যাদবপুর বিশ্ববিদ্যালয়
JADAVPUR UNIVERSITY

DEPARTMENT OF LIFE SCIENCE AND BIOTECHNOLOGY

New Syllabus for the Revised Two Year (Four Semester) Course in M. Sc. in Biotechnology

Offered by
DEPARTMENT OF LIFE SCIENCE AND BIOTECHNOLOGY
FACULTY OF SCIENCE
JADAVPUR UNIVERSITY

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DEPARTMENT OF LIFE SCIENCE AND BIOTECHNOLOGY

1.Name of the department/School	:	**LIFE SCIENCE AND BIOTECHNOLOGY**
2. Name of the course offered [certificate, diploma, degree (UG / PG / M.Phil. / Ph.D.), Extra-departmental, training, vocational, etc.]	:	➢ M.Sc. in Biotechnology ➢ Ph.D. in Science
3. Eligibility criteria, course-wise	:	B.sc. in any branch of Science with 50% Marks in Mathematics at 10+2 levels (H.S., ISC, etc)
4. Dissemination, course-wise (full-time day; part-time, Evening, 2-3 days per week; Distance mode, etc.)		Full Time Day course for M. Sc. in Biotechnology
5. Duration, course-wise :		2 years for M. Sc. in Biotechnology
6. Curriculum/Syllabus, course-wise :		Enclosed herewith

Biotechnology in Jadavpur University

Biotechnology programme in Jadavpur University stared with a master's course M. Tech. (Biotechnology) in the year 1985, the initial objective was to induct engineering graduates into this emerging technology and train them to support the growing biotechnology industry of the country.

Later postgraduates in different science streams were also admitted. The overall experience in fulfilling the above objectives had been satisfactory. At a later stage, however, most of the students coming from the engineering streams were Pharmacy graduates (B. Pharm.), few students used to come from chemical engineering or food Technology. Among the science students the response was more encouraging.

After that, a two year M. Sc. in Biotechnology program was introduced, in which the students form all disciplines of Science, eg. Physics, Chemistry, Mathematics, Zoology, Botany, Physiology, Microbiology and Biochemistry honours graduate were inducted. Most of the graduated students opted for further research to earn their Ph. D. degree from JU as well as other reputed Universities in India and abroad. A small number of students joined various private biotechnology, pharma and other industries. Yet another smaller fraction went for several government sector.

Evolving nature of Biotechnology Education in JU

The current M.Sc. (Biotechnology) curriculum was adopted and modernized in year 2005. In doing so an appropriate blend between science and technology was effected and newer areas such as biostatistics, genomics, proteomics, bio-informatics, bio-economics, intellectual property rights, emerging areas of genomic and transcriptomic technologies used in microbial, plant, animal biotechnology etc were incorporated into the syllabus.

In this revised M. Sc. (Biotechnology) curriculum, the major change that was emphasized is the introduction of the semester module. In addition, many less important topics in various courses were reduced and newer and modern topics, which are more relevant to the current needs of the subject, were introduced. Moreover, in the fourth semester, two new course module were introduced that does not follow the traditional classroom based-teaching learning module. Rather they involve critical skills involving analyses, thinking, presentation and dissemination of knowledge. This new revised syllabus is very time-appropriate, that would train the students to build suitable skills and help them to get appropriate career-option/employment down the line.

Current Needs and prospects

- Catering a quality education to students coming from different backgrounds requires optimization and maintenance of correct subjects/topics in proper blend and providing the advance quality education is a quite challenging.

- With biotechnology (or biological technology) becoming increasingly knowledge (science) Based, the basic sciences such as structural biology, molecular biology, cell biology as well as genomics and proteomics need to be more elaborate than present syllabus can accommodate.

- The current syllabus runs on annual examination based examination system and currently, it is mandatory to transform the course into semester system to be consistent with the UGC requirement and also to be at per with the other M. Sc. courses under faculties if Science at Jadavpur University

- Jadavpur University attracts the best of the students from all over the state from different disciplines.

- The current M. Sc. (Biotechnology) programme needs a through recasting in order to be at par with other M. Sc. (Biotechnology) courses offered at other institution/universities. This is essential for catering the information of the most recently developed cutting-edge technologies to improve the quality of the passed-out students to ensure (i) entry into the appropriate research area and (ii) employment.

With the above mentioned needs and prospects in consideration we are in the process of starting the newly developed syllabus in M. Sc. (Biotechnology) from the next academic session (2019-20).

Department of Life Science and Biotechnology
Jadavpur University

Syllabus of Two Year (Four Semester) course in M. Sc. (Biotechnology)

Semester I

3rd Week of August to 2nd Week of December
Minimum Semester Credit Required: 28
Cumulative Semester Credit Required: 28
Theoretical = 200, Practical = 100

Subject	Course No	Subject Name	Lecture/Contact Hr./Week	Credit	Total Marks
Theory	MSBT131	Cell Biology	3	3	50
Theory	MSBT132	Biochemistry	3	3	50
Theory	MSBT133	Microbial genetics and Molecular Biology-I	3	3	50
Theory	MSBT134	Biomathematics, Biostatistics and Computer	3	3	50
Lab Course	MSBT145L	Microbiology and Biochemistry Laboratory*	20	8	50
Lab Course	MSBT146L	Biophysics and Cell Biology Laboratory*	20	8	50
		TOTAL		28	300

*Out of 50 in Practical

Internal Assessment = 30
Viva = 15
Lab note book = 5

Semester II

1st Week of January to 4th Week of April

Minimum Semester Credit Required: 18

Cumulative Semester Credit Required: 46

Theoretical = 300

Subject Type	Course No	Subject Name	Lecture/Contact Hr./Week	Credit	Total Marks
Theory	MSBT231	Molecular Biology-II and Genetics	3	3	50
Theory	MSBT232	Metabolism and Bioenergetics	3	3	50
Theory	MSBT233	Immunology	3	3	50
Theory	MSBT234	Microbiology	3	3	50
Theory	MSBT235	Bioinformatics	3	3	50
Theory	MSBT236	Bio-analytical Techniques	3	3	50
		TOTAL		18	300

