MSc Biotechnology Course Structure

Semester I

Course code	Title	Theory /Practical	Marks	Credits	Nos of Lectures /week
PSBT 101	Biochemistry	Theory	100	4	4
PSBT 102	Immunology	Theory	100	4	4
PSBT 103	Cell Biology	Theory	100	4	4
PSBT 104	Emerging technologies and molecular diagnostics	Theory	100	4	4
PSBTP 101+ PSBTP 104	Practical I	Practical	100	4	8
PSBTP 102+ PSBTP 103	Practical II	Practical	100	4	8
	TOTAL		**600**	**24**	**32**

MSc Biotechnology Course Structure

Semester II

Course code	Title	Theory /Practical	Marks	Credits	Nos of Lectures/ week
PSBT 201	Bioinformatics and Biostatistics	Theory	100	4	4
PSBT 202	Plant and Animal Biotechnology	Theory	100	4	4
PSBT 203	Bioprocess Engineering and technology	Theory	100	4	4
PSBT 204	Intellectual property rights and Bioethics	Theory	100	4	4
PSBTP 201+ PSBTP 203	Practical III	Practical	100	4	8
PSBTP 202+ PSBTP 204	Practical IV	Practical	100	4	8
	TOTAL		**600**	**24**	**32**

Teaching pattern:

One (01) Credit would be of thirty- forty (30-40) learning hours; of this more than fifty percent of the time will be spent on class room instructions including practical as prescribed by the University. Rest of the time spent invested for assignments, projects, journal writing, case studies, library work, industrial visits, attending seminars / workshops, preparations for examinations etc. would be considered as notional hours. The present syllabus considers (60L as class room teaching and 15 lectures as Notional hours/ paper). Each lecture duration would be for 60 min. The names of the reference books provided in the syllabus are for guidance purpose only. Students and faculty are encouraged to explore additional reference books, online lectures, videos, science journals for latest/ additional information.

Scheme of Examinations:

(a) Internal assessment of 40 marks per course per semester would be conducted.

(b) External assessment of 60 marks per course per semester would be conducted.

(c) Practical examination of 200 marks should be conducted at the end of every semester.

Skeleton- Examination pattern for theory

All Questions are compulsory

Qts No	Topic/ format of the question	Total marks allotted
QI	**Based on Unit I**:	12
QII	**Based on Unit II**:	12
QIII	**Based on Unit III**	12
QIV	**Based on Unit IV**	12
QV	**Based on all the units:** these could have Match the following and /or MCQ and /or definitions and /or answer in one sentence and /or short answers	12
	TOTAL	**60**

Hours 2.5 hr **Total: 60M**

Skeleton- Examination pattern and instructions for Practicals

A learner would have to attempt a part / the entire experiments/ identification questions from Practical I and II for Sem I and Practical II and III for Sem II respectively in a time span of 3 days. The learner will perform experiments in part or in total that would be evaluated for a total of 200M/ semester. The experiments would have to be performed starting with preparation of reagents, glassware etc up-to results and conclusion as per the question asked. Similar format would be followed for Practical II. Submission of certified journals at the time of examinations is compulsory

Practical Examination Pattern in Biotechnology (M.Sc Sem I/II)

Month/Year **10.00 AM to 5.00 PM**

Practical I and II **(**100M+100M**) Total 200M**

Practical III and IV

Perform the following experiment/s marked below: (Given as an example here)

Separate the given protein sample using gel electrophoresis and perform silver staining
The learner is expected to prepare the necessary buffers, ask for requisite glassware, prepare the sample, staining/de staining solutions etc, perform the experiment, cast and run the gel and subsequently interpret the results and conclude accordingly.

OR

Determine the unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer.
A learner is expected to weigh BSA, prepare the dilutions using an appropriate diluent, read the sample, plot the graph. Subsequently the sample provided would be prepared and read and concentration determined accordingly by the learner.

