Department of Biotechnology

Proposed Syllabus
for
M. Sc. Biotechnology
To be effective from Academic Session 2022-2023

Central University of Rajasthan
NH-8, Bandarsindri,
Kishangarh-305817
Distt. Ajmer

Program Objectives

The aim of this program is to provide students with the knowledge and skills; prepare them to work, independently in R & D of both public and private sectors or other employment in biotechnology-based organizations, and also for higher studies at the Doctoral level.

The objectives of the program are as follows:

1. In Depth Knowledge and Understanding

- About the basic and advanced biotechnology field.
- Of current research and development in the field.

2. Skills and Abilities

- For evaluating information relevant to concepts and issues of contemporary biotechnology.
- For analyzing and solving both theoretical and applied biotechnological problems.

3. Critical Judgement and Evaluation

- About legal, ethical, social and business aspects of biotechnology-based products and services.
- To perform biotechnological research or assessments independently and/or in collaboration with other person(s) or team.

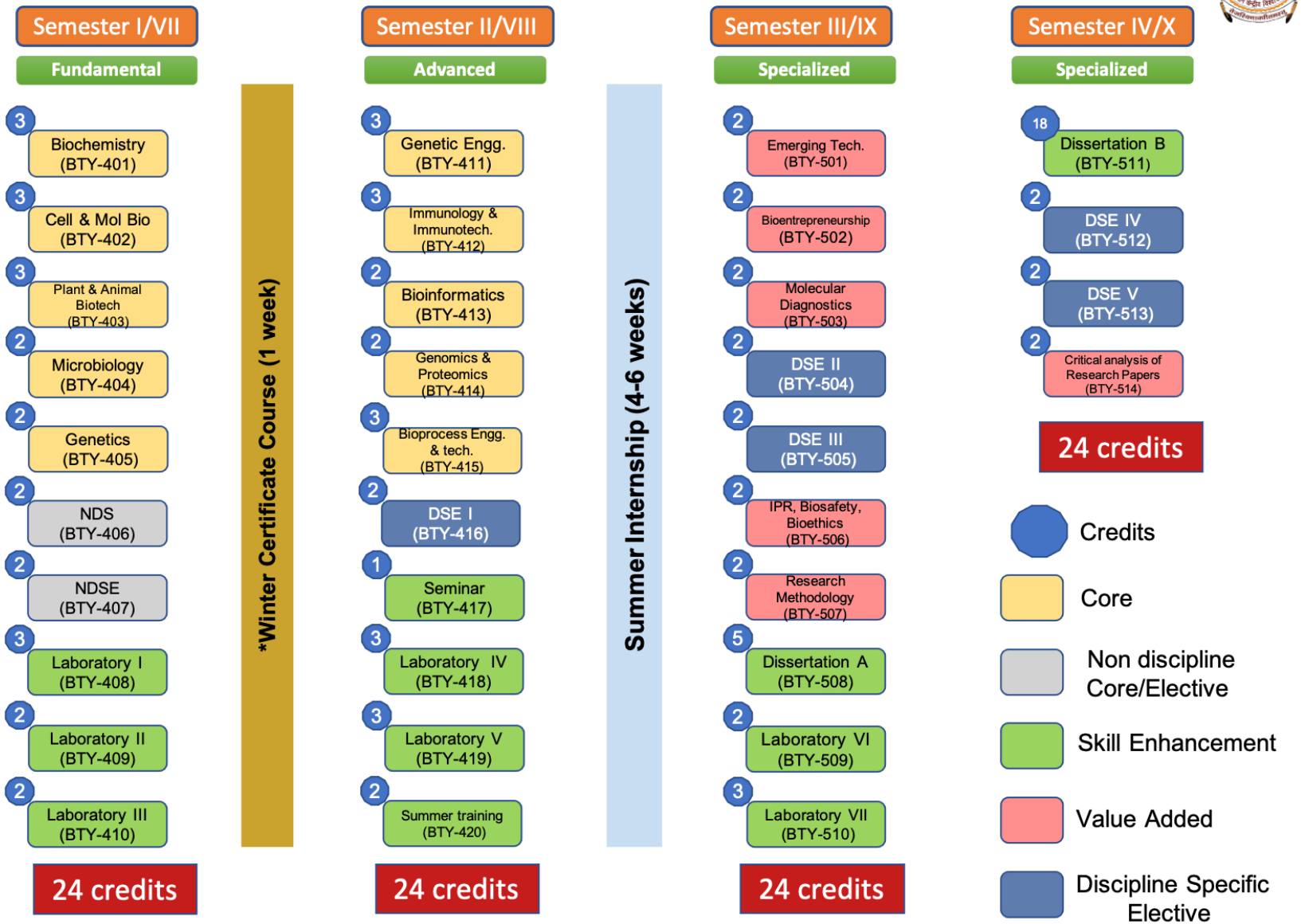
Program Outcomes

At the end of the program the student will be able to:

1.	Demonstrate in-depth knowledge of basic and applied science subjects that constitute the field of biotechnology.
2.	Demonstrate an insight into current research and development in the biotechnology field.
3.	Work in the R & D laboratories of both public and private sectors.
4.	Apply research based knowledge and biotechnological techniques to investigate complex biological problems.
5.	Use software based tools to understand biological systems.
6.	Assess personnel, product and environmental safety, intellectual property and social responsibilities related to modern biotechnological research and development.
7.	Identify measures for environment, health, safety and society following ethical principles.
8.	Participate in R & D projects in biotechnology, able to work in multi-disciplinary teams to attain project objectives, document the activities, and present reports effectively.

Department of Biotechnology

M.Sc. Biotechnology (2 years) and Integrated M.Sc. Biotechnology (VII Sem to X Sem)



*The Department may offer winter certificate course during the winter to enhance the employability.

Int. M.Sc. Biotechnology VII-X Semester and M.Sc. Biotechnology (2-year program) - Revised Course Structure
(Proposed to be implemented from Academic Session 2022-2023 onwards)

Semester I				
Course Code	**Course Name**	**Course**	**Course Type**	**Credits**
BTY-401	Biochemistry	Core	T	3
BTY-402	Cell and Molecular Biology	Core	T	3
BTY-403	Plant and Animal Biotechnology	Core	T	3
BTY-404	Microbiology	Core	T	2
BTY-405	Genetics	Core	T	2
BTY-406	Statistics for Biologists	Core/NDS	T	2
BTY-407	Basics of Chemistry and Physics/NDSE1*	Core /NDSE*	T	2
BTY-408	Laboratory I: Biochemistry and Analytical Techniques	Core/SEC	L	3
BTY-409	Laboratory II: Microbiology	Core/SEC	L	2
BTY-410	Laboratory III: Plant and Animal Biotechnology	Core/SEC	L	2
		Total credits		**24**
Winter Certificate Course (1 week) VA**				
Semester II				
Course Code	**Course Name**		**Course Type**	**Credits**
BTY-411	Genetics Engineering	Core	T	3
BTY-412	Immunology and Immunotechnology	Core	T	3
BTY-413	Bioinformatics	Core	T	2
BTY-414	Genomics and Proteomics	Core	T	2
BTY-415	Bioprocess Engineering and Technology	Core	T	3
BTY-416	Elective I	DSE I	T	2
BTY-417	Seminar	AECC	Tu/P	1
BTY-418	Laboratory IV: Molecular Biology and Genetic Engineering	Core/SEC	L	3
BTY-419	Laboratory V: Immunology	Core/SEC	L	3
BTY-420	Summer Training and Presentation[#]	SEC	P	2
		Total credits		**24**
Summer Training for 6 weeks (2 Credits)[#]				
Semester III				
Course Code	**Course Name**		**Course Type**	**Credits**
BTY-501	Emerging Technologies	Core/VA	T	2
BTY-502	Bioentrepreneurship	Core/SEC/VA	T	2
BTY-503	Molecular Diagnostics	Core/VA/SEC	T	2
BTY-504	Elective II	DSE II	T	2
BTY-505	Elective III	DSE III	T	2
BTY-506	Intellectual Property Rights, Biosafety and Bioethics	Core/VA	T	2
BTY-507	Research Methodology & Scientific Communication Skills	SEC/VA	Tu/P	2
BTY-508	Dissertation A (Review writing, Project Proposal Preparation and Presentation)	SEC	Tu/L	5
BTY-509	Laboratory VI: Bioinformatics	Core/SEC	L	2
BTY-510	Laboratory VII: Bioprocess Engineering and Technology	Core/SEC	L	3
		Total credits		**24**

Semester IV

Course Code	Course Name		Course Type	Credits
BTY-511	Dissertation B (Major Project)	SEC	Tu/L	18
BTY-512	Elective IV	DSE IV	T	2
BTY-513	Elective V	DSE V	T	2
BTY-514	Critical Analysis of Research Papers & Group Discussion	VA/AECC	Tu	2
	Total credits			**24**
	Grand Total Credits			**96**

T: Teaching, **L:** Laboratory, **Tu:** Tutorial, **P:** Presentation, **VA:** Value Added, **SEC:** Skill Enhancement Course

* The students of M.Sc. 2-year program will opt 'Basics of Chemistry and Physics". Integrated M.Sc. VII semester students will choose NDSE.

**: The department may offer winter certificate course during the winter break to enhance the employability of the students.

Recommended Electives:

A. Discipline Specific Electives (DSE)

1. Biological Imaging
2. Computational Biology
3. Drug Discovery and Development
4. Environmental Biotechnology
5. Nanobiotechnology
6. Protein Engineering
7. Vaccines
8. Ecology
9. Molecular Evolution
10. Applied Microbiology
11. Industrial Biotechnology
12. Human Physiology
13. Virology
14. Molecular Plant Pathology
15. Vector Biology
16. Protein misfolding and human diseases
17. **MOOC/NPTEL courses** - Courses may be offered by the Department from the list of courses made available online before beginning of the semester as per suitability of the MSc programme.
18. **Courses offered by Visiting Faculty** - Elective courses can be offered by the visiting faculty from time to time to the Department of Biotechnology. The course title and content will be given by the guest faculty and approved by the Departmental BOS.
19. **Any other electives offered by the Allied Departments.**

B. Non Discipline Specific Electives (NDSE) – As offered by the other departments of the university. **MOOC/NPTEL courses** may also be offered by the Department from the list of courses made available online before beginning of the semester as per suitability of the M.Sc. programme.

@ If the credits of the MOOC/NPTEL course is more than 2 credits, department may allow the student to opt for the same.

S. No.	Course Name	Course Type	No. of Courses	Credits for each course	Total Credits
1.	Core Course	Theory	6	3	18
2.	Core Course	Theory	8	2	16
3.	Core Course	Laboratory	4	3	12
4.	Core Course	Laboratory	3	2	6
5.	DSE	Theory	5	2	10
6.	NDSE	Theory	2	2	4
7.	SEC	Theory/Tu/P	2	2	4
8.	AECC	Tutorial	2	2/1	3
9.	Dissertation	Tu/L	1	5	5
10.	Dissertation	Tu/L	1	18	18
				Total	**96**

Name of the Course: Biochemistry				**Course Code:** BTY 401			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 1	**L**	**T**	**P**	**Credits**	**Contact Hours**
			3	0	0	3	45
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	135	45	90
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

i. The objectives of this course are to build upon undergraduate level knowledge of biochemical principles with specific emphasis on different metabolic pathways.
ii. The course shall make the students aware of various disease pathologies within the context of each topic.

Course outcomes:

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

i. Gain fundamental knowledge in biochemistry.
ii. Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Chemical basis of life	Chemical basis of life: Miller-Urey experiment, abiotic formation of amino acid oligomers, composition of living matter; Water – properties of water, essential role of water for life on earth pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionization and hydrophobicity, emergent properties of biomolecules in water, biomolecular hierarchy, macromolecules, molecular assemblies.	7
2. Protein structure	Structure-function relationships: amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order	7

	structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc.; basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation.	
3. Enzyme kinetics	Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens. Applications of enzymes in industries, health and diagnostics.	7
4. Glycobioloy; Structure and functions of DNA & RNA and lipids	Sugars - mono, di, and polysaccharides with specific reference to glycogen, amylase and cellulose, glycosylation of other biomolecules - glycoproteins and glycolipids; lipids - structure and properties of important members of storage and membrane lipids; lipoproteins. Nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material. Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane bound proteins - structure, properties and function; transport phenomena.	8
5. Bioenergetics	Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism; Introduction to GPCR, Inositol/DAG//PKC and Ca++ signaling pathways; glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane; Calvin cycle and pentose phosphate pathway; glycogen	8

	metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation.	
6. Role of vitamins & cofactors in metabolism	Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation; target of rapamycin (TOR) & Autophagy regulation in relation to C & N metabolism, starvation responses and insulin signalling.	8

Recommended Textbooks and References:

1. Stryer, L. (2015). Biochemistry. (8th ed.) New York: Freeman.
2. Lehninger, A. L. (2012). Principles of Biochemistry (6th ed.). New York, NY: Worth.
3. Voet, D., & Voet, J. G. (2016). Biochemistry (5th ed.). Hoboken, NJ: J. Wiley & Sons.
4. Dobson, C. M. (2003). Protein Folding and Misfolding. Nature, 426(6968), 884-890. doi:10.1038/nature02261.
5. Richards, F. M. (1991). The Protein Folding Problem. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.

Name of the Course: Cell and Molecular Biology						**Course Code:** BTY 402	
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 1	**L**	**T**	**P**	**Credits**	**Contact Hours**
			3	0	0	3	45
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	135	45	90
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The objectives of this course are to sensitize the students to the fact that as we go down the scale of magnitude from cells to organelles to molecules, the understanding of various biological processes becomes deeper and inclusive.

Course outcomes:

On completion of this course, students should be equipped to understand three fundamental aspects in biological phenomenon occurring at the cellular level:

i. what to seek;
ii. how to seek;
iii. why to seek?

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Dynamic organization of cell	Universal features of cells; cell chemistry and biosynthesis: chemical organization of cells; internal organization of the cell - cell membranes: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton, mitochondria, chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes.	7
2. Chromatin structure and dynamics	Chromatin organization - histone and DNA interactome: structure and assembly of eukaryotic and prokaryotic DNA polymerases, DNA-replication, repair and recombination; chromatin control: gene transcription and silencing by chromatin Writers,- Readers and –Erasers; Transcriptional control: Structure and assembly of eukaryotic and prokaryotic RNA Polymerases, promoters and enhancers,	8

	transcription factors as activators and repressors, transcriptional initiation, elongation and termination; post-transcriptional control: splicing and addition of cap and tail, mRNA flow through nuclear envelope into cytoplasm.	
3. Regulation and translation of mRNA	RNA interference; breakdown of selective and specific mRNAs through interference by small non-coding RNAs (miRNAs and siRNAs), protein translation machinery, ribosomes-composition and assembly; universal genetic codes, degeneracy of codons, Wobble hypothesis; Iso-accepting tRNA; mechanism of initiation, elongation and termination; co- and post-translational modifications, mitochondrial genetic code translation product cleavage, modification and activation.	7
4. Cellular transport and trafficking	Molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior.	7
5. Cellular signalling and processes	Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell receptors and transmembrane signalling; cell motility and migration; cell death: different modes of cell death and their regulation.	8
6. Genome instability and cell transformation	Mutations, proto-oncogenes, oncogenes and tumour suppressor genes, physical, chemical and biological mutagens; types of mutations; intra-genic and inter-genic suppression; transpositions- transposable genetic elements in prokaryotes and eukaryotes, role of transposons in genome; viral and cellular oncogenes; tumor suppressor genes; structure, function and mechanism of action; activation and suppression of tumor suppressor genes; oncogenes as transcriptional activators	8

Recommended Textbooks and References:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). Molecular Biology of the Cell (5th Ed.). New York: Garland Science.
2. Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman.
3. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's Genes XI. Burlington, MA: Jones & Bartlett Learning.
4. Cooper, G. M., & Hausman, R. E. (2013). The Cell: a MolecularApproach (6th Ed.). Washington: ASM ; Sunderland.
5. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's World of the Cell. Boston (8th Ed.). Benjamin Cummings.
6. Watson, J. D. (2008). Molecular Biology of the Gene (5th ed.). Menlo Park, CA: Benjamin/Cummings.