Semester III

1st Week of August to 2nd Week of December
Minimum Semester Credit Required: 28
Cumulative Semester Credit Required: 74
Theoretical = 200, Practical = 100

Subject Type	Course No	Subject Name	Lecture/Contact Hr./Week	Credit	Total Marks
Theory	MSBT331	Recombinant DNA Technology	3	3	50
Theory	MSBT332	Plant and Microbial Biotechnology**	6	6	100
Theory	MSBT333	Genomics and Proteomics	3	3	50
Theory	MSBT334	Animal and Developmental Biotechnology **	6	6	100
Lab Course	MSBT345L	Immunology Laboratory	20	8	50
Lab Course	MSBT346L	Molecular Biology and Recombinant Technology Laboratory	20	8	50
		TOTAL		28	300

****Elective, CBCS Course and each of them will carry 6 Credit Points**

*Out of 50 in Practical

Internal Assessment = 30
Viva = 15
Lab note book = 5

Semester IV

1st Week of January to 4th Week of April

Minimum Semester Credit Required: 32

Cumulative Semester Credit Required: 106

Theoretical = 100, Project Based = 100, Grand Viva = 100

Subject Type	Course No	Subject Name	Lecture/Contact Hr./Week	Credit	Total Marks
Theory	MSBT431	Selected Topics in Biotechnology*	3	8	50
Theory	MSBT432	Critical Analysis Research methodology and Scientific Communication Skill¥	3	8	50
Theory	MSBT463	Students Project Work and Dissertation	3	8	100
Theory	MSBT464	Grand Viva	3	8	100
		TOTAL		32	300

Details of the Syllabus

Semester I

MSBT 131: Cell biology

Unit I: Dynamic Organization of cell

Universal features of cells; chemical organization of cells; internal organization of the cell - structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum (UPR and ER stress) and Golgi apparatus, lysosomes (lysosomal membrane potential, Lysosomal storage diseases) and peroxisomes, ribosomes, mitochondria (fission and fusion, aging, maternal inheritance), chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes.

Unit II: Cellular Transport and Trafficking

Membrane transport; Ways to move molecules across membranes; carrier proteins, Ion channels; Muscle contraction and nerve impulse transmission; Nuclear transport (export and import), transport across mitochondria and chloroplasts; Vesicular trafficking in the secretory and endocytic pathway, transport from the ER through the Golgi apparatus, trans-golgi network to the cell surface, exocytosis, molecular mechanism of vesicular transport, protein modification in the secretory pathway

Unit III: Cell Junctions

Cell matrix interactions, Adhesion junction , Tight junctions, Gap junctions – disease relevance.

Unit IV: Cytoskeleton and Cell movement

Microtubules, intermediates filaments, actin filaments. Microtubule and Actin filament Dynamics, Mechanism of muscle contraction. Motors and movements, function of motor proteins, Cilia & Flagella.

Unit V: Cell Cycle and its Regulation

Cell division: mitosis, meiosis and cytokinesis; Yeast and molecular genetics of cell cycle control, cell division control in multicultural animals. roles of cyclins, cdks, phosphatases, protein degradation as mechanisms controlling the unidirectional cell cycle.

Unit VI: Cell Signalling

Molecular mechanism of signal transduction. Integration of signals, second messengers. G Protein Signaling, Ras, RTK, TGF-b/SMAD signalling and Wnt signalling.

Unit VII: Cell Death and Aging

Apoptosis, necrosis and programmed cell death and the role of the mitochondria and caspase signaling in these processes, Hayflick limits, function of telomerase, autophagy.

Unit VII: Molecular Oncology

Causes of cancer. Cancer related genes, including oncogenes and tumor suppressor genes; their normal cellular function, mutagenesis and consequences of their mutant state in cancer. Hereditary cancer. The stepwise transformation process.

Recommended Textbooks and References:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). Molecular Biology of the Cell (5th Ed.). New York: Garland Science.
2. Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman.
3. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's Genes XI. Burlington, MA: Jones & Bartlett Learning.
4. Cooper, G. M., & Hausman, R. E. (2013). The Cell: a Molecular Approach (6th Ed.). Washington: ASM ; Sunderland.
5. Weinberg, Robert A. The Biology of Cancer, New York : Garland Science, 2014] - 876, 6, 30, 28

MSBT 132: Biochemistry

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, biomolecular hierarchy, macromolecules, molecular assemblies.]

Unit II: Protein structure

Structure-function relationships: amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin *etc*.; basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation.

Unit III: Enzyme kinetics

[Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.]

Unit IV: Glycobiology

[Sugars - mono, di, and polysaccharides with specific reference to glycogen, amylose and cellulose, glycosylation of other biomolecules - glycoproteins and glycolipids; lipids - structure and properties of important members of storage and membrane lipids; lipoproteins.]

Unit V: DNA RNA Lipids

Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane bound proteins - structure, properties and function; transport phenomena; nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material.

Recommended Text Books/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.

MSBT133: Microbial Genetics and Fundamentals of Molecular Biology

Fundamentals of Molecular Biology

Unit I: Fundamental Concepts: Biomolecular Structures

Physical Chemistry of Chemical Bonds, Concept of Free Energy, Activation Energy and Coupling of Biochemical Reactions, Week and High Energy Bonds in Biological System, Structure and properties of DNA

Structure and properties of DNA, DNA re-association kinetics (Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNA melting and buoyant density, Structure and properties of RNA, Functional and Catalytic RNAs and Ribozymes, structure of Amino Acids, peptides and proteins.

Unit II: Genome Organization

Organization of eukaryotic chromosomes; Role of nuclear matrix in chromosome organization and function; Matrix binding proteins; Heterochromatin and euchromatin, Nucleosome phasing; DNase I hypersensitive regions; DNA methylation & Imprinting

Unit III: Genome Replication and Maintenance

DNA Replication: Replication initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins; Fidelity; Replication of single-stranded circular DNA;

DNA Repair: Mutagenic agents; Mechanisms of mutagenesis; Assay of mutagenic agents (Ames test), DNA repair- enzymes; Photoreactivation; Nucleotide excision repair; Mismatch correction; SOS repair;

DNA Recombination: Recombination: Homologous and non-homologous; Site specific-recombination; Chi sequences in prokaryotes; Gene targeting; Gene disruption; FLP/FRT and Cre/Lox recombination.