OR

Identification / theory based questions from non-performing practical **25M**

OR

Presentation of papers that have been used to make a poster **10M**

OR

Solve statistical problems **15M**

M.Sc. Biotechnology
Semester –I

Paper-I Biochemistry (PSBT 101)

Units	Topics	Credit	No of lectures
Unit-I Glycobiology & Membrane Biochemistry	Glycosylation of Biomolecules - Synthesis N-linked, O-linked, and GPI linked glycoproteins and role of glycosylation. Lipid aggregates: micelles, bilayers and liposomes- structure, types, preparation, characterization, and therapeutic applications of liposomes. Composition and Architecture of membrane: structural lipids in membranes, membrane bound proteins - structure, properties, and function. Membrane Dynamics: lipid movements, flippase, FRAP, Lipid raft, Membrane fusion. Solubilization of the membrane by using different detergents.	4	15
Unit- II Protein Transport & Membrane Trafficking	Translocation of Secretory Proteins across the ER Membrane, Insertion, Protein Modifications, Folding, and Quality, Control in the ER, Protein sorting and export from Golgi Apparatus. Sorting of Proteins to Mitochondria and Chloroplasts. Molecular Mechanisms of Vesicular Traffic, early and later Stages of the Secretory Pathway, Receptor-Mediated Endocytosis. Protein degradation: Ubiquitin-proteasome pathway and lysosomal proteolysis.		15
Unit- III Biochemistry of Nucleic acids	Forces stabilizing nucleic acid structures, triple helix. Superhelix topology- linking number, Twist and writhing number, measurement of supercoiling and Topoisomerases. Nucleic acid binding protein – Leucine Zipper, Zinc fingers, OB fold, Beta Barrel, Helix-turn-helix, Helix-loop-helix. Biosynthesis of nucleic acids and inborn errors of nucleic acid Metabolism. Methodologies for detection: Protein –Protein and DNA – Protein interactions: Gel retardation assay, DNA foot printing, Yeast 2 Hybrid Method advantages and limitations, yeast split-hybrid and reverse two-hybrid systems, Co-Immunoprecipitation (Co-IP) and Far-		15

	Western Blot Analysis.		
Unit- IV Bioenergetics and regulation of metabolism	Biosynthesis of Amino acids; phenylalanine, tyrosine, threonine and methionine. Bioenergetics- coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism. Elucidation of metabolic pathways: Experimental approaches to the study of Metabolism. Integration of central metabolism; entry/ exit of various biomolecules from central pathways, principles of metabolic regulation. Strategies of energy Metabolism: organ specialization- Brain, Muscle, Adipose Tissue, Liver, Kidney. Metabolic Homeostasis: Regulation of Appetite, Energy Expenditure, and Body Weight; Metabolic Adaptation: Starve–Feed Cycles, insulin signaling and Diabetes Mellitus, target of rapamycin (TOR).		15

References:

1. Stryer, L. (2015). *Biochemistry*. (8th edition) New York: Freeman.
2. Lehninger, A. L. (2012). *Principles of Biochemistry* (6th edition). New York, NY: Worth.
3. Voet, D., & Voet, J. G. (2016). *Biochemistry* (5th edition). Hoboken, NJ: J. Wiley & Sons.
4. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008).
5. Lodish, H. F. (2016). *Molecular Cell Biology* (8th Ed.). New York: W.H. Freeman.
6. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014).
7. *Lewin's Genes XI*. Burlington, MA: Jones & Bartlett Learning.
8. Cooper, G. M., & Hausman, R. E. (2013). *The Cell: a Molecular Approach* (6th Ed.). Washington: ASM; Sunderland.
9. Laouini et.al. Preparation, Characterization and Applications of Liposomes: State of the Art. journal of Colloid Science and Biotechnology Vol. 1, 147–168, 2012
10. Watson, James D., Baker, Tania A., Bell, Stephen P. & Gann, Alexander: Molecular biology of the gene. (6th ed.) New York. Pearson Education Inc., 2008. 0-321-50781-9

Paper II – Immunology (PSBT102)

Unit	Topics	Credit	No of Lectures
I 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.	4	15
II Clinical Immunology	Immunity to infection : bacteria, viral, fungal and parasitic infections (with examples from each group); hypersensitivity: Type I-IV; 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		15
III-Immuno genetics	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 autoimmunity; types of autoimmune diseases; mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV, KIR complex.		15

IV: 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; biosensor assays for assessing ligand –receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, transgenic mice, gene knock outs.		15

References:

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). Kuby Immunology. New York: W.H. Freeman.
2. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). Clinical Immunology. London: Gower Medical Pub.
3. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). Janeway's Immunobiology. New York: Garland Science.
4. Paul, W. E. (2012). Fundamental Immunology. New York: Raven Press.
5. Goding, J. W. (1996). Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology. London: Academic Press.
6. Parham, P. (2005). The Immune System. New York: Garland Science
7. An introduction to Immunology C V Rao Narosa Publishing house
8. Immunology essential and fundamental, Second edition S Pathak & U Palan Parveen Publishing House
9. Text Book of Medical Biochemistry, Praful Godkar. Bahalani Publishers
10. Immunology, An introduction, fourth edition. Ian R Tizard Thomson
11. Immunology, sixth Ed Roitt, Brostoff, Male Mosby, An imprint of Elsevier science Ltd
12. Medical Microbiology, Anantnarayan

