka Egbuna, Anton Ficai, Oluwatosin Ademola Ijabadeniyi, First published:7 October 2024
2. Handbook of Agricultural Biotechnology (1st Ed. 2021) by Dr. Rajendra Kumar Yadav & Dr. Mohammad Shahid:
3. Halford N.G. Plant biotechnology: current and future applications of genetically modified crops. John Wiely Publishers.2006.
4. Ratlege, C. and B. Kristiansen, Basic Biotechnology. Cambridge Univ. Press, London. 2001
5. Chrispeels M.J.et al. Plants, Genes and Agriculture-Jones and Bartlett Publishers, Boston.1994.
6. Biofertilizers: Volume 1: Advances in Bio-inoculants**.** 1st Edition - March 26, 2021 Editors: Amitava Rakshit, Vijay Singh Meena, Manoj Parihar, H.B. Singh, A.K. Singh
   Hammound J, P McGravey & Yusibov.V. Plant Biotechnology, Springer verlag.2000
7. Murray D.R. Advanced methods in plant breeding and biotechnology. Panima Publishing Corporation.1996
8. Suza, W., & Lamkey, K. (Eds.). (2023). Molecular Plant Breeding. Iowa State University Digital Press.

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SEMESTER – II

Paper-VIII (BITE454A8)

(2 Credits, 25 marks)

Review Work and Seminar (*Practical*)

Course Objectives (COBs):

- To familiarize with the students to know the methodology to write the review work by following research article related to the course studied and to write the review work.
- To know the prepare and present the review work by power point presentation

Course Outcomes (COs): On completing the course, the student will be able to:

- Acquire knowledge about the methodology to write the review work by following research article related to the course studied and to write the review work.
- Acquainted with the preparation and present the review work by power point presentation

Course Contents:

1. Student have to review a particular recent research topics by downloading the research article/ news and read carefully the nature of work, aims and objectives, result and discussion and future scope of the research topics.
2. Have to prepare a comprehensive write up on that basis.
3. Have to prepare a power point presentation on that topic and to deliver a seminar before the competent Examiner/ faculty members.

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SEMESTER – II

*Paper-IX(BITE*455A0)

(4 Credits, EA:40 +IA :10)
(40 Hours)

Quality Control in Food and Pharma Industry (*Theory*)

Course Objectives (COBs):

- To give an overall insight about the ethical issues and biosafety to be employed in Biotech research laboratory and Industry.
- To familiarize students with the process to assess the quality of the products/goods of food, Pharma and Chemical Industry.
- To understanding the concept and importance of pharmaceutical quality control and quality assurance as per different standards amended by Government.
- To understand different rules and regulations of international organization of standardization (ISO).

Course Outcomes (COs): On completing the course, the student will be able to:

- Understand the ethical issues and biosafety to be employed in Biotech research laboratory and industry
- Acquire knowledge about with the process to assess the quality of the products/goods of food, pharma and chemical industry.
- Acquainted with the concept and importance of pharmaceutical quality control and quality assurance as per different standards amended by Government.
- understand different rules and regulations of international organization of standardization (ISO).

Course Contents:

Unit- I: Bioethics Legality, morality and ethics, the principles of bioethics, autonomy, human rights, beneficence, privacy justice equality etc. Biosafety Concept and issues, rational Vs subjective perceptions of risks and benefits – relationship between risk hazard, exposure, and safe guards – biosafety concerns at the level of individuals, institutions, society, region country and the world – Lab associated infections. (10H)

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Unit-II: Quality control laboratory: Design of QC laboratory for chemical, instrumental and microbiological analysis. Good Practices in QC laboratory, Schedule L1, standardization of reagents, labeling of reagents, control samples, controls on animal house, data generation and storage, QC documentation, LIMS. (10H)

Unit-III: Concept and importance of pharmaceutical quality control and quality assurance. Process validation, purity and shelf life of pharmaceuticals.: Good Manufacturing Practices (GMP), CGMP, Good Hygienic Practices (GHP), Good Agricultural Practice (GAP), GSP, Storage and distribution of food, sanitation and safety in food services. (10 H)

Unit-IV: International Organization of Standardization (ISO): Overview, structure, interpretation and case studies of food safety and Quality management including ISO-22000, ISO-9001:2000, ISO22000:2005, ISO 17025/CODES/GLP, Retailers standards: BRC food and BRC IOP standards, IFS, SQF: 1000, SQF: 2000. Hazard Analysis Critical Control Point FASSAI

(10 H)

Reference Books:

1. Quality Control in the Food Industry V2,: 1st Edition - December 2, 2012, Latest edition, Editor: S Herschdoerfer
2. Pharmaceutical Quality Control Handbook: December 1989. Rhys Bryant
3. A Text Book Of Pharmaceutical quality assurance: Mr. Mahendra Singh, Mr. Priyesh Pankaj, Mr. Tulsi Das Patel, ISBN : 978-93-7462-913-0
4. GMP/ISO Quality Audit Manual for Healthcare Manufacturers and Their Suppliers (Leonard Steinborn, 6th Ed, CRC Press). Vol I & Vol II.
5. Documentation Practices: A Complete Guide to Document Development and Management of GMP and ISO 9000 Compliant Industries (Carol DeSain**)**
6. Current Good Manufacturing Practices: Pharmaceutical, Biologics, and Medical Device Regulations and Guidance Documents (Mindy J. Allport-Settle, 2nd Ed)

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SEMESTER –I I

*Paper-X (BITO*456X9)

(2 Credits, 25 marks)
(20 Hours)

Field/ Industry Visit (*Practical*)

Course Objectives (COBs):

- To provide exposure to industrial/research laboratory practices in microbiology and biotechnology.
- To bridge the gap between theoretical classroom learning and real-world applications.
- To develop professional skills in documentation, teamwork, and technical communication.