Unit IV: Genome Expression

Prokaryotic 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, and gal operons;
Transcriptional control in lambda phage; Transcript processing; Processing of tRNA and rRNA

Prokaryotic Translation: Translation machinery; Ribosomes; Composition and assembly; Universal genetic code; Degeneracy of codons; Termination codons; Isoaccepting tRNA; Wobble hypothesis; Mechanism of initiation, elongation and termination;

Microbial Genetics

Unit I: Bacterial mutants and mutations: Isolation of mutations; useful phenotypes (auxotrophic; conditional lethal; resistant); Mutation rate; Types of mutations (base pair changes; frameshift; insertions; deletions; tandem duplication); Reversion vs. suppression; Genetic Analyses in Bacteria and Fungi.

Gene transfer in bacteria: Conjugation – F, F', Hfr; F transfer; Hfr-mediated chromosome transfer; Transformation – natural and artificial transformation; Merodiploid generation; Gene mapping;

Unit II: Bacteriophages: Bacteriophage – structure; assay; Lambda phage – genetic map, lysogenic and lytic cycles; Gene regulation; Filamentous phages such as M13; History; Transduction – generalized and specialized;

Unit III: Yeast Genetics: Meiotic crosses, tetrad analyses, non-Mendelian and Mendelian ratios, gene conversion, models of genetic recombination, yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, complementation groups, transposon mutagenesis, synthetic lethality, genetic epistasis.

Recommended Textbooks and References:

1. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.
2. 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.
3. Alberts et al; Molecular Biology of the Cell, 4th edition, Garland, 2002.
4. Robert Weaver, Molecular Biology,
5. Molecular Genetics of Bacteria, By Larry Snider and Wendy Champness, 2007
6. Genomes, by T.A. Brown, Garland Science, 3rd Edition, 2006
7. iGenetics: A Molecular Approach, By Peter J. Russell, 2009

MSBT 134: Biomathematics, Biostatistics and Computer

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. Linear programming.

Nature of the roots of an algebraic equation, multiple roots, Descartes' rule of signs; Algebra of matrices, adjoint and inverse of a matrix, rank of a matrix, matrix method of solution of a system of linear equations, consistency of a system of equations, solution of linear equations.

Unit II: Calculus

Differential calculus (limits, derivatives), integral calculus (integrals, sequences and series *etc*.). Successive differentiation, partial differentiation, integration,
Differential equation of first and second order, Applications of first and second order differential equations, Systems of linear differential equations and its applications, partial derivatives, formation of partial differentiation equations and their solutions.

Unit III: Bio-Statistics

Probability: counting, conditional probability, discrete and continuous random variables; Distributions (Binomial, Normal and Poisson) Error propagation; Fitting a curve to an experimental data set -- linear and non-linear fits. Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation & causality, analysis of variance, factorial experiment design.

Unit IV: Computer:

Introduction of Digital computers: organization of low- and high-level languages binary number system.
Flowcharts and programming techniques. Solutions of differential equations, phase plane analysis, bifurcation analysis, sensitivity analysis and parameter estimation using MATLAB.

Perl/R programming and their application in biological sciences, sequence, strings, motifs and loops subroutines and bugs, mutation and randomization genetic code, restriction maps.

Recommended Textbooks and References:

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

MSBT145L: Microbiology and Biochemistry Laboratory

[Practical Microbiology]

1. Sterilization, disinfection and safety in microbiological laboratory.
2. Preparation of media for cultivation of bacteria.
3. Isolation of bacteria in pure culture by streak plate method.
4. Study of colony and growth characteristics of some common bacteria: *Bacillus, E. coli, Staphylococcus, Streptococcus, etc.*
5. Preparation of bacterial smear and Gram's staining.
6. Enumeration of bacteria: standard plate count.
7. Antimicrobial sensitivity test and demonstration of drug resistance.
8. Maintenance of stock cultures: slants, stabs and glycerol stock cultures
9. Determination of phenol co-efficient of antimicrobial agents.
10. Determination of Minimum Inhibitory Concentration (MIC)
11. Isolation and identification of bacteria from soil/water samples.

[Biochemistry]

1. Preparing various stock solutions and working solutions that will be needed for the course.
2. To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation.
3. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer-Lambert's Law.
4. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography.
5. Purification of an enzyme using some of the following techniques:

a) Ammonium Sulfate precipitation
b) Ion-exchange Chromatography
c) Gel Filtration
d) Affinity Chromatography
e) Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method

6. Characterization of the purified Enzyme:

a) Generating a Purification Table (protein concentration, amount of total protein; Computing specific activity of the enzyme preparation at each stage of purification)
b) Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis

c) Enzyme Kinetic Parameters: K_m, V_{max} and K_{cat}.

7. Absorption Spectroscopy for native and Denatured DNA.

MSBT146L: Biophysics, Cell Biology and Genetics Laboratory

Biophysics

1. Introduction to UV-Spectrophotometer, validation of the Beer- Lambert's Law, Analysis of absorption spectrum of DNA, RNA and Protein, Spectrophotometric quantification of DNA, RNA and Protein at specific wavelength and analysis of their quality.
2. Spectrophotometric Analysis of interaction between DNA and Ethidium Bromide.
3. Spectrophotometric Analysis of interaction between Haemoglobin-Na-Azide interaction.
4. Spectrophotometric study of protein unfolding/denaturation kinetics using myoglobing as a model protein.
5. Titration of Acetic Acid and Amino Acid glycine-HCl using pH meter.
6. Identification of an unknown sample as DNA, RNA or protein using available laboratory tools.
7. Purification and separation of a mixture of proteins in Gel Filtration Chromatography
8. Biophysical methods Fluorescence Spectroscopy
9. Spectrofluoremetric Analysis of interaction between DNA and Ethidium Bromide.
10. Spectrofluoremetric Analysis of interaction between BSA-acrylamide.

