NIRMA UNIVERSITY
INSTITUTE OF SCIENCE
M. Sc. Biotechnology

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1. Programme Learning Outcomes

On satisfactory completion of the programme, students will be able to:

A] Academic literacy

- Critically evaluate research findings that underpin biotechnology and apply them appropriately
- Apply recombinant DNA techniques, bioinformatics and high throughput technology underpinned by the theoretical and technical knowledge to solve methodological problems
- Apply drug and product development concepts and strategies within their professional career
- Apply knowledge and understanding of the principles of genome science and genome analysis to experimentally approach research questions and hypothesis, select and apply appropriate advanced experimental techniques based on their knowledge and understanding of theories underpinning these advanced techniques
- Select, use and understand the development and limitations of databases and their use as tools in genomic analysis.
- Apply their knowledge of management, leadership, knowledge transfer, patenting and entrepreneurship in the work-place
- Acquire, critically evaluate and apply innovative research findings from the literature to their current research or employment

B] Research literacy

- Undertake a sustained piece of original research on a topic of relevance to the context and content of the programme.
- Apply key concepts learned in the course to arising problems in subsequent biological science research settings, synthesize relevant information from a range of appropriate sources to construct and support a rational argument.
- Critically evaluate evidence and argument rationally to produce or judge the validity of conclusions.
- Identify research questions, design the approach and conduct experiments to solve them.
- Interpret data with reference to good scientific practice in experimental design and data collection.
- Conduct research that conforms to 'good lab practice' guidelines.

C] Critical self-awareness and personal literacy

- Understand the limits of various techniques to interpret results, apply them effectively in the work-place
- Take on a management, leadership and/or entrepreneurial role, utilize the skills and theoretical knowledge gained on the course to embark on a range of careers in industry or research
- Apply their skills and knowledge to problem solve in professional situations within the biological science sector.
- Reflect upon learning experiences and apply learned experience to guide personal development and workplace practice
- Use a variety of forms of written communication according to context, including writing full research proposals, abstracts, and thesis, demonstrate effective skills of oral presentation, debate and academic discussion.

- Work independently and manage their own time to complete several tasks in the same time frame.
- Take a strategic, analytical and a creative approach to problem solving.

PLO for Biotechnology Programme

The two year's study of Master of Biotechnology will impart in-depth understanding of basic aspects of biological science pertaining to industrial applications. The courses of Industrial Microbiology & Fermentation Technology, Genetic Engineering, Microbial Genetics, Bio-analytical Techniques, Molecular Microbial Physiology, Agriculture & Environmental Microbiology, Animal Biotechnology, and Vaccinology will make the students ready to contribute to;

- Industry applications of better understanding of the key principles of biochemical functioning at an advanced level
- better awareness of the major issues at the forefront of the discipline
- will possess an in-depth understanding of the area of biochemistry chosen for research emphasis
- ability to design and carry out experiments (safely) and to interpret experimental data
- production of substantial original research of significance and quality sufficient for publication
- ability to present their work through written, oral, and visual presentations, including an original research proposal
- awareness of ethical issues in biochemical research and careers options

2. Programme Educational Outcomes

The objective of the Master's Programme in Biotechnology is to equip the students to apply knowledge of molecular mechanisms of cellular processes in living systems including microbes, plants, and higher order organisms to applied aspects. The laboratory training in addition to theory is included to prepare them for careers in the industry, agriculture, and applied research where biological system is increasingly employed. Basics and current updates in the areas of Industrial Microbiology, Fermentation Technology, Agriculture & Environmental Microbiology are included to train the students and also sensitize them to scope for research. The Masters in Biotechnology Programme will address the increasing need for skilled scientific manpower with an understanding of research ethics involving animals and humans to contribute to application, advancement, and impartment of knowledge in the field of biotechnology globally.

PO1	The student will have good fundamental knowledge of biological systems at cellular and molecular level
PO2	The student will be competent at technical skills related to laboratory experiments involving animal and human ethical guidelines, cyber security, and professional ethics
PO3	The student will have training in scientific thinking, research methodology involving independent planning, executing, and interpreting the scientific investigation
PO4	The student will have training in scientific writing, keeping updated in scientific literature, and also working as a team member
PO5	Through extension activities the student will be trained and sensitized to contribute to social issues involving relevant scientific areas

Institute of Science
Nirma University
Teaching & Examination Scheme of M.Sc. Biotechnology (2018-20)

Semester I **w.e.f A.Y. 2018-19**

Sr. No.	Course Code	Course Title	Teaching Scheme				Examination Scheme				
							Duration		Component Weightage		
			L	LPW/ PW	T	C	SEE	LPW/ PW	CE	LPW/ PW	SEE
1	3SBC101	Metabolism	3	-	-	3	3.0	-	0.60	-	0.40
2	3SBT102	Cell Biology	3	-	-	3	3.0	-	0.60	-	0.40
3	3SBT103	Molecular Biology	3	-	-	3	3.0	-	0.60	-	0.40
4	3SBT109	General & Applied Microbiology	3	-	-	3	3.0	-	0.60	-	0.40
5	3SBT111	Basic Immunology	3	-	-	3	3.0	-	0.60	-	0.40
6	3SBT112	Laboratory I	-	14	-	7	-	10.0	1.00	-	-
7	3SBT113	Seminar I	-	1	-	1	-	-	1.00	-	-
		Total	**15**	**15**		**23**					
Supplementary Courses											
8	3SBT1S2	Basics of Biological Sciences	-	2	-	-	-	-	1.00	-	-
9	3SBT1C1	Cyber Security	1	-	-	-	-	-	1.00	-	-
		Total	**1**	**2**		**-**					

L: Lectures, T: Tutorial, C: Credits, LPW: Laboratory / Project Work, CE: Continuous Evaluation, SEE: Semester End Examination

Supplementary Course
3SBT1S2 Basics of Biological Sciences
3SBT1C1 Cyber Security

Institute of Science
Nirma University
Teaching & Examination Scheme of M.Sc. Biotechnology (2018-20)

Semester II **w.e.f A.Y. 2018-19**

Sr. No.	Course Code	Course Title	Teaching Scheme				Examination Scheme				
							Duration		Component Weightage		
			L	LPW/ PW	T	C	SEE	LPW/ PW	CE	LPW/ PW	SEE
1	3SMB201	Industrial Microbiology & Fermentation Technology	3	-	-	3	3.0	-	0.60	-	0.40
2	3SBT202	Bioanalytical Techniques	3	-	-	3	3.0	-	0.60	-	0.40
3	3SBT203	Genetic Engineering	3	-	-	3	3.0	-	0.60	-	0.40
4	3SBT204	Microbial Genetics	3	-	-	3	3.0	-	0.60	-	0.40
5	3SBT211	Laboratory II	-	14	-	7	-	10.0	1.00	-	-
6	3SBT212	Seminar II	-	2	-	2	-	-	1.00	-	-
		Total	**11**	**16**		**21**					
Supplementary Courses											
7	3SBT2H1	Introduction to Professional Ethics, Rights & Duties	1	-	-	-	-	-	1.00	-	-
8	3SBT2E2	Professional English	1	-	-	-	-	-	1.00	-	-
9	3SBT2H2	Social Extension Activities	-	2	-	-	-	-	1.00	-	-
		Total	**2**	**2**		**-**					
Institute Elective											
1		Elective I	3	-	-	3	3.0	-	0.60	-	0.40
		Total	**3**	**-**		**3**					

Compulsory summer training following semester II for 21 working days

L: Lectures, T: Tutorial, C: Credits, LPW: Laboratory / Project Work, CE: Continuous Evaluation, SEE: Semester End Examination

Elective I

3SMB2E2 Microbial Ecology
3SBC2E1 Human Genetics
3SBC2E2 Reproductive Physiology
x

Supplementary Course

3SBT2E2 Professional English
3SBT2H1 Introduction to Professional Ethics, Rights & Duties
3SBT2H2 Social Extension Activities

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Semester III **w.e.f A.Y. 2019-20**

Sr. No.	Course Code	Course Title	Teaching Scheme				Examination Scheme				
							Duration		Component Weightage		
			L	LPW/ PW	T	C	SEE	LPW/ PW	CE	LPW/ PW	SEE
1	3SBT301	Molecular Microbial Physiology	3	-		3	3.0	-	0.60	-	0.40
2	3SBC304	Cancer Biology	3	-	-	3	3.0	-	0.60	-	0.40
3	3SBT308	Animal Biotechnology	3	-	-	3	3.0	-	0.60	-	0.40
4	3SBT3E1	Genomic & Proteomics	3	-	-	3	3.0	-	0.60	-	0.40
5	3SBT311	Laboratory III	-	8	-	4	-	6.0	1.00	-	-
6	3SBT312	Research Methods	3	6	-	6	-	-	0.60	-	0.40
		Total	**15**	**14**		**22**					
Supplementary Courses											
1		Dissertation Tutorial	-	-	1	-	-	-	1.00	-	-
		Total	**-**	**-**	**1**	**-**	-				
Institute Elective											
1		Elective II	3	-	-	3	3.0	-	0.60	-	0.40
		Total	**3**	**-**		**3**					

L: Lectures, T: Tutorial, C: Credits, LPW: Laboratory / Project Work, CE: Continuous Evaluation, SEE: Semester End Examination

Elective II
3SBC3E1 Structural Biology
3SMB304 Agricultural & Environmental Microbiology
3SBT309 Vaccinology
3SMB307 Microbial Diversity and Systematics

Dissertation Tutorials
3SBC3A1 Neuroendrocrine Regulation of Behavior
3SBC3S1 Understanding Gastrointestinal Hormones and Gut associated Cancer
3SBC3S2 Molecular Mechanisms of Infertility
3SBC3S3 Pathogenesis of Diabetes
3SBC3S4 Genotoxicity Testing for Cancer Risk Assessment
3SBC3S5 Applied Human Cytogenetics
3SBT3S1 Carbon Catabolite Repression
3SBT3S2 Immunological Memory
3SBT3M1 Protein Stability
3SMB3N1 Microbial Community Dynamics and Ecological Succession
3SMB3V1 Antimicrobial Agents

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Teaching & Examination Scheme of M.Sc. Biotechnology (2018-20)

Semester IV **w.e.f A.Y. 2019-20**

Sr. No.	Course Code	Course Title	Teaching Scheme				Examination Scheme				
							Duration		Component Weightage		
			L	LPW/ PW	T	C	SEE	LPW/ PW	CE	LPW/ PW	SEE
1	3SBT402	Dissertation	-	-		26	-	-	0.60	-	0.40
2	3SBT404	Comprehensive Viva Voce	-	2	-	2	-	-	1.00	-	-
		Total	-	**2**		**28**					
Supplementary Courses											
3	3SBT405	CV Writing & Interview Preparation	-	1	-	-	-	-	1.00	-	-
		Total	**-**	**1**	-	**-**	-				

L: Lectures, T: Tutorial, C: Credits, LPW: Laboratory / Project Work, CE: Continuous Evaluation, SEE: Semester End Examination

Nirma University
Institute of Science
M. Sc. Biotechnology

SEMESTER I

L	T	P	C
3	-	-	3

Course Code	**3SBC101**
Course Title	**Metabolism**

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Have an **understanding** of the metabolic pathways - the energy-yielding and energy requiring reactions in life; understand the diversity of metabolic regulation, and how this is specifically achieved in different cells
2. **Evaluate** the different metabolic process occurring in the cells
3. **Relate** the link between the metabolic processes and their regulation as a response to external and internal factors
4. **Analyze** the differences and similarities between the various anabolic and catabolic processes occurring in the body

Syllabus **Teaching hours**: **45 Hours**

Unit 1: Metabolism of Carbohydrates: **5 Hours**
Glycolysis, citric acid cycle, pentose phosphate pathways, glycogenesis and glycogenolysis and their regulation, Gluconeogenesis and its regulation. Metabolism of Fructose and Galactose. Hormonal regulation of carbohydrate metabolism.