Name of the Course: Plant and Animal Biotechnology						**Course Code:** BTY 403	
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 1	**L**	**T**	**P**	**Credits**	**Contact Hours**
			3	0	0	3	45
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	135	45	90
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The objectives of this course are to introduce students to the principles, practices and application of animal biotechnology, plant tissue culture, plant and animal genomics, genetic transformation and molecular breeding of plants and animals.

Course outcomes:

On completion of this course, students should be able to gain fundamental knowledge in animal and plant biotechnology and their applications.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Plant tissue culture	Historical perspective; totipotency; organogenesis; Somatic embryogenesis; establishment of cultures – callus culture, cell suspension culture, media preparation – nutrients and plant hormones; sterilization techniques; applications of tissue culture - micropropagation; somaclonal variation; androgenesis and its applications in genetics and plant breeding; germplasm conservation and cryopreservation; synthetic seed production; protoplast culture and somatic hybridization - protoplast isolation; culture and usage; somatic hybridization - methods and applications; cybrids and somatic cell genetics; plant cell cultures for secondary metabolite production.	8
2. Animal cell culture	Brief history of animal cell culture; cell culture media and reagents; culture of mammalian cells, tissues and organs; primary culture, secondary culture, continuous cell lines, suspension cultures; application of animal cell culture for virus isolation	8

	and in vitro testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.	
3. Plant genetic manipulation	Genetic engineering: Agrobacterium-plant interaction; virulence; Ti and Ri plasmids; opines and their significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation - Agrobacterium-mediated gene delivery; cointegrate and binary vectors and their utility; direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods; screenable and selectable markers; characterization of transgenics; chloroplast transformation; marker-free methodologies; advanced methodologies - cisgenesis, intragenesis and genome editing; molecular pharming - concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds.	8
4. Animal reproductive biotechnology and vaccinology	Animal reproductive biotechnology: structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation, embryo recovery and in vitro fertilization; culture of embryos; cryopreservation of embryos; embryo transfer technology; transgenic manipulation of animal embryos; applications of transgenic animal technology; animal cloning - basic concept, cloning for conservation for conservation endangered species; Vaccinology: history of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, modern vaccines.	8
5. Plant and animal genomics	Overview of genomics – definition, complexity and classification; need for genomics level analysis; methods of analyzing genome at various levels – DNA, RNA, protein, metabolites and phenotype; genome projects and bioinformatics resources for genome research – databases; overview of forward and reverse genetics for assigning function for genes.	6
6. Molecular mapping and marker assisted selection	Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers; DNA fingerprinting-principles and applications; introduction to mapping of genes/QTLs; Laws of segregation in plant crosses, inbreeding, selfing, heterosis, maintenance of	7

	genetic purity, gene pyramiding. marker-assisted selection - strategies for Introducing genes of biotic and abiotic stress resistance in plants: genetic basis for disease resistance in animals; molecular diagnostics of pathogens in plants and animals; detection of meat adulteration using DNA based methods.	

Recommended Textbooks and References:

1. Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. Enfield, NH: Science.
2. Razdan, M. K. (2003). *Introduction to Plant Tissue Culture*. Enfield, NH: Science.
3. Slater, A., Scott, N. W., & Fowler, M. R. (2008). *Plant Biotechnology: an Introduction to Genetic Engineering*. Oxford: Oxford University Press.
4. Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). *Biochemistry & Molecular Biology of Plants*. Chichester, West Sussex: John Wiley & Sons.
5. Umesha, S. (2013). *Plant Biotechnology.* The Energy And Resources.
6. Glick, B. R., & Pasternak, J. J. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. Washington, D.C.: ASM Press.
7. Brown, T. A. (2006). *Gene Cloning and DNA Analysis: an Introduction*. Oxford: Blackwell Pub.
8. Primrose, S. B., & Twyman, R. M. (2006). *Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.
9. Slater, A., Scott, N. W., & Fowler, M. R. (2003). *Plant Biotechnology: The Genetic Manipulation of Plants*. Oxford: Oxford University Press.
10. Gordon,I.(2005).*ReproductiveTechniquesinFarmAnimals*.Oxford: CAB International.
11. Levine,M.M.(2004).*NewGenerationVaccines.*NewYork:M.Dekker.
12. Pörtner,R.(2007).*AnimalCellBiotechnology:MethodsandProtocols*.Totowa,

Name of the Course: Microbiology				**Course Code:** BTY 404			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 1	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)			

Course objectives:

i. The objectives of this course are to introduce field of microbiology with special emphasis on microbial diversity,
ii. morphology, physiology, and nutrition; methods for control of microbes and host-microbe interactions.

Course outcomes:

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

i. Identify major categories of microorganisms and analyze their classification, diversity, and ubiquity.
ii. Identify and demonstrate structural, physiological, genetic similarities, and differences of major categories of microorganisms.
iii. Identify and demonstrate how to control microbial growth
iv. Demonstrate and evaluate interactions between microbes, hosts and environment.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Microbial characteristics	Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; bacterial genetics (transformation, transduction, conjugation), antimicrobial resistance, adaptive microbial physiology.	6
2. Microbial diversity	Microbial taxonomy, classification of microorganisms, criteria for classification of	6

	bacteria, cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, Hyperthermophile archaea, Thermoplasm; eukarya: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes.	
3. Control of microorganisms	Sterilization, disinfection, and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms, novel antimicrobial and antibiofilm measures.	4
4. Virology and Prion Biology	Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation, and identification of viruses; sub-viral particles – viroids and prions.	4
5. Mycology & Phycology	Diversity of algal, fungal and fungal-like organisms, Cellular and reproduction characteristics of model algal and fungal microorganisms. Life cycle, structure, and occurrence – (i) Cellular slime molds (ii) True slime mold (iii) Oomycetes (iv) Chytridiomycetes (v) Zygomycetes (vi) Ascomycetes (vii)Basidiomycetes (viii) Deuteromycetes. Life cycle, thallus organisation and occurrence – (i) Chlorophyceae (ii) Charophyceae (iii) Diatoms (iv) Xanthophyceae (v) Phaeophyceae (vi) Rhodophyceae: (vii) Cyanobacteria. Economic importance of algae & fungi with examples in agriculture, environment, industry, medicine, food,	5
6. Host-microbes interaction	Host-pathogen interaction, ecological impact of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics.	5

Recommended Text and Reference Books:

1. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011).
2. Matthai, W., Berg, C. Y., & Black, J. G. (2005). Microbiology, Principles and Explorations.
3. Tortora, Funke, and Case: Microbiology, An Introduction
4. Brock Biology of Microorganisms, 14th Edition

Name of the Course: Genetics						**Course Code:** BTY 405	
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 1	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The objectives of this course are to take students through basics of genetics and classical genetics covering prokaryotic/ phage genetics to yeast and higher eukaryotic domains. On covering all classical concepts of Mendelian genetics across these life-forms, students will be exposed to concepts of population genetics, quantitative genetics encompassing complex traits, clinical genetics, and genetics of evolution.

Course outcomes:

On successful completion of this course, student will be able to:

i. Describe fundamental molecular principles of genetics;
ii. Understand relationship between phenotype and genotype inhuman genetic traits;
iii. Describe the basics of genetic mapping;
iv. Understand how gene expression is regulated.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Mendelian Genetics	Concept of a gene in pre-DNA era, genetic crosses using phenotypic markers; phenotype to genotype connectivity prior to DNA-based understanding of gene. Mendelian Principles, Monohybrid & dihybrid crosses, back-crosses, test-crosses.	5
2. Neo-Mendelian Genetics	Incomplete Dominance, Codominance, Polygenic Traits, Epistasis, maternal inheritance. Analyses of autosomal and sex linkages, screening of mutations based on phenotypes and mapping the same, hypomorphy, genetic mosaics.	5
3. Sex-determination, and pedigree	Sex determination in *Drosophila*, Sex determination in humans, Autosomal and Sex-linked inheritance, Pedigree analysis, Probability calculation	5

analysis		
4. Bacterial Genetics	Bacterial Reproduction: Transformation, Transduction and Conjugation, mapping of genes in bacterial and phage chromosomes by classical genetic crosses.	5
5. Eukaryotic Genetics	Meiotic crosses, tetrad analyses, gene conversion, models of genetic recombination, yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, complementation groups, transposon mutagenesis, synthetic lethality.	5
6. Population Genetics	Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers theorem, Hardy Weinberg equilibrium, linkage disequilibrium; in-breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness. Introduction to genomics.	5

Recommended Textbooks and References:

1. Hartl, D. L., & Jones, E. W. (1998). Genetics: Principles and Analysis. Sudbury, MA: Jones and Bartlett.
2. Pierce, B. A. (2005). Genetics: a Conceptual Approach. New York: W.H. Freeman.
3. Tamarin, R. H., & Leavitt, R. W.(1991). Principles of Genetics. Dubuque, IA: Wm. C. Brown.
4. Smith, J. M. (1998). Evolutionary Genetics. Oxford: Oxford University Press.

Name of the Course: Statistics for Biologists							**Course Code:** BTY 406
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 1	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The main objective of this course is to introduce the basic concepts of descriptive and inferential statistics emphasizing applications in the field of Life Sciences and prepare them to understand the data and statistical analyses.

Course outcomes:

By the end of the course, Students will demonstrate the ability to:

i. Select and apply appropriate statistical methods to the experimental data.
ii. Use descriptive statistics and graphical methods to summarize data accurately.
iii. Use inferential statistics to make a valid conclusion based on the data available. Select the appropriate statistical tools to analyze a particular research problem.
iv. Describe the goals of various statistical methodologies conceptually.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Introduction of Statistics	Statistics meaning, Examples of common mistakes, Descriptive and Inferential, Statistics, Introduction to statistical tools. Numerical ways to Describe Data Determining Outliers.	5
2. Description of Samples and Populations	Graphical methods to display data. Numerical Measures: Parameter and Statistics; Measures of central tendency; Measures of Variability (including Coefficient of Variation); Measures of Relative Standing (Percentiles, Quartiles, z-Scores); Box and Whiskers Plot	5
3. Probability and probability distribution	Basics of probability. Discrete probability distribution (Binomial and Poisson). Normal Probability distribution.	5
4. Estimations of	Sampling and Sampling Distribution; Estimation of	5

parameters	mean, variance and proportion for a single population; Error of estimation and sample size determination; Estimation of the difference between 2 means, ratio of 2 variances, and difference of 2 proportions for two populations.	
5. Test of Hypothesis	Tests of mean, variance and proportion for a single population; Tests of the difference between 2 means, ratio of 2 variances and difference of 2 proportions for two populations; Interpretation of p - value	5
6. Regression, correlation and analysis of variance	Correlation Analysis; Simple Linear Regression Analysis; One - way ANOVA; Two - way ANOVA; Post-Hoc Test (Tukey-Kramer Test). Chi-Square Tests: Test for goodness of fit; Test for Equality of more than two proportions Test for independence	5

Recommended Textbooks and References:

1. Myra L. Samuels, Jeffrey A. Witmer & Andrew Schaffner. (2021). Statistics for the Life Sciences, 5th edition. Pearson.

2. Rosner, B. (2000). Fundamentals of Biostatistics. Boston, MA: Duxbury Press

Name of the Course: Basics of Chemistry and Physics				**Course Code:** BTY 407			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 1	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The objectives of this course are to cover all essentials required to appreciate physico-chemical principles underlying biological processes.

Course outcomes:

Students should be able to have a firm foundation in fundamentals and application of current chemical and physical scientific theories.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Basic physics for biologists	Physical quantities and their dynamics: definitions and dimensions; vectors & scalars, displacement, velocity, acceleration, kinematic formulas, angular momentum, torque etc. force, power, work, energy (kinetic & potential/electric charge separation, electromagnetic spectrum, photons etc.); springs & Hookes laws; elastic and inelastic collisions;	5
2. Unit II	Newton's law of motions (centripetal and centrifugal forces etc.); simple harmonic motions, mechanical waves, Doppler effect, wave interference, amplitude, period, frequency & wavelength; diffusion, dissipation, random walks, and directed motions in biological systems; low Reynolds number - world of Biology, buoyant forces, Bernoulli's equation, viscosity, turbulence, surface tension, adhesion; laws of thermodynamics: Maxwell Boltzmann distribution, conduction, convection and radiation, internal energy, entropy, temperature and free energy, Maxwell's demon (entropic forces at work in biology, chemical assemblies, self-assembled systems, role of ATP);	5
3. Unit III	Coulomb's law, conductors and insulators, electric	5

	potential energy of charges, nerve impulses, voltage gated channels, ionic conductance; Ohms law (basic electrical quantities: current, voltage & power), electrolyte conductivity, capacitors and capacitance, dielectrics; various machines in biology i.e. enzymes, allostery and molecular motors (molecules to cells and organisms).	
4. Basic chemistry for biologists	Basic constituents of matter - elements, atoms, isotopes, atomic weights, atomic numbers, basics of mass spectrometry, molecules, Avogadro number, molarity, gas constant, molecular weights, structural and molecular formulae, ions and polyatomicions; chemical reactions, reaction stoichiometry, rates of reaction, rate constants, order of reactions,	5
5. Unit V	Arrhenious equation, Maxwell Boltzmann distributions, rate-determining steps, catalysis, free-energy, entropy and enthalpy changes during reactions; kinetic versus thermodynamic controls of a reaction, reaction equilibrium (equilibrium constant); light and matter interactions (optical spectroscopy, fluorescence, bioluminescence, paramagnetism and diamagnetism, photoelectron spectroscopy; chemical bonds (ionic, covalent, Van der Walls forces); electronegativity, polarity; VSEPR theory and molecular geometry, dipole moment, orbital hybridizations; states of matter - vapor pressure, phase diagrams, surface tension, boiling and melting points, solubility, capillary action, suspensions, colloids and solutions;	5
6. Unit VI	Acids, bases and pH - Arrhenious theory, pH, ionic product of water, weak acids and bases, conjugate acid-base pairs, buffers and buffering action etc; chemical thermodynamics - internal energy, heat and temperature, enthalpy (bond enthalpy and reaction enthalpy), entropy, Gibbs free energy of ATP driven reactions, spontaneity versus driven reactions in biology; redox reactions and electrochemistry - oxidation-reduction reactions, standard cell potentials, Nernst equation, resting membrane potentials, electron transport chains (ETC) in biology, coupling of oxidative phosphorylations to ETC; theories of ATP production and dissipation across biological membranes; bond rotations and molecular conformations - Newman projections, conformational analysis of alkanes, alkenes and alkynes; functional groups, optically asymmetric carbon centers, amino acids, proteins, rotational freedoms in polypeptide backbone (Ramachandran plot).	5

Recommended Textbooks and References:

1. Baaquie, B. E. (2000). Laws of Physics: a Primer. Singapore: National University of Singapore.
2. Matthews, C. P., & Shearer, J. S. (1897). Problems and Questions in Physics. New York: Macmillan Company.
3. Halliday, D., Resnick, R., & Walker, J. (1993). Fundamentals of Physics. New York: Wiley.
4. Ebbing, D. D., & Wrighton, M. S. (1990). General Chemistry. Boston: Houghton Mifflin.
5. Averill, B., & Eldredge, P.(2007). Chemistry: Principles, Patterns,and Applications. San Francisco: Benjamin Cummings.
6. Mahan, B. H. (1965). University Chemistry. Reading, MA: Addison-Wesley Pub.
7. Cantor, C. R., & Schimmel, P. R. (2004). Biophysical Chemistry. San Francisco: W.H. Freeman.

