M. Sc. BIOTECHNOLOGY
CURRICULUM and SYLLABUS

DEPARTMENT OF BIOTECHNOLOGY
UNIVERSITY OF CALICUT
KERALA
Pin-673 635
www.universityofcalicut.info

To be followed with the OBE from the academic year
2020 admission onwards

M. Sc. BIOTECHNOLOGY PROGRAMME
UNIVERSITY OF CALICUT
Syllabus for M.Sc. Biotechnology

Eligibility for admission
Bachelor's degree under 10+2+3 pattern of education in Biotechnology, Microbiology, Biochemistry, Biophysics, Bio-Informatics, Genetics, Botany, Zoology, Life Science, Medical Laboratory Technology, Chemistry, Physics, Environmental Science or 4-years Agricultural, Veterinary, Fishery Sciences, Pharmacy, Engineering/Technology(Biotech), B.Sc. (Physician Assistant Course); OR Medicine(MBBS) OR B.D.S with at least 55% marks or any other equivalent degree approved by the University.

Admission Process
Candidates for admission for this programme is selected on the basis of an Entrance test conducted every year by the DBT, Govt of India OR Department of Biotechnology, Calicut University.

Programme structure
The course is designed on semester and credit basis total of four semester and 95 credits covering two academic years. The course covers 16 courses in theory and Eight in practical. For BT 403JC each student will have to give one seminar of one hour duration on topics of current interest in the field which will be assessed by the departmental faculty. The project work commences in the third semester extending up to the end of fourth semester

Counseling
Each course instructor will be the overall counselor for that course

Evaluation
1. **General**
    a. For theory examinations marks for internal assessment and university examinations will be in the ratio of 1:1 for most of the course. Two internal examinations in each course shall be considered and the average of the two will be the marks for internal assessment. Practical examinations will be in the mode of continuous evaluation. There will be two internal practical examinations during each semester for each couce. All examinations in theory and practical are compulsory. Each practical examination will be evaluated for 45 marks. The total of two will be added to 10 marks allocated for assessment of practical records. Students who fail to get a pass minimum of 40 % in theory or practical internal examination will be given another chance (3^{rd}) to reappear for one additional test in theory or practical examination. The marks of which will be

taken into account for averaging in the case of theory or for totaling in the case of practical examination. After evaluation, the answer scripts of internal examination will be given to the students to clear their doubts, if any. Valued scripts shall be maintained in the office till the mark lists are issued

b. For external, supplementary and/or improvement examination the university regulation for other M.Sc courses will be followed

2. **Project Evaluation**

The project dissertation carries a total of 350 marks (Dissertation work – 300 + Presentation and Viva-voce – 50) and will be evaluated separately by both the internal (normally Guide) and external examiners. The Dissertation shall be submitted at the end of the 4th semester

3. **Tabulation of results**

a. Marks obtained in each course, internal and external will be entered separately
b. For a pass the student should score a minimum of 40% in each course and 50% in aggregate (theory and practicals) which will be classified as second class. 60% and above will be classified as first class. 75% and above will be classified as distinction

Note: A course-wise minimum of 40% in each course and 50% aggregate in each in each semester is stipulated for a student to pass his / her examination. If a candidate has scored 50% aggregate but failed to get the course minimum of 40% in any courses, such candidate shall reappear to the concerned only to get the course minimum (40%). The minimum marks of 40% stipulate to for a pass in a course is applicable to the practicals also.

Grievance Cell

Students grievances pertaining to the award of internal marks shall be brought to the notice of the teacher concerned. In the case of failure to settle the grievance, the matter shall be placed in a three member Departmental Committee consisting of HOD, Department council Secretary or senior faculty and the concerned Teacher. HD will be the chairman of the committee and the decision of the committee shall be final.

Programme Outcome (PO) for MSc Biotechnology

Students will attain following capabilities after successful completion of M.Sc Biotechnology programme.

PO1	**Learn basic and modern sciences and engineering principles that are relevant to Biotechnology practices.**
PO2	**Familiarize the principle, methodology and outcome of Biotechnological practices.**
PO3	**Enable to address the relevant problems in health, agriculture, environment and industry through Biotechnological solutions**

PO4	**Able to access social, environmental, public safety and health implications of Biotechnology practices.**
PO5	**Enable to apply knowledge about the Biotechnology guidelines, professional ethics and Bio-entrepreneurship skills while practicing biotechnology.**
PO6	**Ability to prepare proposal for biotechnologically relevant projects with state-of-the-art design, principle, methodology, experiments, data collection, analysis and interpretation for successful implementation.**

M.Sc. Biotechnology – Syllabus

Sl No.	Course code	Title	Credits	Marks		
				Int	Ext	Total
SEMESTER ONE						
1	BT101CC	Biochemistry	3	50	50	100
2	BT102CC	Cell and Developmental Biology	3	50	50	100
3	BT103CC	Biomolecules - Analytical Techniques	3	50	50	100
4	BT104CC	Microbiology	3	50	50	100
5	BT105CC	Basic Mathematics and Statistics	1	25		25
6	BT106CC	Basics of Chemistry and Physics	1	25		25
7	BT107PC	Laboratory I: Biochemistry and Analytical Techniques	4	100		100
8	BT108PC	Laboratory II:Microbiology	4	100		100
9	BT109JC*	Seminar/Journal Club- Critical analysis of Classical Papers	0			
		Total	**22**	**450**	**200**	**650**
SEMESTER TWO						
1	BT201CC	Immunology	3	50	50	100
2	BT202CC	Molecular Biology & Diagnostics	3	50	50	100
3	BT203CC	Bioinformatics – Computer Application	2	50		50
4	BT204CC	Research Methodology and Scientific Communication skills	1	25		25
5	BT205CC	Intellectual Property Rights & Bioethics	3	50	50	100
6	BT206CC	Genetics	3	50	50	100
7	BT207EC	Elective : One Compulsory 1.Microbial Technology 2. Molecular Virology 3. Molecular Oncology 4. Pharmacogenomics 5. Stem Cell Technology 6. Molecular Therapeutics 7. Bacteriology 8. Vaccines	2	50		50

8	BT208JC*	Seminar/Journal Club Emerging Technologies	0			
9	BT209PC	Laboratory III: Molecular Biology	4	100		100
10	BT210PC	Laboratory IV : Immunology	4	100		100
		Total	**25**	**525**	**200**	**725**
		SEMESTER THREE				
1	BT301CC	Bioprocess Engineering and Technology	3	50	50	100
2	BT302CC	Plant and Animal Biotechnology	3	50	50	100
3	BT303CC	Genetic Engineering	3	50	50	100
4	BT304CC	Genomics & proteomics	2	50	50	100
5	BT305CC	Project Proposal preparation and presentation	1			
6	BT306JC*	Seminar/Journal Club	0			
7	BT307PC	Laboratory V : Genetic Engineering	3	100		100
8	BT308PC	Laboratory VI : Bioprocess Engineering and Technology	4	100		100
9	BT309PC	Laboratory VII: Bioinformatics	2	50		50
10	BT309PC	Laboratory VIII: Plant and Animal Biotechnology	4	100		100
		Total	**25**	**550**	**200**	**750**
		SEMESTER FOUR				
1	BT401DC	Dissertation Presentation and Viva-voce	20	150	150 50	300 50
2	BT402EC	Elective : Bio-entrepreneurship	2	50		50
	BT403JC	Academic seminars/Journal Club	1	50		50
		Total	**23**	**250**	**200**	**450**
		Total Credits	**95**	**1775**	**800**	**2575**

*Journal Club/Seminar does not have any credit for I, II and III semesters, so need not be included and printed in I, II and III semester mark-list respectively.

M.Sc. Biotechnology Programme

Syllabus for Ist Semester

Sl No.	Course code	Title	Credits	Marks		
				Int	Ext	Total
1	BT101CC	Biochemistry	3	50	50	100
2	BT102CC	Cell and Developmental Biology	3	50	50	100
3	BT103CC	Biomolecules - Analytical Techniques	3	50	50	100
4	BT104CC	Microbiology	3	50	50	100
5	BT105CC	Basic Mathematics and Statistics	1	25		25
6	BT106CC	Basics of Chemistry and Physics	1	25		25
7	BT107PC	Laboratory I: Biochemistry and Analytical Techniques	4	100		100
8	BT108PC	Laboratory II:Microbiology	4	100		100
*9	BT109JC	Seminar/Journal Club- Critical analysis of Classical Papers	0			
		Total	**22**	**450**	**200**	**650**

SEMESTER ONE

BT 101CC Biochemistry - 3 credits

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

Student Learning Outcomes:

On completion of this course, students should be able to

- Gain fundamental knowledge in biochemistry
- Understand about bio-molecule structure and function
- Select a suitable method to purify bio-molecule
- Analyse the molecular basis of various pathological conditions from the perspective of biochemical reactions.
- Structure function relationship of protein
- ATP its synthesis and use in metabolic pathways.

Unit I

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, .

Unit II

Protein structure

Structure-function relationships: amino acids – structure and functional group properties, peptides and covalent structure of proteins, Ramachandran plot, evolution of protein structure, protein degradation , structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin,etc; basic principles of protein purification; Protein folding, chaperons, diseases associated with protein folding.

Unit III

Enzyme kinetics

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.