Cell Biology

1. Cell Viability assay and determination of proliferation indices in cultured mammalian cell.
2. Immunohistochemistry of tissue section.
3. Monitor and measure doubling time of animal cells.
4. Examination of chicken embryo at different developmental stages in presence of stress.

Genetics

1. Microscopic observation of yeast mating reaction eg. smoo formation, crown (diploid yeast cell) and spore formation.
2. Determination of UV-survival curve of Yeast *Saccharomyces cerevisiae followed by* UV mutagenesis to isolate amino acid auxotroph.
3. Genetic Transfer-Conjugation, gene mapping

Semester II

MSBT231: Molecular Biology II and Genetics

Advanced molecular Biology

Unit I: Eukaryotic DNA Replication

Eukaryotic Chromosome Replication and its tight-coupling with the Cell Cycle, initiation of Eukaryotic DNA replication, regulation of eukaryotic DNA replication during cell cycle. Elongation and termination of the eukaryotic replication, problem associated with the ends of the linear chromosome.

Unit II: Eukaryotic Transcription, mRNA processing and Post-transcriptional Modification

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

Unit III: Nuclear mRNA Biogenesis and Post Transcriptional Modifications of Pre-Messenger RNA (4 Lectures): Processing of Ribosomal and transfer RNAs, Co- and post-translational modifications of messenger RNAs; Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA.

Unit IV: Eukaryotic Translation

Features of mRNA template, Ribosomes, Translation termination, Genetic code in mitochondria; Transport of proteins and molecular chaperones; Protein stability; Protein turnover and degradation

Unit V: Regulation of Gene Expression in Eukaryotes

Conserved mechanism of transcriptional regulation from yeast to human, Recruitment of the protein complex to the genes by eukaryotic activators, Signal integration and combinatorial control, transcriptional repressors, Signal transduction and the control of transcriptional regulators, Epigenetic regulation, regulatory RNAs in eukaryotes – miRNAs, biogenesis and function, Long non-coding RNAs and their role in gene regulation in eukaryotic system

Genetics

Unit I: Mendelian Genetics

Introduction to human genetics; Background and history; Types of genetic diseases; Role of genetics in medicine; Human pedigrees; Patterns of single gene inheritance - autosomal recessive; autosomal dominant; X linked inheritance; Complicating factors - incomplete penetrance; variable expression; Multiple alleles; Co dominance; Sex influenced expression; Hemoglobinopathies - Genetic disorders of hemoglobin and their diseases, Genome polymorphism; uses of polymorphism, Physical mapping; linkage and association

Unit II Non Mendelian inheritance patterns

Mitochondrial inheritance; genomic imprinting; Lyon hypothesis; isodisomy. Complex inheritance – genetic and environmental variation; Heritability; Twin studies; Behavioral traits; Analysis of quantitative and qualitative traits

Unit III: Cytogenetics

Cell division and errors in cell division; Non disjunction; Structural and numerical chromosomal abnormalities – deletion; duplication; translocation; Sex determination; Role of Y chromosome; Genetic recombination; Disorders of sex chromosomes and autosomes.

Unit IV: Developmental genetics

Genes in early development; Maternal effect genes; Pattern formation genes; Homeotic genes; and Signaling and adhesion molecules.

Unit V: Population genetics and evolution

Phenotype; genotype; gene frequency; Hardy-Weinberg law; Factors distinguishing Hardy-Weinberg equilibrium; Mutation selection; Migration; Gene flow; Genetic drift. Human genetic diversity; Origin of major human groups.

Recommended Text Books/References

1. Benjamin Lewin, Gene IX, 9th Edition, Jones and Bartlett Publishers, 2007.
2. 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.
3. Robert Weaver, Molecular Biology, 5th Edition, McGraw-Hill, 2012.
4. Molecular Genetics of Bacteria, By Larry Snider and Wendy Champness, 2007
7. Genomes, by T.A. Brown, Garland Science, 3rd Edition, 2006
8. iGenetics: A Molecular Approach, By Peter J. Russell, 2009
10. Anthony J.F. Griffiths, Susan R. Wessler, Richard C. Lewontin, William M. Gelbart, David T. Suzuki, Jeffrey H. Miller, An Introduction to Genetic Analysis, Eleventh Edition,

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

MSBT232: Metabolism and Bioenergetics

Unit I: Oxidation of carbon fuels
glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Electron transport chain; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation.

Unit II: Photosynthesis
Chloroplasts and two photosystems; proton gradient across thylakoid membrane; Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism;

Unit III: Elucidation and Integration of metabolic pathways
Fatty acid metabolism; Protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway.

Unit IV: Bioenergetics: Thermodynamics – Mathematical description of thermodynamic functions- first, second and third law-isothermal process, entropy enthalpy reversible and irreversible process; equilibria and concept of free energy; chemical potential, Gibbs free energy; coupled interconnecting reactions in metabolism; The Nernst potential, Donnan equilibrium, Chemical equilibrium involving macromolecules;

Recommended Text Books/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.

MSBT233: Immunology

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.

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 maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; Cell-mediated immuneresponses and Hypersensitivity

Unit III: Antigen processing and presentation
Endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens.

Unit IV: 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: rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV, KIR complex.

Unit V: Clinical immunology
Transplantation: immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy; tumor immunology:tumor antigens; immune response to tumors and tumor evasion of the immunesystem, 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.

Recommended Textbooks and References:
1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). *Kuby Immunology*. New York: W.H. Freeman.
2. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). *Clinical Immunology.*

London: Gower Medical Pub.
3. Abul K. Abbas, Andrew H. H. Lichtman, and Shiv Pillai, Cellular and Molecular Immunology. 9th Edition
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.

MSBT234: Microbiology

Unit I
History of Microbiology or Development of microbiology as a scientific discipline. Methods of studying microorganisms.

Unit II
Organization and structure of microbes (Morphology of bacteria, yeast and molds, algae, protozoa, virus, prions) [Microbial morphology: capsule, slime layer, pili, flagella cell wall, matrix material, chemotaxis]

Unit III
Bacterial growth and reproduction [Physical and chemical requirement Energy metabolism Autotroph, Phototroph, Lithotroph etc Growth kinetics Specific growth rate Batch Fedbatch and continuous culture Effect of substrate concentration Monod kinetics Definition of Ks Stress response, Classification system Control of microbes by physical and chemical agents].