Name of the Course: Lab I: Biochemistry & Analytical Techniques				**Course Code:** BTY 408			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 1	**L**	**T**	**P**	**Credits**	**Contact Hours**
				0	6	3	90
Total Evaluation Marks: 100 1. Practical Record: 20 2. Viva Voce: 20 3. E-SE: 60		**Examination Duration:** 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	270	90	180
Teaching format	Lecture (L), Performing Experiments, Demonstration and Record Writing Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

i. To inculcate and impart skill to perform experiments based on their theoretical understandings.
ii. To instil skills and develop expertise to design experiment, organise the data, analyses and it maintenance in practical record books.

Course outcomes:

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

i. perform the experiments independently at the same time they must be aware about the scientific rationale of their outcomes.
ii. to trouble shoot the problems associated with isolation and purification of enzymes, measuring enzyme activity and spectrophotometry.
iii. understand the working principle of high-end instrumentations such as circular dichroism spectrophotometer, NMR, and Mass spectrophotometer.

Course Syllabus

Unit No.	**Content**	**Contact hours**
Syllabus	1. Preparing various stock solutions and working solutions that will be needed for the course. 2. To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation. 3. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis. Spectrophotometer and validating the Beer- Lambert's Law. 4. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer	90

	chromatography. 5. Purification and characterization of an enzyme from a recombinant source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme of the institution's choice). i. Preparation of cell-free lysates ii. Ammonium Sulphate precipitation iii. Ion-exchange Chromatography iv. Gel Filtration v. Affinity Chromatography vi. Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method. vii. Generating a Purification Table (protein concentration, amount of total protein; Computing specific activity of the enzyme preparation at each stage of purification). viii. Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis. ix. Enzyme Kinetic Parameters: Km, Vmax and Kcat 6. Experimental verification that absorption at OD260 is more for denatured DNA as compared to native double stranded DNA. 7. Reversal of the same following DNA renaturation. Kinetics of DNA renaturation as a function of DNA size. 8. Identification of an unknown sample as DNA, RNA or protein using available laboratory tools. (Optional Experiments) 9. Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy). 10. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry.	

Recommended Textbooks and References:

1. An Introduction to Practical Biochemistry (2017) 3rd ed., Plummer, D.T., McGraw Hill Education, ISBN: 978-0070994874.
2. Proteins: Structure and Molecular Properties (2013) Thomas E. Creighton, W H Freeman & Co; 3rd edition (1 December 2013), ISBN-13 : 0716739357-978
3. Principles and Techniques of Biochemistry and Molecular Biology (2018) 8th ed. Wilson K, and Walker J, Cambridge University Press. ISBN: 131661476X.
4. Laboratory Manual of Microbiology and Biotechnology (2014) 1sted.Aneja KR, Scientific International Pvt., Ltd. ISBN: 9789381714553.
5. Microbiology: A Laboratory Manual (2020), 12th ed., Cappuccino, JH, Welsh CT., Pearson Education Inc, ISBN: 9780135203996.
6. An introduction to Practical Biochemistry (2017) 3rd ed., Plummer, DT, McGraw Hill Education, ISBN: 978-0070994874.

Name of the Course: Lab II: Microbiology						**Course Code:** BTY 409	
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 1	**L**	**T**	**P**	**Credits**	**Contact Hours**
			0	0	4	2	60
Total Evaluation Marks: 100 1. Practical Record: 20 2. Viva Voce: 20 3. E-SE: 60		**Examination Duration:** 3 Hrs.					

Workload

	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	150	60	90
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)			

Course objectives:

The objective of this laboratory course is to provide practical skills on basic microbiological techniques.

Course outcomes:

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

i. Isolate, characterize and identify common bacterial organisms;
ii. Determine bacterial load of different samples;
iii. Perform antimicrobial sensitivity tests;
iv. Preserve bacterial cultures.

Course Syllabus

Unit No.	**Content**	**Contact hours**
Syllabus	1. Sterilization, disinfection and safety in microbiological laboratory. 2. Preparation of media for cultivation of bacteria. 3. Isolation of bacteria in pure culture by streak plate method. 4. Study of colony and growth characteristics of some common bacteria: *Bacillus, E. coli, Staphylococcus, Streptococcus, etc.* 5. Preparation of bacterial smear and Gram's staining. 6. Enumeration of bacteria: standard plate count. 7. Antimicrobial sensitivity test and demonstration of drug resistance. 8. Maintenance of stock cultures: slants, stabs and glycerol	60

	stock cultures 9. Determination of phenol co-efficient of antimicrobial agents. 10. Determination of Minimum Inhibitory Concentration (MIC) 11. Isolation and identification of bacteria from soil/water samples.	

Recommended Textbooks and References:

1. Cappuccino, J. G., & Welsh, C. (2016). Microbiology: a Laboratory Manual. Benjamin-Cummings Publishing Company.
2. Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham III, J. (2004). Collins and Lyne's Microbiological Methods (8th ed.). Arnolds.
3. Tille, P. M., & Forbes, B. A. Bailey & Scott's Diagnostic Microbiology.

Name of the Course: Lab III: Plant and Animal Biotechnology				**Course Code:** BTY 410			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 1	**L**	**T**	**P**	**Credits**	**Contact Hours**
			0	0	4	2	60
Total Evaluation Marks: 100 1. Practical Record: 20 2. Viva Voce: 20 3. E-SE: 60		**Examination Duration:** 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	150	60	90

Teaching format	Lecture (L) and Assignments
Instruction medium	English
Recommended prerequisite to attend this course (if any)	N.A.

Course objectives:

The objectives of this course are to provide hands-on training in basic experiments of plant and animal biotechnology.

Course outcomes:

On completion of course, students should be able to gain basic skills in plant and animal biotechnology.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Plant Biotechnology	1. Prepare culture media with various supplements for plant tissue culture. 2. Prepare explants of *Solanum lycopersicum* for inoculation under aseptic conditions. 3. Isolate plant protoplast by enzymatic and mechanical methods and attempt fusion by PEG (available material). 4. Culture Agrobacterium tumefaciens and attempt transformation of any dicot species. 6. Generate an RAPD and ISSR profile of Eremurus persicus and Valleriana wallichii. 6. Prepare karyotypes and study the morphology of somatic chromosomes of Allium cepa, A. sativum, A. tuberosum and compare them on the basis of karyotypes.	30

	7. Pollen mother cell meiosis and recombination index of select species (one achiasmate, and the other chiasmate) and correlate with generation of variation. 8. Undertake plant genomic DNA isolation by CTAB method and its quantitation by visual as well as spectrophotometeric methods. 9. Perform PCR amplification of 'n' number of genotypes of a species for studying the genetic variation among the individuals of a species using random primers. 10. Study genetic fingerprinting profiles of plants and calculate polymorphic information content.	
2. Animal Biotechnology	1. Count cells of an animal tissue and check their viability. 2. Prepare culture media with various supplements for plant and animal tissue culture. 3. Isolation of cells and basics of cell culture; observing cells under a microscope. 4. Monitor and measure doubling time of animal cells. 5. Chromosome preparations from cultured animal cells. 6. Isolation and analysis of DNA from animal tissue by SDS method. 7. Attempt animal cell fusion using PEG.	30

Name of the Course: Genetic Engineering				**Course Code:** BTY 411			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 2	**L**	**T**	**P**	**Credits**	**Contact Hours**
			3	0	0	3	45
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. EOSE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	135	45	90
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

i. The objectives of this course are to teach students with various approaches to conducting genetic engineering and their applications in biological research as well as in biotechnology industries.
ii. The course Genetic engineering is a technology that has been developed based on our fundamental understanding of the principles of molecular biology and this is reflected in the contents of this course.

Course outcomes:

On completion of this course:

i. Students should be endowed with strong theoretical knowledge of this technology.
ii. In conjunction with the practical in molecular biology & genetic engineering, the students should be able to take up biological research as well as placement in the relevant biotech industry.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Introduction and tools for genetic engineering	Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence *in situ* hybridization.	7
2. Different types of	Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, phagemids; Lambda vectors; Insertion and	8

vectors	Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.	
3. Different types of PCR techniques	Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection.	7
4. Sequencing methods and Gene manipulation	Sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP; Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries;	8
5. Protein-DNA interaction	construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.	7
6. Gene silencing and genome editing technologies	Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems e.g. fruit flies (Drosophila), worms (C. elegans), frogs (Xenopus), fish (zebra fish) and chick; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials.	8

Recommended Textbooks and References:

1. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.
4. Selected papers from scientific journals, particularly Nature & Science.
5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

Name of the Course: Immunology and Immunotechnology						**Course Code:** BTY 412	
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 2	**L**	**T**	**P**	**Credits**	**Contact Hours**
			3	0	0	3	45
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	135	45	90
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The objectives of this course are to learn about structural features of components of immune system as well as their function. The major emphasis of this course will be on development of immune system and mechanisms by which our body elicits immune response. This will be imperative for students as it will help them to predict about nature of immune response that develops against bacterial, viral or parasitic infection, and prove it by designing new experiments.

Course outcomes:

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

i. Evaluate usefulness of immunology in different pharmaceutical companies
ii. Identify proper research lab working in area of their own interests
iii. Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out kind of immune responses in the setting of infection (viral or bacterial).

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Immunology: fundamental concepts and overview of the immune system	Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens: immunogens, haptens; Major Histocompatibility Complex: MHC genes, MHC and immune responsiveness and disease susceptibility, Organs of immune system, primary and secondary lymphoid organs.	6
2. Immune responses generated by B and T	Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic	8

lymphocytes	determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; basis of self & non-self discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, receptors and therapeutic uses; antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation, Hapten-carrier system.	
3. Antigen-antibody interactions	Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand –receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knock outs.	8
4. Vaccinology	Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering:chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine.	8
5. Clinical immunology	Immunity to infection : bacteria, viral, fungal and parasitic infections (with examples from each group); hypersensitivity: Type I-IV; autoimmunity; types of autoimmune diseases; mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; transplantation: immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy; tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy; immunodeficiency: primary immunodeficiencies, acquired or secondary immunodeficiencies, autoimmune disorder, anaphylactic shock,	8

	immunosenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy.	
6. Immunogenetics	Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing, human major histocompatibility complex (MHC), Complement genes of the human major histocompatibility complex: implication for linkage disequilibrium and disease associations, genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV, KIR complex.	7

Recommended Textbooks and References:

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). Kuby Immunology. New York: W.H. Freeman.
2. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). Clinical Immunology. London: Gower Medical Pub.
3. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). Janeway's Immunobiology. New York: Garland Science.
4. Paul, W. E. (2012). Fundamental Immunology. New York: Raven Press.
5. Goding, J. W. (1996). Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology. London: Academic Press.
6. Parham, P. (2005). The Immune System. New York: Garland Science.

Name of the Course: Bioinformatics				**Course Code:** BTY 413			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 2	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The objectives of this course are to provide theory and practical experience of the use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.

Course outcomes:

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

i. Develop an understanding of basic theory of these computational tools;
ii. Gain working knowledge of these computational tools and methods;
iii. Appreciate their relevance for investigating specific contemporary biological questions;
iv. Critically analyse and interpret results of their study.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Bioinformatics basics	Bioinformatics basics: Computers in biology and medicine; Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools.	5
2. DNA sequence analysis	DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of	5

	DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.	
3. Multiple sequence analysis	Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.	5
4. Protein modelling	Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structures; sequence alignment- methods, evaluation, scoring; protein completion: backbone construction and side chain addition; small peptide methodology; software accessibility; building peptides; protein displays; substructure manipulations, annealing.	5
5. Protein structure prediction	Protein structure prediction: protein folding and model generation; secondary structure prediction; analyzing secondary structures; protein loop searching; loop generating methods; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; construction of variable and conserved regions; threading techniques; topology fingerprint approach for prediction; evaluation of alternate models; structure prediction on a mystery sequence; structure aided sequence techniques of structure prediction; structural profiles, alignment algorithms, mutation tables, prediction, validation, sequence based methods of structure prediction, prediction using inverse folding, fold prediction; significance analysis, scoring techniques, sequence-sequence scoring; protein function prediction;	5
6. Virtual Library and Docking	Elements of in silico drug design, drug designing tools, methods of in-silico docking, types of virtual library, Searching PubMed, current content, science citation index and current awareness services, electronic journals, grants and funding information.	5

Recommended Textbooks and References:

1. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience.
4. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell.
5. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
6. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.

Name of the Course: Genomics and Proteomics				**Course Code:** BTY 414			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 2	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA - I: 20 2. CIA - II: 20 3. E-SE: 60		**Examination Duration:** 1 Hr 1 Hr 3 Hrs					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The objectives of this course is to provide introductory knowledge concerning genomics, proteomics and their applications.

Course outcomes:

On completion of this course, Students should be able to:

Students should be able to acquire knowledge and understanding of fundamentals of genomics and proteomics, transcriptomics and metabolomics and their applications in various applied areas of biology.

Course Syllabus

Unit No.	**Content**	**Contact Hours (45)**
1. Introduction to Basics of Genomics and Proteomics	Introduction to prokaryotic and eukaryotic genome organization; Genome Sizes, c- Value Paradox, extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast. Central Dogma of Molecular Biology, Significance of studying genomes and proteomes with respect to basic and applied sciences.	4
2. Conventional and modern methods of Genome Mapping	Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, linkage analysis, recombination frequency calculation-based gene mapping, cytogenetic techniques, Fluorescent *in situ* Hybridization technique in gene mapping, somatic cell hybridization, radiation hybrid maps, comparative gene mapping, physical mapping.	4
3. Methods for DNA and	Methods for isolation and preliminary	7

Genome Sequencing for physical mapping Genome Sequence Data Analyses	characterization of Genomic and Extra-Chromosomal DNA. Methods for DNA fragment/ Whole Genome Sequencing. Chemical Modification based DNA sequencing, Sanger's DNA sequencing Method. Automated Sanger's DNA sequencing Method. Next Generation Sequencing Methods (Pyrosequencing, Ion Torrent sequencing, Reversible Chain Termination Sequencing), 3rd Generation Sequencing (Nanopore Sequencing & Single Molecule Real Time Sequencing). Raw Sequence Reads from 1st Generation, NGS and 3rd Generation Sequencing Platforms, Quality Assessment of Raw Reads, Assembly and Annotation of the Sequence Reads.	
4. Genome Projects Comparative and Evolutionary Genomics	Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web. Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; use of genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in genome sequence.	6
5. Functional Genomics and Transcriptomics	Transcript analyses with Northern Blotting, Semi-Quantitative RT- PCR, qRT- RT PCR, Whole Transcriptome Analyses with Microarray, Affymetrix Array and RNA-Seq Approach. Identification and validation of functional annotation of gene, chromosome walking and characterization of chromosomes, mining functional genes in genome, gene function-forward and reverse genetics	5
6. Proteomics and Metabolomics	Aims, strategies and challenges in proteomics; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases. protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics; introduction to metabolomics, lipidomics, metagenomics and systems biology.	4

Recommended Textbooks and References:

1. Arthur M. Lesk: Introduction to Genomics
2. Brown TA: An Introduction to Genomes
3. Jamil Momand, Alison McCurdy: Concepts in Bioinformatics and Genomics

Name of the Course: Bioprocess Engineering and Technology						**Course Code:** BTY 415	
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 2	**L**	**T**	**P**	**Credits**	**Contact Hours**
			3	0	0	3	45
Total Evaluation Marks: 100 1. CIA - I: 20 2. CIA - II: 20 3. E-SE: 60		**Examination Duration:** 1 Hr 1 Hr 3 Hrs					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	135	45	90
Teaching format	Lecture and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The objectives of this course are to educate students about the fundamental concepts of bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.