Unit IV
Glycobiology

Sugars – mono and di saccharides, homo and hetero polysaccharides with specific reference to glycogen, amylose and cellulose, Glycoconjugates-Structure and function, proteoglycans; glycoproteins and glycolipids, glycosylation of biomolecules, lipopolysacharides.

Unit V
Structure and functions of DNA & RNA and lipids

lipids - structure and properties of important members of storage and membrane lipids; Lipids as signaling molecules;Lipoproteins;Self-assembly of lipids, micelle, biomembrane organization nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure, Types of RNA and DNA and importance in evolution of DNA as the genetic material;Chemical properties of nucleic acids.

Unit VI
Bioenergetics

Basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; 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; regulation of oxidative phosphorylation; Photosynthesis – chloroplasts and two photosystems; Calvin cycle and pentose phosphate pathway; reciprocal control of Calvin cycle and pentose phosphate pathway; Fatty acid metabolism; nucleotide biosynthesis; cholesterol metabolism and mevalonate pathway; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation;

Recommended Textbooks and References:

- Stryer, L. (2015). Biochemistry. (8th ed.) New York: Freeman.
- Lehninger, A. L. (2012). Principles of Biochemistry (6th ed.). New York, NY: Worth.
- Voet, D., &Voet, J. G. (2016). Biochemistry (5th ed.). Hoboken, NJ: J. Wiley & Sons.
- Dobson, C. M. (2003). Protein Folding and Misfolding. Nature, 426(6968), 884-890.

doi:10.1038/nature02261.
- Richards, F. M. (1991). The Protein Folding Problem. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.

BT102CC Cell and Developmental Biology – 3 credits

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. This course also gives insight to the developmental process that happens to each to a matured organism or adult individual.

Student Learning Outcomes: Student should be equipped to understand all fundamental aspects in biological phenomenon at the cellular level and the developmental process from the single cell to multi-cellular matured organisms.

Unit I
Introduction to Cells and Methods of Study

Cell Theory, Universal features of prokaryotic and eukaryotic cells; Chemical components and organization of cells.

Visualizing cells and imaging by different types of microscopy – Light, phase contrast and interference, Fluorescence, Confocal, TEM and SEM, Electron tunneling and Atomic Force Microscopy. Manipulating and studying cells – Isolation of cells and basics of cell culture, Flow cytometry.

Unit II
Internal Organization and Extra Cellular Matrix

Internal organization of cells – membrane structure - Composition –lipid bilayer, proteins, glycocalyx; functional dynamics – Principles of membrane transport of ions and macromolecules - Pumps, carriers and channels; Membrane carbohydrates and their significance in cellular recognition Cell junctions and cell adhesion. Extracellular matrix in animals and cell wall in plants.

Unit III
Nucleus, Chromatin and Organelle Genomes

Nucleus – Structure and function - nuclear envelope, lamina, nucleolus – ribosome biogenesis, macromolecular transport ; Chromatin organization and packaging, chromosome structure,lamp-brush

and polytene chromosomes; mitochondria – structure, organization of respiratory chain complexes, ATP synthase, Structure-function relationship; mitochondrial genome, Origin and evolution; Chloroplast-Structure-function relationship; Chloroplast DNA and its significance; Chloroplast biogenesis, Origin and evolution.

Unit IV
Cell Compartmentalization, Protein Trafficking and Cytoskeleton

Cell compartmentalization,Endo-membrane systems - Endoplasmic Reticulum, Golgi complex, lysosomes, peroxisomes – protein trafficking and sorting, - nuclear transport, import of proteins into mitochondria and chloroplast, vesicular trafficking; exocytosis and endocytosis.
Cytoskeleton – microtubules, actin and intermediate filaments, associated proteins (MAPs and actin binding proteins); cell shape and motility; Molecular motors.

Unit V
Cell Signaling, Cell Cycle, Apoptosis and Cancer

General principles of cell signaling – paracrine, synaptic, endocrine, autocrine, combinatorial signaling; signaling molecules, cell surface and intracellular receptor proteins.
Cell cycle and its regulation; Apoptosis – intrinsic and extrinsic pathways; Cancer as a micro evolutionary process, metastasis.

Unit VI
Developmental Biology

Cellular Movements and Pattern Formation – morphogenetic movements and shaping of body plan, laying of body axis planes; Differentiation of germ layers; Cellular polarity; cell memory, cell determination and concept of positional values.
Heirarchy of gene action – maternal, segmentation and homeotic gene effects in *Drosophila*;
Cell lineages and developmental control genes in *C.elegans.*
Plant development – brief outline on meristem, root-shoot axis, growth regulators, homeotic selector genes taking *Arabidopsis* as an example.

Recommended Textbooks and References:

- Alberts et al: Molecular Biology of the cell. 6th Edition. Garland Science,New York / UK
- Lodish et al; Molecular cell Biology, Latest edition, W.H. Freeman & Company, 2000.
- Cell and Molecular Biology – Concepts and Experiments by Gerald Karp. John Wiley and Sons Inc. Latest edition
- Waston et al. Molecular Biology of the gene, Latest Edition, Pearson Prentice Hall, USA.
- B.M. Turner - Chromatin & Gene regulation, Latest Edition, Wiley-Blackwell.

BT103CC Biomolecules - Analytical Techniques — 3 Credits

Course Objectives: The objective of this course is to introduce students to structure of protein and DNA the different techniques used in biotechnology laboratories i.e. techniques in biochemistry, microbiology, molecular biology cell biology immunology and biophysics.

Student Learning Outcomes: On completion of this course, students should be able to understand

- Different level of protein and Nucleic acid structure
- Methods to isolate different biomolecule and Charecterise
- Different analytical as well as preparatory techniques in biotechnology laboratories.

Unit I
Cell disintegration and spectroscopy

Methods of cell disintegration, Precautions needed for isolation and purification of biomolecules Selection and Use of suitable buffers. Detergents and its effect on membrane proteins; Precipitation methods: salting in and salting out.

Electromagnetic spectrum and its interaction with biomolecule. Absorption, emission and reflection of electromagnetic waves. Fluorescence and phosphorescence, general properties of fluorophores, different instruments in general that use fluorescence.

Colorimetery and Spectrophotometery: basic principle and instrumentation. Visible and UV spectrophotometer; Beer- Lambert's Law and its deviations. Methods of measuring stability of a protein; Spectroscopic methods to study physicochemical properties of proteins Theory and application of Circular Dichroism and Optical Rotatory dispersion. far-UV and near-UV CD.

Unit II
Basic and advanced Microscopy

Light Microscopy: lenses and microscopes, refractive index, magnification resolution: Rayleigh's Approach, Darkfield; Phase Contrast; Differential Interference Contrast;

Fluorescence microscopy: optical arrangement, light source; filters 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 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 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). Electron Microscopy:TEM and SEM, Preperation of specimens for Microscopy including EM. Electron tunneling and Atomic Force Microscopy. Live cell imaging.

Unit III

Chromatography and Electrophoresis

Chromatography Techniques- basic principle, Rate theory and plate theory, Basic parts of chromatographic systems Retention time, Resolution of peaks and Peak area calculation. Paper; Thin layer and HPTLC Chromatographic methods; Chromatographic methods for macromolecular separation — Gel permeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; pseudo-affinity and metal affinity chromatography. HPLC and FPLC; Criteria for purely of biomolecules.

Electrophoretic techniques, theory and application of Polyacrylamide and Agarose gel electrophoresis, native and SDS PAGE, Capillary electrophoresis; Iso-electric focusing, 2D Electrophoresis, Gradient electrophoresis; Pulsed field gel electrophoresis. Electrophoresis mobility shift.

Unit IV

Centrifugation and Membrane filtration

Centrifugation- Basic principles; Mathematics & theory (RCF, Sedimentation coefficient); Types of centrifuges - Micro centrifuge, High speed & Ultracentrifuges; preparative centrifugation; differential & density gradient centrifugation and their Applications; Analytical centrifugation;

Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods.
Brief introduction of membrane based techniques: Dialysis and Ultrafiltrition. Microfiltration, , nanofiltration and reverse osmosis processes and current applications in water treatment, and biomolecular seperations. Common problems with membrane systems and some possible solutions: Membrane Fouling, Concentration polarization Tangential flow, Backwashing.

Unit V
Radioactivity and related techniques

Radioactivity and stable isotopes; Pattern and rate of radioactive decay; Units of radioactivity; Measurement of radioactivity; Geiger-Muller counter; scintillation counters basic principle, instrumentation & technique; Brief idea of radiation dosimetry; Cerenkov radiation; Autoradiography; Measurement of stable isotopes; Applications of isotopes in biochemistry; Radiotracer techniques; Distribution studies; Isotope dilution technique; Metabolic studies;Clinical application; Radioimmunoassay.Hydrodynamic properties-hydrogen-deuterium exchange, radioactive DNA and protein labeling and probing.

Unit VI

X-ray, NMR and Mass Spectroscopy

X-ray diffraction of biomolecules. DNA and Protein, Basic equation, crystal preparation methods and data analysis.

Brief introduction to Nuclear Magnetic Resonance spectroscopy - emphasis on parameters that can be measured/obtained from NMR and their interpretation. ESR and Plasma Emission spectroscopy protein structure studies.

Theory and methods of Mass spectrometry -API-electrospray and MALDI-TOF; Ionization techniques; mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of molecules; proteomics, nano LC-MS; Phospho proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry. (Microcalorimetery principle and uses).