Course Outcomes (COs): By the end of this course, students will be able to:

- Students will gain first-hand understanding of industrial processes, laboratory protocols, and organizational workflow.
- Ability to maintain records, prepare detailed reports, and present observations effectively.
- Students will acquire practical experience and professional confidence for future research or industry careers.

Course Contents:

1. **Visit to Industry:** Students will compulsorily participate in educational tour to Microbiology/Biotechnology based Industries conducted by the department and will submit a tour report separately.

2. **Internship:** Students will experience the real-world working experience in industries/research laboratories/ hospitals/ food and dairy units/agricultural organizations/environmental monitoring facilities for 10 days. Students have to maintain a logbook, recording their daily activities and observations. At the end of the training, they must submit a comprehensive report and present their findings through a seminar/viva-voce. Evaluation will be based on performance at the host institution, quality of documentation, report writing, and oral presentation.

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SEMESTER – III

*Paper-I (*BITC501X1*)*

(2 Credits, EA:20 +IA :5)
(20 Hours)

Plant Biotechnology (*Theory*)

Course Objectives (COBs):

- To learn advanced plant tissue culture techniques, evaluating methods for micropropagation, protoplast engineering, haploid production and *in vitro* germplasm conservation.
- To understand plant transformation technology, focusing on *Agrobacterium*-mediated transfer, binary vector design, promoter choices, and organelle-specific genetic integration.
- To analyse genetic engineering strategies for crop improvement, assessing molecular pathways used to introduce resistance to biotic pathogens, abiotic stressors, and herbicides, while optimizing post-harvest attributes.
- To evaluate metabolic engineering and molecular farming systems, exploring the synthesis of secondary metabolites, therapeutic proteins, edible vaccines, and the ethical-regulatory implications of Genetically Modified (GM) crops**.**

Course Outcomes (COs): By the end of this course, students will be able to:

- Apply cellular totipotency principles to establish, maintain, and differentiate callus, suspension cultures, and somatic embryos.
- Design practical protocols for clonal propagation, embryo rescue, virus elimination, and long-term germplasm conservation using cryopreservation.
- Compare the mechanics, integration efficiency, and expression control of *Agrobacterium*-mediated transformation against direct nuclear and plastid transformation methods.
- Appraise the molecular mechanisms used to engineer biotic resistance in crops, including *Bacillus thuringiensis* endotoxins, protease inhibitors, and anti-viral pathways.
- Formulate genetic strategies to modify complex biochemical plant pathways, including starch biosynthesis, lipid profiles, flower pigment expression, and fruit ripening shelf-life.
- Critique the ecological, ethical, and biosecurity risks associated with commercializing GM crops, molecular farming, plantibodies, and oral biopharmaceuticals.

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Course Contents:

Unit I: Cell and tissue culture: Tissue culture media, totipotency of plant cells, Micropropagation, isolation and Maintenance of Callus and suspension cultures; organogenesis and somatic embryogenesis; shoot tip culture, clonal propagation, soma clonal variations and applications of regenerated plant, production of Virus free plants; Embryo rescue; Protoplast isolation, culture & fusion; Production of haploids, hairy root culture. (5H)

Unit II: *Germplasm conservation:* Cryopreservation, DNA banks, gene banks and germplasm conservation. (2H)

Unit III: *Plant transformation technology:* Transformation of plant systems using various methods - *Agrobacterium* mediated gene transfer; Binary vector, co-integrate vector; use of 35S and other Promoters, Reporter genes, Multiple gene transfer, methods of nuclear and organelle transformation. (4H)

Unit IV: *Application of Biotechnology in Plant improvement:* Improvement of photosynthetic efficiency of plants; Concepts of transgenic plants - Developing virus resistant plants, Fungal resistant transgenics, resistant to bacterial pathogens; Resistance to insects (endotoxin gene of *Bacillus thuringensis*), Protease inhibitors and Baculo-viruses; Herbicide resistance; improvement of quality of seed storage Proteins; Manipulation of starch biosynthesis; Genetic engineering of plant oils; post-harvest biotechnology - genetic engineering for extended shelf-life of fruits, genetic manipulation of flower Pigmentation; Development of male sterility; Development of stress – tolerant plants – regulation of gene expression under stress condition; Gene silencing and antisense technology. (6H)

Unit V: *Plants as producers of specialty chemicals:* Molecular farming-benefits and risks, ethical issues related to G.M. crop; Plantibodies, edible vaccines, edible interferons, Production of secondary metabolites using *in vitro* grown cells and tissues (3H)

Reference Books:

1. Chrispeels M.J.et al. Plants, Genes and Agriculture-Jones and Bartlett Publishers, Boston.1994.
2. Gamborg O.L. and Philips G.C.Plant cell, tissue and organ culture (2nd Ed.) Narosa Publishing House. New Delhi.1998
3. Hammound J, P McGravey & Yusibov.V. Plant Biotechnology, Springer verlag.2000
4. Heldt. Plant Biochemistry and Molecular Biology. Oxford and IBH Publishing Co. Pvt.Ltd. Delhi. 1997
5. Lydiane Kyte and John Kleyn. Plants from test tubes. An introduction to Micropropagation (3rd Ed.). Timber Press, Portland. 1996
6. Murray D.R. Advanced methods in plant breeding and biotechnology. Panima Publishing Corporation.1996
7. Nickoloff J.A.Methods in molecular biology, Plant cell electroporation and electrofusion protocols-Humana press incorp, USA. 1995.
8. Sawahel W.A. Plant genetic transformation technology. Daya Publishing House, Delhi.1997
9. Gistou, P and Klu, H.Hand book of Plant Biotechnology (Vol. I & II). John Publication.2004