Paper III- Cell Biology (PSBT 103)

Unit	Topics	Credit	Number of lectures
I- Dynamics and organization of cell	Universal features of cells; cell chemistry and biosynthesis: chemical organization of cells; internal organization of the cell - cell membranes and cell organelle; dynamics of DNA and mechanisms based on central dogma; chromatin control: gene transcription and silencing by chromatin Writers,-Readers and –Erasers; replication, transcription and translation machineries mitochondrial genetic code translation product cleavage, modification and activation.	4	15
II- Cellular signaling, transport and trafficking	Cellular signaling Molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior. Cell signaling- intercellular communications- nerve impulses, neurotransmitters; agonist and antagonist reactions		15
III- Cellular processes – manipulations	Cell cycle and its regulation; cell divisions and related machineries; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell receptors and transmembrane signaling; cell motility and migration; cell death: different modes of cell death and their regulation. Isolation of cells and basics of cell culture; observing cells under a microscope, analyzing and manipulating DNA, RNA and proteins.		15
IV- Genome instability and cell transformation	Mutations, proto-oncogenes, oncogenes and tumor suppressor genes, physical, chemical and biological mutagens; types of mutations; Epigenetic mutations intra-genic and inter-genic suppression; transpositions-transposable genetic elements in prokaryotes and eukaryotes, role of transposons in genome; viral and cellular oncogenes; tumor suppressor genes; structure, function and mechanism of action; activation and suppression of tumor suppressor genes; oncogenes as transcriptional activators.		15

References:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). Molecular Biology of the Cell. New York: Garland Science.

2. Lodish, H. F. (2000). Molecular Cell Biology. New York: W.H. Freeman.

3. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's Genes XI. Burlington, MA: Jones & Bartlett Learning.

4. Cooper, G. M., & Hausman, R. E. (2009). The Cell: a Molecular Approach. Washington: ASM; Sunderland.

5. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's World of the Cell. Boston: Benjamin Cummings.

6. Watson, J. D. (1987). Molecular Biology of the Gene (7th ed.). Menlo Park, CA: Benjamin/Cummings.

7.Ernst J M Helmreich The Biochemistry cell signaling. Oxford University Press (Indian Edition)

Paper IV Emerging technologies and molecular diagnostics (PSBT 104)

Unit	Topics	Credit	Lectures
Unit I- Functional genomics and proteomics	**Genomics** Gene expression by SAGE and Microarrays- Construction of microarrays – genomic arrays, cDNA arrays and oligo arrays and its applications, NGS platforms, high and low read sequences **Proteomics;** ***Separation and Identification of Proteins*** 2D-PAGE, isoelectric focusing, Edman reaction Protein tryptic digestion and peptide mass fingerprinting mass spectrometry, MALDI-TOF ***Protein Expression Profiling***; Protein Microarrays/ Protein chips: Types and applications **Gel-based quantitative proteomics:** DIGE (Difference in Gel Electrophoresis);**Gel-free based quantitative proteomic:** Surface plasmon resonance, MS based used with stable-isotope tagging, ***In vivo labelling***- SILAC, ***Invitro labelling***- ICAT: Clinical and biomedical applications of proteomics, Introduction to metabolomics, lipidomics, metagenomics and systems biology.	**4**	**15**
Unit II Basic and Advanced Microscopy:	Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Darkfield; Phase Contrast; Differential Interference Contrast; fluorescence and fluorescence microscopy: what is fluorescence, what makes a molecule fluorescent, fluorescence microscope; optical arrangement, light source; filter sets: excitation filter, dichroic mirror, and barrier, optical layout for image capture; CCD cameras; back illumination, binning; recording color; three CCD elements with dichroic beamsplitters, boosting the signal. Confocal microscopy. Advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy; Near-Field and Evanescent Waves, Total Internal Reflection Microscopy; Near-Field Microscopy; Beyond the Diffraction Limit: Stimulated Emission Depletion (STED), Super-Resolution Summary, Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM).		**15**