Unit VII

DNA and Protein based techniques

Solid phase biosynthesis of nucleic acids and proteins.PCR, RAPD, RFLP, AFLP, SAGE, DNA - protein interaction; Nucleic acid and protein array, Foot Printing DNA and Protein, sequencing: different techniques.Next Generation sequencing. Southern, Northern and western blotting, Nucleic acid hybridization. FACS: Basics and uses.

Recommended Textbooks and References:

- Freifelder D.; Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd edition, W.H. Freeman & Company, San Fransisco, 1982.
- Keith Wilson and John Walker, Principles and techniques of practical Biochemistry, 5th Edition,Cambridge University Press, 2000.
- D. Holme & H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998.
- R. Scopes, Protein purification-Principles & Practices, 3rd Edition, Springer Verlag,1994.

BT104CC - Microbiology - 3 Credits

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

Student Learning Outcomes: Students should be able to:

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

Unit I

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: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance.

Unit II

Microbial diversity

Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria,

endospore forming bacteria, Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, Hyperthermophilic archae, Thermoplasm; eukarya: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes.

Unit III

Control of microorganisms

Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms.

Unit IV
Virology

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.

Unit V
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.

Recommended Textbooks and References:

- Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). *Microbiology* (5th ed.). New York: McGraw-Hill.
- Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). *Prescott's Microbiology*. New York: McGraw-Hill.
- Matthai, W., Berg, C. Y., & Black, J. G. (2005). *Microbiology, Principles and Explorations*. Boston, MA: John Wiley & Sons.

BT105CC -Basics of Mathematics and Statistics – 1 Credit

Course Objectives: The objective of this course is to give conceptual exposure of essential contents of mathematics and statistics to the students of Biotechnology.

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

- Gain broad understanding in mathematics and statistics
- Recognize importance and value of mathematical and statistical thinking, training, and approach to problem solving, on a diverse variety of disciplines.

Unit I
Algebra

Linear equations, functions: slopes-intercepts, forms of two-variable linear equations; constructing linear

models in biological systems; quadratic equations (solving, graphing, features of, interpreting quadratic models *etc*.), introduction to polynomials, graphs of binomials and polynomials; Symmetry of polynomial functions, basics of trigonometric functions, Pythagorean theory, graphing and constructing sinusoidal functions, imaginary numbers, complex numbers, adding-subtracting-multiplying complex numbers, basics of vectors, introduction to matrices.

Unit II

Calculus

Differential calculus (limits, derivatives), integral calculus (integrals, sequences and series *etc*.).

Unit III

Mathematical models in biology

Population dynamics; oscillations, circadian rhythms, developmental patterns, symmetry in biological systems, fractal geometries, size-limits & scaling in biology, modeling chemical reaction networks and metabolic networks.

Unit IV

Statistics

Probability: counting, conditional probability, discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation & causality, analysis of variance, factorial experiment design.

Recommended Textbooks and References:

- Stroud, K. A., & Booth, D. J. (2009). *Foundation Mathematics*. New York, NY: Palgrave Macmillan.
- Aitken, M., Broadhursts, B., & Haldky, S. (2009) *Mathematics for Biological Scientists*. Garland Science.
- Billingsley, P. (1986). *Probability and Measure.* New York: Wiley.
- Rosner, B. (2000). *Fundamentals of Biostatistics*. Boston, MA: Duxbury Press.
- Daniel, W. W. (1987). *Biostatistics, a Foundation for Analysis in the Health Sciences*. New York: Wiley.

BT106CC - Basics of Chemistry and Physics – 1 Credit

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

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

Unit I

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; 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);
Coulomb's law, conductors and insulators, electric 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).

Unit II

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 polyatomic ions; chemical reactions, reaction stoichiometry, rates of reaction, rate constants, order of reactions, 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; 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).

Recommended Textbooks and References:

- Baaquie, B. E. (2000). *Laws of Physics: a Primer*. Singapore: National University of Singapore.
- Matthews, C. P., & Shearer, J. S. (1897). *Problems and Questions in Physics*. New York: Macmillan

Company.
- Halliday, D., Resnick, R., & Walker, J. (1993). *Fundamentals of Physics.* New York: Wiley.
- Ebbing, D. D., & Wrighton, M. S. (1990). *General Chemistry*. Boston: Houghton Mifflin.
- Averill, B., & Eldredge, P. (2007). *Chemistry: Principles, Patterns, and Applications*. San Francisco: Benjamin Cummings.
- Mahan, B. H. (1965). *University Chemistry*. Reading, MA: Addison-Wesley Pub.
- Cantor, C. R., & Schimmel, P. R. (2004). *Biophysical Chemistry*. San Francisco: W.H. Freeman.

BT107PC - Laboratory I: Biochemistry and Analytical Techniques – 4 credits

Course Objectives: The objective of this laboratory course is to introduce students to experiments in biochemistry, cell biology, molecular biology, immunology and biophysics. The course is designed to teach students the utility of set of experimental methods in biotechnology laboratories.

Student Learning Outcomes: On completion of this course, students should be able to:
- To elaborate concepts of biotechnology laboratory with easy to run experiments
- To familiarize with basic laboratory instruments and understand the principle of measurements using those instruments with experiments.

Laboratory Experiments
- Preparing various stock solutions and working solutions that will be needed for the course.
- To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation.
- To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
- Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography.
- Purification and characterization of an enzyme / protein.
  a) Preparation of cell-free lysates
  b) Ammonium Sulfate precipitation
  c) Ion-exchange Chromatography
  d) Gel Filtration
  e) Affinity Chromatography
  f) Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method
  g) Generating a Purification Table (protein concentration; amount of total protein; Computing specific activity of the enzyme preparation at each stage of purification)
  h) Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis
  i) Enzyme Kinetic Parameters: Km, Vmax and Kcat.
- Experimental verification that absorption at OD is more for denatured DNA as compared to native double stranded DNA. reversal of the same following DNA renaturation. Kinetics of DNA

renaturation as a function of DNA size.

- Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy).
- Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry.

BT108PC - Laboratory II:Microbiology – 4 credits

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

Student Learning Outcomes: Students should be able to

- Isolate, characterize and identify common bacterial organisms
- Determine bacterial load of different samples
- Perform antimicrobial sensitivity tests
- Preserve bacterial cultures

Laboratory Experiments

- Disinfection and safety in microbiological laboratory.
- Prepration of media for cultivation of bacteria-solid and liquid media,sterilty checks.
- Isolation of bacteria from soil by straek plate method.
- Cultivaton of fungi- growth on solid ,mycelia and conidiophore structure.
- Use of rotary shaker for growth of bacteria, ,cotton plugs,laminar air flow cabinets.
- pH preferences for the growth of bacteria and fungi.
- Anaerobic cultures- yeast , methanogenic bacteria.
- Determination of phenol co-efficientof antibacterial agents.
- Determination of Minimum inhibitory concentration(MIC)
- IMVIC TESTS

Recommended Textbooks and References:

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

*BT109JC - Seminar/Journal Club- Critical analysis of Classical Papers

The credit for this course is 0. So this course need not be included in the Mark sheet**.**

Course Objectives: To practice the art of communication and understand the scientific research paper

Student Learning Outcomes: Skill in communication and presentation scientific papers and defending the **queries**.

Students will select some of the classical papers that originally made breakthrough in understanding the fundamentals of biological sciences. The papers will be presented before the audience followed by a question and answer session.

M.Sc. Biotechnology Programme

Syllabus for IInd Semester

SEMESTER TWO						
1	BT201CC	Immunology	3	50	50	100
2	BT202CC	Molecular Biology & Diagnostics	3	50	50	100
3	BT203CC	Bioinformatics – Computer Application	2	50		100
4	BT204CC	Research Methodology and Scientific Communication skills	1	25		25
5	BT205CC	Intellectual Property Rights & Bioethics	3	50	50	100
6	BT206CC	Genetics	3	50	50	100
7	BT207EC	Elective : One Compulsory 1.Microbial Technology 2. Molecular Virology 3. Molecular Oncology 4. Pharmacogenomics 5. Stem Cell Technology 6. Molecular Therapeutics 7. Bacteriology 8. Vaccines	2	50		50
8	BT208JC	Seminar/Journal Club Emerging Technologies (No need to include in the Mark list)	0			
9	BT209PC	Laboratory III: Molecular Biology	4	100		100
10	BT210PC	Laboratory IV : Immunology	4	100		100
		Total	**25**	**525**	**200**	**725**

SEMESTER TWO

BT201CC Immunology – 3 Credits

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 against bacterial, viral or parasitic infection. The different techniques that are used in immunology also will be taught.

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

- Evaluate usefulness of immunology in health and disease context.
- Identify proper research lab working in area of their own interests
- Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic responses.

Unit I

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.

Unit II

Immune responses generated by B and T lymphocytes

Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic 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.

Unit III

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.

Unit IV

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.

Unit V

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, immunosenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy.

Unit VI

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.

Recommended Textbooks and References:

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

BT202CC Molecular Biology & Diagnostics – 3 credit

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 genetic diseases infectious diseases to cancer.

Student Learning 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.

Unit I
DNA Structure; Replication, Repair & Recombination

Structure of DNA - A, B, Z and triplex DNA; DNA Replication: Replicons, mapping origins of replication, salient features of replication: initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins; Fidelity. DNA repair: Enzymes, Photoreactivation; Nucleotide excision repair; Mismatch correction; SOS repair; Recombination: Homologous and non-homologous; Site specific recombination; Chi sequences in prokaryotes. Gene targeting; Gene disruption; FLP/FRT and Cre/Lox recombination.