Unit 2: Metabolism of Lipids: **8 Hours**
Synthesis of various lipids, bile acids and cholesterol. Elongation of fatty acids, Desaturation of fatty acids in microsomes. Regulation of fatty acid synthesis, Cholesterol metabolism. Composition and synthesis of basic groups of Lipoproteins and their changes during transport in the body.

Unit 3: Metabolism of Amino Acids: **8 Hours**
General reactions of amino acid metabolism: transamination, oxidative deamination and decarboxylation. Catabolic fate of α-amino acids and their regulation, glucogenic and ketogenic amino acids. Urea cycle and its regulation. Amino acid biosynthesis.

Unit 4: Metabolism of Nucleotides: **8 Hours**
Biosynthesis of purines and pyrimidines- De novo and salvage pathways and their regulation. Catabolism of purines and pyrimidines. Biosynthesis of ribonucleotides and deoxyribonucleotides.

Unit 5: Enzymes: Basic Bio-thermodynamics **8 Hours**
Enzyme classification and nomenclature, Enzyme kinetics: Michaelis-Menten equation: Formula, Derivation and Significance; Alternate plotting procedures. Types of Inhibitors and their mode of action.

Unit 6: Enzyme Mechanisms and Regulation: **8 Hours**
Different mechanisms of enzyme activity; Strategies for enzyme regulation; Allosteric Enzymes and their Kinetics. Isoenzymes and Multienzyme Complexes.

Suggested Readings:

1. Voet, D., Fundamentals of Biochemistry, J. Wiley, 2008.
2. Voet, D. and Voet, J. G. Biochemistry, 3rd Edition., John Wiley and Sons, 2004. 3. Boyer, R., Concepts in Biochemistry, Brookes, 1999.
3. Metzler, D. E., Metzler, C. M., Biochemistry: the chemical reactions of living cells. Vols. I and II, Academic Press, 2001.
4. Nelson, D. C. and Lehninger, Principles of Biochemistry, Mac Millan, 2000.
5. Murray, R. K., Granner D. K., Mayes, P. A., Rodwell, V. W., Harper's Biochemistry, 27th Edition, McGraw Hill, 2006.
6. Stryer, L., Bery, J. M., Dymoczko, J. L., Biochemistry Only. 6th edition, WH Freeman and Co. New York, 2006.

L	T	P	C
3	-	-	3

Course Code	3SBT103
Course Title	Molecular Biology

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Understand a basic understanding of molecular events of discovery of science and it's biological implications
2. Understand the role of each components of molecular events in prokaryotes as well as eukaryotes
3. Justify and correlate the importance of these molecular events in the gene expression as well as in the gene regulation (Skill Development)
4. Analyze and correlate the deregulation in any event leading to disorders and envisage probable strategies

Syllabus **Teaching hours: 45 Hours**

Unit 1: Genome organization in prokaryotes and eukaryotes **5 Hours**
Structure of DNA and RNA, physical properties of DNA- cot plot, kinetic and chemical complexity, satellite DNA. Organization of the Chromosome, structure of chromatin-nucleosomes, Chromatin domains and isochores, structure and functional organization of centromeres and telomeres.

Unit 2: DNA Replication: **8 Hours**
Prokaryotic DNA polymerase I, II and III, Eukaryotic DNA polymerases, Fidelity and Catalytic Efficiency of DNA polymerases, Okazaki Fragments, Replication Origin, Primosomes, Concurrent Replication mechanism involving leading and copying strands of DNA.

Unit 3: Transcription: **8 Hours**
Prokaryotic and Eukaryotic polymerases, Promotors, Enhancers, silencers, transcriptional activators. Mechanism of Prokaryotic and eukaryotic biosynthesis of rRNA, tRNA and mRNA. Transcriptional inhibitors, Transcription factors and machinery, formation of initiation complex, transcription activators and repressors, elongation and termination

Unit 4: RNA Processing: **8 Hours**
Prokaryotic and eukaryotic rRNA, tRNA, mRNA editing, Capping, Polyadenylation, splicing. Processing of poly A- mRNA, Mi and Si RNAs, Group I and II introns, alternate splicing, RNA transport.

Unit 5: Translation: **8 Hours**
Prokaryotic and Eukaryotic Protein synthesis and processing: Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetases, translational proof-reading, translational inhibitors, post- translational modification of proteins.

Unit 6: Gene Expression Regulation: **8 Hours**
Control of gene expression at transcription and translation level, Regulation of prokaryotic and eukaryotic gene expression, phages and viruses, Operon concept, positive and negative regulation, catabolite repression, role of chromatin remodelling in regulating gene expression and gene silencing.

Suggested Readings:

1. Meyers, R. A. (1995). Molecular biology and biotechnology: a comprehensive desk reference. John Wiley & Sons.
2. Lodish, H. (2008). Molecular cell biology. Macmillan.
3. Brown, T. A. (1991). Essential molecular biology: volume II a practical approach. Oxford University Press.
4. Krebs, J. E., Lewin, B., Goldstein, E. S., & Kilpatrick, S. T. (2014). Lewin's genes XI. Jones & Bartlett Publishers.
5. Watson, J. D., & Levinthal, C. (1965). Molecular biology of the gene. Molecular biology of the gene.

L	T	P	C
3	-	-	3

Course Code	3SBT109
Course Title	General and Applied Microbiology

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Get aquainted with the basic concepts of various fields of Microbiology, and also learn about growth pattern of microbes in different ecosystems.
2. Acquire experimental knowhow of essential microbiological techniques e.g. microscopy, cultivation of microbes, etc.
3. Develop an understanding of various facets of microbes and their applications e.g. medical microbiology, industrial microbiology, agricultural microbiology, etc.

Syllabus **Teaching hours**: **45 Hours**

Unit 1. Introduction: **7 hours**
History of Microbiology; General and Salient features of Bacteria, Archaea, Fungi, Algae and Viruses. Principles of classification.

Unit 2. Microbial Growth and Measurement **8 hours**
Microbial growth, Methods of Cell Growth Determination, Growth Kinetics, Synchronous Growth, Basic Growth Media and Nutritional Requirement**.**

Unit 3. Microbiological Techniques **7 hours**
Sterilization and Preservation techniques; Aseptic Work, Pure and Mixed Culture concept, Enrichment techniques.

Unit 4. Nutritional Diversity **7 hours**
Nutritional diversity, oxygenic and anoxygenic, photosynthesis, respiration, fermentations, chemolithotrophy.

Unit 5. Microbial Ecology **8 hours**
Natural habitats, Interactions among microbial population, Plant-microbe interactions, Animal-microbe interactions.

Unit 6. Applied Microbiology **8 hours**
Overview of applications of microorganisms in Agriculture, Environment, Food, Industry and Medical Sciences.

Suggested Readings:

1. Atlas, R. M. (2001) Principles of Microbiology 3rd Edition, Wm. C. Brown Pub., Iowa, USA.
2. M. T. Madigan J. M. Martinko, & J. Parker Brock biology of microorganisms 9th Edn., Prentice Hall Int. Inc.
3. Sulia, General Microbiology, Oxford, 1999.
4. J. G. Cappuccino, Microbiology a Laboratory Manual, 4th Edn., Adison-Wesley, 1999.
5. Pelzar, Microbiology _ Concepts and Application, Mc Graw Hill.
A. Demain, Manual of Industrial Microbiology and Biotechnology, A. S. M., 1999.
6. Prescott & Klein Microbiology 5th Edn., Mc Graw Hill.
7. G. J. Tortora Microbiology: An Introduction. 9thEdn, Benjamin Cummings, 2006.

General and Applied Microbiology

L	T	P	C
3	-	-	3

Course Code	3SBT111
Course Title	Basic Immunology

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-
1. Develop good understanding on how immune system discriminate self-from non-self.
2. Design irnmunoassays based on the monoclonal antibodies.
3. Evaluate the immune response of the host encountering the pathogen or upon vaccination

Syllabus **Teaching Hours: 45**

Unit 1: Nature of Antigen and Antibody **6 Hours**
Antigen Vs Immunogen, Haptens, Structure and functions of immunoglobulins, Isotypic, allotypic and Idiotypic variations.
Unit 2: Structure and function of primary and secondary lymphoid organs **8 Hours**
MALT system; Lymphocyte circulation, Mechanisms of Migration of immune cells into primary and secondary lymphoid organs.
Unit 3: Complement System - Activation, regulation and abnormalities **8 Hours**
Unit 4: Production of Antibodies and its Applications **8 Hours**
Production of polyclonal and monoclonal antibodies and its clinical applications. Abzymes. Measurement of Antigen – Antibody Interaction: Principles, techniques and applications, Agglutination and precipitation techniques, Radio immunoassay, ELISA, Immunofluorescence assays, Fluorescence activated cell sorter (FACS) techniques. Immuno PCR.
Unit 5: Generation of Diversity of Immunoglobulins and T Cell Receptors **7 Hours**
Unit 6: MHC structure and polymorphism: Antigen processing and presentation, T cell activation **6 Hours**

Suggested Readings:

1.Janeway, C (2012) Janeway's immunobiology. Garland Science 8th Edition.
2.Kindt, T. J (2009). Kuby immunology. Macmillan. 7th Edition
3. Paul, W. E. (2008). Fundamental immunology. Lipincott & Wilkins, 6th Edition
4. Abbas, A. K., Lichtman, A. H., & Pillai, Shiva. (2012). Cellular and molecular immunology WB
Saunders Co. Philadelphia, Pennsylvania, 186-204.7th Edition
5. Coico, R. (2015). Immunology: A Short course. John Wiley & Sons, 7th edition
6. Peter J. Delves, Seamus J. Martin, Dennis R. Burton and Ivan M. Roitt (2017). Roitt's essential immunology John Wiley & Sons. 13th Edition

L	T	P	C
3	-	-	3

Course Code	3SBT102
Course Title	Cell Biology

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

1. Understand and appraise the fundamentals of cell as a unit of living organisms and their organelles in terms of structure and functions
2. Evaluate the cellular mechanisms of cell-cell interactions, cell communications, cell signalling pathways and cell division
3. Evaluate the molecular mechanisms and their cross-talk responsible for various diseases including cancer, diabetes and other diseases, articulate host-environment interactions
4. Demonstrate understanding of in vitro and in vivo isolation of cell, it's utility in various areas of research including stem cell

Syllabus: **Teaching hours: 45**

Unit 1: Plasma membranes: **5 Hours**

Membrane Structure, Molecular Composition and function; Lipid bilayer and protein, diffusion, osmosis, ion channels, active and passive transport, membrane pumps and transporters

Unit 2: Cytoskeleton: **8 Hours**

Microfilaments, Intermediate Filaments and Microtubules – Structure and Dynamics; Microtubules and Mitosis; Cell Movements. Intracellular Transport and the Role of Kinesin and Dynein

Unit 3: Intracellular Protein Traffic: **8 Hours**

Protein Synthesis on Free and Bound Polysomes, Uptake into ER, Membrane Proteins, Golgi Sorting, Post- Translational Modifications

Unit 4: Cell Signaling: **8 Hours**

Cell Surface Receptors; Signaling from Plasma Membrane To Nucleus, Map Kinase Pathways, G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, neurotransmission and regulation

Unit 5: Cell – Cell Adhesion and Communication: **8 Hours**

Ca++ Dependent Cell-Cell Adhesion; Ca++ Independent Cell-Cell Adhesion. Cell Junctions and Adhesion Molecules, Movement of Leukocytes into Tissues, Extracellular matrix

Unit 6: Cell Cycle: **8 Hours**

Mitosis, Meiosis, Cell Cycle, Role of Cyclins and Cyclin Dependent Kinases, Regulation of Cdk – Cycline Activity, Regulation of Cell cycle, senescence and apoptosis

Suggested Readings:

1. Bruce Alberts, Molecular Biology of Cell, 6th Edition, 2015.
2. Bruce Alberts, Molecular Biology of Cell, A Problem Approach, 2015
3. R. Phillips et. Al, Physical Biology of the cell, 2nd Edition, 2013.
4. M. L. Casem, Case studies in Cell Biology, 2016.
5. R. Shrivastava, Apoptosis, Cell Signalling and Human Diseases, Molecular Mechanisms, Volume:1 & 2.
6. Robert Lanza (Editor), Essentials of Stem cell biology, 2nd Edition, 2009.