Unit IV
Microbial interactions (Host microbe interaction Koch's postulates Mechanisms of pathogenicity Diseases Antibiotics and their targets, symbiosis, recycling of matters).

Unit V
Frontiers of Microbiology [Evolution, diversity, Microbes in the extreme environment, Microbes in agriculture Symbiotic Nitrogen fixation , medical biotechnology Industrial Microbiology Food, Secondary metabolites, recombinant products, Environmental Microbiology Waste treatment Xenobiotics Bioremediation , IPR, GMP, GRAS, Process Engineering].

Unit VI
Classification and modes of propagation of bacterial (λ, T4, T7, M13, Qβ, φX174) plant (TMV) and animal viruses (HIV, Baculovirus, Adenovirus), Antiviral agents, interferons.

Recommended Textbooks and References:
1. Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). *Microbiology* (5th ed.)., New York: McGraw-Hill.
2. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). *Prescott's Microbiology*. New York: McGraw-Hill.
3. Matthai, W., Berg, C. Y., & Black, J. G. (2005). *Microbiology, Principles and Explorations*. Boston, MA: John Wiley & Sons.
4. Michael T Madigan and John M Martinko *Brock Biology of Microorganisms* (11th Ed) Prentice Hall

MSBT 235: Bioinformatics

Unit I: Bioinformatics Basics

Bioinformatics basics: Computers in biology and medicine; Introduction to Unix and Linux systems and basic commands; DNA sequence extraction from chromatogram. 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.

Unit II: DNA sequence analysis

DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing. Graph theory and its use in DNA sequence analysis.

Unit III: Multiple sequence analysis

Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.

Unit IV: Protein modeling

Protein modeling; 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.

Unit V: Bioinformatics Laboratory

Using 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).

Recommended Textbooks and References:

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

MSBT234: Bio-analytical Techniques

Unit I: Spectroscopy Techniques
Bimolecular spectroscopy - UV, Visible and Raman and Laser Raman Spectroscopy, Vibrational spectroscopy in biology; Polarization in light scattering Theory and application of linear and Circular Dichroism; Emission Spectroscopy: Fluorescence spectroscopy and its application in biotechnology. Determination MS, NMR, Nuclear Magnetic Resonance spectroscopy, PMR, ESR and Plasma Emission spectroscopy

Unit II: Chromatography Techniques
TLC and Paper chromatography; Chromatographic methods for macromolecule separation - Gel permeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; HPLC and FPLC; Criteria of protein purity

Unit III: Electrophoresis Techniques
Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillary electrophoresis; 2D Electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis

Unit IV: Centrifugation
Basic principles & theory (RCF, Sedimentation coefficient etc); Types of centrifuge - Microcentrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods

Unit IV: Radioactivity
Radioactive & stable isotopes; Pattern and rate of radioactive decay; Units of radioactivity; Measurement of radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle, instrumentation & technique); Brief idea of radiation dosimetry; Cerenkov radiation; Autoradiography; Measurement of stable isotopes; Falling drop method; Applications of isotopes in biochemistry; Radiotracer techniques; Distribution studies; Isotope dilution technique; Metabolic studies; Clinical application; Radioimmunoassay, Radiation Safety.

Unit V: Microscopy
Basic concept of light microscope., Fluorescence microscopy, Confocal, AFM, DIC, Photon microscopy, TEM, SEM, HRSEM, FACs analysis.
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Unit VI: Advanced Techniques:
X-ray Crystallography - Theory and methods; Protein and DNA X-ray Crystallography, API-electrospray and MADI-TOF; Mass spectrometry; Enzyme and cell immobilization techniques; DNA & Peptide Synthesis.

Unit VI: Immunotechniques
ELISA, Immunoprecipitation, diagnosis of infectious diseases, respiratory diseases (influenza etc), Viral diseases –HIV etc, bacterial diseases, enteric diseases, parasitic diseases and mycobacterium diseases, Phage display, immunoarrays. FACs immunocytochemical staining, ELISA for detection of Salmonella in food, ELISA, FACS, FISH techniques. Immunofluorescence technique - Immunoblot analysis of antigens and allergens.

Recommended Text Books/References
1. Freifelder D., Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982.
2. Keith Wilson and John Walker, Principles and Techniques of Practical Biochemistry, 5th Edition, Cambridge University Press, 2000.
3. D. Holme & H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998.
4. R. Scopes, Protein Purification - Principles & Practices, 3rd Edition, Springer Verlag, 1994.
5. Selected readings from Methods in Enzymology, Academic Press.
6. Biophysics: Tools and Techniques. Mark C. Leake,, CRC Press , 2016.
7. Immunodiagnostic Technology and its Applications, Didier Levieux, 2007

Semester III

MSBT 331: Recombinant DNA Technology

Unit I: Tools of Recombinant DNA Technology

1. DNA & RNA manipulating enzymes and other tools used in Recombinant DNA Technology: Restriction endonuclease, DNA polymerases (DNA Pol I, T4, T7, Taq), reverse transcriptase, DNA ligase, Alkaline Phosphatase, Polynucleotide kinase, Terminal Deoxy-nucleotidyl transferase, Topoisomerases, DNase, RNase and others, linkers and adapter, Restriction-modification systems.

2. *Cloning Vectors:* Natural plasmids; their properties and phenotypes; Plasmid biology - copy number and its control; Incompatibility; Plasmid survival strategies; Antibiotic resistance markers on plasmids (mechanism of action and resistance); Genetic analysis using phage and plasmid, Restriction-modification systems: History; types of systems and their characteristics; Methylation-dependent restriction systems; applications, M13 mp vectors; pUC19 and Bluescript vectors.

Bacteriophages; Phagemids; Lambda vectors; Insertion and Replacement vectors; EMBL; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; vaccinia/ bacculo & retroviral vectors; Expression vectors; pMal; GST; pET basedvectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; I nclusion bodies; Methodologies to reduce formation of inclusion bodies; Baculovirus and pichia vectors system, Plant based vectors, Ti and Ri as vectors, Yeast vectors, Shuttle vectors.