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10. Slatu A et al.The genetic manipulation of plant. Oxford University Press.2003
11. Kirakosyan A and Kaufman P.B.Recent Advances in Plant Biotechnology (1st Ed.).Springer Publishers.2009
12. Halford N.G. Plant biotechnology: current and future applications of genetically modified crops. John Wiely Publishers.2006

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SEMESTER – III

*Paper-II (*BITC501X8*)*

(2 Credits, 25 Marks)
(20 Hours)

Plant Biotechnology (*Practical*)

Course Objectives (COBs):

- To understand aseptic setup and culture establishment, executing precision chemical media preparation, tissue surface sterilization, and target tissue isolation.
- To execute advanced plant micropropagation and morphogenesis workflows, manipulating culture environments to induce organogenesis, callus development, anther differentiation, and xylogenesis.
- To apply horticultural grafting and acclimatization practices, managing field survival transitions through specific greenhouse hardening steps and rose grafting.
- To implement genetic transformation methodologies, utilizing *Agrobacterium*-mediated protocols to deliver exogenous genes into host plant tissues.

Course Outcomes (COs): By the end of this laboratory course, students will be able to:

- Formulate and autoclave tissue culture growth media containing precise micro/macro-nutrient and plant growth regulator ratios. Perform chemical surface sterilization protocols on wild, field-grown tissues to successfully initiate aseptic explant cultures.
- Execute multi-stage plant micropropagation, callus induction, and pollen/anther culture techniques for haploid production under sterile laminar flow environments. Analyse cellular differentiation during xylogenesis.
- Conduct successful horizontal or vertical structural tissue grafting techniques specifically tailored for commercial rose propagation.
- Manage the physiological transition of delicate, agar-grown plantlets to greenhouse conditions through systematic soil hardening protocols.
- Demonstrate *Agrobacterium*-mediated transformation by infecting target explants and tracking transient or stable transgene expression indicators.

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Course Contents:

- Preparation of media.
- Grafting in rose plant.
- Surface sterilization of field grown tissues.
- Micropropagation technique.
- Anther, pollen and ovule culture.
- Callus induction, callus and cell suspension culture.
- Study of xylogenesis.
- Hardening of tissue culture generated plants.
- Agrobacterium mediated transformation.

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SEMESTER – III

*Paper-III (*BITC502X1*)*

(2 Credits, EA:20 +IA :5)
(20 Hours)

Animal Biotechnology (*Theory*)

Course Objectives (COBs):

- To learn foundational animal cell culture techniques, including cell line maintenance, characterization, scale-up methods, and cryopreservation protocols.
- Evaluate tissue engineering applications, focusing on 3D cultures, artificial organ design, and the industrial production of therapeutics like vaccines and stem cells.
- Understand mammalian reproductive technologies, covering gametogenesis, the mechanics of *In Vitro Fertilization* (IVF), and Assisted Reproductive Technologies (ART).
- Analyse transgenic technologies, emphasizing gene transfer methods, the development of knockout models, and their ethical and clinical implications

Course Outcomes (COs): By the end of this course, students will be able to:

- Demonstrate proficiency in establishing primary and secondary cell cultures using appropriate media and sterile environments, apply scaling-up and cell synchronization methods to optimize cell biomass production for industrial applications.
- Appraise the utility of stem cells and 3-D tissue engineering matrices in clinical research and drug toxicology screening.
- Outline the physiological and medical steps required for successful ovary stimulation, oocyte retrieval, and embryo transfer in humans and cattle.
- Compare different gene transfer vectors and tools (such as microinjection and electroporation) used to create transgenic animals.

Course Contents:

Unit I: History, basic requirements, cell culture media and reagents, animal cell culture methods, primary culture, secondary culture, suspension cultures, cell lines, continuous cell lines. Cryopreservation and retrieval of cell lines, Characterization of cultured cells, Scaling up of animal cell culture. Cell synchronization. Cell transformation. (5H)

Unit II: tissue engineering (3-D culture, artificial skin and artificial cartilage), Cell culture-based products (vaccines, tPA, blood factor VIII, Erythropoietin etc.), *in vitro* testing of drugs, production of pharmaceutical proteins, stem cells and their application in Research and Industry. (5H)

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Unit III: *In vitro* fertilization (IVF), Sexing of sperms and embryos, spermatogenesis and oogenesis, infertilities in human male and female, Ovary stimulation, Oocyte recovery and uptake, Sperm preparation, IVF and embryo transfer, assisted reproductive technology (ART), IVF in cattle, embryo splitting. (5H)

Unit IV: Transgenic animals, Techniques of gene transfer (Microinjection, lipofection, electroporation, chemical-based transformation, and viral vectors), Targeted gene transfer, Applications of transgenic animal technology, Knockout mice. (5H)

Reference Books:

1. Watson J.D.et al. Molecular Biology of Gene (6th Ed.) Publisher Benjamin Cummings. Pub. Co. Inc. USA. 2008.
2. Glick, B.R. and Pasternak J.J. Molecular Biotechnology. ASM Press, Washington DC.2003.
3. Jenni, P, Mather and David Barnes, Methods in Cell Biology (Vol 57) Academic Press.2001
4. Shantharam, D., Jane F Montgomery. Biotechnology, Biosafety & Biodiversity: Scientific & Ethical issues for Sustainable development. 1999
5. Ian Freshney. R. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (6th Ed.) Wiley & Sons. 2010
6. John Davis., Animal Cell Culture: Essential Methods (1st Ed.) Wiley-Blackwell and Sons publisher. 2011

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SEMESTER – III

*Paper-IV (*BITC502X8*)*

(2 Credits, 25 Marks)
(20 Hours)

Animal Biotechnology (*Practical*)

Course Objectives (COBs):