7. Cell Biology: Translational impact in cancer biology and bioinformatics. Maika G. Mitchell, Academic Press, 2016.
8. Pollard, T. D., and Earnshaw, W. C., Cell Biology 2nd Edition, Saunders Elsevier, 2008.
9. Gerald K., Cell and Molecular Biology, Concept and Experiment, 5th Edition, Wiley, 2007.
10. Kleinsmith, L. J. J. Principles of Cell and Molecular Biology, 2nd Edition, Benjamin Cummings, 1997.
11. Lodish, H., Berk A., Kaiser C. A., Krieger M., Scott M.P., Bretscher A., Ploegh H., and Matsudaira P., Molecular Cell Biology, 6th Edition, Freeman, W. H. and Co., 2008.
12. Roberts, K., Lewis J., Alberts B., Walter P., Johnson A., and Raff. M., Molecular Biology

L	T	P	C
-	-	1	1

Course Code	**3SBT113**
Course Title	**Seminar I**

Course Course Learning Outcomes:
At the end of the course, students will be able to-

1. Understand and present scientific concepts
2. Analyze the scientific idea and concept of the given topic
3. Develop basic presentation skills

Syllabus: **Teaching Hours: 30**

The students have to give seminars on a scientific topic of their interest from any of the biological fields which will be open for discussion. The students will have to submit the hardcopy of the selected topic along with a summarised write up in their own words. This course has been designed to provide a platform for the students to develop their communication, presentation and confidence to face the audience.

SEMESTER II

L	T	P	C
3	-	-	3

Course Code	3SMB201
Course Title	Industrial Microbiology and Fermentation Technology

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Get acquainted with the industrial aspect of the field of Microbiology, and also learn about growth pattern of microbes in different industrial systems. Employability and
2. Acquire experimental knowhow of microbial production of various industrial products such as alcohol, exopolysaccharides, enzymes, etc.
3. Develop an understanding of process control, upstream and downstream process.

Syllabus **Teaching hours**: **45hours**

Unit 1: Introduction to Fermentation Processes **7 Hours**
Range of fermentation processes, Media and materials required for industrial microbiological processes - sources, formulation, antifoams and optimization.

Unit 2: Microbial Growth Kinetics **7 Hours**
Batch culture, Continuous culture, Fed-batch culture, Applications and examples, Scale up of fermentation processes, Sterilization of media, Fermenter and feeds.

Unit 3: Design of a Fermenter **8 Hours**
Functions, construction, and maintenance of aseptic conditions. Types of fermentors, Aeration and agitation (Non-Newtonian fermentations).

Unit 4: Industrial products produced by microorganisms **8 hours**
e.g. Enzymes, organic acids, amino acids. Production of antibiotics, vitamins, alcohol fermentation, Glycerol-based fermentations.

Unit 5: Process Control: **7 Hours**
Enzyme probes - Bio sensors, Control of various parameters, Computer applications in fermentation technology.

Unit 6: Downstream processing **8 Hours**
Unit operations, Recovery and purification of fermentation products.

Suggested Reading:

1. Biochemical Engineering, Aiba, S., Humphrey,A.E. and Millis, N.F. Univ. of Tokyo Press.
2. Process engineering in Biotechnology, Jackson, A. T. Prentice Hall, Engelwood Cliffs.
3. Biochemical Reactors, Atkinson, B., Pion Ltd, London.
4. Fermentation Microbiology & Biotechnology, E L - Mansi and Bryce, Taylor & Francis, 1999.
5. Industrial Microbiology, Prescott & Dunn, Fourth Edition.
6. Industrial Microbiology by Casida. LE, New age International (P) Limited, Publishers.
7. Industrial Microbiology by Prescott & Dunns, AVI Publishing Company Inc.
8. Industrial Microbiology by A.H. Patel.
9. Principles of Fermentation Technology by P.F. Stanbury, A. Whitaker and S.J. Hall, Butterworth Heineman, Aditya Books (P) Ltd.
10. A text book of Industrial Microbiology by Wulf Crueger and Anneliese Crueger, Panima Publishing Corporation.

L	T	P	C
3	-	-	3

Course Code	3SBT202
Course Title	Bioanalytical Techniques

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Understand the principles and applications of various techniques used in the isolation, purification and analysis of biomolecules
2. Apply the concepts of modern anlaytical and instrumental techniques relevant to quantitative measurements in biology
3. Justify and relate the selection of bioanalytical methods to characterize a given sample
4. Critically evaluate the advantages, limitations and future prospects of various bioanalytical techniques

Syllabus **Teaching hours: 45**

Unit 1: Separation and characterization of macromolecules **8 Hours**
Principles and applications of ultracentrifugation, ultrafiltration, precipitation and equilibrium dialysis; Horizontal and vertical electrophoresis. Native and SDS Polyacrylamide gel electrophoresis, 2 D electrophoresis

Unit 2: Chromatography **9 Hours**
Basic principles and applications of Paper chromatography, TLC, Gas Chromatography, Size exclusion chromatography, Ion-exchange chromatography, Affinity chromatography, Reverse phase chromatography, HPLC, FPLC

Unit 3: Spectroscopy **7 Hours**
Basic Principles and Applications of UV/Visible absorption, CD, Raman, Infrared, Fluorescence and Atomic Absorption Spectroscopy

Unit 4: Radioisotope Techniques **6 Hours**
Radioactive decay, half-life, Types of radiations, properties of α, β and γ rays, radioisotope tracer techniques, Measurement of radio activity, autoradiography, radiation protection and measurements, Applications of radioisotopes for analysis of biological samples

Unit 5: Structural determination of Biomolecules: **8 Hours**
Basic Principle, instrumentation and applications of Nuclear Magnetic Resonance & ESR, X-Ray Crystallography, Mass Spectrometry

Unit 6: Microscopy **7 Hours**
Principles and applications of bright field, dark field, phase contrast, DIC etc., fluorescence, confocal, deconvolution, super-resolution, multiphoton, SEM, TEM and various types.

Suggested Readings:

1. Pattabhi, V. and Gautham, N. Biophysics, Kluwer Academic Publishers, 2002.
2. Cooper, A, Biophysical Chemistry, Royal Society of Chemistry, 2004.
3. Christian, G. D., Analytical Chemistry, John Wiley & Sons (Asia) Pvt. Ltd., 2004.
4. Hammes, G. G., Spectroscopy for Biological Sciences, John Wiley & Sons, 2005.
5. Westmeier, Reiner, Electrophoresis in Practice; Wiley-VCH Verlag Gmbh. 2005
6. Michael Hoppert; Microscopic Techniques in Biotechnology, John Wiley & Sons, Inc. 2006

7. Skoog, D. A., Holler, F. J. and Crouch, S. R., Instrumental Analysis, Brooks/Cole Cengage Learning, 2007.
8. Roberts, K., Lewis J., Alberts B., Walter P., Johnson A., and Raff. M., Molecular Biology of the Cell, 5th Edition, Garland Publishing Inc., 2008.
9. Wilson, K. and Walker, J.; Principles and Techniques of Biochemistry and Molecular Biology, 7th edition, Cambridge University press., 2010
10. Robert L. Wixom and Charles W. Gehrke, Chromatography: A Science of Discovery. John Wiley & Sons, Inc. 2010
11. Bhasin, S. K.; Pharmaceutical Organic Chemistry; Elsevier India Pvt. Ltd.. 2012
12. Monk, Paul, Physical Chemistry: Understanding our Chemical World; John Wiley and Sons. 2013
13. Peter Jomo Walla.; Modern Biophysical Chemistry: Detection and analysis of Biomolecules: Wiley Publishing. 2014

L	T	P	C
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Course Code	3SBT203
Course Title	Genetic Engineering

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-
1. Understand the fundamental concept of genetic engineering.
2. Analyse the technique of genetic engineering.
3. Apply the concept and techniques in designing and conducting experiments and research.

Syllabus **Teaching hours**: **45**

Unit 1: Fundamental Tool and Technique in Recombinant DNA Technology **5 Hours**
Restriction enzymes: types, mode of action and nomenclature, RE independent cloning strategies, DNA modifying enzymes rnethylases, DNA polymerases, Klenow-enzyme, reverse transcriptase, terminal transferase, alkaline phosphatase, polynucleotide kinase. Ligase, DNase, RNase and Sl nuclease. Blunt end ligation with linkers. Adapter and homo-polymer tailing, Nick translation, Random priming. Polymerase-Chain-Reaction. Real Time PCR (SYBR and Taqman-based chemistry), Principles and application of nucleic acid hybridizations, Preparation of nucleic acid probes. Radioactive and nonradioactive procedures, DNA sequencing (Maxam and Gilbert method and Sanger method) including automated DNA sequencing.

Unit 2: Cloning Vehicles and their Application **8 Hours**
Cloning vectors, Definition and properties of cloning vectors - plasmids, bacteriophage lambda and M13 - based vectors, cosmids, and shuttle vector, YAC and BACs, viral vector (SV40, retrovirus and Adinovirus), Ti and Ri Plasmids, cloning of PCR product, TA and TOPO cloning, subcloning and GATWAY cloning.

Unit 3: Genomic and cDNA Library **8 Hours**
Strategies for Construction of Genomic library, Construction of cDNA library- mRNA enrichment, Reverse transcription, Selection and screening of recombinant clones- screening of genomic and cDNA libraries.

Unit 4: Cloning interacting genes and in vitro mutagenesis **8 Hours**
Gel retardation assay, DNA footprinting, Yeast Two System and Yeast Three Hybrid System. ChIP-chip split hybrid and reverse hybrid, Phage display and transposon tagging, Site-directed mutagenesis and Protein Engineering, Transcript analysis techniques, Protein-protein interactions by GST- pull down, Western-blot, Far western, co-immunoprecipitation etc.

Unit 5: Expression Strategies for Heterologous Genes **8 Hours**
DNA Transfection methods, Reporter gene assays, Expression in Bacteria, Yeast, Insect and mammalian systems

Unit 6: Application of DNA Recombinant Technology **8 Hours**
Generation of transgenic organism, Gene knockdown and knockout (TALEN, CRISPR/Cas9, RNAi, and antisense). Artificial chromosomes, gene therapy, Recombinant DNA technology in medicine, agriculture and industry.

Suggested Readings:
1. Watson JD., Caudy AA. Myers RM., Witkowski JA. (2007) Recombinant DNA: Genes and Genomes—A Short Course 3rd

2. Hardin, C., Pinczes, J., Riell, A., Presutti, D., Miller, W., & Robertson, D. (2001). Cloning, gene expression, and protein purification (pp. 196-384). Oxford: Oxford University Press.
3. Sambrook, J., Fritsch, E. F., & Maniatis, T. (1989). Molecular cloning: a laboratory manual, Vol I, II and III. Cold spring harbor laboratory press. 3rd revised edition.
4. Glover, D. M., & Hames, B. D. (1995). DNA cloning 3: a practical approach. IRL Press Ltd.
5. Walker, M. R., & Rapley, R. (1997). Route Maps in Gene Technology. Blackwell Science Ltd., Oxford.
6. Kingsman, S. M., & Kingsman, A. J. (1988). Genetic engineering: an introduction to gene analysis and exploitation in eukaryotes. Blackwell Scientific Publications.
7. Glick, B. R., & Pasternak, J. J. (1998). Principles and applications of recombinant DNA. ASM, Washington DC, 683.
8. Primrose, S. B., & Twyman, R. (2013). Principles of gene manipulation and genomics. John Wiley & Sons.
9. Nicholl, D. S. (2008). An introduction to genetic engineering. Cambridge University Press.
10. Singrer M., & Berg, P (1991). Genes & Genomes, a Changing perspective. University Scicnce Books, Mill Valley, California
11. Horve, C. (2016), Gene Cloning and Manipulation. Cambridge: Cambridge University cross. doi: 10. 1017/CB0978051180.
12. Tererrce A. (T.A.) Brown (2017) Genomes 4, Fourth edition. Garland Science: New York, NY.
13. Terence A (T. A) Brown T.A. (2016) Gene cloning and DNA analysis: an introduction 6th ed. Wiley-Blackwell UK.