Course outcomes:

On completion of this course, Students should be able to:

i. Appreciate relevance of microorganisms from industrial context.
ii. Carry out stoichiometric calculations and specify models of their growth.
iii. Give an account of design and operations of various fermenters.
iv. Present unit operations together with the fundamental principles for basic methods in production technique for bio-based products.
v. Calculate yield and production rates in a biological production process
vi. Calculate the need for oxygen and oxygen transfer.
vii. Critically analyze any bioprocess from market point of view.
viii. Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

Course Syllabus

Unit No.	**Content**	**Contact Hours (45)**
1. Introduction to Bioprocess Engineering & Technology	Introduction to Biological Process – Microbes, Plant and Animal Based processes. Biological Processes and their relevance for Biotechnology Industry. Importance of Microorganisms in bioprocess industry. Introduction to bioprocess technology based industrial products: Fermented foods and beverages; food ingredients, colours and flavours, alcoholic beverages, wastes-whey,	6

	molasses, starch substrates and other food and other products and additives. Introduction to bioprocess technology-based bioconversion of wastes to useful products; bacteriocins from lactic acid bacteria. Introduction to applications of bioprocess technology in biofuels and biorefinery.	
2. Microbial metabolic, characteristics relevant for Bioprocess Engineering & Technology.	Introduction to microbial growth and death kinetics (with at least one example from each group, particularly with reference to industrially useful microorganisms including bacteria, actinobacteria, & yeast).Impact of physiological parameters (e.g., growth limiting substrate, temperature, pH, dissolved oxygen, total dissolved organic matter etc.) on growth and product formation in bioprocess. Microbial metabolic pathways relevant for industrial bioprocesses (e.g., Alcohol biosynthesis, acid biosynthesis, antibiotic biosynthesis).	6
3. Stages/ Components of Bioprocess Engineering & Technology & their experimental control - I	**Upstream Processes:** Isolation, screening, and maintenance of industrially important microbes. Alternative approaches for harnessing microbial potentials. Strain improvement for increased yield and other desirable characteristics. Recombinant microbial strains development and optimization for production of recombinant proteins, vaccines, growth factors etc. Optimization of microbial growth and product formation through substrate optimization and control of the physiological parameters.	8
4. Stages/ Components of Bioprocess Engineering & Technology & their experimental control - II	**Fermentation Processes:** Comparison of microbial growth under conditions of low cell density and high cell density growth set up. Common modes of high cell density microbial growth with Batch, Fed Batch, Continuous Culture, and Steady State Continuous Culture fermentation (Chemostat, Turbidostat, Biostat). Bioreactors: Definition, Principle, Design, Types and Applications (Stirred Tank Bioreactors; Bubble Column Bioreactors; Airlift Bioreactors; Fluidized Bed Bioreactors; Packed Bed Bioreactors; and Photo-Bioreactors. Use of bioreactors for control of Physiological parameters of microbial growth and product formation. Bioprocess for large scale animal and plant cell cultivation.	10

5. Stages/ Components of Bioprocess Engineering & Technology & their experimental control - III	**Downstream Processes:** Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.	8
6. Bioprocess economics & Industry Specific Case Studies	Mass and Energy Balance Equation for determination of process efficiency. Product specific market analysis for consumer base, product requirement, per unit sale cost etc. Input costs: equipment and plant and operational costs; bioprocess cycle times, recovery costs; water usage and recycling; effluent treatment and disposal. Applications of bioprocess technology in food processing industry, biofuels and biorefinery.	7

Recommended Textbooks and References:

1. Stanbury, P. F., & Whitaker, A. Principles of Fermentation Technology.
2. El-Mansi, M., & Bryce, C. F. Fermentation Microbiology and Biotechnology.
3. Shuler, M. L., & Kargi, F. Bioprocess Engineering: Basic Concepts.
4. Doran P. M. Bioprocess Engineering Principles.

Name of the Course: Seminar				**Course Code:** BTY 417			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 2	**L**	**T**	**P**	**Credits**	**Contact Hours**
			0	2	0	1	15
Total Evaluation Marks: 100 Presentation: 100		**Examination Duration:** Seminar: 45 min					
Workload							
	Total workload	**Amount of attendance time**		**Time for Self-Study**			
Respective hours	45	15		30			
Teaching format	Personal interaction with respective mentor						
Instruction medium	English						
Recommended prerequisite to attend this course (if any)	N.A.						

Course objectives:

The objectives of this course are to familiarize students with current literature reading, critical thinking and analysing modern day scientific discoveries using basic and high-end tools and technologies.

Course outcomes:

Students should be able to train in the exercise of hypothesis building and methods of addressing the hypothesis with readily available technology.

Course Syllabus

Unit No.	Content	Contact Hours
How the course module work	Students should choose a relevant and recent research article in consultation with his/her mentor. Students should read the article thoroughly with a scientific bent of mind in order to pick up and grasp how the scientific idea was conceived to address the existing knowledge gap and how different experiments were planned to prove the conceived idea. The students will subsequently discuss the article with their respective mentors in detail for further analysis of the article. In the end the students are required to prepare a short presentation of 15-20 min covering the article and present in front of the committee and defend it.	30

Name of the Course: Lab IV: Molecular Biology and Genetic Engineering							**Course Code:** BTY 418
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 2	**L**	**T**	**P**	**Credits**	**Contact Hours**
			0	0	6	3	90
Total Evaluation Marks: 100 1. Practical Record: 20 2. Viva Voce: 20 3. E-SE: 60		**Examination Duration:** 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	270	90	180
Teaching format	Practical (P) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The objectives of this course are to provide students with experimental knowledge of molecular biology and genetic engineering.

Course outcomes:

Students should be able to gain hands- on experience in gene cloning, protein expression and purification. This experience would enable them to begin a career in industry that engages in genetic engineering as well as in research laboratories conducting fundamental research.

Course Syllabus

Unit No.	**Content**	**Contact hours**
Syllabus	1. Concept of lac-operon: a) Lactose induction of B-galactosidase. b) Glucose Repression. c) Diauxic growth curve of E.coli 2. UV mutagenesis to isolate amino acid auxotroph 3. Phage titre with epsilon phage/M13 4. Genetic Transfer-Conjugation, gene mapping 5. Plasmid DNA isolation and DNA quantitation 6. Restriction Enzyme digestion of plasmid DNA 7. Agarose gel electrophoresis 8. Polymerase Chain Reaction and analysis by agarose gel electrophoresis 9. Vector and Insert Ligation 10. Preparation of competent cells 11. Transformation of E.coli with standard plasmids, Calculation of transformation efficiency 12. Confirmation of the insert by Colony PCR and Restriction mapping	60

	13. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in E.coli, SDS-PAGE analysis 14. Purification of His-Tagged protein on Ni-NTA columns a) Random Primer labeling b) Southern hybridization.	

Name of the Course: Lab V: Immunology						**Course Code:** BTY 419	
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 2	**L**	**T**	**P**	**Credits**	**Contact Hours**
			0	0	6	3	90
Total Evaluation Marks: 100 1. Practical Record: 20 2. Viva Voce: 20 3. E-SE: 60		**Examination Duration:** 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	270	90	180
Teaching format	Practical (P) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The objectives of this laboratory course are to develop an understanding about practical aspects of components of immune system as well as their function. Basic as well as advanced methods will be taught to detect different antigen and antibody interactions, isolation of different lymphocyte cells etc. and how they can be used in respective research work.

Course outcomes:

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

i) Evaluate usefulness of immunology in different pharmaceutical companies;

ii) Identify proper research lab working in area of their own interests;

iii) Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out kind of immune responses in setting of infection (viral or bacterial) by looking at cytokine profile.

Course Syllabus

Unit No.	**Content**	**Contact hours**
Syllabus	1. Selection of animals, preparation of antigens, immunization and methods of blood collection, serum separation and storage. 2. Antibody titre by ELISA method. 3. Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion. 4. Complement fixation test. 5. Isolation and purification of IgG from serum or IgY from chicken egg. 6. SDS-PAGE, Immunoblotting, Dot blot assays. 7. Blood smear identification of leucocytes by Giemsa stain. 8. Separation of leucocytes by dextran method.	60

	9. Demonstration of Phagocytosis of latex beads and their cryopreservation. 10. Separation of mononuclear cells by Ficoll-Hypaque and their cryopreservation. 11. Demonstration of ELISPOT. 12. Demonstration of FACS.	

Name of the Course: Emerging Technologies				**Course Code:** BTY 501			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 3	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)			

Course objectives:

This course is broad-based in nature encompassing several new technologies that current experimental researchers are employing to probe complex system biology questions in life-sciences. The objectives of this course are to teach basics of the new principles to students so as to appreciate current-day research tool-kit better.

Course outcomes:

Students should be to learn history, theoretical basis and basic understanding of latest technologies in area of biotechnology. They should also be able to learn about various applications of these technologies. The students may also learn one application in depth through an assignment and/or seminar.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Optical microscopy methods	**Basic Microscopy:** Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Darkfield; Phase Contrast; Differential Interference Contrast; fluorescence and fluorescence microscopy: what is fluorescence, what makes a molecule fluorescent, fluorescence microscope; optical arrangement, light source; filter sets: excitation filter, dichroic mirror, and barrier, optical layout for image capture; CCD cameras; back illumination, binning; recording color; three CCD elements with dichroic beamsplitters, boosting the signal. **Advanced Microscopy:** Confocal microscope: scanning optical microscope, confocal principle, resolution and point spread function, light source: gas lasers & solid-state, primary beamsplitter; beam	6

	scanning, pinhole and signal channel configurations, detectors; pixels and voxels; contrast, spatial sampling: temporal sampling: signal-to- noise ratio, multichannel images. nonlinear microscopy: multiphoton microscopy; principles of two-photon fluorescence, advantages of two-photon excitation, tandem scanning (spinning disk) microscopes, deconvolving confocal images; image processing, three-dimensional reconstruction; advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy; Near-Field and Evanescent Waves, Total Internal Reflection Microscopy; Near-Field Microscopy; Beyond the Diffraction Limit: Stimulated Emission Depletion (STED), Super-Resolution Summary, Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM).	
2. Mass spectrometry	Ionization techniques; mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phospho proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry.	6
3. Systems Biology	High throughput screens in cellular systems, target identification, validation of experimental methods to generate the omics data, bioinformatics analyses, mathematical modeling and designing testable predictions.	5
4. Structural Biology	X-ray diffraction methods, solution & solid-state NMR, cryo-electron microscopy, small- angle X-ray scattering, Atomic force microscopy.	5
5. CRISPR-CAS	History of its discovery, elucidation of the mechanism including introduction to all the molecular players, development of applications for in vivo genome engineering for genetic studies, promise of the technology as a next generation therapeutic method.	4
6. Nanobodies	Introduction to nanobodies, combining nanobody with phage-display method for development of antibody against native proteins, nanobody as a tool for protein structure-function studies, use of nanobodies for molecular imaging, catabolic antibodies using nanobodies.	4
Recommended Textbooks and References: 1. Campbell, I. D. (2012). Biophysical Techniques. Oxford: Oxford University Press. 2. Serdyuk, I. N., Zaccai, N. R., & Zaccai, G. (2007). Methods in Molecular		

Biophysics: Structure, Dynamics, Function. Cambridge: Cambridge University Press.
3. Phillips, R., Kondev, J., & Theriot, J. (2009). Physical Biology of the Cell. NewYork: Garland Science.
4. Nelson, P. C., Radosavljević, M., & Bromberg, S. (2004). Biological Physics: Energy, Information, Life. New York: W.H. Freeman.
5. Huang, B., Bates, M., & Zhuang, X. (2009). Super-Resolution Fluorescence Microscopy. Annual Review of Biochemistry, 78(1), 993-1016. doi:10.1146/annurev. biochem.77.061906.092014.
6. Mohanraju, P., Makarova, K. S., Zetsche, B., Zhang, F., Koonin, E. V., & Oost, J. V. (2016). Diverse Evolutionary Roots and Mechanistic Variations of the CRISPR-Cas Systems. Science, 353(6299). doi:10.1126/science.aad5147.
7. Lander, E. (2016). The Heroes of CRISPR. Cell, 164(1-2), 18-28. doi:10.1016/j. cell.2015.12.041.
8. Ledford, H. (2016). The Unsung Heroes of CRISPR. Nature, 535(7612), 342-344. doi:10.1038/535342a.
9. Jinek, M., Chylinski, K., Fonfara, I., Hauer, M., Doudna, J. A., & Charpentier,E. (2012). A Programmable Dual-RNA-Guided DNA Endonuclease in Adaptive Bacterial Immunity. Science, 337(6096), 816-821. doi:10.1126/science.1225829.
10. Hamers-Casterman, C., Atarhouch, T., Muyldermans, S., Robinson, G., Hammers, C., Songa, E. B., Hammers, R. (1993). Naturally Occurring Antibodies Devoid of Light Chains. Nature, 363(6428), 446-448. doi:10.1038/363446a0.
11. Sidhu, S. S., & Koide, S. (2007). Phage Display for Engineering and Analyzing Protein Interaction Interfaces. Current Opinion in Structural Biology, 17(4), 481-487. doi:10.1016/j.sbi.2007.08.007.
12. Steyaert, J., & Kobilka, B. K. (2011). Nanobody Stabilization of G Protein-Coupled Receptor Conformational States. Current Opinion in Structural Biology,
21(4), 567-572. doi:10.1016/j.sbi.2011.06.011.
13. Vincke, C., & Muyldermans, S. (2012). Introduction to Heavy Chain Antibodies and Derived Nanobodies. Single Domain Antibodies, 15-26. doi:10.1007/978-1-61779- 968-6_2.
14. Verheesen, P., & Laeremans, T. (2012). Selection by Phage Display of Single Domain Antibodies Specific to Antigens in their Native Conformation. Single Domain Antibodies, 81-104. doi:10.1007/978-1-61779-968-6_6.
15. Li, J., Xia, L., Su, Y., Liu, H., Xia, X., Lu, Q. Reheman, K. (2012). Molecular Imprint of Enzyme Active Site by Camel Nanobodies. Journal of Biological Chemistry J. Biol. Chem., 287(17), 13713-13721. doi:10.1074/jbc.m111.336370.
16. Sohier, J., Laurent, C., Chevigné, A., Pardon, E., Srinivasan, V., Wernery, U. Galleni, M. (2013). Allosteric Inhibition of VIM Metallo-β-Lactamases by a Camelid Nanobody. Biochemical Journal, 450(3), 477-486. doi:10.1042/bj20121305.
17. Chakravarty, R., Goel, S., & Cai, W. (2014). Nanobody: The "Magic Bullet" for Molecular Imaging? Theranostics, 4(4), 386-398. doi:10.7150/thno.8006.