Unit III CRISPER CAS and Molecular cytogenetics	**CRISPER CAS**: History of its discovery, elucidation of the mechanism including introduction to all the molecular players development of applications for *in vivo* genome engineering for genetic studies, promise of the technology as a next generation therapeutic method Introduction to chromosomal abnormalities. **Advanced Cytogenetic techniques and applications** - FISH , M-FISH ,SKY, CGH, Microarrays principle, methodology. Molecular Approaches for Delineating, Marker Chromosomes, Prenatal Diagnosis of Common Aneuploidies, Preimplantation FISH Diagnosis of Aneuploidies, Molecular Cytogenetics in Reproductive Pathology Interphase FISH Studies of Chronic Myeloid Leukemia, FISH Detection of HER2 Amplification in Breast Cancer, Chromogenic In Situ Hybridization and FISH in Pathology,		**15**
Unit IV Diagnostic Microbiology	Techniques: Molecular amplification techniques • Target amplification systems • Probe amplification systems • Signal amplification PCR in molecular diagnostics; viral and bacterial detection Quantitation of organisms – internal controls, external standards, calibrators, absolute and relative quantification Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing Detection and identity of microbial diseases Direct detection and identification of pathogenic-organisms/ viruses E.g. TB and HIV Clinical utility of molecular diagnostics tests (NAAT) for Hepatitis and AIDS. Molecular identification of fungal pathogens Pharmacogenetics		**15**

References:

1. Campbell, I. D. (2012). *Biophysical Techniques*. Oxford: Oxford University Press.
2. Serdyuk, I. N., Zaccai, N. R., & Zaccai, G. (2007). *Methods in Molecular Biophysics: Structure, Dynamics, Function*. Cambridge: Cambridge University Press.
3. Phillips, R., Kondev, J., & Theriot, J. (2009). P*hysical Biology of the Cell*. New York: Garland Science.
4. Huang, B., Bates, M., & Zhuang, X. (2009). *Super-Resolution Fluorescence Microscopy.* Annual Review of Biochemistry, 78(1), 993-1016. doi:10.1146/annurev.biochem.77.061906.092014.
5. Mohanraju, P., Makarova, K. S., Zetsche, B., Zhang, F., Koonin, E. V., & Oost, J. V. (2016). *Diverse Evolutionary Roots and Mechanistic Variations of the CRISPR-Cas Systems.* Science, 353(6299). doi:10.1126/science.aad5147.

6. Lander, E. (2016). *The Heroes of CRISPR.* Cell, 164(1-2), 18-28. doi:10.1016/j. cell.2015.12.041.
7. Ledford, H. (2016). *The Unsung Heroes of CRISPR*. Nature, 535(7612), 342-344. doi:10.1038/535342a.
8. *Molecular Imaging* Theranostics, 4(4), 386-398. doi:10.7150/thno.8006 Coleman, W. B., & Tsongalis, G. J. (2010). *Molecular Diagnostics: for the Clinical Laboratorian*. Totowa, NJ: Humana Press.
9. Molecular biology of the cell by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Rafi, Keith Roberts, and Peter Walter. 5th ed. 2008
10. Molecular Microbiology Diagnostic Principles and practice third edition, David H. Persing and Fred C. Tenover Copyright _ 2016 by ASM Press
11. Methods in Molecular Biology, Vol. 204: Molecular Cytogenetics: Protocols and Applications, Edited by: Y. S. Fan © Humana Press Inc., Totowa, NJ 2001
12. Genome 3 TA Brown
13. Molecular Biotechnology – Principles and applications of recombinant technology, Glick 4th edition 2010
14. Microarray and Microplates: Applications in biomedical sciences Shu Ye, Ian Day, 2003, Bios Scientific Ltd, oxford.
15. Human Molecular Genetics. Tom Strachan and Andrew Read, 2004, 3rd Edition, Garland Science.
16. Introduction to human molecular genetics. Jack Pasternak, 2005, 2nd Edition, Wiley publication.
17. Microarray bioinformatics by Dov Sketel , Cambridge university press 2003

Practical I PSBTP 101+ PSBTP 104 **4 Credits**

1. To prepare an Acetate and Phosphate buffers using the Henderson-Hassel Bach equation.
2. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
3. Protein gel staining techniques: silver staining, Activity staining: LDH, glycoprotein staining
4. Viscosity studies of proteins
5. Identification of sugars in fruit juices using thin layer chromatography.
6. Isolation of starch from potato and its estimation by anthrone method.
7. The isolation and assay of glycogen from liver and skeletal muscles of bird/mammal.
8. Antimicrobial sensitivity test and demonstration of drug resistance.
9. Operation and maintenance of light microscope – Write up
10. Microscopy types Confocal, Fluorescence, STORM – demonstrations/videos and pictures – Write up
11. Photo album of chromosomal abnormalities in normal and disease condition
    numerical detected by using different probes – centromeric, locus specific, telomeric Structural - Translocations and fusion genes
    Detection of inversions and interstitial deletions by SKY
    CGH for a disease or cancer
12. Demonstration/ video of 2D PAGE
13. Demonstration of Affinity chromatography