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Course Code	3SBT204
Course Title	Microbial Genetics

Course Learning Outcomes (CLO):
At the end of the course, students will be able to -

1. Identify types of mutations including spontaneous and induced mutations and understand mechanisms of mutagenesis, DNA damage repair and DNA recombination pathways
2. Understand molecular mechanisms of gene transfer in microbes and phages and relate the role of these mechanisms for fine structure mapping of genes
3. Apply the knowledge on the results of genetic experiments to find out number of genes involved in a process, gene order, distance between genes and fine structure mapping of genes
4. Integrate the role of extrachromosomal elements including plasmids and transposons in genetic analysis and their roles in evolution.

Syllabus **Teaching hours: 45**

Unit I: Principles of Microbial Genetics **7 Hours**
Basic procedure and terminology, selection and classification of variations, Mutations – Types and screening; Mechanism of mutagenesis, Directed mutations, Use of mutations

Unit 2: Genetic Analysis of Bacteria: **9 Hours**
Genetic mapping, Linkage and Multifactor Crosses, Deletion mapping, Complementation, Gene transfer mechanisms—transformation, conjugation, transduction.

Unit 3: Phage Genetics **8 Hours**
Genetics of temperate and virulent phage, Lytic phage - Phage mutants, genetic recombination in phages; Fine structure mapping of T4 *rII* locus.

Unit 4: DNA Damage and Repair: **6 Hours**
Types and mechanisms of DNA repair

Unit 5: Recombination: **7 Hours**
Models of recombination - homologous, site-specific and non-homologous or illegitimate recombination. Transposons in bacteria and yeast; Mechanism of transposition.

Unit 6: Extra-chromosomal Genetic Elements: **8 Hours**
Plasmids – Classification, Incompatibility, copy number control; Genetics of restriction modification systems.

Suggested Readings:

1. Brown, T.A. Genetics - A Molecular Approach, 3rd edition, BIOS Scientific Publishers, 2004.
2. Brown, T.A. Genomes 3, G.S. Garland Science, 2007.
3. Dale, J.W. and Park, S.F. Molecular Genetics of Bacteria, 5th edition, Wiley-Blackwell, 2010.
4. Das, H.K. Textbook of Biotechnology, 2nd edition, Wiley Dreamtech, 2005.
5. Gardner, E.J. Simmons, M.J. and Snustad, D.P. Principles of Genetics, 8th edition, John Wiley and sons, 2004.
6. Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T. (Eds.), Lewin's Genes X, 10th edition, 2011.

7. Maloy, S.R., Cronan Jr., J.E. and Freifelder, David. Microbial Genetics, 2nd edition, Narosa Publishing House, 2009.
8. Snustad, D.R. and Simmons, M.J. Principles of Genetics, 5th edition, John Wiley and sons, 2010.

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Course Code	**3SBT211**
Course Title	**Laboratory II**

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Understand the basics of bioinformatics tools, immunological techniques and experiments related to molecular biology, microbial genetics, microbial fermentation.
2. Analyze the data obtained from molecular analysis of RNA, DNA and protein, clinical biochemistry, genetics and fermentation experiments and interpret the results.
3. Apply the techniques based on requirement in analysis of biomolecules for conducting research.

Syllabus **Teaching Hours: 120**

Pubmed searches, Scopus and Biological databases, Structure visualization and statistical methods, sequence similarity search, Prediction of protein structure, Docking of protein and ligand, In-silico cloning, phylogenetic analysis; Nucleic acid isolation and estimation, Horizontal gel electrophoresis, UV Survival curve, UV mutagenesis, Isolation of drug resistant mutants, Lac Operon Experiments; Microbial production, recovery and estimation of Exopolysaccharide, Alcohol and Citric acid, Solid state fermentation; Antibody production and isolation, ELISA, Immunoglobulin purification.

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Course Code	3SBT212
Course Title	Seminar II

Course Learning Outcomes (CLO):

1. Understand the concepts of scientific paper presentation.
2. Analyze the scientific writing and data presented in Research papers.
3. Apply the knowledge and skill for structured writing and presentation of technical research reports.

Syllabus **Teaching Hours: 30**

The students have to give seminars on a research paper of their interest from any of the biological fields which will be open for discussion. The students will have to submit the hardcopy of the selected manuscript along with a summarised write up of the paper in their own words. This course has been designed to provide a platform for the students to develop their communication, presentation and confidence to face the audience.

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Course Code	3SBC203
Course Title	Advanced Immunology

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Understand how MHCs play critical role in shaping specific adaptive immune responses
2. Select target antigen or immunogen against which immune response is generated
3. Design adjuvant to induce B and T cell responses
4. Develop strategies to regulate immune response against the self

Syllabus **Teaching hours: 45**

Unit 1: Major Histocompatibility Complex (MHC) Genes and Products **9 Hours**
Polymorphism of MHC genes, Role of MHC antigens in immune responses, MHC antigens in transplantation.

Unit 2: **10 Hours**
Antigen processing and presentation, Cytokines and Chemokines; Microbial Associated Molecular Patterns – TLR, NLRs.

Unit 3: B Lymphocyte Development and Differentiation **6 Hours**
B cell differentiation in Bone marrow, B cell signal transduction, Antigen dependent B cell differentiation - primary and secondary follicles.

Unit 4: T lymphocyte development and Differentiation **10 Hours**
Thymus – Negative and positive selection. T lymphocyte Activation and differentiation - subtypes of Th cells, CD8 T cell activation, γδ T lymphocytes, T and B cell memory.

Unit 5: Tolerance **7 Hours**
Peripheral tolerance, Immunosuppression, Transplantation

Unit 6: Clinical Immunology **7 Hours**
Hypersensitivity - Types I, II, III and IV; Autoimmunity; Cancer immunology.

Suggested Readings:

1. Murphy, K., & Weaver, C. (2016). Janeway's immunobiology. Garland Science.
2. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2007). Kuby immunology. Macmillan.
3. Greenberg, S., Silverstein, S. C., & Paul, W. E. (1993). Fundamental immunology. Fundamental Immunology, 509.
4. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2014). Cellular and molecular immunology. Elsevier Health Sciences.
5. Coico, R., & Sunshine, G. (2015). Immunology: a short course. John Wiley & Sons.
6. Delves, P. J., Martin, S. J., Burton, D. R., & Roitt, I. M. (2016). Roitt's essential immunology. John Wiley & Sons.

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Course Code	3SBC2E1
Course Title	Human Genetics

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Understand and appraise the fundamental principles of inheritance, structural and functional aspects of cellular genetic material, will learn collecting and interpreting genetic related history, making pedigree chart, and linkage and association prediction studies
2. Evaluate various laboratory approaches of study of genetic material including conventional and updated methods of genomic studies for nuclear and mitochondrial genetic elements, coding and non-coding DNA and RNA
3. Demonstrate understanding regarding various models of study of genetic etiology involved in various single gene, complex, and multifactorial disease conditions; Evaluate the molecular mechanisms and their cross-talk responsible for various diseases including cancer, diabetes and other dreadful diseases, articulate host-environment interactions
4. Demonstrate understanding of available knowledge and can employ them by making use of various updated databases related to human genetic, genomic, phenotypic, and genetic conditions related databases

Syllabus **Teaching hours:45**

Unit 1: Mendelian principles of inheritance **10 Hours**

Dominance, segregation, independent assortment; alleles, multiple alleles, pseudo-allele, complementation tests; Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters; extra chromosomal inheritance: Inheritance of Mitochondrial and chloroplast genes, maternal inheritance, mitochondrial mutations and myopathies.

Unit 2: Organization of human genome and genes **9 Hours**

General organization of human Genome-Nuclear and Mitochondrial, Mitochondrial Genome organization, distribution of tandems and interspersed repetitive DNA, Gene distribution and density in human nuclear genome, Organization of genes: rRNA encoding Genes, mRNA encoding Genes, small nuclear RNA genes, Overlapping genes, genes within genes, multigene families, pseudo genes, truncated genes and gene fragments.

Unit 3: Gene mapping **10 Hours**

Pedigree analysis, LOD score for linkage testing, linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids; strategies in identifying human disease genes in pre and post Human Genome project; low and high resolution mapping; principles and strategies for identifying unknown disease or susceptibility genes

Unit 4: Animal Models for Human Diseases **6 Hours**

Potential of using animal models for human diseases, Types of animal models, transgenic animals, procedures of production and application in the study of different diseases; Gene editing and gene therapy**,** Induced pluripotent stem cells; transgenic animals to model complex diseases.

Unit 5: Cytogenetics and other methods of detection of genetic aberrations **6 Hours**

Human chromosomes structure, number and classification, methods of chromosome preparation, banding patterns. Structural and numerical alterations of autosomes and sex chromosomes; Molecular cytogenetic techniques, Fluorescence in situ hybridization using various types of probes, Multiplex FISH and spectral karyotyping, comparative genomic hybridization, microarray, Whole Exome and Whole Genome sequencing.

Unit 6: Data Mining in Genetics Research & Clinical Management **4 Hours**

Introduction to Internet based cataloguing of Genetic Aberrations in various diseases including Cancer, OMIM, Mitelman database of chromosome aberrations in cancer, Borgaonkar database of chromosomal variations in man, London Dysmorphology Database, Human Variome project, Human Phenome project, Encode project, Phenomizer and other automation approaches in phenotyping.

Suggested Readings:

1. A short history of Medical Genetics – Peter Harper, Oxford Uni. Press, 2008
2. ISCN 2016, Jean McGowan-Jordan, A. Simons, M. Schmid; Karger, 2016
3. Rooney D. E., and Czepulkowski, B. H., Human Cytogenetics: A Practical Approach (Vol. I & II), 1992 Edition, Oxford University Press, 1992.
4. Peter Russell, iGenetics, A molecular approach, Third Edition, 2010.
5. H-J. Muller & T. Roder, Microarrays, The Experiment series, 2006.
6. Klug et.al, Concepts of Genetics, 10th Edition, 2012.
7. P.W. Hedrick, Genetics of populations, 4th Edition, 2011.
8. D. Peter Snustad & M.J. Simmons, Principles of Genetics, 5th Edition.2010.
9. Griffith A. J.F., Wessler S.R., Carroll, S.B., and Doebley J., Introduction to Genetic Analysis, 10th Edition, W. H. Freeman, 2010.
10. Benjamin P., Genetics: A Conceptual Approach & Problem Solving, 2008, W. H. Freeman, 2008.
11. Hedrick, P. W. (2011) Genetics of Populations, 4th Edn., Jones & Bartlett Publ.
12. Vogel and Motulsky's Human Genetics: Problems and approaches, Michael R. Speicher, Stylianos E. Antonarakis, Arno G. Motulsky, Springer; 4th ed. 2010 edition.
13. The AGT Cytogenetics Laboratory Manual, M.J.Barch, T.Knutsen, and J.Spurbeck.,Third Edition,Lippincott-Raven Publishers, Philadelphia (1997)
14. Genomic Imprinting and Uniparental Disomy in Medicine by Eric Engel, Stylianos E. Antonarkis, Wiley-Liss, Inc. ISBNs: 0-471-35126-1 (Hardback); 0-471-22193-7
15. Ricki Lewis Human Genetics Concepts and Applications 10th Edition, 2011, McGraw-Hill Science.
16. The Science of Genetics, Atherly et al (1999), Saunders
17. Robbins & Cotran, Pathologic Basis of Disease, 8th Edition, Elsevier, 2010.
18. Strachan Tom and Read Andrew P. (2011) Human Molecular Genetics, 4th Edition, Garland Science (Taylor and Francis Group), London and New York.