Name of the Course: Bioentrepreneurship				**Course Code:** BTY 502			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 3	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60

Teaching format	Lecture (L) and Assignments
Instruction medium	English
Recommended prerequisite to attend this course (if any)	N.A.

Course objectives:

Research and business belong together and both are needed. In a rapidly developing life science industry, there is an urgent need for people who combine business knowledge with the understanding of science & technology. Bio-entrepreneurship, an interdisciplinary course, revolves around the central theme of how to manage and develop life science companies and projects. The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.

Course outcomes:

Students should be able to gain entrepreneurial skills, understand the various operations involved in venture creation, identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centers and various agencies. The knowledge pertaining to management should also help students to be able to build up a strong network within the industry.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Innovation and entrepreneurship in bio-business	Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (e.g. pharmaceuticals vs. Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision	5
2. Business forms, ownership types	Forms of Business Organization e.g. Partnerships, Pvt Ltd etc. Ownership Structure, Formation of a company,	5

and cooperate structure	Private, Public and global enterprises, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India).	
3. Licensing the Technology: Biotechnology Commercialization	Government's Investment in basic Biomedical Research, Translation of academic research to products for the public good, Accessing academic technologies and Collaborations, Technology Transfer Office Set-Up and licensing from Universities and research laboratories, Advantages for a biotech Start-Up to work with the national Institutes and Universities.	5
4. Bio markets - business strategy and marketing	Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.	5
5. Finance and accounting	Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.	5
6. Technology management	Technology – assessment, development & upgradation, Managing technology transfer, Intellectual Property Protection strategies for Biotechnology innovations, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).	5

Recommended Textbooks and References:

1. Adams, D. J., & Sparrow, J. C. (2008). Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham: Scion.
2. Shimasaki, C. D. (2014). Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
3. Onetti, A., & Zucchella, A. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Routledge.
4. Jordan, J. F. (2014). Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press.
5. Desai, V. (2009). The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House.

Name of the Course: Molecular Diagnostics						**Course Code:** BTY 503	
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 3	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The objectives of this course are to sensitize students about recent advances in molecular biology and various facets of molecular medicine which has potential to profoundly alter many aspects of modern medicine including pre-or post-natal analysis of genetic diseases and identification of individuals predisposed to disease ranging from common cold to cancer.

Course outcomes:

Students should be able to understand various facets of molecular procedures and basics of genomics, proteomics and metabolomics that could be employed in early diagnosis and prognosis of human diseases.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Genome biology in health and disease	DNA, RNA, Protein: An overview; chromosomal structure & mutations; DNA polymor- phism: human identity; clinical variability and genetically determined adverse reactions to drugs.	4
2. Genome: resolution, detection and analysis and diagnostic metabolomics	PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF-MS; Bioinformatics data acquisition & analysis. Metabolite profile for biomarker detection the body fluids/tissues in various metabolic disorders by making using LCMS & NMR technological platforms. Quality	6

	oversight; regulations and approved testing.	
3. Detection and identity of microbial diseases	Direct detection and identification of pathogenic-organisms that are slow growing or currently lacking a system of in vitro cultivation as well as genotypic markers of microbial resistance to specific antibiotics.	5
4. Detection of inherited diseases	Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: Fragile X Syndrome: Paradigm of new mutational mechanism of unstable triplet repeats, von-Hippel Lindau disease: recent acquisition in growing number of familial cancer syndromes.	5
5. Molecular oncology	Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates.	5
6. Cancer-related biomarkers	Predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies.	5

Recommended Textbooks and References:

1. Campbell, A. M., & Heyer, L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.
2. Brooker, R. J. (2009). Genetics: Analysis & Principles. New York, NY: McGraw-Hill.
3. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, DC: ASM Press.
4. Coleman, W. B., & Tsongalis, G. J. (2010). Molecular Diagnostics: for the Clinical Laboratorian. Totowa, NJ: Humana Pres

Name of the Course: Intellectual Property Rights, Biosafety and Bioethics						**Course Code:** BTY 506	
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 2	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60

Teaching format	Lecture (L) and Assignments
Instruction medium	English
Recommended prerequisite to attend this course (if any)	N.A.

Course objectives:

The objectives of this course are:-

i. To provide basic knowledge on intellectual property rights and their implications in biological research and product development;

ii. To become familiar with India's IPR Policy;

iii. To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products;

iv. To become familiar with ethical issues in biological research. This course will focus on consequences of biomedical research technologies such as cloning of whole organisms, genetic modifications, DNA testing.

Course outcomes:

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

i. Understand the rationale for and against IPR and especially patents; Understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations;

ii. Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents;

iii. Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms, national and international regulations;

iv. Understand ethical aspects related to biological, biomedical, health care and biotechnology research.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Introduction to IPR and International	Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge,	6

treaties	geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.	
2. Patents	Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting- introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement-meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.	6
3. Biosafety basics	Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs.	3
4. Biosafety regulations for academics and industry	principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development	5

	of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools.	
5. National and International Regulations	International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).	5
6. Bioethics	Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.	5

Recommended Textbooks and References:

1. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub.
2. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI.
3. Complete Reference to Intellectual Property RightsLaws. (2007). Snow White Publication Oct.
4. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.
5. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/
6. Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences - Case Studies of Policy Challenges from New Technologies, MIT Press
7. World Trade Organisation. http://www.wto.org
8. World Intellectual Property Organisation. http://www.wipo.int
9. International Union for the Protection of New Varieties of Plants. http://www.upov.int
10. National Portal of India. http://www.archive.india.gov.in
11. National Biodiversity Authority. http://www.nbaindia.org
12. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry
of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/

divisions/csurv/geac/annex-5.pdf
13. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J. W., Burachik, M., Gray, A., Wu,
F. (2009). Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9
14. Craig, W., Tepfer, M., Degrassi, G., & Ripandelli, D. (2008). An Overview of General
Features of Risk Assessments of Genetically Modified Crops. Euphytica, 164(3), 853-880. doi:10.1007/s10681-007-9643-8
15. Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants. 2008.
16. Guidelines and Standard Operating Procedures for Confined Field Trials of Regulated Genetically Engineered Plants. 2008. Retrieved from http://www.igmoris.nic.in/guidelines1.asp
17. Alonso, G. M. (2013). Safety Assessment of Food and Feed Derived from GM Crops: Using Problem Formulation to Ensure "Fit for Purpose" Risk Assessments. Retrieved from http://biosafety.icgeb.org/inhousepublicationscollectionbiosafetyreviews.

Name of the Course: Research Methodology and Scientific Communication Skills				**Course Code:** BTY 507			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 3	**L**	**T**	**P**	**Credits**	**Contact Hours**
			0	2	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The objectives of this course are to give background on history of science, emphasizing methodologies used to do research, use framework of these methodologies for understanding effective lab practices and scientific communication and appreciate scientific ethics.

Course outcomes:

Students should be able to:

i. Understand history and methodologies of scientific research, applying these to recent published papers;
ii. Understand and practice scientific reading, writing and presentations;
iii. Appreciate scientific ethics through case studies.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. History of science and science methodologies	Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology.	4
2. Preparation for research	Choosing a mentor, lab and research question; maintaining a lab notebook.	4
3. Process of communication	Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; barriers to effective communication; non-verbal communication- interpreting non-verbal cues; importance of body	8

	language, power of effective listening; recognizing cultural differences;	
4. Presentation skills	Formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness.	6
5. Scientific communication	Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts;	4
6. Publishing scientific papers	Peer review process and problems, recent developments such as open access and non- blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.	4

Recommended Textbooks and References:

1. Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press.
2. On Being a Scientist: a Guide to Responsible Conduct in Research. (2009). Washington, D.C.: National Academies Press.
3. Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. American Scientist, 78 (Nov-Dec 1990), 550-558.
4. Mohan, K., & Singh, N. P. (2010). Speaking English Effectively. Delhi: Macmillan India.
5. Movie: Naturally Obsessed, The Making of a Scientist.

Name of the Course: Dissertation A (Review writing, Project Proposal Preparation and Presentation)						**Course Code:** BTY-508	
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 3	**L**	**T**	**P**	**Credits**	**Contact Hours**
			0	2	3	5	75
Total Evaluation Marks: 100 1. Synopsis: 20 2. Poster Presentation: 20 3. Oral Presentation: 60		**Examination Duration:** Presentation: 45 min					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	225	75	150
Teaching format	Personal interaction with mentor		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The purpose of this course is to help students organize ideas, material and objectives for their dissertation and to begin development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers..

Course outcomes:

Students should be able to demonstrate the following abilities:

i. Formulate a scientific question; Present scientific approach to solve the problem;

ii. Interpret, discuss and communicate scientific results in written form;

iii. Gain experience in writing a scientific proposal;

iv. Learn how to present and explain their research findings to the audience effectively.

Course Syllabus

Unit No.	**Content**	**Contact hours**
Project proposal preparation	Selection of research lab and research topic: Students should first select a lab wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven. Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in	75

	mind ethical standards of conduct in the collection and evaluation of data and other resources. **Writing Research Proposal:** With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, etc. Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for dissertation.	
Poster Presentation	Students will have to present the topic of their project proposal after few months of their selection of the topic. They should be able to explain the novelty and importance of their research topic.	
Oral Presentation	At the end of their project, presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.	

Name of the Course: Lab VI: Bioinformatics						**Course Code:** BTY 509	
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 3	**L**	**T**	**P**	**Credits**	**Contact Hours**
			0	0	4	2	60
Total Evaluation Marks: 100 1. Practical Record: 20 2. Viva Voce: 20 3. E-SE: 60		**Examination Duration:** 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	180	60	120
Teaching format	Practical (P) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The aim of this course is to provide practical training in bioinformatic methods including accessing major public sequence databases, use of different computational tools to find sequences, analysis of protein and nucleic acid sequences by various software packages.

Course outcomes:

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

i. Describe contents and properties of most important bioinformatics databases;
ii. Perform text- and sequence-based searches and analyze and discuss results in light of molecular biological knowledge;
iii. Explain major steps in pairwise and multiple sequence alignment, explain principle and execute pairwise sequence alignment by dynamic programming;
iv. Predict secondary and tertiary structures of protein sequences.

Course Syllabus

Unit No.	**Content**	**Contact hours**
Syllabus	1. Using NCBI and Uniprot web resources. 2. Introduction and use of various genome databases. 3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt. 4. Similarity searches using tools like BLAST and interpretation of results. 5. Multiple sequence alignment using ClustalW. 6. Phylogenetic analysis of protein and nucleotide sequences. 7. Use of gene prediction methods (GRAIL, Genscan, Glimmer). 8. Using RNA structure prediction tools. 9. Use of various primer designing and restriction site	60

	prediction tools. 10. Use of different protein structure prediction databases (PDB,SCOP, CATH). 11. Construction and study of protein structures using Deepview/PyMol. 12. Homology modelling of proteins. 13. Use of tools for mutation and analysis of the energy minimization of protein structures. 14. Use of miRNA prediction, designing and target prediction tools.	

Name of the Course: Lab VII: Bioprocess Engineering and Technology							**Course Code:** BTY 510
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 3	**L**	**T**	**P**	**Credits**	**Contact Hours**
			0	0	3	3	90
Total Evaluation Marks: 100 1. Practical Record: 20 2. Viva Voce: 20 3. E-SE: 60		**Examination Duration:** 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	270	90	180
Teaching format	Practical (P) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The objectives of this laboratory course are to provide hands-on training to students in upstream and downstream unit operations.

Course outcomes:

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

i. Investigate, design, and conduct experiments, analyze and interpret data, and apply the laboratory skills to solve complex bioprocess engineering problems.

ii. Apply skills and knowledge gained will be useful in solving problems typical of bio industries and research

Course Syllabus

Unit No.	**Content**	**Contact Hours**
Syllabus	**1. Basic Microbiology techniques** a) Scale up from frozen vial to agar plate to shake flask culture. b) Instrumentation: Microplate reader, spectrophotometer, microscopy. c) Isolation of microorganisms from soil samples. **2. Experimental set-up** a) Assembly of bioreactor and sterilization. b) Growth kinetics. c) Substrate and product inhibitions. d) Measurement of residual substrates. **3. Data Analysis** a) Introduction to Metabolic Flux Analysis (MFA). **4. Fermentation** a) Batch. B) Fed-batch. C) Continuous. **5. Downstream operations**	90

	a) Microfiltrations: Separation of cells from broth. b) Bioseparations: Various chromatographic techniques and extractions. **6. Introduction to Bio-analytics** a) Analytical techniques like HPLC, FPLC, GC, GC-MS etc. for measurement of amounts of products/substrates.	

Recommended Textbooks and References:

1. Shuler M. I. & Kargi. F. Bioprocess Engineering: Basic Concepts
2. Debabrata Das, Debayan Das: Biochemical Engineering A Laboratory Manual
3. Stanbury, P. F., & Whitaker, A. Principles of Fermentation Technology.

<table>
<tr><td colspan="4">Name of the Course:
Dissertation B (Major project)</td><td colspan="4">Course Code:
BTY 511</td></tr>
<tr><td rowspan="2">Batch:
2022-23</td><td rowspan="2">Programme: M.Sc. Biotechnology</td><td rowspan="2">Semester:
4</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hours</td></tr>
<tr><td>0</td><td>3</td><td>15</td><td>18</td><td>NA</td></tr>
<tr><td colspan="3">Total Evaluation Marks: 100

1. Lab Work: 60
2. Thesis writing: 20
3. Oral Presentation: 20</td><td colspan="5">Examination Duration:

Seminar: 45 min</td></tr>
<tr><td colspan="8">Workload</td></tr>
<tr><td></td><td colspan="2">Total workload</td><td colspan="2">Amount of attendance time</td><td colspan="3">Time for Self-Study</td></tr>
<tr><td>Respective hours</td><td colspan="2">NA</td><td colspan="2">NA</td><td colspan="3">Lab Work</td></tr>
<tr><td>Teaching format</td><td colspan="7">Personal interaction with mentor and lab work</td></tr>
<tr><td>Instruction medium</td><td colspan="7">English</td></tr>
<tr><td>Recommended prerequisite to attend this course (if any)</td><td colspan="7">N.A.</td></tr>
<tr><td colspan="8">Course objectives:
The objectives of this course are to prepare the students to adapt to the research environment and understand how projects are executed in a research laboratory. It will also enable students to learn practical aspects of research and train students in the art of analysis and thesis writing.</td></tr>
<tr><td colspan="8">Course outcomes:
Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments. Students should be able to demonstrate considerable improvement in the following areas:
i. In-depth knowledge of the chosen area of research.
ii. Capability to critically and systematically integrate knowledge to identify issues that must be addressed within framework of specific thesis.
iii. Competence in research design and planning.
iv. Capability to create, analyse and critically evaluate different technical solutions.
v. Ability to conduct research independently.
vi. Ability to perform analytical techniques/experimental methods.
vii. Project management skills.
viii. Report writing skills.
ix. Problem solving skills.
x. Communication and interpersonal skills.</td></tr>
<tr><td colspan="2">Planning & performing experiments and thesis writing</td><td colspan="5">Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate method-ologies and evidence, apply appropriate</td><td></td></tr>
</table>

	techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment. Subsequently, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application. The students are required to prepare a short presentation of 15-20 min covering the work and present in front of the committee and defend it.	