- To master basic and advanced aseptic handling techniques required for maintaining, preparing, and engineering animal cell cultures in vitro. Comprehend the viability indices, and cell-density quantification rules.
- To acquire practical proficiency in isolating specialized cell lineages (lymphocytes) and primary embryonic tissues using gradient and enzymatic dissociation pathways.
- To evaluate developmental milestones and structural organogenesis in vertebrate models using chronological avian embryo mapping techniques.
- To understand artificial breeding technologies and assisted reproductive frameworks utilized in commercial aquaculture and biomedical sciences**.**

Course Outcomes (COs): By the end of this course, students will be able to:

- Identify and classify distinct animal cell structures, organelles, and mitotic phases using tissue-specific fixatives and staining procedures.
- Formulate, sterile-filter, and optimize synthetic animal cell culture media containing correct physiological balances of nutrients, buffers, and sera. Quantify total cell density and viability index via dye-exclusion assays using a hemocytometer to evaluate population health.
- Execute density-gradient isolation protocols to harvest pure lymphocyte populations safely from peripheral blood samples. Isolate and propagate primary cell cultures from avian models utilizing standardized workflows.
- Map and stage the morphological development of chick embryos chronologically according to Hamburger-Hamilton metrics.
- Demonstrate hormonal hypophysation procedures to artificially trigger spawning and captive breeding cycles in fish species.
- Evaluate the physiological steps of in-vitro gamete preparation, co-incubation, and fertilization success in simulated reproductive setups**.**

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Course Contents:

1. Cytological studies of animal cells
2. Preparation of animal cell culture media.
3. Isolation and culture of Lymphocytes.
4. Cell viability study and counting
5. Preparation of Primary culture from chick embryo
6. Development study of chick embryo
7. Hypophysation of Fish
8. Demonstration of IVF.

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SEMESTER – III

*Paper-V (*BITC503X1*)*

(2 Credits, EA:20 +IA :5)
(20 Hours)

Virology and Oncology (*Theory*)

Course Objectives (COBs):

- To master viral architecture and genetics, focusing on the replication strategies, lifecycles, and genetic regulation of diverse bacteriophages, plant viruses, and animal viruses.
- To deconstruct the molecular basis of cancer, exploring cellular transformation, proto-oncogene activation, tumour suppressor networks, and intracellular signalling pathways.
- To analyse the mechanisms of tumour progression, including the processes of apoptosis evasion, angiogenesis, invasion, metastasis, and the role of the microbiome.
- To evaluate modern oncology therapies, assessing the physiological mechanisms, clinical advantages, and limitations of chemotherapy, radiation, and immunotherapy.

Course Outcomes (COs): By the end of this course, students will be able to:

- Differentiate between the structural properties and replication cycles of major bacterial, plant, and animal viruses (including HIV, Hepatitis-B, and Influenza). Explain the genetic switch between the lytic and lysogenic pathways in bacteriophage lambda at a molecular level.
- Distinguish between benign and malignant tumours based on cellular morphology, tissue organization, and growth characteristics. Map the signal transduction pathways of growth factors and transcription factors that drive uncontrolled cell proliferation.
- Detail the biochemical steps of apoptosis, including the caspase cascade and death signalling pathways.
- Compare the mechanism of action, efficacy, and side effects of current cancer treatment modalities.

Course Contents:

Unit I: Virus: Morphology, ultrastructure and genetic system of Bacteriophages (lambda, T4, T7, M13), plant viruses, (TMV, Potato virus X and Y, CaMV, CMV, TYMV), Animal viruses (vaccinia, adeno, hepatitis-B, Influenza, HIV), lytic cycle, lysogeny, Viral Replication, Retroviral replication and integration, Fine structure gene expression in phase lambda: Early transcription events, Molecular basis of Lytic and Lysogenic pathways. Site specific recombination in bacteriophage lambda. (8H)

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Unit II: Basic characteristics of cancer cells, Hyperplasia, dysplasia, anaplasia and neoplasia, characteristics of benign and malignant tumors. Carcinogenesis: Radiation and chemical carcinogenesis and their mechanism, Role of free radicals, and antioxidants in cancer. (3H)

Unit III: Cellular proto-oncogenes and their activation mechanism, Tumor suppressor genes p53, p21, Rb, BRACA1 and BRACA2, telomeres, telomerase and immortality, Invasion and metastasis, VEGF signaling and angiogenesis, Growth factors (EGF, TNF, TGF) and growth factor receptors, signal transduction in cancer, and the mechanism of transcription factors. (6H)

Unit IV: Role of microbiomes in cancer, Epigenetics and cancer, Apoptosis detailed mechanism and the role of caspases. Death signaling pathways, different forms of cancer therapy (Chemotherapy, radiation therapy, immunotherapy) and their brief mechanism, advantages, and limitations. (3H)

Reference Books:

1. Kumar, D.U. An Introduction to Epigenetics of Cancer. 2025. 1st ed. B P Internation.
2. Kalkan, R. Cancer Epigenetics. 2024. 1st ed. Springer Cham.
3. Gray, S.G. Epigenetic Cancer Therapy. 2023. 2nd ed. Academic Press.
4. Qazi, A.S., Tariq, K. Therapeutic Approaches in Cancer Treatment. 2023. 1st ed. Springer Cham.
5. Tollefsbol, T.O. Cancer Epigenetics. 2019. 1st ed. CRC Press.
6. Sarkar, F.H. Epigenetics and Cancer. 2013. 1st ed. Springer Dordrecht.