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Course Code	3SMB2E2
Course Title	Microbial Ecology

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-
Understand principles of ecology and interactions among microorganisms and their environment
Analyze beneficial and pathogenic interactions of microorganisms with plants and animals
Comprehend role of microorganisms in biogeochemical cycling of elements

Syllabus **Teaching hours:45**

Unit 1: Fundamentals of ecology **5 Hours**
The ecosystem, energy in ecological systems, energy partitioning in food chains and food webs, history and scope of ecology
Unit 2: Interactions among microbial populations **7 Hours**
positive positive and negative interactions, interactions between diverse microbial populations
Unit 3: Interactions between microorganisms and plants **8 Hours**
Interaction with plant roots– rhizosphere and mycorrhizae, interactions with aerial plant structures, microbial diseases of plants
Unit 4: Microbial interactions with animals **9 Hours**
Microbial contribution to animal nutrition, fungal predation on animals, other symbiotic relationship eg. Symbiotic light production and novel prokaryotic endosymbionts, ecological aspects of animal diseases.
Unit 5: Biogeochemical cycling I **8 Hours**
Carbon cycle, Hydrogen cycle, Oxygen cycle
Unit 6: Biogeochemical cycling II **8 Hours**
Nitrogen cycle, Sulphur cycle, Phosphorus cycle, cycling of other elements

Suggested Readings:

1. Atlas, R.M. and Bartha, R. Microbial Ecology, 4th edition, Pearson Education, 2009.
2. Maier, R.M., Peppper, I.L. and Gerba, C.P. Environmental Microbiology, 2nd edition, Elsevier Academic Press, 2009.
3. Paul and Clerk, Soil Microbiology and Biochemistry, 2007.
4. Paul, E.A. (Ed.). Soil Microbiology, Ecology and Biochemistry, 3rd edition, Academic Press, 2007.
5. Pepper, I.L. and Gerba, C.P. Environmental Microbiology – A Laboratory Manual, 2nd edition, Elsevier Academic Press, 2005.
6. Manahan, S.E. Environmental Chemistry, 9th edition, CRC Press, 2010.
7. Odum, E.P. and Barrett, G.W, Fundamentals of Ecology, 5th edition, Cengage Learning, 2005

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Course Code	3SBC2E2
Course Title	Reproductive Physiology

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Demonstrate an understanding of structure and function of reproductive systems.
2. Apply the basic knowledge to understand the molecular mechanisms of gametogenesis and its regulation.
3. Analyze the functional modulation and establish a relationship between various functional aspects of reproductive physiology
4. Evaluate and interpret the cause of pathogenicity or dysfunction and critically identify the mode of action.
5. Create and develop therapeutic or preventive strategies for reproductive irregularities.

Syllabus **Teaching hours: 45**

Unit 1: Human Reproductive System **8 Hours**
Structure, function of male and female reproductive function; Functional assessment of male and female functioning; Mechanism and molecular events of fertilization, Preembryonic Development, Pregnancy, Labour and Lactation.

Unit 2: Gamatogenesis **10 Hours**
Spermatogenic Cycle; Its Molecular changes, Hormonal Regulation, Spermiation and Spermiogenesis; Sperm capacitation; Molecular and Biochemical changes, decapacitation. Process of folliculogenesis and its hormonal control. Recruitment, selection, dominance of follicle and signaling for ovulation. Follicle wall: Theca, differentiation, steroid hormone synthesis, menstrual cycle and Menopause. Mechanism and hormonal control of ovulation; Histogenesis, function, maintenance and luteolysis during Corpus Luteum. Prostaglandins and their role in reproduction.

Unit 3: Gonadal Steroidogenesis **9 Hours**
Autocrine, Paracrine and Endocrine Regulation of Gonadal Steroidogenesis, Regulation of Expression of Genes Encoding Steroidogenic Enzymes.

Unit 4: Molecular Aspect of Sex Differentiation **5 Hours**
Location of Sry -Gene and its Critical Period of Expression, Specfic Cell Type Engaged in SRY - Gene Expression, Downstream Genes Regulation by SRY -- Gene Like Amh Gene, Arometase Gene, Ar-Gene, 5a-Reductase Gene, Sox -9 gene and Z-Gene.

Unit 5: Stress and Reproduction **5 Hour**
Stress and Pituitary Gonadotropin, Stress and Cytokines, Oxidative Stress and Reproductive Activities

Unit 6: Reproductive Immunology **8 Hours**
Role of immunological cells in the male and female reproductive system, understanding the normal and abnormal physiological events influenced by reproductive immune cells.

Books Recommended

1. Knobil, E. and Neil, J. D., The Physiology of Reproduction, Vol 1 and 2, Raven Press, 1988.
2. Wang, C., Male Reproductive Function, Kluwer Academic Publishers, 1999.

3. Zuckerman, B. S. Z., Weir, B. J. and Baker, T. G., The Ovary, Academic Press, 1977.
4. Leung, P. C. K. and Adashi, E. Y. (Ed), The Ovary, Elsevier (Academic Press), 2004.
5. Desjardins, C. and Ewing, L. L., Cell and Molecular Biology of Testis, Oxford University Press, USA, 1993
6. Yen, S. S. C., Jaffe, R. B., and Barbieri, R. L. (Ed), Reproductive Endocrinology: Physiology, Pathophysiology, and Clinical Management, Saunders Publisher. USA, 1999.
7. Chedrese, P. J., Reproductive Endocrinology: A Molecular Approach, Springer Publishers, 2009.
8. Carrell, D. T. and Peterson, C. M., Reproductive Endocrinology and Infertility, Springer Publishers 2010.

SEMESTER III

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Course Code	3SBT301
Course Title	Molecular Microbial Physiology

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Describe the principles of the energy-yielding and consuming reactions, the various catabolic and anabolic pathways, the transport systems and the mechanisms of energy conservation in microbial metabolism
2. Recognize the extent of metabolic diversity present in this microbial world and identify various physiological groups of bacteria with their metabolic special features.
3. Analyze microbial physiology related topics by working on assignments and to compose a concise report
4. Critically think and integrate conceptual information into an understanding of signal transduction, adaptation to stress and differentiation of microbial systems

Syllabus **Teaching hours**: **45**

Unit 1: Central Metabolism **10 Hours**

Glycolysis, ED pathway, phosphoketolase pathway oxidative pentose phosphate pathway TCA cycle, glyoxalate cycle, gluconeogenesis, regulatory aspects, Metabolism of sugars other than glucose

Unit 2: Electron transport chains and Phototrophy **9 Hours**

Mitochondrial and bacterial electron transport chains, Aerobic respiration and anaerobic respiration; Bacteriorhodopsin and energy generation, oxygenic and anoxygenic Photosynthesis. Mechanism of photosynthesis in bacteria, cyanobacteria and algae

Unit 3: Chemolithotrophy and CO_2 fixation **10 Hours**

Nitrate reduction: assimilatory vs. dissimilatory, nitrification, denitrification, electron transport in iron bacteria, sulphur bacteria Calvin cycle, reductive TCA cycle

Unit 4: Signal Transduction in Prokaryotes **6 Hours**

Two component system, Phospho-relay, Chemotaxis- Genes and Proteins involved in chemotactic response to attractant and repellent

Unit 5: Microbial Adaptation to stress **6 Hours**

Temperature, salt and osmotic stress and oxidative stress, Quroum sensing.

Unit 6: Differentiation in Microbial Systems **4 Hours**

The model of Sporulation in Bacillus, the two component signalling system, stages of Sporulation, Proteins and genes involved in Sporulation.

Suggested Readings:

1. White, D., Physiology and Biochemistry of prokaryotes, 3rd Edn. Oxford Univ. Press, 2007.
2. Moat, A. G. and Foster, J. W., Microbial Physiology, 3rd Edition, Wiley-Liss Publ, 1995.
3. E. L. Sharoud, Bacterial Physiology – A Molecular Approach, Springer, 2008.
4. Byung Hong Kim, Geoffrey Michael Gadd, Bacterial Physiology and Metabolism, Cambridge University Press, Cambridge, 2008.
5. Doelle HW, Bacterial Metabolism, Elsevier India Pvt. Ltd., New Delhi, 2005.
6. Gerhard Gottschalk, Bacterial Metabolism, 2nd edn., Springer-Verlag, New York, 2006.

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Course Code	3SBC304
Course Title	Cancer Biology

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Describe and appraise the fundamentals of cellular processes involving molecular genetic basis of multistep process of carcinogenesis
2. Illustrate mechanisms of physical, biological, and chemical cancer causing agents as well as spontaneous cancer onset in terms of role of oncogenes and tumour suppressor genes, deregulation of cell cycle and differentiation in cancer cells
3. Articulate host-environment interactions including susceptibility factors in cancer predisposition; cancer classification systems; principles of cancer diagnosis, prognosis, and response to therapy and management in the laboratory
4. Demonstrate understanding of cancer control for disease-free, relapse-free, and metastasis-free longer survival using knowledge of molecular players and factors governing cancer spread from primary sites, metastasis cascade, and invasion.

Syllabus **Teaching hours**: **45**

Unit 1: Introduction to Cancer Biology **8 Hours**

History of cancer and various theories of carcinogenesis, Warning signs of cancer; Hallmarks of cancer; Types of cancer; cancer classification systems: TNM, FAB, WHO; Cancer staging and Grading; Global Trends in cancer incidence and death rate; Baseline and environmentally induced cancer rate

Unit 2: Molecular Cell Biology of Cancer **8 Hours**

Proto-oncogenes and Oncogenes, Mechanisms of inactivation of proto-oncogenes and affected cellular pathways; modulation of growth factors, receptors, signal transduction, and cell cycle; Retroviruses and Oncogenes; Tumour suppressor genes, two-hit theory, Identification and detection of oncogenes and tumor suppressor genes, mi-RNA and other regulators of cellular pathways and cancer

Unit 3: Cancer Genetics, Cytogenetics and Genomics **8 Hours**

Constitutional and Acquired Genetic Determinants of Cancer; Genetic Predisposition to Cancer; Familial Cancers; Molecular pathogenesis of acquired chromosomal aberrations, fusion genes, gene amplification, whole genome, various approaches for detection of genetic changes and targeted therapy with examples of clinical importance

Unit 4: Principles of Carcinogenesis **8 Hours**

Physical, Chemical and Biological Carcinogenesis, Genotoxic and non-genotoxic Metabolism and Targets of Carcinogenesis, Molecular mechanism of Carcinogenesis. Cancer risk factors and differential susceptibility, Cancer metabolism

Unit 5: Cancer Metastasis **8 Hours**

Metastatic cascade; Basement Membrane disruption; Three-step theory of Invasion; Heterogeneity of metastatic phenotype; Epidermal Mesenchymal Transition, Molecular signatures and organ preference in metastasis, Proteinases and invasion

Unit 6: Therapeutic Approaches **5 Hours**

Strategies for cancer treatment; Tumor markers and molecular markers for cancer diagnosis,

prognosis, and therapy decisions; Cancer Immunology and therapeutic interventions, Targeted drug delivery and drug delivery systems, Cancer vaccine, Clinical trials, Gene Therapy, Targeted therapy, personalized medicine, survival and response monitoring.