Unit II
Prokaryotic & Eukaryotic Transcription

Prokaryotic Transcription; Transcription unit; Promoters-Constitutive and Inducible; Operators; Regulatory elements; Initiation; Attenuation; Termination-Rho-dependent and independent; Anti-termination; Transcriptional regulation-Positive and negative; Operon concept - lac, trp, ara, his, gal; Transcriptional control in lambda phage. Eukaryotic transcription and regulation; RNA polymerase structure and assembly; RNA polymerase I, II, III; Eukaryotic promoters and enhancers; General

Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); Activators and repressors; Transcriptional and post-transcriptional gene silencing.

Post Transcriptional Modifications: hnRNA, mRNA processing: 5'-Cap formation; 3'-end processing and polyadenylation; RNA Splicing; processing of tRNA and rRNA; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA.

Unit III
Translation & Transport

Translation machinery; Ribosomes; Composition and assembly; Universal genetic code; Degeneracy of codons; Termination codons; Isoaccepting tRNA; Wobble hypothesis; Mechanism of initiation, elongation and termination; Co-and post-translational modifications; Genetic code in mitochondria; Transport of proteins and molecular chaperones; Protein stability; Protein turnover and degradation.

Unit IV
Molecular Oncology

Nonsense, missense and point mutations; Intragenic and Intergenic suppressions; Frameshift mutations; Physical, Chemical and biological mutagens; Transposition – Transposable genetic elements in prokaryotes and eukaryotes; Mechanisms of transposition; Role of transposons in mutation; Viral and cellular oncogenes; Tumor suppressor genes from humans; Structure, function and mechanism of action of pRB and p53 tumor suppressor proteins; Activation of oncogenes and dominant negative effect; Suppression of tumor suppressor genes; Oncogenes as transcriptional activators; Molecular diagnostics in detection of human cancer. Predictive biomarkers for personalized onco-therapy of human Cancer such as leukemia and melanoma.

Unit V
Molecular Diagnostics

History of diagnostics; Age of molecular diagnostics; Significance, Scope, Rise of diagnostic industry in Indian and global scenario; Design and operation of a molecular diagnostics laboratory; Introduction to evidence-based molecular diagnostics; Molecular Techniques for diagnosis - PCR- RFLP, ARMS-PCR, ELISA, Multiplex-PCR, SSCP, CSGE, DGGE, DHPLC, MALDI-TOF, DNA Sequencing, Molecular markers:16SrRNA typing; detection of viral pathogens through PCR; good laboratory practices; different levels of biosafety; containment; diagnostic sensitivity and specificity; quality oversight; regulations and approved testing.

Recommended Textbooks and References:

- Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007
- J.D. Watson, N.H. Hopkins, J.W. Roberts, J.A. Seitz & A.M. Weiner; Molecular Biology of the Gene, 6th

Edition, Benjamin Cummings Publishing Company Inc, 2007.
- Alberts et al; Molecular Biology of the Cell, 4th edition, Garland, 2002.
- David E Bruns, Edward R Ashwood, & Carl A Burtis; Fundamentals of Molecular Diagnostics, Saunders/Elsevier 2007
- Lela Buckingham and Maribeth Flaws; Molecular Diagnostics: Fundamentals, Methods, & Clinical Applications; F. A. Davis Company 2008

BT203CC - Bioinformatics – Computer Application – 2 Credits

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.

Student Learning Outcomes: Student should be able to:

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

Unit I

Bioinformatics basics

Bioinformatics basics: Computers in biology and medicine; Introduction to operating systems ; windows and Open Source systems ; Data Structure and Data bases; Database management system; Database browsing and Data retrieval, Protein and Nucleic acid databases;Structuraldatabases; Database introduction ;NCBI; publicly available tools; resources at EBI;Sequence database and genome database, Databases such as Gen Bank; EMBL; DDBJ; Swiss-prot ; PIR MIPS;TIGR; Hovergen; Tair; PlasmoDB; ECDC; Searching for sequence database like FASTA and BLAST algorithm. Resources on web; database mining tools.

Unit II

DNA sequence analysis

Algorithmbasics;databases and search tools:biologicalbackground for sequence analysis; Handling BiologicalSequences such as searching of databases similar sequence;DNA sequence analysis:genebank sequence database;submitting DNA sequences to databases and database searching; sequence alignment; pair wise alignment techniques; BLAST; Types of BLAST; Importance of BLAST

Unit III

Multiple sequence analysis

Multiple sequence analysis;multiple sequence alignment; flexible sequence similarity searching with the FAST Aprogram package; use of CLUSTAL Wand CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centers; submitting aligned sets of sequences, updating submitted

sequences, Basic methods in phylogenetic analysis.

Unit IV

Protein modeling&Protein structure prediction

Protein structure prediction; Methods for modeling; Homology modeling; Threading and protein structure prediction; Structure-structure comparison of macromolecules with reference to proteins; Force fields; Molecular energy minimization; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; construction of variable and conserved regions; evaluation of models; structure prediction on a mystery sequence; PDB (Protein Data Bank) and Swissprot; Uniprot.

Unit V

insilico drug design &Virtual library

File formats for storage and dissemination of molecular structure. Elements of in silico drug design; Virtual library: Molecular Interaction Studies: Types of Docking; Docking Softwares; Ligand Preparations; Target Preparations; Searching Drug Databases; Searching PubMed, current content, science citation index and current awareness services, electronic journals, grants and funding information; Activity predictions.

Recommended Textbooks and References:

- Lesk, A.M.(2002).*IntroductiontoBioinformatics*.Oxford:OxfordUniversityPress.
- Mount, D.W.(2001). *Bioinformatics: Sequence and Genome Analysis.* Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
- Baxevanis, A.D., & Ouellette, B.F.(2001). *Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins*. NewYork: Wiley-Inter science.
- Pevsner,J.(2015). *Bioinformatics and Functional Genomics*. Hoboken, NJ.: Wiley-Blackwell.
- Bourne, P.E., &Gu,J.(2009).*Structural Bioinformatics*.Hoboken,NJ:Wiley-Liss.
- Lesk, A.M.(2004).*Introduction to Protein Science: Architecture,Function, and Genomics.* Oxford: Oxford University Press.
- S. C. Rastogi, Parag Rastogi, Namita Mendiratta (2008) Bioinformatics Methods And Applications: Genomics Proteomics And Drug Discovery.

BT204CC - Research Methodology and Scientific Communication skills – 1 Credit

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.

Student Learning Outcomes: Students should be able to:

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

Unit I

History of science and science methodologies

Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist *vs* holistic biology.

Unit II

Preparationfor research

Choosing a mentor, lab and research question; maintaining a lab notebook.

Unit III

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; on-verbal communication-interpreting non-verbal cues; importance of body language, power of effective listening; recognizing cultural differences; 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

Unit IV

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; 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.

Recommended Textbooks and References:

- Valiela, I. (2001). *Doing Science: Design, Analysis, and Communication of Scientific Research.* Oxford: Oxford University Press.
- *On Being a Scientist: a Guide to Responsible Conduct in Research.* (2009). Washington, D.C.: National Academies Press.
- Gopen, G. D., & Smith, J. A. *The Science of Scientific Writing*. American Scientist, 78 (Nov-Dec 1990),

550-558.
- Mohan, K., & Singh, N. P. (2010). *Speaking English Effectively*. Delhi: Macmillan India.
- Movie: Naturally Obsessed, The Making of a Scientist.

BT205CC - Intellectual Property Rights & Bioethics – 3Credits

Course Objectives: The objectives of this course are:

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

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

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

Unit I

Introduction to IPR

Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, 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.

Unit II
Patenting

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.

Unit III
Biosafety

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; 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 of analysis plan; risk assessment of transgenic crops *vs* cisgenic plants or products derived from RNAi, genome editing tools.

Unit IV

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).

Unit V
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.

Recommended Textbooks and References

- Ganguli, P. (2001). *Intellectual Property Rights: Unleashing the Knowledge Economy.* New Delhi: Tata McGraw-Hill Pub.
- *National IPR Policy*, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
- *Complete Reference to Intellectual Property Rights Laws*. (2007). Snow White Publication Oct.
- Kuhse, H. (2010). *Bioethics: an Anthology*. Malden, MA: Blackwell.
- 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/
- Karen F. Greif and Jon F. Merz, *Current Controversies in the Biological Sciences -Case Studies of Policy Challenges from New Technologies*, MIT Press
- World Trade Organisation. http://www.wto.org
- World Intellectual Property Organisation. http://www.wipo.int
- International Union for the Protection of New Varieties of Plants. http://www.upov.int
- National Portal of India. http://www.archive.india.gov.in
- National Biodiversity Authority. http://www.nbaindia.org
- 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
- 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
- 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
- Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants. 2008.
- Guidelines and Standard Operating Procedures for Confined Field Trials of Regulated Genetically Engineered Plants. 2008. Retrieved from http://www.igmoris.nic.in/guidelines1.asp
- 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.

BT206CC - Genetics – 3 Credits

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.

Student Learning Outcomes On successful completion of this course, student will be able

- Describe fundamental molecular principles of genetics
- Understand relationship between phenotype and genotype in human genetic traits
- Describe the basics of genetic mapping;
- Understand how gene expression is regulated.