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Vidyasagar University
Syllabus of M.Sc. Course in Biotechnology
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SEMESTER – III

*Paper-VI (*BITC503X8*)*

(2 Credits, 25 Marks)
(20 Hours)

Microbiology (*Practical*)

Course Objectives (COBs):

- To understand fundamental and structural staining methodologies, utilizing simple, differential, endospore, and capsule protocols to characterize bacterial morphology.
- To execute isolation, quantification, and growth tracking, mastering serial dilution frameworks to isolate environmental samples and construct bacterial growth kinetics.
- To perform standardized biochemical profiling, evaluating metabolic phenotypes and enzymatic pathways via IMViC tests, substrate hydrolysis, and intracellular enzyme assays.
- To apply medical and ecological microbiology principles, implementing standardized antibiotic susceptibility screening alongside biological environmental testing protocols

Course Outcomes (COs): By the end of this laboratory course, students will be able to:

- Perform slide-based microscopic preparations including simple, Gram, endospore, and negative capsule staining to determine cell structural properties.
- Quantify viable bacterial populations from heterogeneous air and soil samples using pure culture serial dilution and colony-counting methods.
- Construct and interpret a bacterial growth curve by tracking culture optical density over time to determine generation time.
- Determine antibiotic susceptibility profiles and Minimum Inhibitory Concentrations (MIC) using standardized agar cup diffusion and serial dilution assays.
- Analyse bacterial metabolic capabilities by executing and scoring the IMViC series, starch/gelatine hydrolysis, and cellular enzyme assays (catalase, oxidase, lipase, protease).
- Isolate fastidious symbiotic nitrogen-fixing *Rhizobium* bacteria directly from localized leguminous root nodules.
- Evaluate water safety compliance by setting up and evaluating presumptive coliform tests and rapid H_2S strip tests

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Course Contents:

1. Staining technique **i)** simple staining **ii)** differential staining **iii)** endospore staining **iv)** capsule staining
2. Pure culture method – Enumerate the number of bacteria from air and soil.
3. Preparation of bacterial growth curve
4. Assay of antibiotics by agar cup method and dilution method
5. Biochemical tests **i)** Indole tests **ii)** Methyl red test **iii)** Voges Proskauer tests **iv)** Starch hydrolysis tests **v)** Tests for catalase, lipase, protease, amylase and oxidase **vi)** Gelatin hydrolysis test **vii)** Citrate Utilization Test.
6. Isolation of *Rhizobium* from legume root nodule
7. Water microbiology – Testing for quality of water (coliform test), H_2S strip test.

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SEMESTER – III

*Paper-VII (*BITC504X0*)*

(4 Credits, EA:40 +IA :10)
(40 Hours)

Analytical Instrumentation (Theory)

Course Objectives (COBs):

- To impart core knowledge regarding radioactivity, spectroscopy, thermal analysis, and separation techniques used in biological and pharmaceutical research.
- To explain the principles of advanced structural determination techniques, including X-ray crystallography, NMR, and electron microscopy.
- To familiarize students with the operations and applications of modern chromatographic and electrophoretic instrumentation.
- To illustrate how physical and chemical methodologies are applied to solve complex problems in biological systems and pharmaceutical analysis.

Course Outcomes (COs):

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

- Apply radiochemical concepts to design safety-compliant experiments involving radioisotopes in biological systems and Evaluate Thermal and Electrochemical Data from TGA, DTA, and DSC curves to quantify chemical and pharmaceutical compounds.
- Analyse spectroscopic profiles to characterize molecular structures and electronic properties and elucidate protein structures using X-ray crystallography and NMR spectroscopy to determine the three-dimensional structures of proteins and macromolecules.
- Optimize chromatographic systems to effectively isolate, identify, and quantify complex biomolecules and drugs and Execute Macromolecular Separations to separate nucleic acids and proteins based on size, charge, or isoelectric point.
- Utilize Advanced Imaging and Cytometry to analyse cellular populations.

Course Contents:

Unit I: Isotopes and radioactivity: Radioactivity, autoradiography, G.M. Counter, scintillation counter, use of radioisotopes in biological system. (5 Hrs.)

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Unit II: Thermal and Electroanalytical Methods: Thermogravimetry (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC), potentiometry, and voltammetry. Basic Understanding of Chemical and Pharmaceutical analysis (6 Hrs.)

Unit III: Spectroscopy: Ultraviolet and visible adsorption spectroscopy, Infrared spectroscopy, Raman spectroscopy, Resonance Raman spectroscopy, Circular Dichroism (CD) spectroscopy. (6 Hrs.)

Unit IV: Determination of structure of proteins: X-ray Crystallography, Nuclear Magnetic Resonance method. (5 Hrs.)

Unit V: Electrophoresis: PAGE and Agarose Gel Electrophoresis, Pulsed Field Electrophoresis, Isoelectric focusing, capillary Gel electrophoresis. (6 Hrs.)

Unit VI: Chromatography: Paper chromatography, Thin-layer chromatograph, Ion exchange chromatography, Affinity chromatography. HPLC, GC-MS and LC-MS (6 Hrs.)

Unit VII: Electron microscopy: Freezing, sample preparation, Imaging, Low dose of electrons methods used in cryo-microscopy, confocal microscopy, Flow cytometry (6 Hrs.)

Reference Books:

1. Inorganic quantitative analysis by Vogel.
2. Practical HPLC analysis by Veronica Meyer
3. Instrumental methods of Analysis by Skoog, Holler and Nieman.
4. Devlin, T.M. (1997). Biochemistry with clinical correlations, Wiley-Liss Inc. NY
5. Chromatography: Concepts and Contrasts by James M. Miller.
6. Basic Principles of Chromatography and HPLC by Arunadevi S. Birajdar.
7. Electron Microscopy by Bozzella and Russell.
8. Principles and Techniques of Biochemistry and Molecular Biology. 2018. 8th ed. Cambridge Univ. Press. By Hofmann, A., Clokie S. Wilson & Walker's
9. Physical biochemistry: applications to biochemistry and molecular biology *2nd ed.* David Friefilder

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SEMESTER – III

Paper-VIII (BITO505X0)

(4 Credits, EA:40 +IA :10)
(40 Hours)

MOOCS (Theory)

Course Objectives (COBs):

- To provide global, barrier-free access to high-quality higher education without strict entry prerequisites.
- To cover foundational theories, advanced concepts, or specialized industry skills within a compact timeline (typically 4 credits and 12 weeks).
- To design a self-paced, asynchronous learning environment supported by multi-modal resources like e-tutorials and e-content.
- To offer collaborative learning windows via centralized peer discussion forums and crowdsourced problem-solving.
- To implement automated testing matrices (such as quizzes and peer-reviewed metrics) capable of grading thousands of students simultaneously.