Suggested Readings:

1. Weinberg R., Biology of Cancer, Garland Science, June, 2010
2. D. Liebler, Proteomics in cancer research, 2004
3. David M. Terrian, Cancer cell signalling, Methods and protocols, Volum 218 (Methods in Molecular Biology), 2003.
4. Strachan Tom and Read Andrew P. (2010) Human Molecular Genetics, 4th Edition, Garland Science (Taylor and Francis Group), London and New York
5. K.L. Rudolph, Telomeres and Telomerase in ageing, disease, and cancer, 2008.
6. Maly B.W.J., Virology: A practical approach, IRL Press, Oxford, 1987.
7. Dunmock N.J and Primrose, S.B., Introduction to modern Virology, Blackwell Scientific Publications. Oxford, 1988.
8. Knowles, M.A., Selby P., An Introduction to the Cellular and Molecular Biology of Cancer, Oxford Medical publications, 2005.
9. Vincent, T. De Vita, Lawrence T. S., Rosenberg, S. A., Cancer: Principles & Practice of Oncology, 10th Edition, Lippincot, 2011
10. http://atlasgeneticsoncology.org
11. http://cgap.nci.nih.gov/Chromosomes/Mitelman
12. http://www.humanvariomeproject.org
13. https://www.genome.gov/hapmap

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Course Code	3SBT308
Course Title	Animal Biotechnology

Course Learning Outcomes (CLO)

At the end of the course, students will be able to -

1. Describe the basics of maintenance of mammalian cell and generation of cell line using proper sterile techniques and optimum conditions of growth to develop mamalian cells.
2. To identify and comprehend experimental knowhow of various techniques involved in cell separation and quantitation using latest technology.
3. To relate and evaluate the applications of animal biotechnology gene therapy, toxicity testing, cancer research, animal breeding, vaccine production and other biotechnological products of industrial and medical benefits.
4. To relate to the social, cultural, economical, legal issues associated and comprehend the need of Bioethics and IPR in biotechnological research.

Syllabus **Teaching hours**: **45**

Unit 1: The Culture Media for Animal Cell culture **9 Hours**

Introduction, history and concept of biotechnology. Media and Supplements, Serum, Serum Free Media, Natural Media, Feeder Layer on Substrate, Gas Phase for Tissue Culture. Source of Tissue, Primary culture. Stages of Commitment and Differentiation, Proliferation, Malignancy.

Unit 2: Subculture and Cell lines **9 Hours**

Cross Contamination, Terminology, Naming and Choosing cell line and its maintenance. Criteria for subculture, growth cycle and split ratio, propagation in suspension and attached culture

Unit 3: Cloning and hybridoma technology **6 Hours**

Vectors and Cloning, Somatic Cell Fusion, Hybridomas, HAT Selection, Medium, Suspension Fusion, Selection of Hybrid Clones, Organ Culture, Tumourigenesis

Unit 4: Cell Separation and Quantitation **9 Hours**

Separation techniques based on density, size, sedimentation velocity, antibody based techniques - immune panning, magnetic sorting, and fluorescence activated cell sorting. Quantitation- Cell counting, cell weight, DNA content, protein, rate of synthesis, measurement of cell proliferation**.**

Unit 5: Characterization and differentiation **6 Hours**

Authentication, Record keeping, Provenance, parameters of characterization, Lineage and Tissue markers, cell morphology, Karyotyping, Chromosome banding. Differentiation- commitment, terminal differentiation. Lineage selection, proliferation and differentiation, commitment and lineage, markers of differentiation, induction of differentiation, cell interaction- homotypic and heterotypic. Cell – matrix interaction.

Unit 6: Applications of animal biotechnology and related problems **6 Hours**

Artificial animal breeding, cloning and transgenic animals, medicines, vaccines, diagnosis of diseases and disorders, gene therapy forensic application. Social, Cultural, Economical, Legal problems. Bioethics. IPR.

Suggested Readings:

1. Freshney, I., Cultures of Animal Cells, John Wiley and Sons Inc, 2010.

2. Cibelli, J., Robert P., Keith L.H.S., Campbell H., and West M. D., (Editors) Principles of Cloning, St. Diego Academic Press, 2002.
3. Mathur, S., Animal Cell and Tissue Culture, Agrobios (India), 2000.
4. Panno, J., The New Biology Series: Animal Cloning, Viva books Pvt. Ltd, New Delhi, 2010.
5. Mepham B. M., Bioethics- An introduction for Bioscience by, 2nd Edition, Oxford University Press, 2008.
6. Jacker, N. S., Johnson A. R., Pearlman R. A., Bioethics- An introduction to the history method and practice, 2nd Edition, Johnson Bartlett Publ. New York. 2010
7. Satheesh, M. K. Bioethics and Biosafety, I.K. International Publishing House Ltd, New Delhi. 2005
8. Glick, B. R., and Pasternak J. J., Molecular Biotechnology - Principles and applications of recombinant DNA, ASM Press, 3rd Edition., 2003.
9. Sullivan, S., Cowen C., and Eggan K., Human Embryonic Stem Cell: The Practical Handbook, 2007.
10. Freshney, R. I. (2010) Culture of Animal Cells, 6th Edn., Wiley-Blackwell.
11. Ramadass, P, Animal Biotechnology: Recent Concepts and Developments
12. Portner, Ralf. Animal Cell Biotechnology: Methods and Protocols.

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Course Code	3SBT3E1
Course Title	Genomics and Proteomics

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-
1. Describe the understanding of origin and evolution of genomics and genome mapping.
2. Apply the knowledge to establish new, molecular classification of the disease.
3. Evaluate the possibilities for application of pharmacogenomics and proteomics in drug discovery and development of personalized medicine**.**

Syllabus **Teaching Hours: 45**

Unit 1: Origin and Evolution of genomics and genome mapping **8 Hours**
Different databases, Alignment and homology tools, Origin of genomics, the first DNA genomes, microcolinearity, DNA based phylogenetic trees, genomes and human evolution, evolution of nuclear, mitochondrial and chloroplast genome, the concept of minimal genome and possibility of synthesizing it, genetic maps, physical maps, EST and transcript maps, functional maps, comparative genomics and colinearity, synteny in maps.

Unit 2: Whole Genome sequencing and analysis **5 Hours**
Genome sequencing methods review, analysis of the genomes of viruses, bacteria, archae, eukaryotic – fungi, parasites, insects, plant genomes (Arabidopsis and rice), Animal genomes (fruit fly, mouse, human)

Unit 3: Annotation of whole genome sequence and functional genomics **8 Hours**
In Silico methods, insertion mutagenesis (T-DNA and transport insertion), Targeting Induced Local Lesions in Genomes (TILLING), management of data, gene expression and transcript profiling, EST contigs and unigene sets, use of DNA chips and microarrays.

Unit 4: Pharmacogenomics **8 Hours**
Use in biomedicine involving diagnosis and treatment of diseases, genomics in medical practice, personalized medicine, DNA polymorphism and treatment of diseases, application of SNP-technology-mapping genes underlying monogenic and multigenic disorder, use of SNP in pharmacogenomics, pharmacogenomics and industry.

Unit 5: Proteomics **8 Hours**
Introduction and overview of tools used in proteomics studies, protein - protein interaction, DNA- Protein interaction, application of quantitative proteomics for the analysis of protein - protein interactions and protein linkage maps, understand yeast two-hybrid and mass spectrometry based techniques for the analysis of protein complexes and their significance and limitations.

Unit 6: Drug Discovery and Development **8 Hours**
Structure prediction and human proteomics, mutant proteins, use of computer simulations and knowledge-based methods in the design process, proteomic methods for the detection and analysis of protein biomarkers for the detection and classification of disease, De-novo design; making use of databases of sequence and structure, protein structure and drug discovery, proteins in disease, current issues, drug targets, drug efficacy, protein chips and antibody microarray, techniques and future approaches of proteomics in cancer research.

Suggested Readings:
1. Pevsner, J., Bioinformatics and Functional Genomics, Second Edition, Wiley-Blackwell, 2009.

2. Mount, D. W., Bioinformatics: Sequence and Genome Analysis, CBS Publishers, 2004
3. Liebler, D., Introduction to Proteomics: Tools for New Biology, Human Press Totowa, 2002.
4. Campbell, A.M. & Heyer, L.J., Discovering Genomics, Proteomics and Bioinformatics. Benjamin/Cummings, 2002.]

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Course Code	3SBC3E1
Course Title	Structural Biology

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-
1. Demonstrate the understanding of architecture and building blocks of proteins.
2. Apply the thermodynamic concepts of protein stability and relate structure to its function
3. Analyse the significance of protein misfolding and associated disorders.
4. Evaluate macromolecular complexes and their biological complexity.

Syllabus: **Teaching hours**: **45**

Unit 1: Introduction **6 hours**
Overview of structural biology - Levels of structures in Biological macromolecules; Noncovalent forces determining biopolymer structure; Principles of minimization of conformational energy.

Unit 2: Protein Structure **9 hours**
Proteins primary, secondary and tertiary structures - Structural implications of the peptide bond; Ramachandran Diagram; Structural classification of proteins, structural motifs, profiles and protein families; Methods and techniques for study of protein structure and its perturbations.

Unit 3: Protein Folding **7 hours**
Folding in vivo and in vitro; protein stability, thermodynamics and kinetics; Effect of various factors on folding; Folding intermediates- kinetic, equilibrium and molten globule intermediates; Techniques for studying the structure and folding of proteins; chaperones, peptidyl prolyl isomerase (PPI), Protein disulfide isomerase (PDI); Protein structure and disease; Therapeutic approaches; Comparison of the structure and stability of proteins of mesophilic and extremophilic origin.

Unit 4: Biomolecular Interactions **9 hours**
Molecular recognition, supramolecular interactions, Protein-protein interactions and their importance.

Unit 5: Nucleic Acids Structure and Protein-Nucleic Acid Interaction **7 hours**
Structural parameters for A-, B-, C-, D- and Z-DNA, Structure of RNA; Specific and non-specific nucleic acid-protein complexes and the functional importance of protein-nucleic acid interactions; Macromolecular assemblies.

Unit 6: Membrane Structure **7 hours**
Lipid structure and their organization; Comparison between different membrane models; carrier transport, ion transport, active and passive transport, ion pumps, water transport, use of liposomes for membrane models and drug delivery systems.

Suggested reading:

1. Branden, C. and Tooze, J., Introduction to Protein Structure, Garland Publishing Inc., 1999.
2. Tinoco, I., Sauer, K., Wang, J. C., and Puglisi, J. D., Physical Chemistry: Principles and Applications in Biological Sciences, 4th ed., Prentice Hall, 2001.

3. Grisshammer, R. K., Buchanan, S. K., Structural Biology of Membrane proteins, Royal Society of Chemistry, 2006.
4. Rice, P. A. and Correl, C. C., Protein-Nucleic Acid Interactions: Structural Biology, RSC Publishing, 2008.
5. Blackburn, M. G., Gait, M. J., Loakes, D. and Williams, D. M., Nucleic Acids in Chemistry and Biology, RSC Publishing, 2006.
6. Creighton, T. E. Proteins: Structure and Molecular Properties, W. H. Freeman, 1995.
7. Creighton, T. E. (Editor), Protein Function: A Practical Approach, Oxford University Press, 2002.
8. Lesk, A. M., Introduction to Protein Architecture: The Structural Biology of Proteins, US Oxford University Press, USA, 2001.

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Course Code	3SMB304
Course Title	Agriculture & Environmental Microbiology

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Describe role of microorganism in recycling soil nutrients, biodegradation of complex plant polymers, sustaining and improving plant growth through improving nutrient availability, production of plant growth promoting substances and inhibiting pathogens.
2. Critically discuss the need for environmental microbiology and agricultural microbiology and explain their limitations.
3. Clarify application of microorganisms in varied fields of agricultural and environmental microbiology like bioremediation, biofertilizers and waste water treatment.
4. Analyse various aspects of N_2 fixation, P solubilization, PGPR, biodegradation and bioremediation mechanisms provided by microbes

Syllabus **Teaching hours: 45**

Unit 1: Biological Nitrogen fixation **10 Hours**
Physiology and Biochemistry of Nitrogen fixing organisms, Genetics and regulation of nif gene expression, Signalling factors and molecular interaction in establishing Rhizobia legume symbiosis

Unit 2: Phosphate Biofertilizers **6 Hours**
PSMs (**Skill Development & Employability**), Inorganic phosphate solubilization and its mechanisms, Phosphate mineralizers – phytate and organic phosphate hydrolyzing bacteria, and Ecto- and Endo- Mycorrhizae

Unit 3: Plant Growth Promoting Rhizobacteria **6 Hours**
PGPR in improving plant growth, Mechanism in plant growth promotion, Factors affecting rhizosphere colonization.

Unit 4: Environmental Problems and Monitoring **8 Hours**
Pollution and its classification, Effluent standards: examination of waste water characteristics, municipal and industrial waste water, Global environmental problems: global warming, acid rain, ozone depletion, Sampling and analysis, Environmental monitoring and audit, Environmental laws and policies in India.