Unit II: Techniques of Recombinant DNA Technology

1. Basic methods of Molecular Biology: Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence in situ hybridization; Western Blot, Chromatin Immunoprecipitation; DNA-Protein Interactions-Electromobility shift assay; DNaseI footprinting; Methyl interference assay; RAPD, RFLP, AFLP, PFGE

2. *PCR and Its Applications:* Primer design; Fidelity of thermostable enzymes; DNA polymerases; Types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T vectors; Proof reading enzymes; PCR in gene recombination; Deletion; addition; Overlap extension; and SOEing; Site specific mutagenesis; PCR in molecular diagnostics; Molecular markers, Viral and bacterial detection; PCR based mutagenesis.

3. *Sequencing methods*: Enzymatic DNA sequencing; Chemical sequencing of DNA; Automated DNA sequencing; Emulsion and bridge PCR; 454 pyrosquencing, (SOLiD) sequencing, Solexa Illumina sequencing, RNA sequencing. Restriction Mapping and Site directed mutagenesis

Unit III: Gene Cloning Methods

1. Cloning Methodologies: Isolation and preparation of DNA fragments from prokaryotic and eukaryotic source. Insertion of Foreign DNA into Host Cells; Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning; Expression cloning; Jumping and hopping libraries; Southwestern and Far-western cloning; Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression

Different types of cloning and expression methods of gene in prokaryotic and eukaryotic host cell system using different vectors (by restriction enzyme, PCR product cloning and other methods). Screening and Expression of cloned gene. Subcloning strategies.

Unit IV: Application of Recombinant DNA Technology

Chemical Synthesis of oligonucleotides; Introduction of DNA into mammalian cells; Transfection techniques; Gene silencing techniques; Introduction to siRNA; siRNA technology; Micro RNA; Construction of siRNA vectors; Principle and application of gene silencing; Gene knockouts and Gene Therapy; Creation of knockout mice; Disease model; Somatic and germ-line therapy- in vivo and ex-vivo; Gene replacement; Gene targeting; Transgenics; cDNA and intragenic arrays; Differential gene expression and protein array; stem cells; induced pluripotent stem cells (iPS cells); Therapeutic approach of iPS cells; CRISPR-Cas9 system

Recommended Textbooks and References:

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

MSBT332 : Plant and Microbial Biotechnology

Unit I: Reporter genes, Gene transfer and selection of regenerated transformed plantlets through embryognenesis or multiple shoot emergence. Chloroplast transformation: techniques, relative advantages over nuclear transformation. Determination of copy number: multiple insertion events.

Unit II: Applications of Plant Biotechnology: Biopesticides, Bt toxins and their biology, structure and mode of action of different Bt toxin in relation to host range specificity and toxicity, Other insecticide proteins - characteristic mode of action. Disease resistance genes and their biological use. Metabolic engineering for stress tolerance, nutritional improvement, flower colour and other agronomically important characters. Virus mediated expression of protein regulation of gene expression in plants. Plants as bioreactors. Plant genomics. Importance of Arabidopsis thaliana as a model plant. Molecular markers in plant genomic analysis. Plant virus: RNA and DNA genome and their expression. Importance as vector.

Unit III: Isolation , identification and selection of microbial strains. Strain improvement to increase product formation. Maintenance and preservation of microbial cultures. Aerobic and anaerobic carbon utilization: renewable and nonrenewable substrates.

Unit IV: Waste management: treatment of solid and liquid waste. Bioremediation of xenobiotic compounds. Microbial enzyme production. Microbial fuel and chemical production. Food production involving microbes. Secondary metabolite production. Microbial recovery of metals.

Recommended Textbooks and References:

1. Glazer and Mikado: Microbial Biotechnology, Fundamentals of Applied Microbiology (Freeman)
2. L E Casida , Jr: Industrial Microbiology (New Age Intl Pub)
3. Prescott & Dunn's: Industrial Microbiology (4^{th} Ed) (REED)
4. Manual of Industrial Microbiology and Biotechnology (ASM Press), 2^{nd} Ed: Demain & Davis editors in chief.
5. Algae-Anatomy, Biochemistry and biotechnology-L. Barsanti& P. Gualtieri. Taylor & Francis, 2006.
6. Biotechnology and Plant Disease Management Edited by Zamir K. Punja, S. H. De Boer, Hélène Sanfaçon. CAB Direct.
7. Biotechnology and Plant Breeding, 1st Edition (2014), by Borém & Fritsche-Neto (Elsevier).
8. Plant Biotechnology and Agriculture by Arie Altman and PM Hasegawa (Elsevier 2012).
9. Plant Stress and Biotechnology by by Devarajan Thangadurai, Wei Tang, and Song-Quan Song, Oxford Book Co.

MSBT 333: Genomics and Proteomics

Unit I: Basics of genomics and proteomics
Brief Recapitulation of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast.

Unit II Genome mapping
Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, *in situ* hybridization, comparative gene mapping.

Unit III Genome Sequencing Projects and Genomic Techniques and Tools
Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web, Vectors for large scale genome projects, Clone-by-clone strategy, shotgun sequencing and Sequencing Standards

Unit IV Comparative genomics
Identification and classification of organisms using molecular markers- 16S rRNA typing/ sequencing, SNPs and Pharmacogenomics; use of genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in genome sequence, Human and other vertebrate Genome, Personal genomics, The minimal genome and the Barcode of Life.

Unit V Functional Genomics
Transcriptome analysis for identification and functional annotation of gene, Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in genome, gene function- forward and reverse genetics, gene ethics; protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics; introduction to metabolomics, lipidomics, metagenomics and systems biology.

Unit VI Proteomics
Aims, strategies and challenges in proteomics; Protein separations, protein analyses, Quantitative proteomics, Identification and analysis of proteins by 2D gel electrophoresis, Isoelectric focusing, Spot visualization and picking, Tryptic digestion of protein and peptide fingerprinting; Mass spectrometry, mass spectrum (base peak, molecular ion, fragment ion, metastable ion), Ion source (MALDI, electrospray, chemical ionization), mass analyzer (quadrupole, TOF, Ion trap) ; Detector (multiplier), Clinical proteomics, Protein-protein interaction: solid ELISA, pull-down assay, co-immunoprecipitation, yeast-two hybrid system, application, proteome databases.

