# List of Courses Focus on Employability/ Entrepreneurship/ Skill Development

**Department : *Biotechnology***

**Programme Name : *M.Sc.***

***Academic Year : 2021-2022***

***List of Courses Focus on Employability/ Entrepreneurship/Skill Development***

| Sr. No. | Course Code | Name of the Course |
|---|---|---|
| 1. | MBT 103T | **Plant and Animal Biotechnology** |
| 2. | MBT 104T | **Microbiology** |
| 3. | MBT 106T | **Biostatistics** |
| 4. | MBT 107L | **Biochemistry and Analytical Techniques** |
| 5. | MBT 108L | **Microbiology** |
| 6. | MBT 109L | **Plant and Animal Biotechnology** |
| 7. | MBT 201 T | **Genetic Engineering** |
| 8. | MBT 203T | **Bioinformatics** |
| 9. | MBT 204T | **Genomics and Proteomics** |
| 10. | MBT 205T | **Molecular Diagnostics** |
| 11. | MBT 206T | **Research Methodology and Scientific Communication Skills** |
| 12. | MBT 207T | **Environmental Biotechnology** |
| 13. | MBT 208T | Human Genomics |
| 14. | MBT 209T | **Nanobiotechnology** |
| 15. | MBT 301 T | **Bioprocess Engineering and Technology** |
| 16. | MBT 302T | **Emerging Technologies** |
| 17. | MBT 304T | **Bioentrepreneurship** |
| 18. | MBT 305T | **Intellectual Property Rights, Biosafety and Bioethics** |
| 19. | MBT 306T | **Project Proposal Preparation and Presentation** |

| | | |
|---|---|---|
| 20. | MBT 308T | **Microbial Technology** |
| 21. | MBT 309 T | **Animal Biotechnology** |
| 22. | MBT 310 T | **Computational Biology** |
| 23. | MBT 311 T | **Drug Discovery and Development** |
| 24. | MBT 312 T | **Vaccines** |
| 25. | MBT 313 T | **Protein Engineering** |
| 26. | MBT 314 T | **Medical Microbiology and Infection Biology** |
| 27. | MBT 316L | **Laboratory VI: Bioprocess Engineering and Technology** |
| 28. | MBT 317 L | **Laboratory VII: Bioinformatics** |
| 29. | MBT 401 | Dissertation |

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# Syllabus
## M.Sc.Biotechnology
## (2021-22)

| M.Sc. Biotechnology PG Semester I | | | | |
|---|---|---|---|---|
| Code | Course opted | Subjects | Hours/ week | Credits |
| MBT 101 T | Core -1 | Biochemistry | 03 | 3 |
| MBT 102T | Core -2 | Cell and Molecular Biology | 03 | 3 |
| MBT 103T | Core -3 | Plant and Animal Biotechnology | 03 | 3 |
| MBT 104T | Core -4 | Microbiology | 02 | 2 |
| MBT 105T | Core-5 | Genetics | 02 | 2 |
| MBT 106T | Core-6 | Biostatistics | 03 | 3 |
| | | Laboratory | | |
| MBT 107L | Lab 01 | Biochemistry and Analytical Techniques | 08 | 4 |
| MBT 108L | Lab 02 | Microbiology | 04 | 2 |
| MBT 109L | Lab 03 | Plant and Animal Biotechnology | 04 | 2 |
| | | Total | 32 | 24 |

| M.ScBiotechnologyPG Semester II | | | | |
|---|---|---|---|---|
| Code | Course opted | Subjects | Hours/ week | Credits |
| MBT 201 T | Core -1 | Genetic Engineering | 03 | 3 |
| MBT 202T | Core -2 | Immunology | 03 | 3 |
| MBT 203T | Core -3 | Bioinformatics | 03 | 3 |
| MBT 204T | Core-4 | Genomics and Proteomics | 02 | 2 |
| MBT 205T | Core -5 | Molecular Diagnostics | 02 | 2 |
| MBT 206T | Core -6 | Research Methodology and Scientific Communication Skills | 02 | 2 |
| MBT 207T | Elective-1 | Environmental Biotechnology | 02 | 2 |
| MBT 208T | Elective-1 | Human Genomics | | |
| MBT 209T | Elective-1 | Nanobiotechnology | | |
| *MBT 210S | Elective | MOOCs course to be selected/opted from SWAYAM portal (SWAYAM-BIOTECH-1) | | |
| | | Laboratory | | |
| MBT 211L | Lab 01 | Molecular Biology and Genetic Engineering | 08 | 4 |
| MBT 212 L | Lab 02 | Immunology | 06 | 3 |
| | | Total | 31 | 24 |

| M.ScBiotechnologyPG Semester III | | | | |
|---|---|---|---|---|
| Code | Course opted | Subjects | Hours/ week | Credits |
| MBT 301 T | Core -1 | Bioprocess Engineering and Technology | 03 | 3 |
| MBT 302T | Core -2 | Emerging Technologies | 02 | 2 |
| MBT 303T | Core -3 | Critical Analysis of Classical Papers | 02 | 2 |
| MBT 304T | Core-4 | Bioentrepreneurship | 02 | 2 |
| MBT 305T | Core -5 | Intellectual Property Rights, Biosafety and Bioethics | 02 | 2 |
| MBT 306T | Core -6 | Project Proposal Preparation and Presentation | 02 | 2 |
| MBT 307T | Core -7 | Research Seminar | 02 | 2 |

Department of Biotechnology, GGV

# Plant and Animal Biotechnology

Credits 2

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

**Student Learning Outcomes**
Students should be able to gain fundamental knowledge in animal and plant biotechnology and their applications.