Unit 5: Bio-Treatment Kinetics and Reactor Design **8 Hours**
Principals of biological treatments, Biological treatments: Composting, Suspended growth systems, Attached growth systems, Bioreactor design: Activated Sludge Process, Tickling Filters, Fluidised bed and Packed bed reactor, Rotating Biological Contractors, Oxidation Ponds and Ditches, Lagoons, Anaerobic Reactors.

Unit 6: Bioremediation and Biodegradation **7 Hours**
Bioremediation principles and Processes: Biosorption, Bioaccumulation, Bioconversion, Biotransformation, Bioleaching, Biodegradation, Detoxification, Activation, Acclimatization and Co-metabolism, strategies and techniques of bioremediatio***)***: in situ and ex situ, of Hydrocarbons, Pesticides and Dyes, GMO's in bioremediation and biodegradation.

Suggested Readings:

1. Alexander, M. Biodegradation and Bioremediation, Academic Press, 1994.

2. Arceivala, S.J. and Asolekar, S.R., Wastewater treatment for Pollution Control and Reuse, 3rd edition, Tata McGraw Hill, 2007.
3. Atlas, R.M. and Bartha, R. Microbial Ecology, 4th edition, Pearson Education, 2009.
4. Bhatia, S.C. Handbook of Environmental Microbiology, Vol. III, Atlantic Publishers, 2008.
5. Das, H.K. Textbook of Biotechnology, 2nd edition, Wiley Dreamtech, 2005.
6. Dworkin, M., Falkow, S., Rosenberg, E., Schleifer, K.H., Stackebrandt, E. (Eds.). The Prokaryotes. Vol. I – VII, Springer, 2006.
7. Evans, G.M. and Furlong, J.C. Environmental Biotechnology – Theory and Application, John Wiley and Sons, 2004.
8. Hurst Christon J., Manual of Environmental Microbiology, ASM Press, Washington DC, 2007.
9. Khan M. S., Zaidi A. and Musarrat J. Microbes for legume improvement, Springer Wien, New York, 2010.
10. Maier, R.M., Peppper, I.L. and Gerba, C.P. Environmental Microbiology, 2nd edition, Elsevier Academic Press, 2009.
11. Paul and Clerk, Soil Microbiology and Biochemistry, 2007.
12. Paul, E.A. (Ed.). Soil Microbiology, Ecology and Biochemistry, 3rd edition, Academic Press, 2007.
13. Pepper, I.L. and Gerba, C.P. Environmental Microbiology – A Laboratory Manual, 2nd edition, Elsevier Academic Press, 2005.
14. Rao, N. S. Subba, Soil Microbiology, 4th edition, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2008.
15. Thakur, I.S. Environmental Biotechnology – Basic concepts and Applications, I.K. International, 2006.
16. Varma A., Oelmuller R. Advanced Techniques in Soil Microbiology, Springer (India) Pvt. Ltd, 2007.

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Course Code	3SBT309
Course Title	Vaccinology

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Have an idea about the history of various vaccines (subunit vaccines, peptide, DNA and RNA vaccines, live & killed vaccines and edible vaccines), composition of vaccines
2. Learn and develop understanding on the effective delivery of developed vaccine formulation to achieving robust immune responses
3. Understand the various methods to develop vaccines against viral diseases including, HIV, hepatitis, flu etc.
4. Learn and understand the basics of bacterial, protozoan vaccines with reference to malaria parasite
5. To design an efficacious vaccine based on our understanding of the immune response generated due to natural infection as well as the same induced by successful vaccines tried in human beings since 18th century.

Syllabus **Teaching hours**: **45**

Unit 1: Introduction to Vaccinology and Classification **7 Hours**
History of vaccines, Immunological principles, Composition of vaccines: vaccine, adjuvant, conservative Concepts of vaccine development, types of vaccine (Conventional vaccines; Live and killed vaccines; New generation vaccines; Subunit vaccines; Synthetic peptide vaccines; Anti-idiotype vaccines; Recombinant DNA vaccines; Deleted mutant vaccines; Reassortment vaccines; DNA vaccines; Edible vaccines) vaccine, heat killed, X-irradiated, or live attenuated whole pathogen., challenges and possibilities with new vaccines and vaccine strategies.

Unit 2: Development of novel vaccines and Vaccine Delivery **6 Hours**
Novel adjuvants, vaccine formats (DNA, viral vectors, dendritic cells), vaccines in development (HIV, malaria, pandemic influenza), Adjuvants; Carriers; Haptens; Vaccine delivery using nanoparticles; Standardization of vaccines; Safety, sterility and potency testing.

Unit 3: Vaccines for viruses **8 Hours**
HIV, CMV, flu, Hepatitis, herpes viruses, Conventional vaccines killed and attenuated, modern vaccines—recombinant proteins, subunits, DNA vaccines, peptides, immunomodulators (cytokines), Antisense RNA, siRNA, ribozymes, *in silico* approaches for drug designing.

Unit 4: Vaccine for bacteria **8 Hours**
Shigella, vibrio cholera, diphtheria, tetanus, pertusis, pneumococcus meningitis, toxoplasma, mycobacterium (BCG)

Unit 5: Vaccine for protozoa and parasite **8 Hours**
Malaria, Leishmaniasis, Entamoeba histolytica, schistosomiasis and other helminthic infections.

Unit 6: Reverse vaccinology and immunoinformatics **8 Hours**
Databases in Immunology, B-cell epitope prediction methods, T-cell epitope prediction methods, Resources to study antibodies, antigen-antibody interactions, Structure Activity Relationship – QSARs and QSPRs, QSAR Methodology, Various Descriptors used in QSARs:

Electronics; Topology; Quantum Chemical based Descriptors. Use of Genetic Algorithms, Neural Networks and Principle Components Analysis in the QSAR equations.

Suggested Readings:

1. Plotkin, S. A., Orenstein, W. A., and Offit, P. A., Vaccines. 5th Editon, Elsevier, 2008.
2. Immunopotentiators in Modern Vaccines by Schijns and O'Hagen
3. Robinson, A., Hudson, M.J., Cranage, M.P. Vaccine Protocols, C Second Edition, Humana Press, NY, 2003.
4. Chimeric Virus like Particles as Vaccines. Wolfram H. Gerlich (Editor), Detlev H. Krueger (Editor), Rainer Ulrich (Editor), November 1996 Publisher: Karger, S. Inc
5. Kindt, Kuby-Immunology (complements)
6. Current protocols in Immunology
7. Complement regulators and inhibitory proteins. Nat immunology Review volume 9, Oct 2009, 729-40.

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Course Code	3SMB307
Course Title	Microbial Diversity and Systematics

Course Learning Outcomes (CLO):
At the end of the course, students will be able to -

1. Recognize the extent of microbial diversity present in this world including prokaryotic and eukaryotic microbes and the importance of microbial diversity in different habitats including extreme environments
2. Understand conventional and molecular methods used for studying microbial diversity and problems and limitations in microbial diversity studies.
3. Describe the microbial classification schemes and methods used for taxonomy, distinguish and differentiate the use of various taxonomic tools apt for classification and identification of microorganisms.
4. Apply the knowledge of biochemistry and physiology of extremophiles for their application potentials in Biotechnology

Syllabus **Teaching hours: 45**

Unit 1: Principles of Microbial Diversity **9 Hours**
Evolution of life, Principles and concepts of microbial diversity, Ecological diversity, Structural and Functional Diversity. Methods of studying microbial diversity– microscopy, nucleic acid analysis, physiological studies, CLPP, FAME.

Unit 2: Issues of Microbial Diversity **7 Hours**
Problems and limitations in microbial diversity studies, Diversity Indices, Loss of diversity, Sustainability and Resilience, Indicator species, Exploitation of microbial diversity, Conservation and economics**.**

Unit 3: Microbial Classification and Taxonomy **9 Hours**
Phenetic, Phylogenetic and Genotypic classification, Numerical Taxonomy, Taxonomic Ranks, Techniques for determining Microbial Taxonomy and Phylogeny – classical and molecular characteristics, phylogenetic trees; major divisions of life, Bergey's Manual of Systematic Bacteriology, Prokaryotic Phylogeny and major groups of bacteria.

Unit 4: The Archaea **7 Hours**
Ecology, Archaeal cell walls and membranes, genetics and molecular biology, metabolism, archaeal Taxonomy, Phylum Crenarchaeota, Phylum Euryarchaeota.

Unit 5: Eukaryotic Diversity **7 Hours**
Physiological variation, identification, cultivation and classification of important groups of fungi, algae and protozoa

Unit 6: Microbial Diversity in Extreme Environments **6 Hours**
Habitat, diversity, physiology, survival and adaptation, and biotechnological potentials of: Cold and thermal environment, Saline and deep sea environment, Anaerobic environment, Osmophilic and xerophilic environment, Alkaline and acidic environment.

Suggested Readings:

1. Cavicchioli, R. Archaea – Molecular and Cellular Biology, ASM Press, Washington, 2007.
2. Dworkin, M., Falkow, S., Rosenberg, E., Schleifer, K.H., Stackebrandt, E. (Eds.). The Prokaryotes. Vol. I – VII, Springer, 2006.

3. Garrity, G.M. and Boone, D.R. (Eds.), Bergey's Manual of Systematic Bacteriology, 2nd edition, Vol. I, Springer, 2001.
4. Garrity, G.M., Brenner, D.J., Kreig, M.R. and Staley, J.T. (Eds.), Bergey's Manual of Systematic Bacteriology, 2nd edition, Vol. II, Springer, 2005.
5. Gerday, C. and Glansdorff, N. Physiology and Biodiversity of Extremophiles, ASM Press, Washington, 2007.
6. Hurst, C.J, Crawford, R.L., Garland, J.L., Lipson, D.A., Mills, A.L. and Stetzenbach, L.D. Manual of Environmental Microbiology, 3rd Edition, ASM Press, Washington, 2007.
7. Madigan, M.T. and Martinko, J.M. Brock Biology of Microorganisms, 11th edition, Pearson Prentice Hall, 2006.
8. Mueller, G.M., Bills, G.F. and Foster, M.S. Biodiversity of Fungi – Inventory and Monitoring Methods, Elsevier Academic Press, 2004.
9. Willey, J.M., Sherwood, L.M. and Woolverton, C.J. Prescott, Harley and Klein's Microbiology, 7th edition, McGraw Hill, 2008.

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Course Code	3SBT311
Course Title	Laboratory III

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Understand the basics of primary cell and cell line culture, wastewater characterisation, microbial physiology of agriculturally and environmentally important microbes and bioremediation.
2. Analyse the data obtained from cell culture, water analysis and microbial experiments to interpret the results.
3. Apply and correlate the knowledge obtained to analyse various agricultural and environmental conditions for designing probable treatment strategies.

Syllabus: **Teaching Hours: 120**

Hepatocytes, Pancreatic, and Lymphocyte – isolation, cell preparation, cell viability, counting, and culture; Diauxie growth of E. coli, Catabolite repression in E.coli, MPN of Azospirillum and sulphate reducers, Estimation of soil microbial activity and soil respiration, Isolation and enumeration of Rhizobium, phosphate solubilizers and Actinomycetes, Rhizosphere effect; Estimation of BOD, Testing for microbiological quality (Coli-form test) for potable water and physico-chemical characterization of wastewater, Biosorption of Metals.

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Course Code	3SBT312
Course Title	Research Methods

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Demonstrate skills for literature review and understanding of research and review articles.
2. Propose original research proposal and demonstrate skills for effective communication through its defence.
3. Application of bio-statistical tools for evaluation of statistical relevance of results obtained.

Syllabus **Teaching hours**: **135**

Theory

Unit 1: Research

Definition of Research, Applications of Research and Types, Validity, Literature Review, Develop a Theoretical and Conceptual Framework, Writing up the Review, Formulating and Research Problem- Sources, Considerations, Definition of Variables, Types, Research Modeling:
Types of Models, Model Building and Stages, Data Consideration.