Course Outcomes (COs): Upon successful completion of this course, students will be able to:

- Engage in Continuous Self-Learning, demonstrate advanced self-regulation, time management and independent digital research capabilities.
- Earn Professional/Academic Credentials and secure valid certificates, professional badges, or transferable academic credits to boost career profiles or university transcripts.

Course Contents:

Students have to register and select a Massive Open Online Courses (MOOCs) from SWAYAM platform of their choice. They have to complete the course and submit the assignment/quizzes given to them in order to sit in the end semester examination.

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SEMESTER – III

*Paper-VII (*BITO505X9*)*

(2 Credits, (EA:25)
(20 Hours)

*(*Social Service/Community Engagement (Practical)

Course Objectives (COBs):

- To cultivate deep civic awareness, exploring the socio-economic, environmental, and structural factors that impact marginalized or underserved populations.
- To develop community-based intervention strategies, learning how to conduct grass-roots needs assessments and build sustainable project models alongside local stakeholders.
- To apply academic learning to real-world challenges, utilizing multidisciplinary problem-solving skills to address community-identified priorities.]
- To foster personal and professional leadership traits, building cross-cultural communication, emotional intelligence, teamwork, and ethical reflective practices.

Course Outcomes (COs): By the end of this course, students will be able to:

- Analyse complex social issues (such as literacy, public health, or environmental distress) by evaluating localized socioeconomic and systemic data.
- Collaborate effectively with non-governmental organizations (NGOs), local government bodies, and diverse community members to execute service initiatives.
- Evaluate the legal, ethical, and environmental sustainability impacts of public welfare and community development programs.
- Refine personal civic values and career goals through systematic, structured reflections on fieldwork experiences and community interactions.

Course Contents:

Students will serve the society in any form (by spreading social awareness on microbial diseases / water quality testing and hygiene/fermented food/ Soil Health and organic Farming Awareness/School Science outreach programme/ Nutrition and Anemia Screening) and will prepare a detailed report and submit during semester examination. Evaluation will be based on both the assigned report and presentation.

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SEMESTER – IV

*Paper-I (*BITC551X1*)*

(2 Credits, EA:20 +IA :05)
(20 Hours)

Nanobiotechnology (Theory)

Course Objectives (COBs):

- To master the core fundamentals of nanotechnology, analysing dimensional classifications, quantum structures, and diverse organic, inorganic, and carbon-based nanomaterials.
- To evaluate synthesis and characterization methodologies, contrasting top-down and bottom-up engineering approaches with a heavy emphasis on sustainable green synthesis.
- To assess the environmental and physiological impacts of nanoparticles, studying industrial wastewater detoxification, agricultural nano-fertilizers, and mechanisms of biological toxicity.
- To analyse advanced nanomedicine systems, focusing on targeted intracellular drug delivery vehicles, diagnostic application.

Course Outcomes (COs): By the end of this course, students will be able to:

- Classify nanomaterials based on their dimensions and molecular compositions. Contrast the physical, chemical, and biological mechanisms used to engineer nanoparticles, identifying the precise advantages of green chemistry.
- Interpret raw analytical data from material characterization tools including XRD, SEM, TEM, and FTIR spectroscopy to evaluate nanoparticle morphology.
- Appraise the ecological potential of nanoparticles for organic dye degradation, agricultural enrichment, and heavy metal remediation in wastewater.
- Formulate a conceptual framework for utilizing liposomes, dendrimers, and gold nanoshells as functional vehicles for site-specific drug and gene delivery.

Course Contents:

Unit I: Introduction to nanotechnology. historical perspectives, characteristic, classification by dimension and composition, development of quantum structures - quantum well, quantum wire and quantum dot. Basic concept of nanoclusters, Solid solutions, thin film, Nanocomposites (Metal Oxide and Polymer based), Core Shell Nanostructure, Buckyballs, Carbon nano tubes, Zeolites minerals, Dendrimers, Micelles, Liposomes, Block Copolymers, Porous Materials, Metal Nanocrystals, Semiconductor nanomaterials, emergence of bio nanotechnology. [6H]

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Unit II: Synthesis of nanoparticles, 'Top-Down' and 'Bottom-Up' approaches, physical, chemical, and biological approach of nanoparticle synthesis, limitations and advantages of physical, chemical and green synthesis approach. Characterization of nanoparticles, UV spectrophotometer, XRD, SEM, TEM, HR-TEM, FTIR and dynamic light scattering, etc. [5H]

Unit III: Applications of nanoparticles, antimicrobial activity, cytotoxicity of nanomaterials, phytotoxicity of nanoparticles. antioxidant activity, anticancer activity, anti-inflammatory activity, dye degrading potential, nano fertilizers, application of nanoparticles in the treatment of Industrial wastewater, and pollution control. [5H]

Unit IV: Nanomedicine, Drug delivery, gene delivery, protein delivery, and uptake, Microbial synthesis of nano drugs, metal nano particles and drug delivery vehicles, diagnostic applications of nanotechnology, [4H]

Reference Books:

1. Jeremy Ramsden, Essentials of Nanotechnology, Ventus Publishing ApS, 2014
2. Nanotechnology: A Gentle Introduction to the Next Big Idea, by Mark A. Ratner and Daniel Ratner.
3. Introduction to Nanoscience by Gabor L Hornyak, Joydeep Dutta and H. F. Tebbals.
4. Nanomaterials: An Introduction to Synthesis, Properties and Applications by Thomas Varghese and K. M. Balakrishna.
5. Nano Comes to Life: how nanotechnology is transforming Medicine and the future of Biology by Sonia Contera.