Unit I
Genetics of bacteria and bacteriophages

Concept of a gene in pre-DNA era; mapping of genes in bacterial and phage chromosomes by classical genetic crosses-using conjugation, Transduction and Transformation to map bacterial genes; Bacteriophage gene mapping;genetic complementation and other genetic crosses using phenotypic markers; fine structure analysis of bacteriophage genes; phenotype to genotype connectivity prior to DNA-based understanding of gene.

Unit 2
Yeast Genetics
yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, complementation groups, transposon mutagenesis, synthetic lethality, genetic epistasis.

Unit 3
Plant Genetics
Laws of segregation in plant crosses, Mendelism, Phenotype and genotype, Monohybrid and Dihybridcross, Back cross, Test cross,, Reciprocal cross, Incomplete dominance, Co-dominance, lethal alleles, Gene interaction, epistasis, extrachromosomal Inherittance, cytoplasmic male sterility, hybrid vigour, heterosis.

Unit 4
Drosophila and Human Genetics

Multiple alleles, Chromosome theory of heredity, Chromosomes and sex determination Humans and Flies, Dosage compensation of genes, Linkage; crossing over, analyses of autosomal linkage, complete and incomplete linkage, sex linkages, screening of mutations based on phenotypes and mapping the same, Morgan units, chi-square tests, two point test cross and three point test cross for gene mapping in flies, pedigree analysis in mapping human genes, Sex linked inheritance and Hemophilia, Penetrance and expressivity of characters.

Unit 5
Population genetics and genetics of evolution

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, adaptive landscape, spatial variation & genetic fitness.

Unit 6

Quantitative Genetics of complex traits QTL

Complex traits, Inherittance of complex traits,polygene hypothesis, mapping QTLs, genomics to understand the biology of QTL'S.

Recommended Textbooks and References:

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

Electives Courses
(one course compulsory)
BT 207 EC1. Microbial Technology - 2 credits

Course Objectives: The objectives of this course are to introduce students to developments/ advances made in field of microbial technology for use in human welfare and solving problems of the society.

Student Learning Outcomes: On completion of this course, students would develop deeper understanding of the microbial technology and its applications.

Unit I

Isolation and screening of industrially important microbes; Large scale cultivation of industrial microbes ; strain improvement to improve yield of selected compounds e.g. antibiotics, enzymes or recombinant proteins.

Unit II

Basic principles of bioprocess as applied to selected microbes; Process optimization of selected products. Penicillin, Ethanol, Citric acid.

Unit III

Recombinant protein production in microbes; Commercial issues pertaining to the production of recombinant products from microbes; Downstream processing approaches; Industrial microbes as cloning hosts (streptomyces/Yeast).

Unit IV

Environmental application of microbes; Ore leaching; Toxic waste removal; soil remediation.

Unit V

Microbial application in food and healthcare industries; Food processing and food preservation; Antibiotics and enzymes of pharmaceutical use.

Texts/References

- Glazer and Nikaids, Microbial Biotechnology, 2nd Edition, Cambridge University Press, 2007
- Comprehensive Biotechnology
- Principles of Fermentation Technology.

Journal :

- Nature Biotechnology
- Trends in Microbiology
- Current opinion in Microbiology.

BT207EC2 Molecular Virology – 2 Credits

Course Objectives: In this **course** the students will learn advanced knowledge of different aspects of **virology** from classification, life cycle up to the application of viruses in various biotechnological applications at molecular level

Student Learning Outcomes: On successful completion of the course students will learn about the structure, replication, classification and different applications of bacterial, plant and animal viruses.

Unit I

General properties of viruses- Structure and Morphology, Cultivation. Methods used for viral quantification and enumeration. Electron-microscopic studies Viral classification DNA and RNA viruses, Laboratory requirements for cultivation. Lawn culture, Embryonated egg inoculation, Animal inoculation, Permissive and non-permissive hosts or cells. Tissue - Types of celllines used for the study Detection of virus growth in cell culture

Unit II

Viral Tropism, Factors responsible for viral tropism. Replication of DNA viruses and RNA viruses, effects of viruses on the host cells – cyto-pathic effect. Immune aversion mechanism of viruses, Emerging viral diseases. Virus Host interaction- Acute infection, chronic/persistent infection latent infection and slowly progressive virus infection Viral inclusion bodies - methods of staining and demonstration.

Unit III

Animal viruses Poxviruses, Papilloma Viruses, Human Herpes Viruses, Adenoviruses, Picornaviruses, Rotaviruses, Paramyxoviruses and Rhabdoviruses, Reoviruses, Retroviruses Flaviviruses,

Coronaviruses Human Swine fever virus Cancer causing RNA and DNA Viruses. Viral arthritis. Control of animal viral diseases, Antiviral agents, Combination therapy, Nucleic acid based therapies.

Unit IV

Bacteriophages Lambda phage, T phages, Filamentous phages M 13 phages. Lytic and lysogenic cycles of Lambda phage. M13 replication Types of plant viruses, Economic losses due to important viruses;DNA viruses, RNA viruses, satellite viruses, satellite RNA, satellite DNA, viroids, virusoids; Disease symptoms, local and systemic movement of viruses, plasmodesmata and virus movement. Genomic Organization of DNA viruses; Caulimovirus – eg. Cauliflower mosaic virus, Replication of CaMV, Badnavirus – Rice trungro virus (RTBV); Nanovirus – Banana bunchy top virus. Potato virus Y (PVY), , Citrus triesteza virus; Bromovurudae, Alfalfa mosaic virus, Rice dwarf virus.

Unit V

Virus detection and diagnosis; Infectivity assays- Sap transmission, insect vetor transmission, agroinfection (using Agrobacterium); Ultracentrifugation, electron microscopy, serological methods, immunelectrophoresis in gels, direct double-antibody sandwich method, Dot ELUSA, Immunosorbent electron microscopy (ISEM), Decoration technique, Polymerase chain reaction; DNA and oligonucleotide microarray; Gene silencing, PTGS & TGS, viral suppressors of gene silencing.

Texts/ References

- Ed. C.L. Mandahar, Molecular biology of Plant viruses, Kluwer academic publishers, Dordrect, 1999.
- Roger Hull (Ed), Mathews Plant Virology, 4th Edition, Academic Press, San Diego, 2002.
- D.G.A. Walkey (Ed), Applied Plant Virology, 2nd Edition, Chapman & Hall, London, 1991.
- Text Book of Microbiology :Ananthanarayanan & Jayaram Panikker
- Medical Virology : Fenner and White
- Principles and Practice of Infectious diseases – Madell, Bennett, Dolin Vol- 1 & 2
- Medical Microbiology : David Greenwood, Slack, Peutherer
- Essentials of Diagnostic Virology: G. Storch
- Notes on Medical Virology By Morag.C. Timbury
- Diagnostic methods in Clinical Virology : N.R. Grist
- Fundamentals of Molecular Virology By Nicholas H. Acheson

BT207EC3 Molecular Oncology– 2 Credits

Course Objectives: In this course the students will learn the different stages in the development of cancer at the molecular level, the different approaches in the treatment of cancer.

Student Learning Outcomes: On successful completion of the course students will learn about basic properties of tumour cells, carcinogenic substances, the molecular mechanism for origin of cancer, oncogenes, antioncogenes, tumour markers, chemotherapy and immunotherapeutic approaches related to cancer.

Unit 1

Introduction to human cancers: An overview of the cancer problem;epidemiology;Causes of cancer; Cancer and environment-physical, ionizing and non-ionizing radiation, chemical agents and radio nuclides, biological carcinogens; viruses in cancer,General characteristics and hallmarks of cancers and cancer cells, cancer diagnosis; tumor markers-tumor specific and tumor associated markers, cancer prevention and cancer vaccines.

Unit II

Cancer genetics: Oncogenes; Tumour suppressor Genes; defects in DNA repair and genetic instability; Epigenetic modification, Chromosomal aberrations in neoplasia; centrosome malfunction; Cell cycle check point and cancer; telomerase activity, heterogeneity and clonal evolution in cancer

Unit III

Cell transformation and Carcinogenesis:mechanism of carcinogenesis, sporadic and hereditary cancers, Molecular biology of cancers; carcinoma; sarcoma;leukemia; lymphoma; myeloma; Cell signaling pathways relevant to cancer viz. MAPK, AKT/PKB, p53, Wnt signaling.

Unit IV

Cancer therapeutics:Molecular mechanisms of cancer chemotherapy, cell cycle specific and cell cycle non-specific agents-DNA damaging agents; antimetabolites; antimitotic agents; antitumor antibiotics; apoptotic pathways, Targeted drug therapy-Targeting cell cycle, growth factor receptor and signaltransducing molecules, hormone analogues, cancer, immunotherapy and gene therapy.

Unit V

Cancer Research: Basic research, translational research, clinical research, research in the area of prevention and epidemiology, causes, development and molecular biology of cancer, diagnosis and treatment. *In vitro* and *invivo* techniques, methods and models in cancer research.

Texts/References

- Genetics of Cancer: Genes Associated with Cancer invasion, Metastasis and Cell Proliferation; GV Sherbet and M S Laksmi; Academic Loress
- The Biology of Cancer; Robert A Weinberg; Garland Science.

- Alberts et al., Molecular Biology of the Cell, Carland 2008.
- Molecular Genetics of Cancer, 2nd Revised Edition, Bios, 2001.