<table>
<tr><td colspan="5">Name of the Course:
Critical Analysis of Research Papers & Group Discussion</td><td colspan="4">Course Code:
BTY 514</td></tr>
<tr><td>Batch:
2022-23</td><td>Programme: M.Sc. Biotechnology</td><td>Semester:
4</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td>Contact Hours</td></tr>
<tr><td></td><td></td><td></td><td>0</td><td>2</td><td>0</td><td>2</td><td>30</td></tr>
<tr><td colspan="3">Total Evaluation Marks: 100

Presentation: 100</td><td colspan="5">Examination Duration:

Seminar: 45 min</td></tr>
<tr><td colspan="8">Workload</td></tr>
<tr><td></td><td colspan="2">Total workload</td><td colspan="2">Amount of attendance time</td><td colspan="3">Time for Self-Study</td></tr>
<tr><td>Respective hours</td><td colspan="2">90</td><td colspan="2">30</td><td colspan="3">60</td></tr>
<tr><td>Teaching format</td><td colspan="7">Lecture and Assignments</td></tr>
<tr><td>Instruction medium</td><td colspan="7">English</td></tr>
<tr><td>Recommended prerequisite to attend this course (if any)</td><td colspan="7">N.A.</td></tr>
<tr><td colspan="8">Course objectives:
The objectives of this course are to familiarize students with current literature reading, critical thinking and analysing modern day scientific discoveries using basic and high-end tools and technologies.</td></tr>
<tr><td colspan="8">Course outcomes:
Students should be able to train in the exercise of hypothesis building and methods of addressing the hypothesis with readily available technology.</td></tr>
<tr><td colspan="8">Course Syllabus</td></tr>
<tr><td>Unit No.</td><td colspan="6">Content</td><td>Contact Hours</td></tr>
<tr><td>How the course module work</td><td colspan="6">Students should choose a relevant and recent research article in consultation with his/her mentor. Students should read the article thoroughly with a scientific bent of mind in order to pick up and grasp how the scientific idea was conceived to address the existing knowledge gap and how different experiments were planned to prove the conceived idea.
The students will subsequently discuss the article with their respective mentors in detail for further analysis of the article. In the end the students are required to prepare a short presentation of 15-20 min covering the article and present in front of the committee and defend it.</td><td>30</td></tr>
</table>

RECOMMENDED ELECTIVES

Name of the Course: Biological Imaging						**Course Code:** DSE	
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)			

Course objectives:

The objectives of this course are to provide complete overview of state-of-art live-cell imaging techniques using microscopes currently available in literature. Livecell imaging techniques allow real-time examination of almost every aspect of cellular function under normal and experimental conditions. With live-cell imaging experiments, main challenges are to keep cells alive and healthy over a period of time. The growing number of live-cell imaging techniques means one can obtain greater amounts of information without stressing out cells.

Course outcomes:

On completion of this course, students shall be able to gain a complete overview of super-resolution field from fundamentals to state-of-art methods and applications in biomedical research. The students shall learn the comparative advantages and disadvantages of each technique, covers all key techniques in field of biomedical science. The students shall also learn how to use new tools to increase resolution in sub-nanometer-scale images of livingcells and tissue, which leads to new information about molecules, pathways and dynamics and state-of-the-art examples of applications using microscopes.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Light and fluorescent microscopy	One of the most basic techniques for live-cell imaging is widefield fluorescent microscopy. Standard inverted research grade microscopes can yield valuable results if you are imaging adherent cells, large regions of interest (such as organelles) or very thin tissue sections (less than 5 micrometer). In widefield, a CCD camera is usually used to capture images and the epi-fluorescence illumination source can be a mercury lamp, xenon lamp, LED's, etc.	6

	Each of light sources require carefully matched interference filters for specific excitation and emission wavelengths of your fluorophore of interest. With widefield microscopy, your specimen is only exposed to excitation light for relatively short time periods as the full aperture of emission light is collected by the objectives. Widefield fluorescence microscopy can be used in combination with other common contrast techniques such as phase contrast and differential interference contract (DIC) microscopy. This combination is useful when performing live-cell imaging to examine general cell morphology or viability while also imaging regions of interest within cells	
2. Confocal laser scanning microscopy (CLSM)	CLSM has ability to eliminate out-of-focus light and information. It is also possible to obtain optical serial sections from thicker specimens. A conjugate pinhole in optical path of confocal microscope prevents fluorescence from outside of focal plane from being collected by photomultiplier detector or imaged by camera. In CLSM, a single pinhole (and single focused laser spot) is scanned across specimen by scanning system. This spot forms a reflected epi-fluorescence image back on original pinhole. When specimen is in focus, fluorescent light from it passes through pinhole to detector. Any out-of-focus light is defocused at pinhole and very little of this signal passes through to detector meaning that background fluorescence is greatly reduced. The pinhole acts as a spatial filter for emission light from the specimen	5
3. Spinning disc confocal microscopy (SDCM)	This method utilises a 'Nipkow Disc' which is a mechanical opaque disc which has a series of thousands of drilled or etched pinholes arranged in a spiral pattern. Each illuminated pinhole on disc is imaged by microscope objective to a diffraction-limited spot on region of interest on specimen. The emission from fluorophores passes back though Nipkow disc pinholes and can be observed and captured by a CCD camera. The effect of spinning disc is that many thousands of points on specimen are simultaneously illuminated. Using SDCM to examine a specimen means that real-time imaging (30-frames-per-second or faster) can be achieved, which is extremely useful if you are looking at dynamic changes within living cells over a wide spectrum oftime-scales.	5
4. Light-sheet fluorescence microscopy (LSFM, or SPIM)	This method enables one to perform live-cell imaging on whole embryos, tissues, and cell spheroids in vivo in a gentle manner with high temporal resolution and in three dimensions. One is able to track cell movement over extended periods of time and follow development of organs and tissues on a cellular level. The next evolution of light-sheet fluorescence microscopy, termed lattice light-sheet microscopy as developed by Eric Betzig (Nobel Prize Laureate 2014 for PALM super-resolution microscopy) will even allow live-cell imaging with super-resolved in vivo cellular localization capabilities	4
5. Super-resolved	Super-Resolution in a Standard Microscope: From Fast	5

fluorescence microscopy	Fluorescence Imaging to Molecular Diffusion Laws in Live Cells; Photo switching Fluorophores in SuperResolution Fluorescence Microscopy; Image Analysis for Single-Molecule Localization Microscopy Deconvolution of Nanoscopic Images; Super-Resolution Fluorescence Microscopy of the Nanoscale Organization in cells; Correlative Live-Cell and SuperResolution Microscopy and Its Biological Applications; SAX Microscopy and Its Application to Imaging of 3D-Cultured Cells; Quantitative Super-Resolution Microscopy for Cancer Biology and Medicine.	
6. Re-scan confocal microscopy	Structured Illumination Microscopy; Correlative Nanoscopy: AFM Super-Resolution (STED/STORM) ; Stochastic Optical Fluctuation Imaging.	5

Recommended Textbooks and References:

1. Rajagopal Vadivambal, Digvir S. Jayas. (2015). Bio-Imaging: Principles,Techniques, and Applications. ISBN 9781466593671 - CAT# K20618.
2. Alberto Diaspro, Marc A. M. J. van Zandvoort. (2016). Super-Resolution Imagingin Biomedicine. ISBN 9781482244342 - CAT# K23483.
3. Taatjes, Douglas, Roth, Jürgen (Eds.). (2012). Cell Imaging Techniques Methods and Protocols. ISBN 978-1-62703-056-4.

Name of the Course: Computational Biology							**Course Code:** DSE
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)			

Course objectives:

The objective of this course is to provide students with theory and practical experience of essentials to aid for genomic, proteomic and metabolomics courses and drug design program.

Course outcomes:

On completion of this course, the students are expected to: • Develop an understanding of the basic theory of these computational tools; • Develop required database extraction, integration, coding for computational tools and methods necessary for all Omics; • Create hypothesis for investigating specific contemporary biological questions, provide help to experiment with or develop appropriate tools; • Critically analyze and interpret results of their study with respect to whole systems

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Introduction to computational biology basics and biological databases	Computers in biology and medicine; Overview of biological databases, nucleic acid & protein databases, primary, secondary, functional, composite, structural classification database, Sequence formats & storage, Access databases, Extract and create sub databases, limitations of existing databases.	4
2. Pairwise and multiple sequence alignments	Local alignment, Global alignment, Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots. Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman Algorithm, Hidden Markov Model: Viterbi Algorithm. Heuristic approach: BLAST, FASTA. Building Profiles, Profile based functional identification.	4
3. Genome analysis	Polymorphisms in DNA sequence, Introduction to Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation,	6

	Comparative genomics, Probabilistic functional gene networks, Human genome project, Genomics and crop improvement. Study available GWAS, ENCODE, HUGO projects, extract and build sub databases; Visualization tools including Artemis and Vista for genome comparison; Functional genomics case studies	
4. Structure visualization	Retrieving and drawing structures, Macromolecule viewing platforms, Structure validation and correction, Structure optimization, Analysis of ligand-protein interactions; Tools such as PyMol or VMD	4
5. Molecular modelling	Significance and need, force field methods, energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; RMS fit of conformers and protein chains, assigning secondary structures; sequence alignment: methods, evaluation, scoring; protein curation: backbone construction and side chain addition; different types of protein chain modelling: ab initio, homology, hybrid, loop; Template recognition and alignments; Modelling parameters and considerations; Model analysis and validation; Model optimization; Substructure manipulations, annealing, protein folding and model generation; loop generating methods; loop analysis; Analysis of active sites using different methods in studying protein–protein interactions.	5
6. Structure and ligand based drug development	Molecular docking: Types and principles, Semi-flexible docking, Flexible docking; Ligand and protein preparation, Macromolecule and ligand optimization, Ligand conformations, Clustering, Analysis of docking results and validation with known information. Extraprecision docking platforms, Use of Small-molecule libraries, Natural compound libraries for virtual high throughput screenings. Quantitative structure activity relationships; Introduction to chemical descriptors like 2D, 3D and Group-based; Radar plots and contribution plots and Activity predictions, Pharmacophore modeling, Pharmacophore-based screenings of compound library, analysis and experimental validation	7

Recommended Textbooks and References:

1 Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. ColdSpring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics.Hoboken, NJ: Wiley-Liss.
3. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.
4. Campbell, M & Heyer, L. J. (2006), Discovering Genomics, Proteomicsand Bioinformatics, Pearson Education.
5. Oprea, T. (2005). Chemoinformatics in Drug Discovery, Volume23. Wiley Online Library.
6. Gasteiger, J. & Engel,T. (2003), Chemoinformatics: a Textbook, Wiley OnlineLibrary.

Name of the Course: Drug Discovery and Development							**Course Code:** DSE
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)			

Course objectives:

This course will give a broad overview of research and development carried out in industrial setup towards drug discovery.

Course outcomes:

On completion of this course, students should be able to understand basics of R&D in drug discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Target identification and molecular modelling	Identification of target or drug leads associated with a particular disease by a number of different techniques including combinations of molecular modeling, combinatorial libraries and high-throughput screening (HTS); Conceptualizing the automation of the HTS process and the importance of bioinformatics and data processing in identification of lead compounds; Rational drug design, based on understanding the three-dimensional structures and physicochemical properties of drugs and receptors; Modelling drug/ receptor interactions with the emphasis on molecular mechanisms, molecular dynamics simulations and homology modelling; Conformational sampling, macromolecular folding, structural bioinformatics, receptor-based and ligand-based design and docking methods, in silico screening of libraries, semi-empirical and ab-initio methods, QSAR methods, molecular diversity, design of combinatorial libraries of drug-like molecules, macromolecular and chemical databases	7
2. Lead optimization	Identification of relevant groups on a molecule that interact with a receptor and are responsible for biological activity; Understanding structure activity	5

	relationship; Structure modification to increase potency and therapeutic index; Concept of quantitative drug design using Quantitative structure–activity relationship models (QSAR models) based on the fact that the biological properties of a compound are a function of its physicochemical parameters such as solubility, lipophilicity, electronic effects, ionization, stereochemistry, etc.; Bioanalytical assay development in support of in vitro and in vivo studies (LC/MS/MS, GC/MS and ELISA).	
3. Preclinical development	Principles of drug absorption, drug metabolism and distribution - intestinal absorption, metabolic stability, drug-drug interactions, plasma protein binding assays, metabolite profile studies, Principles of toxicology, Experimental design for preclinical and clinical PK/PD/TK studies, Selection of animal model; Regulatory guidelines for preclinical PK/ PD/TK studies; Scope of GLP, SOP for conduct of clinical & non clinical testing, control on animal house, report preparation and documentation Integration of non-clinical and preclinical data to aid design of clinical studies	5
4. Drug manufacturing	Requirements of GMP implementation, Documentation of GMP practices, CoA, Regulatory certification of GMP, Quality control and Quality assurance, concept and philosophy of TQM, ICH and ISO 9000; ICH guidelines for Manufacturing, Understanding Impurity Qualification Data, Stability Studies.	5
5. Clinical trial design	Objectives of Phase I, II, III and IV clinical studies, Clinical study design, enrollment, sites and documentation, Clinical safety studies: Adverse events and adverse drug reactions, Clinical PK, pharmacology, drug-drug interaction studies, Statistical analysis and documentation	4
6. Fundamentals of regulatory affairs and bioethics	Global Regulatory Affairs and different steps involved, Regulatory Objectives, Regulatory Agencies; FDA guidelines on IND and NDA submissions, Studies required for IND and NDA submissions for oncology, HIV, cardiovascular indications, On-label vs. off-label drug use GCP and Requirements of GCP Compliance, Ethical issues and Compliance to current ethical guidelines, Ethical Committees and their set up, Animal Ethical issues and compliance	4

Recommended Textbooks and References:

1. Krogsgaard-Larsen et al. Textbook of Drug Design and Discovery. 4th Edition. CRC Press.
2. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.
3. Nally, J. D. (2006) GMP for Pharmaceuticals. 6th edition. CRC Press
4. Brody, T. (2016) Clinical Trials: Study Design, Endpoints and Biomarkers, Drug Safety, and FDA and ICH Guidelines. Academic Press.

Name of the Course: Environmental Biotechnology				**Course Code:** DSE			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)			

Course objectives: This course aims to introduce fundamentals of Environmental Biotechnology. The course will introduce major groups of microorganisms tools in biotechnology and their most important environmental applications. The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature.

Course outcomes:
On completion of course, students will be able to understand use of basic microbiological, molecular and analytical methods, which are extensively used in environmental biotechnology.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Introduction to environment	Introduction to environment; pollution and its control; pollution indicators; waste management: domestic, industrial, solid and hazardous wastes; strain improvement; Biodiversity and its conservation;	5
2. Microbial Ecology	Role of microorganisms in geochemical cycles; microbial energy metabolism, microbial growth kinetics and elementary chemostat theory, relevant microbiological processes, microbial ecology	5
3. Bioremediation	Bioremediation: Fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT etc.), technological aspects of bioremediation (in situ, ex situ)	5
4. Role of microorganisms in	Application of bacteria and fungi in bioremediation: White rot fungi vs specialized	5

bioremediation	degrading bacteria: examples, uses and advantages vs disadvantages; Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration phytostabilization)	
5. Biotechnology and agriculture	Bioinsecticides: Bacillus thuringiensis, Baculoviruses, uses, genetic modifications and aspects of safety in their use; Biofungicides: Description of mode of actions and mechanisms (e.g. Trichoderma, Pseudomonas fluorescens); Biofertilizers: Symbiotic systems between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi symbiosis), Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application.	5
6. Biofuels	Environmental Biotechnology and biofuels: biogas; bioethanol; biodiesel; biohydrogen; Description of the industrial processes involved, microorganisms and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi.	5

Recommended Textbooks and References:

1. G. M. Evans and J. C. Furlong (2003), Environmental Biotechnology: Theory and Applications, Wiley Publishers.
2. B. Ritmann and P. L. McCarty, (2000), Environmental Biotechnology: Principle & Applications, 2nd Ed., McGraw Hill Science.
3. Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited.
4. J. S. Devinny, M. A. Deshusses and T. S. Webster, (1998), Biofiltration for Air Pollution Control, CRC Press.
5. H. J. Rehm and G. Reed, (2001), Biotechnology – A Multi-volume Comprehensive Treatise, Vol. 11, 2nd Ed., VCH Publishers Inc

Name of the Course: Protein Engineering				**Course Code:** DSE			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)			

Course objectives:

The aim of this course is to introduce methods and strategies commonly used in protein engineering.