Unit 2: Research Design

Design of Experiments, Objectives, Strategies, Replication, Randomization, Blocking, Guidelines for Design of Experiments, Simple Comparative Experiments- Two Sample T-Test, P-Value, Confidence Intervals, Paired Comparisons, Single Factor Experiment: Analysis of Variance (ANOVA), Randomized Complete Block Design.

Unit 3: Research Proposal

Contents-Preamble, The Problem, Objectives, Hypothesis To Be Tested, Study Design, Setup, Measurement Procedures, Analysis of Data, Organization of Report; Displaying Data tables, Graphs and Charts, Writing a Research Report- Developing an Outline, Key Elements- Objective, Introduction, Design or Rationale of Work, Experimental Methods, Procedures, Measurements, Results, Discussion, Conclusion, Referencing and Various Formats for Reference Writing of Books and Research Papers, Report Writing- Prewriting Considerations, Thesis Writing, Formats of Report Writing, Formats of Publications in Research Journals.

Practicals

The students have to perform wet lab experimentation on the topic of project assigned to them such as standardisation of the protocols.

Suggested Readings:

1. Central Drugs Standard Control Organization Http://CDSCO.NIC.IN/
2. Http://WWW.Patentoffice.NIC.IN/
3. WWW.OECD.ORG/DATAOECD/9/11/33663321.PDF
4. Http://WWW.FDA.GOV/FDAC/Special/Testtubetopatient/Studies. Html
5. Ranjit Kumar, Research Methodology- A Step-By-Step Guide for Beginners, Pearson Education, Delhi. 2006.

6. Trochim, William M.K., 2/E, Research Methods, Biztantra, Dreamtech Press, New Delhi, 2003.
7. Montgomery, Douglas C. 5/E, Design and Analysis of Experiments, Wiley India, 2007.
8. Kothari, C.K., 2/E, Research Methodology- Methods and Techniques, New Age International, New Delhi, 2004.
9. Besterfield, Dale H. 3/E, Total Quality Management, Pearson Education, New Delhi, 2005.

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Course Code	3SBC3A1
Course Title	Neuroendocrine Regulation of Behavior

Course Learning Outcomes (CLO)

At the end of the course, students will be able to -

1. To describe the role of various neuro- hormones involed in auditory and optical senses, feeding and emotional behavior
2. To discuss the pathophysiological changes associated with mental and behavioural disorders and debate the role and effect of available psychotic drugs.
3. To identify and relate various behavioural models to study cognitive and motor behaviour

Syllabus **Teaching hours**: **15**

Emotion and behaviour - Neuro-anatomy of limbic system; Behavioural control of hormonal secretion, feeding behaviour; drinking behaviour; emotional behaviour, Physiological changes associated with emotion and Integration of emotional behaviour; Physiology in brief of vision and auditory sense; Motivation, addiction and its neurobiology. Behavioural model of fear, anxiety and depression and related psychotic drugs.

Suggested Readings:

1. Purves, D, Augustine, G., Neuroscience, Sinauer, 2000.
2. Tortora, G. J. and Derrickson, B. H., Principles of Anatomy and Physiology, Weily and Sons, 2009
3. Breedlove, M. C., Watson, N. V., Rozenzweig M. R., Biological Psychology: An Introduction to Behavioural, Cognitive and Clinical Neuroscience. Sinauer Associates, 6th Edition, 2010.
4. Amthor Frank, Neuroscience for dummies. USA John Wiley & Sons Canada Ltd. 2012.
5. Kolb, Bryan; Whishaw, Ian Q. An Introduction to Brain and Behavior, New York Worth Publishers 2011
6. Turkingtons, C., The Brain and Brain Disorders, Viva Books, 2009
7. Kandel, E., Schwartz, J. and Jessell T., Essentials of Neural Science and Behaviour, McGraw-Hill, 2003.

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Course Code	**3SBC3S1**
Course Title	**Understanding Gastrointestinal Hormones and Gut Associated Cancer**

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Understand the diversity of G I Tract hormones and gastrointestinal associated cancers
2. Determine the probable targets and causes of hormonal modulation and cancer induction.
3. Analyse and evaluate the molecular mechanism and probable targets as therapeutic approaches

Syllabus **Teaching hours**: **15**

Introduction to Gut associated cancers and their pathogenesis, Molecular markers identification, Genetic & Epigenetic markers, Mechanism of Induction, Existing therapies, New Trends in cancer therapy, Gut Hormones involved in metabolism and gastric cancer, Role of hormone in cancer, Identification of newer therapeutic targets.

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Course Code	3SBC3S2
Course Title	Molecular Mechanisms of Infertility

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Understand the causes for the initiation of reproductive infertility.
2. Determine the probable targets for the treatment.
3. Analyse and evaluate the molecular mechanism and probable role of stress and immunology in infertility

Syllabus **Teaching hours**: **15**

Incidences and etiology of Male and female infertility, molecular mechanism of induction of infertility, role of mitochondria, hormones and immunological mediators, identification of molecular markers for male and female infertility.

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Course Code	3SBC3S3
Course Title	Pathogenesis of Diabetes

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Understand the mechanisms of onset of diabetes and differentiating it from obesity.
2. Determine the role of triad i.e., interaction of gut, liver and pancreas in diabetes.
3. Analyse and evaluate the molecular mechanism and probable targets as therapeutic approaches.

Syllabus **Teaching hours**: **15**

Type I and II Diabetes, Mechanism of induction, Metabolic Disturbances, Drug and Diet Induced Diabetes, Endocrine Disorders, Role of Gut microflora, Role of Liver and Pancreas in diabetes, Identification of Therapeutic strategies.

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Course Code	3SBC3S4
Course Title	Genotoxicity Testing for Cancer Risk Assessment

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Understand methods and mechanisms of laboratory tools for biological safety assessment
2. Apply cell culture techniques based cytogenetic and genetic damage assays
3. Appreciate regulatory guidelines and best practices in study of biological effect of environmental factors on genome

Syllabus **Teaching hours**: **15**

Cell culture techniques for in vitro cytogenetics assays: Chromosome breakage, Cytokinesis blocked micronucleus assay, Comet assay, Sister Chromatid Exchange assay, in vitro metabolic activation systems, Regulatory guidelines and best practices of Genotoxicity studies; National and International regulations for establishing genotoxicity of a substance, application in safety studies of novel drugs, nanoparticles, and other environmental agents and exposed population; OECD, EPA guidelines for scoring and analysis

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Course Code	3SBC3S5
Course Title	Applied Human Cytogenetics

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Grasp methods and mechanisms of cell culture methods for karyotyping using various tissues
2. Apply ISCN guidelines for interpretation of genetics analysis
3. Understand normal and abnormal genetic constitution of human at chromosomal level and scope of molecular genetic analysis
4. Appraise genotype-phenotype correlation in various human genetic conditions

Syllabus **Teaching hours**: **15**

In vitro short term culture techniques for metaphase chromosome preparations from blood, bone marrow, and other tissue samples; chromosome banding, karyotyping, ISCN guidelines, Clinical applications in Prenatal Genetic Diagnosis, Pregnancy, Post-Natal, and Cancer; Introduction to molecular cytogenetics; FISH & m-FISH.

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Course Code	3SBT3S1
Course Title	Carbon Catabolite Repression

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Understand the physiological and molecular mechanisms that regulate preferential utilization of carbon source
2. Learn the strategies of preferential C utilization in multisubstrate environment like soil and its impact on microbial physiology

Syllabus **Teaching hours**: **15**

Response to Carbon sources: Catabolite repression, Inducer Expulsion, Permease synthesis, repression models in *E. coli* and *Pseudomonas*, Reverse Catabolite repression, Catabolite repression and Mineral phosphate solubilization.

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Course Code	3SBT3S2
Course Title	Immunological Memory

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Understand how memory T and B cells are generated following natural infection
2. Evaluate and analyse the immune response to provide long-term protection
3. Manipulate the antigenic exposure to immune system to generate memory T cells
4. Design immunomodulator(s) to induce long-term protection

Syllabus **Teaching Hours: 15**

Generation of T cell and B cell memory, Requirement for maintenance of memory T cells, Interaction of memory B cells with memory T cells, Role of Innate Immunity in maintenance of memory T cells

L	T	P	C
1	-	-	1

Course Code	3SBT3M1
Course Title	Protein Stability

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Describe the factors affecting the chemical and physical stability of proteins.
2. Comparative Analysis of stability of extremophilic and mesophilic proteins and application of techniques to measure stability.
3. Propose hypothesis for dissertation using literature survey, case studies and group presentation.

Syllabus **Teaching Hours: 15**

Chemical and Physical stability of Proteins; Thermodynamic aspects of stability; Factors affecting protein stability; Two-state model of protein stability; Protein denaturation and denaturants; Stability of extremophilc proteins and comparative analysis with mesophilic proteins; Role of different amino acid residues in protein stability, Techniques to study and measure protein stability.

L	T	P	C
1	-	-	1

Course Code	3SMB3N1
Course Title	Microbial Community Dynamics and Ecological Succession

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Identify role of microorganisms and microbial community shifts in ecological succession. They will understand aspects of sustainability, resilience and importance of indicator species.
2. Understand various methods for microbial diversity estimations and multivariate statistical tools and to use them.

Syllabus **Teaching hours: 15**

Principles and concepts of microbial diversity, Ecological diversity, Loss of diversity, Sustainability and Resilience, Indicator Species, Ecological Succession, Methods used for 'Microbial Diversity Analysis', Multivariate statistical tools for Microbial Diversity Analysis using SPSS.

L	T	P	C
1	-	-	1

Course Code	**3SMB3V1**
Course Title	**Antimicrobial Agents**

Course Learning outcomes:
At the end of the course, students will be able to-

1. Be familiar with currently available antimicrobial agents, their scope and limitations.
2. Learn evolution of drug-resistance, its molecular basis, and also be familiar with strategies for discovery and development of novel antimicrobials.
3. Understand the need for finding novel drug targets

Syllabus **Teaching hours: 15**

A concise overview of currently available antimicrobial agents; Drug-resistance among pathogens, and its molecular basis; Strategies for development of novel antimicrobials; challenges involved; Antimicrobial susceptibility tests: Utility, limitations and challenges.

SEMESTER IV

L	T	P	C
1	-	-	26

Course Code	3SBT402
Course Title	Dissertation

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Develop understanding in the field of scientific research at the academic as well as industrial sector. This will students to identify scientific problems and design proposals to address and implement ideas. This enables them to communicate the same to a greater audience.
2. This will benefit the students to perform well in their job interviews and to design their CV which can evoke interest in the employers to know more about the candidate.

Outline:
The students have to carry out their dissertation work. They have to perform wet lab experimentation on the topic of project assigned to them. The Viva will be conducted as intrim presentation as well as final presentations, where the students have to defend their dissertation work

L	T	P	C
-	-	2	2

Course Code	**3SBT404**
Course Title	**Comprehensive Viva voce**

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. Develop understanding in the field of scientific research at the academic as well as industrial sector. This will students to identify scientific problems and design proposals to address and implement ideas. This enables them to communicate the same to a greater audience.
2. Shape up their career in the field of research at the academic as well as industrial sector. This will be helpful to students in identifying scientific problems and design proposals to address and implement ideas, enables them to communicate the same to a greater audience.

Outline:

Viva voce will be conducted towards the end of the semester which will be covering the complete syllabus. This will test the student's learning and understanding during the course of their post graduate programme. In doing so, the main objective of this course is to prepare the students to face interview both at the academic and the industrial sector.

L	T	P	C
-	-	1	-

Course Code	**3SBT405**
Course Title	**CV Writing and Interview Preparation**

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

1. To perform well in their job interviews and to design their CV which can evoke interest in the employers to know more about the candidate.

Outline:
This course will be guiding the students to prepare their CV as per the requirement of the employer both at the academic as well as industrial sector. This will also help the students to prepare for job interviews with the help of Mock Interviews, Group Discussions and interpersonal communication skills.