BT207EC 4. Pharmacogenomics – 2 Credits

Course Objectives: The main objectives of the course are to give students an understanding about the pharmacogenomics principles of human genetics and genomics in drug therapy optimization and personalized medicine.

Student Learning Outcomes: On successful completion of the course students will learn about genetic basis of variability in drug response can contribute to drug efficacy and toxicity, adverse drug reactions and drug-drug interaction.

Unit I

Pharmacogenomics; Pharmacogenetics; Benefits; Practical applications of pharmacogenomics; The promise of Pharmacogenimics today leading to personalized medicines; human genetic variation-examples of CYP gene variations leading to variable metabolism of drugs; Distribution of variation; Mutations & its kind; Natural selection; variation in ethnic groups, races.

Unit II

Pharmacology; clinical pharmacology; Drugs; Drug Legislation & safety; Types of Drugs – examples of latest drugs; Drug potency and Efficacy; ADME of Drug- Drug absorption; Drug distribution; Drug metabolism & Drug excretion;

Unit III

Drug efficacy & toxicity; drug therapeutic levels; Therapeutic Index; Drug abuse; Drug respose in patients by correlating gene expression; Regulation of gene expression; Polymorphism; Alleles; Single nucleotide polymorphism; Genotyping; example of TPMT and DPD gene mutation and their impact in treatment strategy.

Unit IV

Genetic markers-Biomarkers in early drug development; Biomarkers in Clinical development; Biomarkers for molecular Diagnostics – example of cancer biomarkers; Pharmacogenetics & drug development.

Texts/References

- Wu R and Lin M, Statstical & Computational Pharmacogenomics, CRC Press, 2008.
- Yan Q Pharmacogenomics in Drug Discovery and development, Springer-Verlag New York, LLC,

2008.
- Meyer UA and Tyndale RF, Pharmacogenomics, 2nd Edition, CRC Press, 2005.
- Innocenti F, Pharmacogenomics: Methods and Applications Springer-Verlag New York, LLC, 2005.
- Rothstein MA and Collins FS, Pharmacogenomics: Social, Ethical, and Clinical Dimensions, Wiley John & Sons, Inc., 2003.

BT207EC 5 Stem Cell Technology – 2 credits

Course Objectives: The main objectives of the course are to give students understanding about different types of stem cells, their characterization and therapeutic uses.

Student Learning Outcomes: Students will learn about:
- The different types of stem cells
- Generation of different types of stem cells
- Regulating stem cell differentiation and maintenance.
- Advantages of stem cell therapy for complex diseases.

Unit I
Introduction to stem Cells
Definition, Classification and Sources
Unit II

Stem cell differentiation, Blastocyst and inner cell mass cells; Organogenesis; Mammalian Nuclear Transfer Technology;

Unit III
Characterization of stem cell, Stem cells cryopreservation.

Unit IV

Application of Stem Cells

Overview of embryonic and adult stem cells for therapy Neurodegenerative diseases; Parkinson's, Alzheimer, Spinal Code Injuries and other Brain Syndromes; Tissue systems Failures; Diabetes; Cardiomyropathy; Kidney failure; Liver failure; Cancer; Hemophilia etc.

Unit V

Human Embryonic Stem Cells and Society

Human stem cells research: Ethical considerations; Stem cell religion consideration; Stem cell based therapies: Pre clinical regulatory consideration and Patient advocacy.

Texts/References

- Ann A.Kiessling, Human Embryonic Stem Cells: An Introduction to the Science and Therapeutic Potential, Jones and Bartett, 2003.
- Peter J. Quesenberry, Stem Cell Biology and Gene Therapy, 1st Edition, Willy-Less, 1998.
- Robert Lanja, Essential of Stem Cell Biology, 2nd Edition, Academic Press, 2006.
- A.D.Ho., R.Hoffiman, Stem Cell Transplantation Biology Processes Therapy, Willy-VCH, 2006.
- C.S. Potten, Stem Cells, Elsevier, 2006.

BT207EC6 Molecular Therapeutics – 2 Credits

Course Objectives: In this course the students will learn the different approaches for development of novel drug and drug delivery systems.

Student Learning Outcomes: Students will learn about:

- Drug delivery systems including gene delivery
- Therapeutic approaches using stem cells and its pros and cones
- Recombinant therapeutic products and importance
- Immunotherapeutic approaches against cancers

Unit I

Gene therapy; Intracellular barriers to gene delivery; Overview of inherited and acquired diseases for gene therapy; Retro and adeno virus mediated gene transter; Liposome and nanoparticles mediated gene delivery.

Unit II

Cellular therapy; Stem cells: definition, properties and potency of stem cells; Sources: embryonic and adult stem cells; Concept of tissue engineering; Role of scaffolds; Role of growth factors; Role of adult and embryonic stem cells; Clinical applications; Ethical issues

Unit III

Recombinant therapy; Clinical applications of recombinant technology, Erythropoietin; Insulin analogs and its role in diabetes; Recombinant human growth hormone; Streptokinase and urokinase in thrombosis; Recombnant coagulation factors.

Unit IV

Immunotherapy; Monoclonal antibodies and their role in cancer; Role of recombinant interferons; Immunostimulants; Immunosupressors in organ transplants; Role of Cytokine therapy in cancers; Vaccines: types, recombinant vaccines and clinical applications.

Unit V

Gene silencing technology; Antisense therapy; siRNA; Tissue and organ transplantation; Transgenics and their uses; Cloning; Ethical issues.

Texts/References

- Bernhard Palsson and Sangeeta N Bhatia, Tissue Engineering, 2nd Edition, Prentice Hall, 2004.
- Pamela Greenwell, Michelle McCulley, Molecular Therapeutics: 21st century medicine, 1st Edition, Sringer, 2008.

BT207EC 7. Bacteriology – 2 Credits

Course Objectives: In this course the students will learn about the fundamentals of bacteriology

Student Learning Outcomes: Students will learn about:

- Basic structure of a bacterial cell
- Classification of bacteria
- Techniques for propagation and maintanence
- Pathogenesis of bacteria, therapeutic approaches and drug resistance

Unit I

Prokaryotic cell structure, Nucleolus, plasma membrane, cell wall, flagella, Bacterial electron transport chain

Unit II

Classification, difference between Eu-bacteria and Archebacteria, Biochemical tests Numerical classification, Phylogenic and molecular characterization,

Unit III

Bacterial culture media, types of media, simple chemically defined media, complex media, culturing aerobic and anaerobic bacteria

Unit IV

Bacterial diseases, Typhoid, Cholera leprosy and tuberculosis Clinical symptoms, diagnosis and treatments.

Unit V

Generations of antibiotics and its action, development of resistance against antibiotics, Multiple antibiotic resistance and MAR indexing

BT207EC 8. Vaccines – 2 Credits

Course Objectives: In this course the students will learn about different types of vaccines and their importance

Student Learning Outcomes: Students will learn about:

- Role of vaccines in immune protection
- Different types of vaccines
- Production of vaccines
- Composition of vaccines
- Successes in vaccine technology

Unit I

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.

Unit II

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.

Unit III

Immune response to vaccination

Vaccination and immune response; Adjuvants in Vaccination; Modulation of immune responses: Induction of 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.

Unit IV

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.

Unit V

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); Disease specific vaccine design: Tuberculosis Vaccine; Malaria Vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola, Zika).

Recommended Textbooks and References

- Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). *Immuno Biology: the Immune System in Health and Disease*. USA: Garland Science Pub.
- Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). *Kuby Immunology*. New York: W.H. Freeman.
- Kaufmann, S. H. (2004). *Novel Vaccination Strategies*. Weinheim: Wiley-VCH.
- Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.

BT208JC - Seminar/Journal Club Emerging Technologies - 0 credit

The credit for this course is 0. So this course should not be included in the Mark sheet.

Course Objectives: To practice the art of communication and understand the scientific research paper

Student Learning Outcomes: Skill in communication and presentation scientific papers and defending the queries.

Students will select some of the research papers that have published in a reputed journal. The papers will be presented before the audience followed by a question and answer session.

BT209PC - Laboratory III: Molecular Biology – 4 Credits

Course Objectives: The objectives of this course are to provide students with experimental knowledge of molecular biology and cell biology

Student Learning Outcomes: Students should be able to gain hands-on experience in molecular biology and cell biology.

Laboratory Experiments

- Concept of lac-operon:

1. Lactose induction of B-galactosidase.
2. Glucose Repression.
3. Diauxic growth curve of *E.coli*

- UV mutagenesis to isolate amino acid auxotroph
- Phage titre with epsilon phage/M13
- Genetic Transfer-Conjugation, gene mapping
- Plasmid DNA isolation and DNA quantitation
- Restriction Enzyme digestion of plasmid DNA
- Agarose gel electrophoresis
- Polymerase Chain Reaction and analysis by agarose gel electrophoresis
- Vector and Insert Ligation
- Preparation of competent cells
- Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency
- Confirmation of the insert by Colony PCR and Restriction mapping
- Expression of recombinant protein, concept of soluble proteins and inclusion body formation in *E.coli,* SDS-PAGE analysis
- Purification of His-Tagged protein on Ni-NTA columns
- Random Primer labeling
- Southern hybridization

Recommended Textbooks and References:

- Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual.*
- Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press

BT210PC - Laboratory IV : Immunology – 4 Credits

Course Objectives: The objectives of this course are to provide students with experimental knowledge of immunological techniques

Student Learning Outcomes: Students should be able to gain

- Preparation of antigen for immunization
- Methods of harvesting serum from immunized animals
- Detection of antigen antibody reaction
- Purification of Antibody
- Different types of immunological technique

Laboratory Experiments

- Selection of animals, preparation of antigens, immunization and methods of blood collection, serum separation and storage.
- Antibody titre by ELISA method.
- Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion.
- Complement fixation test.
- Isolation and purification of IgG from serum or IgY from chicken egg.