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SEMESTER – IV

*Paper-II (*BITC551X8*)*

(2 Credits, EA:25 Marks)
(20 Hours)

Nanobiotechnology (Practical)

Course Objectives (COBs):

- Understand the fundamentals of eco-friendly, green, and microbial synthesis pathways for nanomaterials using biological extracts.
- Master the laboratory protocols for extracting phytochemicals and utilizing them as reducing and capping agents.
- Acquire skills in utilizing analytical instruments to characterize the structural and morphological properties of nanoparticles.
- Evaluate the therapeutic potential of synthesized nanomaterials through antioxidant and antimicrobial bioassays.
- Assess the ecological safety and cellular biocompatibility of nanomaterials using in vitro screening models.

Course Outcomes (COs): Upon successful completion of this course, students will be able to:

- Isolate bioactive phytochemicals from plant matrices using optimized extraction methods and execute the green synthesis of metallic or metal-oxide nanoparticles by optimizing reaction parameters like pH and temperature.
- Demonstrate how to use microorganisms and their extracts as biological factories for scaling up nanoparticle production.
- Analyse the optical properties of nanoparticles using UV-Visible Spectroscopy and interpret functional groups, surface coating and chemical bonding interactions using FTIR,
- Quantify the free-radical scavenging capacity of nanoparticles using standard antioxidant assays (e.g., DPPH or ABTS).
- Determine the minimum inhibitory concentration (MIC) and zones of inhibition against pathogenic strains.
- Appraise the phytotoxic impact of nanomaterials on seed germination and seedling growth metrics and measure cellular safety by executing an Erythrocyte Haemolysis Assay to calculate percentage haemolysis and verify biocompatibility.

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Course Contents:

1. Preparation of plant extract for nanoparticle synthesis
2. Green synthesis of nanoparticles using plant extract.
3. Microbial Biosynthesis of nanoparticles.
4. Characterization of nanoparticles using UV- Spectrophotometer and FTIR.
5. Evaluation of the antioxidant activity of nanoparticles.
6. Evaluation of the antimicrobial activity of nanoparticles.
7. In Vitro Phytotoxicity Studies of synthesized nanomaterials
8. In Vitro Biocompatibility Assessment (Erythrocyte Hemolysis Assay) of synthesized nanomaterials

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SEMESTER – IV

*Paper-III (*BITC552X0*)*

(2 Credits, EA:20 +IA : 05)
(20 Hours)

Genomics and Proteomics (Theory)

Course Objectives (COBs):

- To master eukaryotic gene organization and mapping techniques, exploring gene families, genomic paradoxes, and diverse polymorphic DNA fingerprinting markers.
- To evaluate modern sequencing and genomics workflows, contrasting Sanger sequencing with Next-Generation Sequencing (NGS) alongside gene isolation, identification, and functional annotation.
- To analyse the strategies and technologies of proteomics, studying advanced protein separation, high-resolution mass spectrometry, and real-time kinetic tracking methods.
- To deconstruct macromolecular interaction networks, evaluating experimental techniques to detect DNA-protein and protein-protein interactions for clinical and biomedical diagnostics.

Course Outcomes (COs): By the end of this course, students will be able to:

- Explain the genetic implications of the C-value paradox, gene clusters, and multigene families across different living systems.
- Select appropriate molecular markers (such as SNPs, STRs, RAPD, or AFLP) for specific applications in DNA fingerprinting, barcoding, and genetic mapping.
- Outline the complete pipeline for structural and functional genomic analysis, from genomic DNA isolation to functional gene annotation and microarray analysis.
- Compare the throughput, chemical mechanisms, and data outputs of Sanger sequencing with Next-Generation Sequencing (NGS) technologies.
- Interpret protein profiles and structural configurations using 2D gel electrophoresis, MALDI-TOF mass spectrometry, and Surface Plasmon Resonance (SPR).
- Design experimental assays (such as yeast two-hybrid, ChIP, or protein chips) to map intracellular protein-protein and DNA-protein interaction networks.

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Course Contents:

Unit I: Organization of genes across living systems, gene content and C value paradox – gene cluster and gene families. restriction mapping, chromosome walking and chromosomal localization of genes, DNA Fingerprinting - RAPD, ISSR, DArT, SNP, STR, AFLP, c-DNA AFLP, RFLP, SNP expressed sequenced Tags (ESTs), DNA barcoding, Microarray, Concept of structural and functional genomics -isolation, identification and function annotation of a gene. [5H]

Unit II: Concept of structural and functional genomics -isolation, identification and function annotation of a gene. Methods of preparing genomic DNA, DNA sequence analysis methods, Sanger Di deoxy method, next generation sequencing, Gene disease association, fungal genome and genomics. PCR based Analysis. [5H]

Unit III: Proteomics: Aims, strategies and challenges in proteomics, structural and functional proteomics. Proteomics technologies: Protein sequencing techniques, 2D gel electrophoresis, MALDI-TOF, Surface Plasmon resonance (SPR), and mass spectrometry. [5H]

Unit IV: DNA-protein interactions: DNA binding motif, and methods for detecting DNA-protein interactions, protein motifs and domains, methods for protein-protein interactions detection, protein chips, clinical and biomedical applications of proteomics. [5H]

Reference Books:

1. Rastogi, S.C., Rastogi, P., Mendiratta, N. Bioinformatics Methods and Applications: Genomics, Proteomics and Drug Discovery. 2022. 5th ed. PHI.
2. Rudolph, M. Genomics and Proteomics: Functional and Computational Aspects. 2019. 1st ed. Syrawood Publishing House.
3. Keerthi Kumar, S., Mathivanan, S. Proteome Bioinformatics. 2017. 1st ed. Springer, Humana, New Yark.
4. Kussmann, M., Stover, P.J. Nutrigenomics and Proteomics in Health and Disease. 2017. 2nd ed. John Wiley & Sons Ltd.
5. Campbell, A.M., Heyer, L.J. Discovering Genomics, Proteomics, and Bioinformatics. 2007. 2nd ed. San Francisco, CSHL Pearso/Benjamin Cummings.