References

1. Principles and techniques of Biochemistry and molecular biology (7th Ed, 2010) Keith Wilson and John Walker, Cambridge university Press.
2. Biochemistry Laboratory (2nd Ed, 2012) Rodney Boyer, Pearson's Publication.
3. Biochemical Methods, Sadasivam and Manikam(3rd Ed, 2008)New age international publishers,2008.
4. An Introduction to Practical Biochemistry (3rd Edition), David T Plummer, Tata McGraw Hill Publishing Company Limited, 1992.

Practical II PSBTP 102+PSBTP 103 **4 credits**

1. Preparation of TAB and sterility testing
2. Demonstration of Western blotting
3. Perform serum electrophoresis (horizontal)
4. To perform the Dot blot assays
5. In-vitro demonstration of phagocytosis and calculating phagocytic index.
6. Latex bead agglutination / precipitation test for detection of rheumatoid factor (RF)
7. Separation of lymphocytes on Ficol Histopaque and viability count
8. Visit to a blood bank and preparation of report
9. Cell permeability testing- osmotic fragility
10. Isolation of cell organelle by differential centrifugation techniques from plant / animal sources
11. Isolation of mitochondrial DNA
12. Isolation of chloroplast DNA
13. Cell motility studies (bacteria, algae, cyanobacteria, protozoans,)
14. Cell death /apoptosis studies using flow-cytometry demonstration
15. Isolation and identification of mutagens of plant origin (demonstration/ video)

References

1. A Handbook of Practical Immunology – G P Talkwar
2. Practical immunology, Frank Hay, 4th Edition , Blackwell Science
3. Introduction to Practical Biochemistry, D.T. Plummer, Tata MacGraw Hill
4. Biochemical Methods, Sadasivam and Manikam(3rd Ed, 2008). New age international publishers,2008.
5. Laboratory Manual of Microbiology, Biochemistry and Molecular Biology, Jyoti Saxena Mamta Baunthiyal Indu Ravi , Scientific Publishers (India) 5 A, New Pali Road, P.O. Box 91 Jodhpur 342 001 (India)
6. Medical Laboratory Technology 2nd edition Authors Kanai, L Mukherjee and Swarajit Ghosh .McGraw Hill publications,2010.
7. Practical Immunology,Frank Hay,4thEdition,BlackwellScience
8. Medical Microbiology,Anantnarayan
9. An Introduction to Practical Biochemistry (3rd Edition), David T Plummer, Tata McGraw Hill Publishing Company Limited, 1992.
10. Nigam and Ayyagari. (2007). Lab Manual in Biochemistry, Immunology and Biotechnology. TATA McGraw Hill.
11. Cell Biology Lab Manual-http://www.ihcworld.com/_protocols/lab_protocols/cellbiology-lab-manual-heidcamp.htm
12. Text Book of Medical Biochemistry, Praful Godkar. Bahalani

MSc Biotechnology

Semester II

Paper I -Biostatistics and Bioinformatics (PSBT 201)

Unit	Topic	Credit	lectures
I Basics of Bioinformatics and DNA sequence analysis	Bioinformatics basics: Computers in biology and medicine; Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools. DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.		**15**
II Multiple sequence alignments and protein modelling	Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis. Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structures; sequence alignment- methods, evaluation, scoring; protein completion: backbone construction and side chain addition; small peptide methodology; software accessibility; building peptides; protein displays; substructure manipulations, annealing.	**4**	**15**
III-Biostatistics	Introduction and scope of statistics in biological studies and basic concepts. Collection of data, by different sampling methods: Simple random sampling, stratifies random sampling and systemic sampling. Measures of central tendency; Mean, Median and Mode. Measures of		**15**

	Dispersion: Variance/ standard deviation, coefficient of variation and standard error. Confidence limits for mean and proportion. Probability and Basic concepts: Normal and binomial distribution. Correlation and regression analysis for a bivariate data: Scatter diagram		
IV- Biostatistics	Test of Hypothesis: Null hypothesis, alternate hypothesis, test statistics, Type I and Type II errors, level of significance and critical region. Z test: for a single sample, two samples and two sample proportion. t-test a single sample, two samples and testing the significance of the correlation. Coefficient: t paired test, x^2 test: As a goodness of fit and in 2x2 contingency test		

References:

1. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience.
4. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell.
5. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
6. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.
7. S. P. Gupta, Statistical Methods, (45th Revised Edition), Publisher SCHAND
8. William G. Cochran, Sampling Techniques (3th Edition), Wiley and sons
9. Boris V. Gnedenko, Theory of Probability (6th Edition), CRC Press, 13-May-1998
10. Oscar Kempthorne, Klaus Hinkelmann, Design and Analysis of Experiments, Volume1: Introduction to Experimental Design, 2nd Edition, ISBN: 978-0-471-72756-9 December 2007
11. Acheson Johnston Duncan, Quality Control and Industrial Statistics (5th Edition), Irwin; 5 edition January 1, 1986
12. BK Mahajan, Methods in Biostatistics (7th Edition), Published December 1st 2008 by JP Medical Ltd

Paper II-Plant and Animal Biotechnology (PSBT 202)

Unit	Topic	Credit	lectures
I Plant tissue culture and Animal cell culture	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.	4	15
II Plant Genetic manipulations	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.		15
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		15

	production, recombinant approaches to vaccine production, modern vaccines.		
IV 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.		**15**

References

1. Biology of plant metabolomics, Robert Hall, Annual Plant Reviews, 43, Chichester, West Sussex; Ames, Iowa : Wiley-Blackwell, 2011
2. Plant Biotechnology. Umesha, S. (2013).
3. Glick, B. R., & Pasternak, J. J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, D.C.: ASM Press.
4. Brown, T. A. (2006). Gene Cloning and DNA Analysis: An Introduction. Oxford: Blackwell Publishers.
5. Primrose, S. B., & Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
6. Slater, A., Scott, N. W., & Fowler, M. R. (2003). Plant Biotechnology: The Genetic Manipulation of Plants. Oxford: Oxford University Press.
7. Gordon, I. (2005). Reproductive Techniques in Farm Animals. Oxford: CAB International.
8. Levine, M. M. (2004). New Generation Vaccines. New York: M. Dekker.
9. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press.
10. Chawla, H. S. (2000). Introduction to Plant Biotechnology. Enfield, NH: Science.
11. Razdan, M. K. (2003). Introduction to Plant Tissue Culture. Enfield, NH: Science.
12. Slater, A., Scott, N. W., & Fowler, M. R. (2008). Plant Biotechnology: n Introduction to Genetic Engineering. Oxford: Oxford University Press.
13. Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). Biochemistry & Molecular Biology of Plants, Wiley 2002

Paper III -Bioprocess engineering and technology (PSBT 203)

Unit	Topics	Credit	Lectures
I Basic principles of biochemical engineering	**Sources of Microorganisms Used in Biotechnology**- Literature search and culture collection supply, Isolation de novo of organisms producing metabolites of economic importance. **Strain Improvement**- Selection from naturally occurring variants, Manipulation of the genome of industrial organisms in strain improvement **Bioreactor design and analysis** Media formulation and optimization methods; sterilization of bioreactors aeration and agitation in bioreactors KLa value (factors affecting and methods of determination), heat transfer in bioprocess measurement and control of bioprocess parameters. **Bioprocess economics**		15
Unit II Production of proteins from recombinant microorganisms	**Principles of Microbial Growth** Batch Fermentation, Fed-Batch Fermentation Continuous Fermentation **Maximizing the Efficiency of the Fermentation Process** High-Density Cell Cultures, Increasing Plasmid Stability, Quiescent *E. coli* Cells, Protein Secretion and Reducing Acetate **Bioreactors** **Typical Large-Scale Fermentation Systems** Two-Stage Fermentation in Tandem Airlift Reactors, Two-Stage Fermentation in a Single Stirred-Tank Reactor, Batch versus Fed-Batch Fermentation **Harvesting Microbial Cells** **Disrupting Microbial Cells** **Downstream Processing** Protein Solubilization **Large-Scale Production of plasmid DNA** .	4	15
Unit III Applications of enzyme technology in food processing	**Introduction and scope** 1. Enzymes sourced from animals and plants used in food manufacturing technology 2. Enzyme usage in food applications. **Mechanism of enzyme function and reactions in food processes** 1 Starch-processing and related carbohydrates. 2. Lipases for the production of food components: interesterified fat 3. Enzymes in protein modification: hydrolyzed		15