- SDS-PAGE, Immunoblotting, Dot blot assays.
- Blood smear identification of leucocytes by Giemsa stain.
- Separation of leucocytes by dextran method.
- Demonstration of Phagocytosis of latex beads and their cryopreservation.
- Separation of mononuclear cells by Ficoll-Hypaque and their cryopreservation.
- Demonstration of ELISPOT.
- Demonstration of FACS.

M.Sc. Biotechnology Programme

Syllabus for IIIrd Semester

Sl No.	Course code	Title	Credits	Marks		
				Int	Ext	Total
SEMESTER THREE						
1	BT301CC	Bioprocess Engineering and Technology	3	50	50	100
2	BT302CC	Plant and Animal Biotechnology	3	50	50	100
3	BT303CC	Genetic Engineering	3	50	50	100
4	BT304CC	Genomics & proteomics	2	50	50	100
5	BT305CC	Project Proposal preparation and presentation	1			
6	BT306JC	Seminar/Journal Club	0			
7	BT307PC	Laboratory V : Genetic Engineering	3	100		100
8	BT308PC	Laboratory VI : Bioprocess Engineering and Technology	4	100		100
9	BT309PC	Laboratory VII: Bioinformatics	2	50		50
10	BT309PC	Laboratory VIII: Plant and Animal Biotechnology	4	100		100

Total	**25**	**550**	**200**	**750**

SEMESTER Three

BT 301CC - Bioprocess Engineering and Technology - 3 credits

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.

Student Learning Outcomes: Students should be able to:

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

Unit I

Basic principles of biochemical engineering

Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics.

Unit II

Stoichiometry and models of microbial growth

Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth.

Unit III

Bioreactor design and analysis

Batch and continuous fermenters; modifying continuous reactors: chemostat with recycle, fed-batch operations- Variable Volume fed -batch, fixed volume fed-batch ; conventional fermentation v/s

biotransformation; immobilized cell systems; large scale animal and plant cell cultivation; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.

Unit IV

Downstream processing and product recovery

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.

Unit V

Fermentation economics

Low cost & High cost biotech products. Market analysis; equipment and plant costs; media; sterilization, heating and cooling; aeration and agitation; bath-process cycle times and continuous cultures; recovery costs; water usage and recycling; effluent treatment and disposal.

Unit VI

Applications of enzyme technology in food processing

Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions *e.g.* starch and sugar conversion processes; high-fructose corn syrup; interesterified fat; hydrolyzed protein *etc.* and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases, and various other enzyme catalytic actions in food processing. (α-amylase, pectinase, lactase)

Unit VII

Applications of microbial technology in food process operations and production, biofuels and biorefinery

Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling (Sauerkraut), producing colours (β carotene , Zeaxanthine, canthaxanthin and flavours(Lactic acid bacteria,streptococcus, yeasts, penicilium.sp), alcoholic beverages and other products; process wastes-whey, molasses, starch substrates (cormsteep liquor, tapioca processing wastes) and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria – production and applications in food preservation; biofuels (Methane, Bioethanol) and biorefinery.

Recommended Textbooks and References:

- Shuler, M. L., & Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts.* Upper Saddle River, NJ: Prentice Hall.
- Stanbury, P. F., & Whitaker, A. (2010). *Principles of Fermentation Technology*. Oxford: Pergamon Press.
- Blanch, H. W., & Clark, D. S. (1997). *Biochemical Engineering.* New York: M. Dekker.
- Bailey, J. E., & Ollis, D. F. (1986). *Biochemical Engineering Fundamentals*. New York: McGraw-Hill.

- El-Mansi, M., & Bryce, C. F. (2007). *Fermentation Microbiology and Biotechnology.* Boca Raton: CRC/Taylor & Francis.

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.

Student Learning Outcomes Students should be able to gain fundamental knowledge in animal and plant biotechnology for their maintenance in the laboratory and their specific use in different applications

Unit I

Plant tissue culture and animal cellculture

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.

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 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.

Unit II

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.

Unit III

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.

Unit IV

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.

Unit V

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; 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:

- Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. Enfield, NH: Science.
- Razdan, M. K. (2003). *Introduction to Plant Tissue Culture*. Enfield, NH: Science.
- Slater, A., Scott, N. W., & Fowler, M. R. (2008). *Plant Biotechnology: an Introduction to Genetic Engineering*. Oxford: Oxford University Press.
- Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). *Biochemistry & Molecular Biology of Plants*. Chichester, West Sussex: John Wiley & Sons.
- Umesha, S. (2013). *Plant Biotechnology.* The Energy And Resources.
- Glick, B. R., & Pasternak, J. J. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. Washington, D.C.: ASM Press.
- Brown, T. A. (2006). *Gene Cloning and DNA Analysis: an Introduction*. Oxford: Blackwell Pub.
- Primrose, S. B., & Twyman, R. M. (2006). *Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.
- Slater, A., Scott, N. W., & Fowler, M. R. (2003). *Plant Biotechnology: The Genetic Manipulation of Plants*. Oxford: Oxford University Press.
- Gordon, I. (2005). *Reproductive Techniques in Farm Animals*. Oxford: CAB International.
- Levine, M. M. (2004). *New Generation Vaccines.* New York: M. Dekker.
- Pörtner, R. (2007). *Animal Cell Biotechnology: Methods and Protocols*. Totowa, NJ: Humana Press.

BT303CC - Genetic Engineering – 3 credits

Course Objectives: 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. 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.

Student Learning Outcomes Given the impact of genetic engineering in modern society, the students should be endowed with strong theoretical knowledge of this technology. In conjunction with the practicals in molecular biology & genetic engineering, the students should be able to take up biological research as well as placement in the relevant biotech industry.

Unit I
Introduction and tools for genetic engineering

Basic principles of genetic engineering, Scope and 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
Recombinant Screening and selection Labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, subtractive hybridization ,fluorescence *in situ* hybridization.

Unit II
Different types of vectors

Cloning vectors: Plasmid-based, Bacteriophage-based (Lambda - Insertion and Replacement vectors M13 / mp vectors), Phagemids (pUC18/19 and Bluescript vectors), Cosmids, Artificial chromosomes (YACs, BACs, PACs, HACs).

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.

Unit III
Introduction of foreign DNA into host, Genomic/cDNA libraries, transcript mapping, protein-DNA interaction

Insertion of foreign DNA into host cells - transformation, electroporation, transfection
construction of libraries; genomic libraries - walking /hopping /jumping libraries. Isolation of total RNA /mRNA ; reverse transcriptase and cDNA synthesis, cDNA libraries - full length / vector-primed.
S1 mapping, Primer extension, RNase protection and Reporter assays.

Construction of microarrays – types -genomic arrays, cDNA arrays and oligo arrays and applications.
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.

Unit IV
Different types of PCR techniques

Basic principles of PCR: requirements for a standard reaction ; 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; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.

Unit V
DNA sequencing, Mutagenesis, protein engineering, gene-silencing and genome-editing

DNA sequencing techniques, Sangers / Maxam Gilbert method, Automated DNA sequencing, pyro-sequencing, Next –generation sequencing technologies.
Site-directed mutagenesis and protein engineering.
Gene silencing techniques - introduction to siRNA/vectors and siRNA technology; Micro RNA.
Principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops. Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice and disease models. Genetic manipulation in different model systems (e.g. *Drosophila,C. elegans*)
Genome editing by CRISPR-CAS technology ; Chinese and American clinical trials.

Recommended Textbooks and References:

- Old, R. W., Primrose, S. B., & Twyman, R. M. (Latest edition). *Principles of Gene Manipulation: an Introduction to Genetic Engineering*. Oxford: Blackwell Scientific Publications.
- Molecular Cloning : A laboratory manual- Sambrook and Russell. Vol I,II, and III CSHL.
- Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
- Brown, T. A. (2006). *Genomes* (3rd ed.). New York: Garland Science Pub.
- DNA cloning: A practical approach- D.M Glover and B,D, Hames
- Molecular biotechnology- Glick and Pasternak
- Technical Literature from Stratagene, Promega, Novagen, New England Biolab *etc.*

BT304CC - Genomics & proteomics – 2 credits

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

Student Learning Outcomes: 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

Unit I

Basics of genomics and proteomics

Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast.

Unit II

Genome mapping

Genetic and physical maps; tools for genom analysis, 16S rRNA typing /sequencing, DNA fingerprinting ,RFLP, microsatellite/minisatellite, HVR, VNTR, RAPD, AFLP,sts, ESTS, markers for Genome mapping; methods and techniques used for mapping, physical mapping, generating maps based on somatic cell hybridization techniques, radiation hybrid maps, HAPPY maps, cytogenetic techniques,FISH technique in gene mapping, insitu- hybridization, comparison of mapping techniques.