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SEMESTER – IV

*Paper-IV (*BITC553X9*)*

(2 Credits, EA: 25 Marks)
(20 Hours)

Grand Viva (Practical)

Course Objectives (COBs):

- To evaluate the comprehensive understanding of concepts, techniques, and applications covered across the two-year programme.
- To assess the students' ability to integrate theoretical knowledge with experimental/practical skills in microbiology and biotechnology.
- To develop confidence in scientific communication, critical reasoning, and problem-solving through expert interaction.

Course Outcomes (COs): By the end of this course, students will be able to:

- Students will demonstrate holistic knowledge of core and advanced topics in microbiology, biotechnology, and related interdisciplinary fields.
- Students will gain the ability to critically analyse, interpret, and apply concepts to real-world biological and industrial challenges.
- Students will enhance their oral presentation, defence, and discussion skills before an expert panel, preparing them for research, industry, or higher studies.

Course Contents:

Students will be evaluated on all the topics discussed in the two years programme by a panel of experts both external and internal.

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SEMESTER – IV

*Paper-V (*BITC554X9*)*

(8 Credits, EA: 80, IA: 20)
(20 Hours)

Research Project and Dissertation (Practical)

Course Objectives (COBs):

- To provide students with hands-on training in independent research methodology, experimental design, and data analysis.
- To encourage critical thinking, creativity, and problem-solving in addressing research questions in microbiology/biotechnology.
- To develop scientific writing and presentation skills through dissertation preparation and defence before experts.

Course Outcomes (COs): By the end of this course, students will be able to:

- Conduct independent laboratory research, analyse results, and draw meaningful scientific conclusions.
- Produce a dissertation report demonstrating clarity, scientific rigor, and adherence to academic standards.
- Communicate their research findings through oral presentations and defend them before an expert panel.

Course Contents:

Three months duration research work to be done at any laboratory. The outcome of the work is to be presented during end-term examination with submitting a project dissertation write up duly certified by the host institute and supervisor. A presentation of the accomplishments will be required before a panel of experts. Evaluation will be based on both the project report and presentation.

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SEMESTER – IV

*Paper-VI (*BITC555X9*)*

(4 Credits, EA: 40 , IA : 10)
(20 Hours)

Internship/Applied field or Industry Project/ Entrepreneurship (Practical)

Course Objectives (COBs):

- To familiarize students with the structure, requirements, and standards of national grant proposal formats.
- To develop skills in formulating innovative, feasible, and impactful research/start-up ideas in biological sciences.
- To train students in professional scientific communication, budgeting, and proposal defence before experts.

Course Outcomes (COs): By the end of this course, students will be able to:

- Design a structured and well-justified research/start-up proposal with clear objectives and methodology.
- Demonstrate the ability to prepare project timelines, budget plans, and address feasibility issues.
- Effectively defend their proposal through critical discussion, demonstrating confidence, clarity, and depth of subject knowledge.

Course Contents:

A grant proposal on any relevant topic in biology will have to be prepared by students following the format of DST/DBT/ICMR, India. The students will also be required to defend the proposal before a panel of experts. Both the written proposal and its defence will be taken into consideration for evaluation

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SEMESTER – IV

*Paper-IV (*BITC556X0*)*

(2 Credits, EA: 20, IA: 05)
(20 Hours)

Intellectual Property Right and Bio-Entrepreneurship (Theory)

Course Objectives (COBs):

- To provide basic knowledge on intellectual property rights and their implications in biological research and product development
- To become familiar with India's IPR Policy
- To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products

Course Outcomes (COs): By the end of this course, students will be able to:

- Understand the rationale for and against IPR and especially patents.
- Understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations.
- Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents.

Course Contents:

Unit-I: Intellectual property (IP): Introduction, history and evolution of patent laws. Types of IP: Patents, trademarks, copyright & related rights, Idea-expression dichotomy, industrial design, traditional knowledge, geographical indications, significance of IPR. (5H)

Unit- II: International conventions and treaties: History of GATT & TRIPS agreement, World trade organization, post TRIPS scenario, Madrid agreement, Hague agreement, Budapest treaty, patent cooperation treaty, Indian patent act 1970 & recent amendments, India's IPR policy, and World intellectual property organization (WIPO). (5H)

Unit- III: Discovery vs invention: A concept of 'prior art', invention in context of 'prior art', introduction & classifications of patents, and patentability criteria. Diamond vs Chakraborty case study, IP as a factor in R&D, legal and IPR issues in biotechnology, licensing and compulsory licensing, patent infringement and legal action. (5H)

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Unit-IV: Concept of entrepreneurship: Introduction and scope in bio-entrepreneurship, risk and benefits, general idea about bio-sector firms and commercialization of a biotechnological pharmaceutical product, introduction to the entrepreneurship development programs (MSME, DBT, BIRAC, and Make in India), incubation center, and start-up India. (5H)

Recommended Books:

1. Gurnani, S.R. Intellectual Property Rights. 2024. 1st ed. C. Jamnadas & Co.
2. Ganguli, P. Intellectual Property Rights: Unleashing the Knowledge Economy. 2017. 1st ed. McGraw Hill Education.
3. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Government of India (http://www.ipindia.nic.in).
4. World Trade Organization (http://www.wto.org).
5. World Intellectual Property Organization (http://www.wipo.int).

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