Course outcomes:

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

iii. Analyse structure and construction of proteins by computer-based methods;
iv. Describe structure and classification of proteins;
v. Analyse purity and stability of proteins and explain how to store them in best way;
vi. Explain how proteins can be used for different industrial and academic purposes such as structure determination, organic synthesis and drug design.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Introduction to protein engineering	Protein engineering – definition, applications; Features or characteristics of proteins that can be engineered (definition and methods of study) – affinity and specificity; Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, etc. Protein engineering with unnatural amino acids and its applications.	5
2. Stability of protein structure	Methods of measuring stability of a protein; Spectroscopic methods to study physicochemical properties of proteins: far-UV and near-UV CD; Fluorescence; UV absorbance; ORD; Hydrodynamic properties–viscosity, hydrogen-deuterium exchange; Brief introduction to NMR spectroscopy – emphasis on parameters that can be measured/obtained from NMR and their interpretation.	5
3. Forces	Forces stabilizing proteins – Van der waals, electrostatic,	6

stabilizing proteins & Protein engineering methods	hydrogen bonding and weakly polar interactions, hydrophobic effects; Entropy – enthalpy compensation; Experimental methods of protein engineering: directed evolution like gene site saturation mutagenesis; Module shuffling; Guided protein recombination, *etc.*, Optimization and high throughput screening methodologies like GigaMetrix, High throughput microplate screens *etc.*	
4. Application	Application to devices with bacteriorhodopsin as an example; Engineering antibody affinity by yeast surface display; Applications to vaccines, Peptidomimetics and its use in drug discovery.	5
5. Computational approaches	Computational approaches to protein engineering: sequence and 3D structure analysis, Data mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles and thermophiles vis-à-vis those from mesophiles; Protein design,Directed evolution for protein engineering and its potential.	5
6. Case studies	Case Studies.	5

Recommended Textbooks and References:

1. Introduction to Proteins: Structure, Function, and Motion, Second Edition By Amit Kessel, Nir Ben-Tal, Chapman and Hall/CRC, 2018
2. Edited by T E Creighton, (1997), *Protein Structure: a Practical Approach*, 2nd Edition, Oxford university press.
3. Cleland and Craik, (2006), *Protein Engineering, Principles and Practice*, Vol 7, Springer Netherlands.
4. Mueller and Arndt, *Protein Engineering Protocols*, 1st Edition, Humana Press.
5. Ed. Robertson DE, Noel JP, (2004), *Protein Engineering Methods in Enzymology*, 388, Elsevier Academic Press.
6. J Kyte; (2006), *Structure in Protein Chemistry*, 2nd Edition, Garland publishers.

Name of the Course: Nanobiotechnology				**Course Code:** DSE			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)			

Course objectives:

i. The course aims at providing a general and broad introduction to multi-disciplinary field of nanotechnology.
ii. It will familiarize students with the combination of the top-down approach of microelectronics and micromechanics with the bottom-up approach of chemistry/biochemistry; a development that is creating new and exciting cross-disciplinary research fields and technologies.
iii. The course will also give an insight into complete systems where nanotechnology can be used to improve our everyday life.

Course outcomes:

On successful completion of this course, students should be able to describe basic science behind the properties of materials at nanometre scale, and the principles behind advanced experimental and computational techniques for studying nanomaterials.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Introduction to Nanobiotechnology	Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.	4
2. Nano-films	Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation.	4
3. Nano-particles	Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for	5

	enhanced permeation through various anatomical barriers.	
4. Application of Nano-particles	Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.	5
5. Nano-materials	Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in sythesis, applications of nanobiocatalysis in the production of drugs and drug intermediates.	6
6. Nano-toxicology	Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment; Ecotoxicity models and assays; Life Cycle Assessment, containment.	6

Books recommended

1. GeroDecher, Joseph B. Schlenoff, (2003); *Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials*, Wiley-VCH Verlag GmbH & Co. KGaA
2. David S. Goodsell, (2004); *Bionanotechnology: Lessons from Nature*; Wiley-Liss
3. Neelina H. Malsch (2005), *Biomedical Nanotechnology*, CRC Press
4. Greg T. Hermanson, (2013); *Bioconjugate Techniques*, (3rd Edition); Elsevier
5. Recent review papers in the area of Nanomedicine.

Name of the Course: Vaccines				**Course Code:** DSE			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. EOSE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)			

Course objectives:

This course will provide students with an overview of current developments in different areas of vaccines.

Course outcomes:

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

vii. Understand fundamental concepts of human immune system and basic immunology;
viii. Differentiate and understand immune responses in relation to infection and vaccination;
ix. Understand requirement and designing of different types of vaccines;
x. Understand importance of conventional and new emerging vaccine technologies.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Fundamentals of immune system	Overview of Immune system; Human Immune system: Effectors of immune system; Innate & Adaptive Immunity; Activation of the Innate Immunity; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Correlates of protection.	5
2. Immune response to infection	Protective immune response in bacterial; viral and parasitic infections; Primary and Secondary immune responses during infection; Antigen presentation and Role of Antigen presenting cells: Dendritic cells in immune response; Innate immune response; Humoral (antibody mediated) responses; Cell mediated responses: role of CD4+ and CD8+ T cells; Memory responses: Memory and effector T and B cells, Generation and Maintenance of memory T and B cells.	5
3. Immune response to	Vaccination and immune response; Adjuvants in Vaccination; Modulation of immune responses: Induction of	5

vaccination	Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems - Microbial adjuvants, Liposomal and Microparticles as delivery systems; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and Mucosal Immunity.	
4. Vaccine types & design	History of vaccines, Conventional vaccines; Bacterial vaccines; Viral Vaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine.	5
5. Vaccine technologies	New Vaccine Technologies; Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination; Vaccines for targeted delivery (Vaccine Delivery systems);	5
6. Disease specific vaccine design & emerging vaccines	Disease specific vaccine design: Tuberculosis Vaccine; Malaria Vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola, Zika, Corona). Case studies	5

Recommended Textbooks and References:

1. Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). *Immuno Biology:the Immune System in Health and Disease*. USA: Garland Science Pub.
2. Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). *Kuby Immunology*. New York: W.H. Freeman.
3. Kaufmann, S. H. (2004). *Novel Vaccination Strategies*. Weinheim: Wiley-VCH.
4. Vaccinology: Principles and Practice, by Editors: W. John W. Morrow, Nadeem A. Sheikh, Clint S. Schmidt, D. Huw Davies; Wiley Blackwell, 2012
4. Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.

Name of the Course: Ecology				**Course Code:** DSE			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. EOSE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)			

Course objectives:

i. To understand the concepts of ecology and molecular evolution.
ii. The course shall make the students understand ecosystems and origin of life.

Course outcomes:

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

i. Understanding the complex interaction between different organisms and the environment.
ii. Use the principles of evolution to understand the diversity of life.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1.	Physical environment, biotic environment, biotic and abiotic interactions; Habitat and niche: Concept of habitat and niche, niche width and overlap, fundamental and realized niche, resource partitioning, character displacement;	6
2.	Characteristics of a population, population growth curves, population regulation, life history strategies (*r* and *K* selection), concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.	6
3.	Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis; Community ecology:	5
4.	Nature of communities, community structure and attributes, levels of species diversity and its measurement, edges and ecotones; Ecological succession: Types, mechanisms, changes involved in succession	5
5.	Structure and function, energy flow and mineral cycling (CNP), primary production and decomposition;	4
6.	Structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, estuarine).	4

Books recommended

1. Ecology from Individuals to Ecosystems by Begon, M., Townsend, C. R., and Harper, J. L.; Wiley-Blackwell, US
2. Ecology: Principles and Applications by Chapman, J. L. and Reiss, M. J. Cambridge University Press, UK
3. Environmental Science by Kemp, M. J.; The McGraw-Hill Companies
4. Evolution by Barton, N.H., Briggs, D.E.G., Eisen, J.A., Goldstein, D.B., Patel, N.H.; Cold Spring Harbor Laboratory Press, New York

Name of the Course: Molecular Evolution						**Course Code:** DSE	
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. EOSE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)			

Course objectives:

To develop an understanding of the diversity and organization of genomes with emphasis on interpreting this variation in a phylogenetic perspective.

Course outcomes:

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

i. Understand how and why DNA sequences and genomes change.
ii. Reconstruct the evolutionary history of genes, genomes, and organisms.

Course Syllabus

Unit No.	**Content**	**Contact hours**
I	Molecular systematics, approaches to studying molecular evolution; Molecular constraints on phylogeny reconstruction, homoplasy	5
II	Genome organization, Gene structure and molecular characters; Selection and Neutrality of genes	5
III	Rates of molecular evolution; Molecular clocks; Patterns of nucleotide substitution	4
IV	Nuclear Genome: Genome size variation and gene duplication; Highly repetitive DNAs, ribosomal genes	4
V	Nuclear Genome: mini- and micro-satellite DNAs, SINES, LINES Nuclear Genome, Repetitive DNAs and Multigene families, Concerted evolution and molecular drive	6
VI	Nuclear Genome: Transposable elements, Evolution of single copy genes; Extrachromosomal DNA, Chloroplast and mitochondrial DNAs; Rates of evolution, Patterns of change	6

Name of the Course: Applied Microbiology				**Course Code:** DSE			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 4. CIA-1: 20 5. CIA-2: 20 6. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)			

Course objectives:

i. The objectives of this course are to introduce to various applied aspects of microbiology with special emphasis on microbial enzyme technology, agriculture microbiology, environment microbiology, waste-water management and microbial biogeochemistry.

Course outcomes:

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

i. Understand diverse aspects of applications of microbial metabolism and genetic capabilities.

ii. Understand the technological approaches available for exploration and exploitation of microbial capabilities with enhancing the industrial, agricultural and environmental sustainability.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Microbial Metabolism	Structure and function of biomolecules: Carbohydrates, proteins, lipids. Enzymes: Characteristics, Ribozymes, co-enzymes, mechanism of action - binding of substrate and lowering of activation energy, covalent catalysis, acid- base catalysis, allosteric regulation, enzyme inhibition. Metabolism: General concepts, laws of thermodynamics, redox potential, free energy change of the reaction's catabolism – anabolism, ATP as high energy phosphate compound, ATP synthesis. Bacterial photosynthesis. Assimilation of sulphur, phosphorus and nitrogen.	5

2. Microbial Genetics	Microbial Genetics: Genetic recombination; Transformation, Transduction, Conjugation. Molecular models and mechanism of Gene expression and regulation: Operons and regulons, repression and activation of Lac operon, feedback inhibition and regulation of virulence genes in pathogenic bacteria. Signal transduction in microbes. Application of microbe in recombinant DNA Technology.	6
3. Microbial Enzyme Technology	Enzymes from microbial sources, large scale production of enzymes, recovery of enzymes, enzyme purification methods - enzyme precipitation, separation by chromatography, enzyme reactors. Immobilized enzymes: Physical and chemical methods of immobilization, immobilization supports, kinetics of immobilized enzymes. Enzyme catalysis in polar medium, reverse micellar entrapment of enzymes and its applications. Application of enzymes: synthesis of chemicals using enzymes, food technology and medicine. Enzymes in diagnostic assays. Enzyme electrodes, immunoenzyme techniques. Commercial products of microbes: Antibiotics, biopolymers, biosensors, biopesticides Production of biofuels. Microbial toxins: Types, biochemical and molecular basis of toxin production, implications. Genetically engineered microbes, anti-HIV, anticancer, antifungal, antiplasmodial, anti-inflammatory compounds.	5
4. Agricultural Microbiology	Soil microorganisms in agroecosystems: Types of microbial communities; soil microbial diversity: significance and conservation; effect of agricultural practices on soil organisms. Biological nitrogen-fixation: The range of nitrogen fixing organisms; mechanism of nitrogen fixation (Biochemistry of nitrogenase); genetics of nitrogen-fixation. Rhizobium-Legume Association; Symplasmids, N2 fixation by non-leguminous plants. Chemical transformation by microbes: Organic matter decomposition, nutrient mineralization, and immobilization; transformation of carbon and carbon compounds. Biofertilizer: Mass cultivation of microbial inoculants; green manuring; algalization; Azolla. Microbial products and plant health: Plant growth promoting rhizobacteria (PGPR); significance of	5

	mycorrhizae. Microbial herbicides; biological control.	
5. Environmental Microbiology & Wastewater Management	Aeromicrobiology: Microorganisms in indoor and outdoor air environment, nature of bioaerosols, their fate and transport; aeroallergens and allergies. Soil microorganisms and their significance in soil quality management. Microorganisms in aquatic environments and their significance in water quality management. Definition of extremophiles its domain, Energy transduction in extremophiles in general, physiology and biochemistry of various extremophiles such as thermophiles, acidophiles, alkaliphiles, psychrophiles and halophiles. Brief introduction to wastewater and various stages of wastewater treatment: Primary, secondary, and tertiary treatment. Indicator microorganisms for water quality, Definition of biosensors, its various types and biotechnological significance. Use of microorganisms as dead living cells and Immobilized cells for removal of heavy metals from wastewater.	5
6. Microbial Biogeochemistry	The role of microbes in biosphere: Structure and organisation of microbial communities. Exploration and quantification of the microbial diversity; Cultivation and non-cultivation approaches; complementarities between cultivation and non-cultivation approaches; Microbial crusts: Formation, composition and function. Microbial aspects of biogeochemical cycling of C, N, P and S. Survival strategies of microbes in extreme habitats. Microbial leaching: Copper, Gold, Uranium.	4

Recommended Text and Reference Books:

5. Caldwell, Daniel R. Microbial Physiology and Metabolism,
6. Nelson, DL & Cox, MM. Lehninger Principles of Biochemistry,
7. Jeremy W. Dale, Simon F. Park. Molecular Genetics of Bacteria,
8. James D. Watson, et al., Molecular Biology of the Gene
9. Biotechnology. Volume 7 A - Enzymes in Biotechnology. Ed.: H. J. Rehm and G. Reed.
10. Advances in Agricultural Microbiology. Editor: N.S. Subba Rao
11. Raina M. Maier, Ian L. Pepper and Charles P. Gerba. Environmental Microbiology
12. Fenchel & King & Blackburn. Bacterial Biogeochmistry.

Name of the Course: Industrial Biotechnology				**Course Code:** DSE			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 7. CIA - I: 20 8. CIA - II: 20 9. EOSE: 60		**Examination Duration:** 1 Hr 1 Hr 3 Hrs					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The course aims to provide fundamental insights to biological processes for the manufacturing of products that have industrial significance. It blends the principles from diverse science and engineering disciplines. The major focus of this course is on the industrial applications for students to gain practical knowledge with emphasis on major bottlenecks for the operation of biotechnology industries.