Recommended Textbooks and References:

1. Robert Weaver, Molecular Biology, 5th Edition, McGraw-Hill, 2012.
2. Genomes, by T.A. Brown, Garland Science, 3rd Edition, 2006
3. Anthony J.F. Griffiths, Susan R. Wessler, Richard C. Lewontin, William M. Gelbart, David T. Suzuki, Jeffrey H. Miller, An Introduction to Genetic Analysis, Eleventh Edition,
4. Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. (2006) Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
5. Liebler, D. C. (2002). Introduction to Proteomics: Tools for the New Biology. Totowa, NJ: Humana Press.
3. Campbell, A. M., & Heyer, L. J. (2003). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.

MSBT 334: Animal and Developmental Biotechnology

Unit I: Animal Cell Culture

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, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.

Unit II: 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.

Unit III: Developmental Biology

Gametogenesis, fertilization and development: Gamete formation, cell surface molecules in sperm-egg recognition, Zygote, cleavage, morula, blastula, gastrula, 3 germ layers formation and embryogenesis; Morphogenesis and organogenesis: Gamet production and fertilization in Sea urchin; Molecular regulation of development in Drosophila (maternal gene, pair rule gene); Life cycle and certain feature of development in C. elegans, Drosophila; Extraembryonic membrane development in chick

Unit 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; genetic basis for disease resistance in animals; molecular diagnostics of pathogens in plants and animals; detection of meat adulteration using DNA based methods.

Unit V: 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 VI: Molecular Medicine

Therapeutic production of antibodies, antibody mediated drug delivery. Transgenic animals for the production of therapeutic agents, transgenic animals as disease model. Development of targeted drug delivery, Nucleic acid as therapeutic agents.

Unit VII: Molecular Diagnosis

Molecular cytogenetics – Fluorescence In Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH), Recombinant DNA Technology in medicine, Polymerase Chain Reaction in clinical diagnostics, DNA sequencing of representative clones to detect mutation(s), PCR-SSCP to detect mutations.

Unit VIII: Gene therapy

Delivery of therapeutic gene, non viral delivery system, tissue engineering, Ethical problems around prenatal diagnosis.

Recommended Textbooks and References:

1. Glick, B. R., & Pasternak, J. J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, D.C.: ASM Press.
2. Brown, T. A. (2006). Gene Cloning and DNA Analysis: an Introduction. Oxford: Blackwell Pub.
3. Primrose, S. B., & Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
4. Pörtner, R. (2007). *Animal Cell Biotechnology: Methods and Protocols*. Totowa, NJ: Humana Press.
6. Glick, B. R., & Pasternak, J. J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, D.C.: ASM Press.
7. Brown, T. A. (2006). Gene Cloning and DNA Analysis: an Introduction. Oxford: Blackwell Pub.
8. Primrose, S. B., & Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
10. Gordon, I. (2005). Reproductive Techniques in Farm Animals. Oxford: CAB International.
11. Levine, M. M. (2004). New Generation Vaccines. New York: M. Dekker. 12. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press.

MSBT 345L: Laboratory IV: Molecular Biology and Recombinant DNA Technology Laboratory

1. Genomic DNA isolation and Agarose gel electrophoresis
2. Plasmid DNA isolation and DNA quantitation
3. Restriction Enzyme digestion of plasmid DNA
4. Polymerase Chain Reaction and analysis by agarose gel electrophoresis
5. Vector and Insert Ligation
6. Preparation of competent cells
7. Transformation of E. coli with standard plasmids, Calculation of transformation efficiency
8. Confirmation of the insert by Colony PCR and Restriction mapping

MSBT 346L: Immunology Laboratory

1. Double diffusion, Immuno-electrophoresis.
2. SDS-PAGE, Immunoblotting,
3. Separation of mononuclear cells by Ficoll-Hypaque and their cryopreservation.
4. Demonstration of ELISPOT.
5. Demonstration of localization of protein by Indirect immunolabeling

Semester IV

MSBT 431: Selected Topics in Biotechnology

The objective of this course is to provide the students with an exposure of ethical issues, safety, the rights of the intellectual properties, new and emerging techniques of Biotechnology. The module will be executed by exposing the students to the following topics (at least five selected topics each semester). In-house and external experts in the following areas will deliver two/three lectures per topic. Each student will be given the presentation/lecture file and additional study and reading materials to thoroughly study on these topics.

1. Intellectual Property Rights, Biosafety and Bioethics
2. Modeling and Analysis of Bioprocesses Engineering and Technology
3. Cell and Tissue Engineering
4. Molecular Diagnostics and Therapeutics
5. Nanobiotechnology
6. Bioentrepreunership
7. Project Proposal Preparation and Presentation
8. Biological Imaging
9. Protein Engineering
10. Vaccines

At the end of the semester, the students will appear in an examination (MCQ type questions to be given by each subject expert, 5/10 MCQ questions for ten/five topics covered). Based on their performance they will be evaluated.

MSBT 432: Critical Analysis of Research methodology and Scientific Communication Skill

The objectives of this course are to teach the students to think critically when study/read the papers of scientific discoveries, emphasizing whether the methodologies used to do those research were appropriate and relevant, provide them with the ideas how the major and crucial conclusions were deduced, use framework of various methodologies for understanding effective lab practices and scientific communication and appreciate scientific ethics.

The total number of students will be divided into 5-6 groups and each group will be assigned a mentor, who will provide each student a specific topic along with few key reference papers. The student will study the topic, from multiple papers/review articles/papers as needed, deliver a presentation (25 marks), which will be evaluated by all the teachers consisting of one/two external examiners). In addition, they will also write a review article which consists of a background of the

topic, current development in the area, and future perspective describing which way the future research should be directed (25 marks). They will submit their papers within a deadline, which will be evaluated subsequently by all the teachers.

MSBT 433: Student's Project Work and Dissertation

The objectives of this course are to prepare the students to adapt to the research environment and understand how projects are executed in a research laboratory. It will also enable students to learn practical aspects of research and train students in the art of analysis and thesis writing.