Unit III

Genome sequencing projects

DNA sequencing-principles;Sangers / Maxam Gilbert method, pyro-sequencing, Next –generation sequencing technologies; translation to large scale projects; Stratagies for whole genome sequencing, whole genome shot gun sequencing, Hierarchical shot gun sequencing;Recognition of coding and non-coding sequences and gene annotation; Human Genome Project, genome sequencing projects for microbes, plants and animals, project.

Unit IV

Comparative genomics

Comparing genomes by sequence alignment; SNPs; Methods for SNP analysis, Genome wide association studies, International Hap Map Project, use of genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in genome sequence [Annotation].

Unit V

Proteomics

Aims, strategies and challenges in proteomics; proteomics technologies: protein expression profiling, 2D-PAGE, multiplex proteomics, DIGE analysis, Multi-dimensional liquid chromatography-mass spectrometry analysis , High throughput protein annotation and correlative data base searching, Peptide mass finger printing, computational methods for protein annotation and proteome analysis; MALDI-TOF MS in quantitative proteomics, ICA tags, MCA tags, Enzymatic stable isotopic labelling,

metabolic labelling ;Analysis of protein modifications, phosphoproteomics-IMAC and MS analysis; mass cytometry;Proteome databases.

Unit VI

Functional genomics and proteomics

Transcriptome analysis for identification and functional annotation of gene-Direct sequence sampling, SAGE, Microarrays, Spotted microarrays and oligonucleotide chips;protein-protein and protein-DNA interactions-yeast 2-hybrid system, protein chips, Reverse phase Protein Array, analytical and functional protein chips , PCR directed protein-in situ arrays, PISA, NAPPA, DAPA; functional proteomics; clinical and biomedical applications of proteomics; introduction to metagenomics and systems biology.

Recommended Textbooks and References:

- Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
- Liebler, D. C. (2002). Introduction to Proteomics: Tools for the New Biology. Totowa, NJ: Humana Press.
- Campbell, A. M., & Heyer, L. J. (2003). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.

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

BT305CC - Project Proposal preparation and presentation – 1 credit

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.

Student Learning Outcomes: Students should be able to demonstrate the following abilities:

- Formulate a scientific question
- Present scientific approach to solve the problem
- Interpret, discuss and communicate scientific results in written form
- Gain experience in writing a scientific proposal
- Learn how to present and explain their research findings to the audience effectively.

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 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.

BT306JC - Seminar/Journal Club

The credit for this course is 0. So this course should not be included in the Mark sheet.

Course Objectives: To practice the art of communication and understand the scientific research paper

Student Learning Outcomes: Skill in communication and presentation scientific papers and defending the **queries**.

Students will select some of the research papers that have published in a reputed journal. The papers will be presented before the audience followed by a question and answer session.

BT307PC - Laboratory V : Genetic Engineering – 3 credits

Course Objectives: The objectives of this course are to provide students with experimental knowledge of molecular biology and genetic engineering.
Student Learning Outcomes: Students should be able to gain handson 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.

Laboratory Experiments

- Concept of lac-operon:
  a. Lactose induction of B-galactosidase.

b. Glucose Repression.

c. Diauxic growth curve of *E.coli*

- UV mutagenesis to isolate amino acid auxotroph
- Phage titre with epsilon phage/M13
- Genetic Transfer-Conjugation, gene mapping
- Plasmid DNA isolation and DNA quantitation
- Restriction Enzyme digestion of plasmid DNA
- Agarose gel electrophoresis
- Polymerase Chain Reaction and analysis by agarose gel electrophoresis
- Vector and Insert Ligation
- Preparation of competent cells
- Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency
- Confirmation of the insert by Colony PCR and Restriction mapping
- Expression of recombinant protein, concept of soluble proteins and inclusion body formation in *E.coli,* SDS-PAGE analysis
- Purification of His-Tagged protein on Ni-NTA columns

a. Random Primer labeling

b. Southern hybridization.

Recommended Textbooks and References:

- Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual.*
- Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

BT308PC - Laboratory VI : Bioprocess Engineering and Technology – 4 credits

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

Student Learning Outcomes: Students should be able to

- Investigate, design and conduct experiments, analyze and interpret data, and apply the laboratory skills
- Apply skills and knowledge gained will be useful in solving problems typical of Credits bio industries and research.

Laboratory Experiments

1. Basic Microbiology techniques
    - Scale up from frozen vial to agar plate to shake flask culture.
    - Instrumentation: Microplate reader, spectrophotometer, microscopy.
    - Isolation of microorganisms from soil samples.
2. Experimental set-up
    - Assembly of bioreactor and sterilization.
    - Growth kinetics.

- Substrate and product inhibitions.
- Measurement of residual substrates.

3. Data Analysis
    - Introduction to Metabolic Flux Analysis (MFA).
4. Fermentation
    - Batch.
    - Fed-batch.
    - Continuous.
5. Unit operations
    - Microfiltrations: Separation of cells from broth.
    - Bioseparations: Various chromatographic techniques and extractions.
6. Bioanalytics
    - Analytical techniques like HPLC, FPLC, GC, GC-MS *etc.* for measurement of amounts of products/substrates.

Recommended Textbooks and References:

- Shuler, M. L., & Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts*. Upper Saddle River, NJ: Prentice Hall.
- Stanbury, P. F., & Whitaker, A. (2010). *Principles of Fermentation Technology*. Oxford: Pergamon Press.
- Blanch, H. W., & Clark, D. S. (1997). B*iochemical Engineering*. New York: M. Dekker.
- Bailey, J. E., & Ollis, D. F. (1986). *Biochemical Engineering Fundamentals.* New York: McGraw-Hill.
- El-Mansi, M., & Bryce, C. F. (2007). *Fermentation Microbiology and Biotechnology*. Boca Raton: CRC/Taylor & Francis.

BT309PC - Laboratory VII: Bioinformatics – 2 credits

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.

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

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

Laboratory Experiments

- Usage of NCBI and Uniprot web resources.
- Introduction and use of various genome databases.
- Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt.
- Similarity searches using tools like BLAST and interpretation of results.
- Multiple sequence alignment using ClustalW.
- Phylogenetic analysis of protein and nucleotide sequences.
- Use of gene prediction methods (GRAIL, Genscan, Glimmer).
- Using RNA structure prediction tools.
- Use of various primer designing and restriction site prediction tools.
- Use of different protein structure prediction databases (PDB, SCOP, CATH).
- Construction and study of protein structures using Deepview/PyMol.
- Homology modelling of proteins.
- Use of tools for mutation and analysis of the energy minimization of protein structures.
- Use of miRNA prediction, designing and target prediction tools.

BT309PC - Laboratory VIII: Plant and Animal Biotechnology – 4 credits

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

Student Learning Outcomes: On completion of course, students should be able to gain basic skills in plant and animal biotechnology

Laboratory Experiments

Plant Biotechnology

- Prepare culture media with various supplements for plant tissue culture.
- Prepare explants of for inoculation under aseptic conditions.
- Attempt *in vitro* andro and gynogenesis in plants.
- Isolate plant protoplast by enzymatic and mechanical methods and attempt fusion by PEG.
- Culture *Agrobacterium tumefaciens* and attempt transformation of any dicot species.
- Generate an RAPD and ISSR profile of plants.
- Prepare karyotypes and study the morphology of somatic chromosomes
- Pollen mother cell meiosis and recombination index of select species and correlate with generation of variation.
- Undertake plant genomic DNA isolation by CTAB method and its quantitation by visual as well as spectrophotometeric methods.
- 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.
- Study genetic fingerprinting profiles of plants and calculate polymorphic information content.

Animal Biotechnology

- Count cells of an animal tissue and check their viability.
- Prepare culture media with various supplements for plant and animal tissue culture.
- Prepare single cell suspension from spleen and thymus.
- Monitor and measure doubling time of animal cells.
- Chromosome preparations from cultured animal cells.
- Isolate DNA from animal tissue by SDS method.
- Attempt animal cell fusion using PEG.

M.Sc. Biotechnology Programm
Syllabus for IVth Semester

Sl No.	Course code	Title	Credits	Marks		
				Int	Ext	Total
SEMESTER FOUR						
1	BT401DC	Dissertation	20	150	150 50	300 50
2	BT402EC	Elective : Bioentrepreneurship	2	50		50
3	BT403JC	Academic seminars/Journal Club	1	50		50
		Total	**23**	**250**	**200**	**450**

BT401DC – Dissertation – 20 credits

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.

Student Learning Outcomes: Students should be able to demonstrate the following abilities

- Formulate a scientific question
- Present scientific approach to solve the problem
- Interpret, discuss and communicate scientific results in written form
- Gain experience in writing a scientific proposal
- Learn how to present and explain their research finding

Planning & performing experiments

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 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.

Thesis writing

At the end of their project, 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.

BT402EC - Elective Bioentrepreneurship – 2 credits

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.

Student Learning 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 centres and various agencies. The knowledge pertaining to management should also help students to be able to build up a strong network within the industry

Unit I

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, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.

Unit II

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.

Unit III

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.

Unit IV

Technology management

Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

Recommended Textbooks and References:

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

BT403JC - Academic seminars/Journal Club – 1 credit

Credit and Marks for the seminar/Journal club is given to the candidate in the 4th semester only based on the overall performance.

Course Objectives: To practice the art of communication and understand the scientific research paper

Student Learning Outcomes: Skill in communication and presentation scientific papers and defending the **queries**.

Students will select some review paper published in a reputed journal. The papers will be presented before the audience followed by a question and answer session.

XXXXXXXXX