Course outcomes:

On completion of this course, Students should be able to:

i. Understand the fundamental principles of industrial biotechnology.
ii. Understand the importance of microbial, plant and animal systems for the biotechnologically relevant products
iii. Calculate yield and production rates in a biological production process
iv. Calculate the need for oxygen and oxygen transfer.
v. Critically analyze any bioprocess from market point of view.
vi. Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

Course Syllabus

Unit No.	**Content**	**Contact Hours**
1. Introduction to Basics of Industrial Biotechnology	• Introduction to Global Scenario of Biotechnology Industry. • Introduction to Microbes, Plant and Animal Based processes Biological Processes relevant to Industrial Biotechnology. • Introduction to various classes of bioprocess technology products manufactured in the Industrial Biotechnology Processes. • Example case studies of products and processes	6

	from the biotechnology-based industry.	
2. Microbial Growth Kinetics, Product Formation Kinetics, and control of physiological parameters affecting	• Microbial growth, Microbial growth kinetics, Physiological parameters affecting microbial growth. • Product formation and product formation kinetics in Microbial Growth linked and Growth- non linked products. • High Density Microbial Growth with use of fermentation process. Batch Culture Fermentation, Feb Batch Culture Fermentation & Continuous Culture. • Fermentation: Instrumentation (Types of bioreactors).	5
3. Enzymes, Enzyme Discovery, and Enzyme Engineering for Industrial Biotechnology	• Enzyme catalysts as innovative bioscience solutions to chemicals manufacture. • Enzymes relevant in drug discovery, bioprocessing, and therapeutics. • Key attributes of enzyme catalysed processes to be considered for successful scale-up. • Enzyme engineering for new routes to biofuels, bulk and commodity chemicals and novel chemical transformations. • Choice of free enzyme or whole cell catalyst, co-factors and co-factor recycling, multi-phase reactions, enzyme stability and throughput.	6
4. Pharmaceuticals and Fine Chemicals relevant in Industrial Biotechnology	• Production of pharmaceuticals and fine chemicals using whole cell based or purified enzyme-based biocatalysts. • Example based description of products, product manufacturing routes, and mechanism of the relevant enzyme reactions. • Sustainability drivers and metrics for relevant manufacturing routes.	4
5. Biotherapeutics and Glycoscience relevant in Industrial Biotechnology	• Fundamental concepts of Biotherapeutics (using natural catalytic reactions - to make revolutionary medicines, that too complex to be synthesized by simple chemistry). • Production of safe and effective biopharmaceuticals, using various types of expression systems. • Case studies-based illustration of industrial context of biotherapeutic production.	5

	• Glycoscience: (glycan-based solutions in pharmaceuticals, food security and biomaterials),	
6. Industrial Biotechnology for Bioenergy and Biomaterials	• Fundamental concepts of Bioenergy (renewable energy extracted from organic biological material such as plants and animals, wood, waste etc. • Current approaches and prospects of biofuel production, and associated challenges. • Biomaterials (metallic components, polymers, ceramics, or composite materials) and their applications. • Current trends and the future of biomaterials research and biomanufacturing technologies.	4

Recommended Textbooks and References:

1. Industrial Microbiology: Samuel Cate Prescott and Cecil Gordon Dunn
2. A textbook of Industrial Microbiology: Wulf Crueger and Anneliese Cruege
3. Biochemical Engineering Fundamentals: Bailey and Ollis
4. Biochemical Engineering: Blanch and Clark
5. Biochemical Engineering: Aiba, Humphrey and Millis

Name of the Course: Human Physiology				**Course Code: DSE**			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 . CIA-1: 20 . CIA-2: 20 . E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)			

Course objectives: To build knowledge base of biochemical principles with specific emphasis on different metabolic pathways in the humans.

Course outcomes: Understanding of different metabolic pathways and its regulation within different types of organs in the human body.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1.	Digestive system: Gastrointestinal anatomy and functions, motility, Nervous control and Blood circulation; Food intake and regulation; Digestive processes, Enzymes and secretions in the oral cavity and their functions, Digestive glands and their regulation, Gastrointestinal disorders	5
2.	Cardiovascular system: Heart, Function of heart valves; Cardiac cycle-origin, conduction and regulation of Heart beat, ECG, Blood circulation, Regulation of Blood circulation Micro-circulation and Lymphatic system, Blood cells, Blood plasma, Blood groups, Hemostasis and Blood coagulation, Cardiac disorders	6
3.	Respiratory system: Pulmonary ventilation, Mechanics of Pulmonary ventilation, Volumes and capacities; Principles of Gaseous exchange, Transport of gases, control and regulation of respiration, Respiratory disorders	4
4.	Nervous system: Components of the nervous system, Neuron and glial cells - different types, structure, function; Synapse: Nerve impulse transmission, Neurotransmitters. Organization of nervous system-CNS and PNS; Somatic nervous system, Autonomic nervous system-Sympathetic and Parasympathetic system, enteric nervous system; special senses, vision, hearing, taste and smell	6
5.	Uro-genital system: Body fluids and kidney, Mechanism of urine formation and regulation, Haemodialysis and Homeostatic imbalances in excretion, Kidney diseases and diuretics; Reproductive and	5

	hormonal function of the male, Female hormones and reproductive cycle, Pregnancy and lactation, Growth and development of foetus	
6.	Skeletal system: Components of skeletal system, Axial and appendicular system, skeletal muscles, Mechanism of muscle contraction, Excitation of skeletal muscles, neuromuscular junction; Bone structure and function	4

Books recommended

1. Guyton and Hall Textbook of Medical Physiology by John E. Hall; Saunders.
2. Ganong's Review of Medical Physiology by Kimm E. Barrett, Susan M. Burman, Scott Biotano, Hedwen Brooks; Mcgraw Hill.
3. Human Physiology: The Mechanisms of Body Function by Arthur J. Vander, James Sherman & Dorothy S. Luciano; McGraw-Hill Higher Education.

Name of the Course: Virology				**Course Code:** DSE			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** As offered	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

This course will provide students with an overview of structure, life cycle and diseases of viruses and methods those are employed to diagnose, study and inhibit them.

Course outcomes:

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

i. Understand fundamental concepts of the structure, life cycle and diseases associated with animal and plant viruses;
ii. Differentiate and understand concepts of molecular methods used to study viruses;
iii. Understand requirement and designing of various approaches to inhibit viral infection and replication.

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Introduction	Brief history of virology, basic virology: structure and classification of animal and plant viruses; Satellite viruses; Viroids; Prions	5
2. Particals & interactions	The Function and Formation of Virus Particles; Capsid Symmetry and Virus Architecture; Enveloped Viruses; Complex Virus Structures; Protein–Nucleic Acid Interactions and Genome Packaging; Virus Receptors: Recognition and Binding; Other Interactions of the Virus Capsid with the Host Cell	5
3. Genome and replication	Genome organization of DNA and RNA, animal and plant viruses: The Structure and Complexity of Virus Genomes; Large & small DNA genomes; Positive-Strand RNA Viruses; Negative-Strand RNA Viruses; Segmented and Multipartite Virus Genomes; Reverse Transcription and	5

	Transposition; Overview of animal & plant (RNA and DNA) virus replication; Investigation of virus replication	
4. Virological methods	Virological Methods: Electron microscopy, Tissue culture growth of viruses; Virus quantitation assays, Viral serology, Neutralization assays; ELISA, IFA, Haemagglutination and Haemagglutination-inhibition tests; Complement fixation, Western blot, RIPA and Immunohistochemistry; Molecular methods: Hybridization, PCR, Real time PCR, Sequencing, Microarray, Gene silencing	5
5. Infection and Pathology	Virus Infections of animals & Plants; Immune Responses to Virus Infections in Animals; Viruses and Apoptosis; Virus–Host Interactions; Evasion of Immune Responses by Viruses; The Course of Virus Infections; Diseases causes by animal and plant viruses; Mechanisms of Cellular Injury; Viruses and Immunodeficiency; Cell Transformation by Viruses; Viruses and Cancer; New and Emergent Viruses; Economic loss due to virus infections	5
6. Antivirals and viral vaccines	Antivirals and Viral Vaccines: Conventional vaccines -killed and attenuated; Modern vaccines—Recombinant proteins, Subunits, DNA vaccines, Peptides, Immunomodulators (cytokines) & RNA vaccines; Vaccine delivery & adjuvants; Large scale manufacturing; Anti-sense RNA, siRNA, miRNA, ribozymes, *in silico* approaches for drug designing	5

Books recommended

• Basic Virology, Fourth Edition, by Martinez J. Hewlett, David Camerini, David C. Bloom; Wiley, 2021.

• Virology: Principles and Applications, 2nd Edition, by John Carter, Venetia Saunders, Wiley, 2013,

• Principles of Molecular Virology, 4th edition, by Alan J. Cann, Elsevior Academic Press, 2005

• Fields Virology (5th Edition) Vols. I, II by Knipe D.M., Howley P.M., Griffin D.E.; Lippincott, Williams & Wilkins, 2006.

• Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses by Flint S.J., Racaniello V. R., Enquist L.W., Rancaniello V.R., Skalka A.M.; American Society Microbiology, 2000.

• Plant Virology (4th Edition) by Hull R.; Mathews Academic Press, San Diego, 2002

• Veterinary Virology, (3rd Edition) by Murphy F.A., Gibbs E.P.J., Holzmek M.K. and Studdert M.J.; Academic Press. 1999.

• Virology Methods Manual (1st Edition) by Mahy B.W.J. and Kangaroo H.O., Academic Press, 1996.

Name of the Course: Molecular Plant Pathology				**Course Code:** DSE			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA - I: 20 2. CIA - II: 20 3. EOSE: 60		**Examination Duration:** 1 Hr 1 Hr 3 Hrs					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	N.A.		

Course objectives:

The course aims to provide fundamental insights to plant pathogens and how the interaction between plants and their pathogens are carried at the molecular level. One of the key aspects of the course is to understand how plants respond to different pathogen infections and what strategies could be employed to make crop plants more resilient against invading pathogens.

Course outcomes:

On completion of this course, Students should be able to:

i. Understand the basics of plant pathology.
ii. Understand the strategies of pathogenicity
iii. Understand how plants respond to pathogen infections
iv. Understand how the available knowledge can be utilized for improving plant resistance.

Course Syllabus

Unit No.	**Content**	**Contact Hours**
1. Introduction to plant pathology	Introduction to plant stress biology (abiotic and biotic), brief history of plant pathology and disease triangle, basics of plant pathology	6
2. Plant-microbe interaction	Symbiosis vs pathogenesis, strategies of pathogenicity of bacteria, fungi and viruses, concept of effector proteins, suppression of plant immune responses	5
3. Plant defence	Plant immune responses, programmed cell death, hypersensitive response, systemic acquired resistance, zig-zag model, gene-for-gene hypothesis, R proteins, Reactive oxygen species (ROS)	6

4. Plant defence regulation	Role of plant hormones in defense response, understanding molecular pathways, transcriptional and post-transcriptional regulation, role of post-translational modifications in defense response.	5
5. Defence strategies	Physical, chemical and biological control strategies, genetic engineering approaches, hybrid breeding approaches.	4
6. Miscellaneous	Nematodes as plant pathogens, introduction to concept of immunity memory, introduction to immune priming.	4

Name of the Course: Vector Biology							**Course Code:** DSE
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:** 1	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	Basic knowledge of biology at Graduate level		

Course objectives:

The course structure has been designed with the aim of imparting knowledge about the general anatomy and physiology of insects, introduction to crop and human disease vectors and their control strategies. Besides, the course will introduce the mechanism of pesticide resistance in insects and alternative vector control strategies, about beneficial and economically important insects

Course outcomes:

An understanding of insect world, their basic biology and disease vectors. Understanding of modern areas of vector control strategies and harnessing the potential of beneficial insects

Course Syllabus

Unit No.	**Content**	**Contact hours**
1. Classification, basic anatomy, and morphology of insects	Insect classification; major insect orders, families and their examples. Types of mouthparts and antennae, tentorium and neck sclerites. Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; Wings: structure and modifications, venation, wing coupling apparatus; Legs: structure and modifications. Abdomen- Segmentation and appendages; Genitalia Insect sense organs (mechano-, photo- and chemoreceptors).	5
2. Insect developmental processes	Mechanism of moulting, metamorphosis and sex-determination.	5
3. Introduction to disease	Basic biology (life cycle, reproduction, host-seeking behaviour) of major insect vectors and	5

vectors	pests and the major diseases caused by vector borne pathogens	
4. Basic concepts in Vector Biology	Vector competence, extrinsic/intrinsic incubation period, entomological inoculation rate and vectorial capacity.	5
5. Vector Control strategies	Chemical, mechanical, and biological insect control methods. Integrated pest management. Introduction to Sterile insect technology.	5
6. Genetic manipulations in insects	Overview of Current technologies to generate Genetically engineered insect. Genetically engineered insect and public health.	5

Books recommended

• IMMS General Textbook of Entomology, Volume 2: Classification and Biology by Imms, A.D., Richards, O.W., Davies R.G.; Springer Nature Switzerland AG
• The Insects-Structure and Function (5th Edition) by Chapman R.F., Simpson S.J. and Douglas A.E.; Cambridge University Press
• A Textbook of Applied Entomology by Srivastava K. P. and Dhaliwal G. S.; Kalyani Publishers
• Insect Molecular Genetics: An Introduction to Principles and Applications (4th Edition) by Hoy M. A.; Academic Press
Sterile Insect Technique; Principles and Practice in Area-Wide Integrated Pest Management (2nd Edition) Edited by V. A. Dyck, J. Hendrichs, A.S. Robinson; CRC Press

Name of the Course: Protein Misfolding and Human Diseases				**Course Code:** DSE			
Batch: 2022-23	**Programme:** M.Sc. Biotechnology	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hours**
			2	0	0	2	30
Total Evaluation Marks: 100 1. CIA-1: 20 2. CIA-2: 20 3. E-SE: 60		**Examination Duration:** 1 Hr. 1 Hr. 3 Hrs.					

Workload			
	Total workload	**Amount of attendance time**	**Time for Self-Study**
Respective hours	90	30	60
Teaching format	Lecture (L) and Assignments		
Instruction medium	English		
Recommended prerequisite to attend this course (if any)	Prior knowledge of biochemistry at the graduation level.		

Course objectives:

iii. To provide essential concept about protein structures and folding intermediates, and refolding.

iv. The primary goal of this course is to enhance knowledge about protein folding, misfolding and aggregation, and their relationship to human disease.

Course outcomes:

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

v. Gain fundamental knowledge in protein biochemistry.

vi. Understand the molecular basis of human diseases associated with protein misfolding and aggregation

Course Syllabus

Unit No.	**Content**	**Contact hours**
1.	Factors governing the transition of amino acid sequences of polypeptide chains to their three-dimensional structure, with the reference to globular and fibrous proteins.	5
2.	*Concept of In vivo* folding of newly synthesized proteins and their interactions with chaperonins and other helper proteins.	5
3.	Understanding protein misfolding, aggregation of misfolded proteins ordered and random protein aggregates.	5
4.	Role of protein aggregates in human diseases: with reference to Alzheimer's and Parkinson's diseases	5
5.	Experimental approaches to study protein misfolding and aggregation: Sequence determinants, kinetics and pathways for the *in vitro* refolding of proteins, protein structures and folding intermediates.	5
6.	Introduction to the concepts and strategies to combat the toxic protein aggregates, anti-amyloid approaches	5