	protein 4., Enzymes in bread making - flavour, texture and keeping quality 5. Enzymes in dairy product manufacture 6. Enzymes in fruit and vegetable processing and juice extraction 7.Enzymes in fish and meat processing 8. Beer Production using Immobilized Cell Technology.		
Unit IV Applications of microbial technology in food process operations and production, biofuels and biorefinery	1.Microbial biomass production: mushrooms, SCP 2.Fermented foods from: meat and fish, bread, Vegetables (sauerkraut, cucumber), Legumes and Oil Seeds soya bean fermentations 3. Beverages a) Stimulant Beverages -coffee, cocoa and tea fermentations b) Alcoholic beverages - Cider production 4.Food additives and supplements a) Lipids, Nucleosides, nucleotides and related compounds- Vitamins b) Natural food preservatives- bacteriocins from lactic acid bacteria – production and applications e.g. Nisin c) Microbial production of colours and flavours. d) Polyhydric alcohols: low-calorie sweetener particularly useful for sweetening food products for diabetics e) Microbial exopolysaccharides - Xanthan gum 5. Process Food wastes- for bioconversion to useful products (Compost, biofuels, biomass cheap source of raw material in fermentation etc).		15

References:

1. Shuler, M. L., & Kargi, F. (2002). Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press.
3. Bailey, J. E., & Ollis, D. F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill.
4. El-Mansi, M., & Bryce, C. F. (2007). Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Francis.
5. Lee, Y. K. (2013). Microbial Biotechnology: Principles and Applications. Hackensack, NJ: World Scientific.
6. Alexander N. Glazer and Hiroshi Nikaido -Microbial Biotechnology: Fundamentals of Applied Microbiology, 2nd Edition
7. Michael Waites and Morgan , Rockney and Highton -Industrial microbiology : An Introduction
8. Robert Whitehurst and Maarten Van Oort - Enzymes in food technology 2nd ed
9. Nduka Okafor Modern industrial microbiology and biotechnology Science Publishers, Enfield, NH, USA **(**2007)

Paper IV Intellectual property rights and Bioethics (PSBT 204)

Title	Details	Credits	Number of lectures
Unit 1 Introduction to IPR	Introduction to intellectual property; types of IP: patents, trademarks, trade secrets, copyright & related rights, industrial design, geographical indications, Biodiversity importance and legislation, International convention and treaties; plant variety protection and farmers rights act. , traditional knowledge.	4	**15**
Unit 2 Patents	Basics of patents: eligibility criteria, classification of patents, categories, special patents and patenting biological products. Patentable and Non-patentable inventions in India and abroad. Process of Patenting, Patent Search and Inventor's homework, drafting patent applications, patenting systems. Rights of the patent holder, assignment and licensing of patents and patent Infringement, case studies. Patent Agent.		**15**
Unit 3 Patentability of Biotechnology Inventions	Patentability of Biotechnology Inventions in India, Statutory Provisions Regarding Biotechnological Inventions Under the Current Patent Act 1970 (as Amended 2005). Biotechnological Inventions as Patentable Subject Matter, Territorial Nature of Patents,: From Territorial to Global Patent Regime, Interpreting TRIPS in the Light of Biotechnology Inventions, Feasibility of a Uniform Global Patent System, Merits and Demerits of Uniform Patent Law, Relevance of the Existing International Patent, Tentative Harmonisation Efforts, Implications of Setting up a Uniform World Patent System.		**15**
Unit 4 Bioethics	Introduction, bioethics in health care- euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, organ transplantation. Ethics of clinical research, Bioethics in research – cloning and stem cell research, Human and animal experimentation, Agricultural biotechnology - Genetically engineered food, environmental risk, labelling and public opinion. Bioterrorism.		**15**

References

1. Ganguli, P. (2001). *Intellectual Property Rights: Unleashing the Knowledge Economy*. Tata McGraw-Hill Publishing Company.
2. Karen F. Greif, Jon F. Merz - Current Controversies in the Biological Sciences_ Case Studies of Policy Challenges from New Technologies (Basic Bioethics)-The MIT Press (2007)
3. V. Sreekrishna - Bioethics and Biosafety in Biotechnology-to New Age International Pvt Ltd Publishers (2007)
4. Padma Nambisan (Auth.) - An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology- Academic Press (2017)
5. Kshitij Kumar Singh (auth.) - Biotechnology and Intellectual Property Rights_ Legal and Social Implications-Springer India (2015)
6. David Castle - The Role of Intellectual Property Rights in Biotechnology Innovation (2011)
7. Goel, D., & Parashar, S. (2013). *IPR, Biosafety and Bioethics*. Pearson Education India.
8. Singh, S. S. (2004). The Law of Intellectual Property Rights. *Deep and Deep Publications, New Delhi*, 96.
9. Talwar Shabana; *Intellectual Property Rights in WTO and Developing Countries*, Edition 2010, Serials Publications, New Delhi.
10. Helga Kuhse_ Udo Schüklenk_ Peter Singer_ (eds.) - Bioethics_ An Anthology-Wiley-Blackwell (2016)
11. National Guidelines for Biomedical and Health Research on Human Participants (ICMR – 2017)
12. ICMR-DBT National Guidelines for Stem Cell Research - 2017