In this course each student will be assigned to a scientist/faculty member belonging to a different Research Institute/University to carry out a small research project in his/her laboratory. Each student will be working on a separate problem for 12 weeks/3 months, which would be designed by the external supervisor. At the end of the tenure each students would write a dissertation/thesis on the work they carried out describing in detail the background, materials & methods, results, discussion, future work, and reference as well as present their work in from of panel of examiners consisting of the internal and external examiners. They will be evaluated on the basis of their dissertation (25 marks) and presentation (25 marks).

MSBT 434: Grand Viva

A grand viva examination will be conducted at the end of semester IV which include all the topics taught in all the courses and subjects from semester I to semester IV. The major objective of this course is to test overall knowledge a students gathered during the entire tenure of the M. Sc. in Biotechnology Course at JU and also to prepare the students for the job and Ph. D. interviews for their future job search.

EXAMINATION RULES FOR DEGREE OF MASTER OF SCIENCE COMMON FOR ALL M.SC COURSES (SEMESTER SYSTEM) OF JU UNDER THE FACULTY OF SCIENCE

1. All M.Sc (day) courses will be of two-year four-semester course and all M.Sc (evening) courses will be of three-year four-semester course.- First Semester, Second Semester, Third Semester and Fourth Semester under the Faculty of Science.

2a) **For Day course** -: The Examination shall be held at the end of each semester

2b) Students must pass (a minimum of 40%) separately in every paper of all the four semesters examinations and those who pass in a paper shall not be permitted to sit for the examination in that paper again. Non-appearance in a paper/examination will be count as failure in that paper/ examination and count towards a chance.

3. No student shall be permitted to sit for the M.Sc. examination after the lapse of FIVE ACADEMIC SESSIONS (day) from the SESSION of ADMISSION to the M.Sc. first semester class.

4. Each student will have to pass every paper **separately** in each semester of the programme of study. If a student fails to pass or appear in one or more papers in the first semester and second semester examinations, he/she may appear in that-those paper(s) at the regular semester examination along with the regular students in the next academic session.

A Special Supplementary examination for the third semester and fourth semester (taking both the semester together) will be held normally after 30 days from the publication of fourth semester results. Students, who do not have any back papers in any of the previous 1st & 2nd semesters, shall be only eligible to appear at the supplementary examination. Students who fail to submit their dissertation, seminars and comprehensive viva will not come under the purview of the supplementary examination.

5. A student will appear in all the papers meant for/taken at the regular semester examinations (first semester, second semester, third semester and fourth semester) to be held after the conclusion of the respective semester programme of studies and as per the date announced by the Controller of Examinations on the basis of the Academic calendar, fixed by the Faculty Council for the P.G. & U.G. Studies in Science.

5. A student will carry on with the subsequent semester programme of studies irrespective of the result of the previous semester examination.

7. Student must complete the seminar and submit dissertation/ project before commencement of the fourth semester examination. The grand viva-voce(whenever applicable) will be held after the completion of examination on theoretical and practical papers of the fourth semester examination.

8. Eligibility of a student to sit for any semester examination will be further guided by the existing 'attendance rule' of the Faculty of Science.

9. The dissertation/project will be adjudicated by a panel of examiners, including one external examiner (out side of Jadavpur University) to be appointed by Controller of Examinations in consultation with the Head of the Department.

10. A Viva-voce will be conducted by those examiners who have adjudicated the dissertation/ project. Viva-voce will be a defense of the dissertation/project and it will be treated as a part of the examination. Non-appearance in viva-voce, however, will be count as failure for which candidate will be required to appear at the Special Supplementary Examination provided however provision as laid down in (7) above is applicable to him/her.

11. If a student fails to submit his/her dissertation/project within the stipulated date, he/she may submit the same prior to holding of the fourth semester Special Supplementary Examination. The date of submission will be announced by the Controller of Examinations in consultation with Head of the Department.

12. Student for availing of the number of chance/chances may be required to enroll their names as casual student. Such casual enrolment is required for those who will not be able to clear their back papers/grand viva/seminar/dissertation/project within the regular tenure.

13. For the grand viva (wherever applicable), teachers of the department will be the examiner along with one external examiner (out side Jadavpur University) to be appointed by Controller of Examinations in consultation with the Head of the Department.

14. Pass mark will be 40% in each paper both in theoretical and in practical examination, and /grand viva/seminar/dissertation/project. Candidate securing 60% or more of the aggregate marks in the total number of papers in all the semesters including /grand viva/seminar/dissertation/project will be declared to have passed in First Class and other successful candidates securing 40% and above but below 60% of the aggregate marks in the total number of papers in all the semesters including /grand viva/seminar/dissertation/project will be declared to have passed in Second Class.

15. A student who has passed in all the semester papers in the regular semester examination and submitted his/her project/dissertation/grand viva within the schedule date shall be placed in their

appropriate class and shall hold such position in their respective class list in order of merit as the percentage of marks secured by them may warrant.

16. A student who had appeared in any examination along with the student of the next academic session and / or appeared at the Supplementary Examination and/or submitted/completed his/her project/dissertation/grand viva not at the first chance will be placed in appropriate class in order of merit but shall be placed below the list of the candidates as determined under the clause above irrespective of the fact that he/she might have secured higher aggregate of marks that the candidate whose merit list has been determined according to the same provision.

17. Grafting of a maximum 5 marks among the final semester theoretical papers only may be allowed to the final semester students who have passed all the papers of previous semester examinations. No grafting shall be made from practical papers/project/dissertation/grand viva etc.

18. All the theoretical papers will be evaluated by the internal examiners. Practical/dissertation/ project/grand viva etc. will be evaluated by both internal and external examiners.

19. The result will be declared in grade system for each semester. In the final semester grade card, there will be a provision for indicating both total marks (theoretical and practical) and class obtained.

20. All the other regulations/rules which are not mentioned above (1 to 19) shall be under the existing regulations/rules of the University.

CLASSIFICATION OF GRADES

GRADE	MARKS (Theoretical/Practical)
A	75% and above
B	65% to below 75%
C	50% to below 65%
D	40% to below 50%
X	Below 40% (Failed)