Practical III-PSBTP 201+ PSBTP 203 **4 credits**

1. Using NCBI and Uniprot web resources
2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt.
4. Similarity searches using tools like BLAST and interpretation of results.
5. Multiple sequence alignment using ClustalW.
6. Phylogenetic analysis of protein and nucleotide sequences.
7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8. Using RNA structure prediction tools.
9. Use of various primer designing and restriction site prediction tools.
10. Use of different protein structure prediction databases (PDB, SCOP, CATH).
    (Practicals in biostatistics could be clubbed into a test paper for 25M for the practical examinations/ problems could be asked for 5 / 10M)
11. Measures of central tendency: Mean, median and mode for grouped and ungrouped data
12. Measures of dispersion: Standard deviation for grouped and ungrouped data: standard value for the mean and proportion
    Confidence limits for the mean and proportion
13. Probability: Normal distribution and Binomial distribution use of normal tables
14. Correlation and Regression: Estimation of correlation coefficient, to fit regression equations from bivariate data
15. Test of hypothesis: a) Z-test, b) t-test c) x^2 test d) f-test
16. Use of microorganism to produce a product. Detect utilization of substrate and formation of product at time intervals. Attempt purification of product e.g. enzyme.
1. Immobilize an organism / enzyme and detect the conversion of substrate to product.
2. Microbial pigment:
    a. production – factors affecting – pH, temp, nutrients, static/ shaker conditions, submerged/ surface.
    b. extraction – soluble and insoluble pigments- organic solvent extraction and purification.
3. Demonstration of media optimization by Placket Burman test- demonstration
4. Methods for measurement of cell mass:
    a. Direct physical measurement of dry weight, wet weight, or volume of cells after centrifugation.
    b. Indirect measurement of chemical activity such as nutrient utilization and product synthesized.
    c. Turbidity measurements employ a variety of instruments to determine the amount of light scattered by a suspension of cells.
5. Analytical techniques like HPLC, FPLC, GC, GC-MS *etc.* for measurement of amounts of products/substrates. Demonstration
6. Quality Assurance in a food industry – Field visit and report
7. Method validation for any biochemical test (Accuracy, Limit of Detection, Limit of Quantitation, Specificity, Linearity and range, Ruggedness and Robustness) – Report writing

Practical IV
PSBTP 202 + PSBTP 204

Plant tissue culture

1. Prepare culture media with various supplements for plant tissue culture.
2. Prepare explants of *Valleriana wallichii* for inoculation under aseptic conditions.
3. Isolate plant protoplast by enzymatic and mechanical methods and attempt fusion by PEG (available material).
4. Culture *Agrobacterium tumefaciens* and attempt transformation of any dicot species.
5. Generate a RAPD and ISSR profile of *Eremurus persicus* and *Valleriana wallichii*.
6. Prepare karyotypes and study the morphology of somatic chromosomes of *Allium cepa, A. sativum, A. tuberosum* and compare them on the basis of karyotypes.
7. Undertake plant genomic DNA isolation by CTAB method and its quantitation by visual as well as spectrophotometric methods.
8. Study genetic fingerprinting profiles of plants and calculate polymorphic information content. Demonstration

Animal cell culture:

9. Count cells of an animal tissue and check their viability.
10. Prepare culture media with various supplements for plant and animal tissue culture.
11. Prepare single cell suspension from spleen and thymus.
12. Monitor and measure doubling time of animal cells.
13. Chromosome preparations from cultured animal cells
14. Isolate DNA from animal tissue by SDS method.
15. Attempt animal cell fusion using PEG.
16. To study a patent and to develop a patent application for a product or process.
17. To write SOPs of 4 laboratory equipment or instruments.
18. Journal club- a minimum 2 weeks activity of reading and discussing research papers preferably with a mentor and making a poster in a group of 3/2 for presentation in form of Microsoft PowerPoint /coral draw. Poster prepared to be appended in the journal. Teachers are requested to encourage students to participate/ attend conferences/ seminars/ avishkar. The group of students to be evaluated for the same for 5M each in the practical examinations
19. Compilation of information on recommended biosafety practices in a Biotechnology/ Biology laboratory. (demonstration by field visit or video)