| | |
|---|---|
| **Unit I**<br>**Plant tissue culture andanimalcellculture**<br>10 lectures | Plant tissue culture: totipotency; media preparation – nutrients and plant hormones; sterilization techniques; organogenesis; Somatic embryogenesis; establishment of cultures – callus culture, cell suspension culture, 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:- methods and applications; cybrids; plant cell cultures for secondary metabolite production.<br>Animal cell culture: brief history of animal cell culture; cell culture media and reagents; culture of mammalian cells, primary culture, secondary culture, continuous cell lines, suspension cultures; application of animal cell culture for *in vitro* testing of drugs, testing of toxicity of environmental pollutants, production of human and animal viral vaccines and pharmaceutical proteins. |
| **Unit II**<br>**Plant genetic manipulation**<br>10 lectures | 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; production of industrial enzymes and pharmaceutically important compounds. |
| **Unit III**<br>**Animal reproductive biotechnology and vaccinology**<br>8 lectures | 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 endangered species; Vaccinology: introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production. |
| **Unit IV**<br>**Plant and animal genomics**<br>4 lectures | Overview of genomics – definition, complexity and classification; need for genomics level analysis; methods of analyzing genome at various levels – DNA, RNA, protein, metabolites and phenotype; genome projects and bioinformatics resources for genome research – databases; overview of forward and reverse genetics for assigning function for genes. |

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Unit V

**Molecular mapping and marker assisted selection**

8 lectures

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.

Recommended Textbooks and References:

1. Chawla,H.S.(2000).*IntroductiontoPlantBiotechnology*.Enfield,NH:Science.
2. Razdan,M.K.(2003).*IntroductiontoPlantTissueCulture*.Enfield,NH:Science.
3. Slater,A.,Scott,N.W.,&Fowler,M.R.(2008).*PlantBiotechnology:anIntroduction toGeneticEngineering*.Oxford:OxfordUniversityPress.
4. Buchanan,B.B.,Gruissem,W.,&Jones,R.L.(2015).*Biochemistry&Molecular BiologyofPlants*.Chichester,WestSussex:JohnWiley&Sons.
5. Umesha,S.(2013).*PlantBiotechnology*.TheEnergyAndResources.
6. Glick,B.R.,&Pasternak,J.J.(2010).*MolecularBiotechnology:Principlesand Applications of Recombinant DNA*. Washington, D.C.:ASMPress.
7. Brown,T.A.(2006).*GeneCloningandDNAAnalysis:anIntroduction*.Oxford: BlackwellPub.
8. Primrose,S.B.,&Twyman,R.M.(2006).*PrinciplesofGeneManipulationand Genomics*. Malden, MA: BlackwellPub.
9. Slater,A.,Scott,N.W.,&Fowler,M.R.(2003).*PlantBiotechnology:TheGenetic Manipulation of Plants*. Oxford: Oxford UniversityPress.
10. Gordon,I.(2005).*ReproductiveTechniquesinFarmAnimals*.Oxford: CABInternational.
11. Levine,M.M.(2004).*NewGenerationVaccines*.NewYork:M.Dekker.
12. Pörtner,R.(2007).*AnimalCellBiotechnology:MethodsandProtocols*.Totowa, NJ: HumanaPress.

## Microbiology

Credits: 2

**CourseObjectives**

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

**Student Learning Outcomes**

Students should be able to:

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

Unit I

**Microbial characteristics**

6 lectures

History and scope of microbiology, a brief idea of microbial diversity, Principles of classification of microbes: Morphological, metabolic and molecular criteria for the classification.

Unit II

**Microbial diversity**

9 lectures

Ultra structure and classification of bacteria, fungi, algae and virus, extremophiles. Biotechnological potential of microbes, Growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods (isolation, purification, enrichment techniques and maintenance and enumeration), mode of nutrition

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|---|---|
| Unit III<br>**Control of microorganisms**<br>3 lectures | Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms. Antibiotics, antiviral, antifungal, antimicrobial resistance |
| Unit IV<br>**Microbial genetics**<br>5 lectures | Microbial genetics: modes of genetic exchange in microbe, transformation, transduction, conjugation, evolutionary significance. |
| Unit V<br>**Host-microbes interaction**<br>5 lectures | Host-pathogen interaction, ecological impact of microbes; symbiosis, microbes and nutrient cycles; microbial communication system; bacterial quorum sensing, microbial fuel cells, prebiotics and probiotics, industrial and environmental application of microbes |

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,Principlesand Explorations*.Boston,MA:JohnWiley&Sons.

## Bio-Statistics

Credits 2

**Course Objectives** The objective of this course is to give conceptual exposure of statistics, error analysis, hypothesis testing, and design of experiments in biological systems

**Student Learning Outcomes**

On completion of this course, students should be able to:
- Understand how to sum-arise statistical data;
- Apply appropriate statistical tests based on an unders-tanding of study question, type of study and type ofdata;
- Interpret results of statistical tests and application in biologicalsystems.

| | |
|---|---|
| Unit I<br>**Introduction**<br>5 lectures | Types of biological data (ordinal scale, nominal scale, continuous and discrete logical systems data), frequency distribution and graphical representations (bar graph, histogram, box plot and frequency polygon), cumulative frequency distribution, populations, samples, simple random, stratified and systematic sampling. |

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| | |
|---|---|
| Unit II<br>**Descriptive statistics, Probability and distribution**<br>10 lectures | Measures of Location, Properties of Arithmetic Mean, median, mode, range, Properties of the Variance and Standard Deviation, Coefficient of Variation, Grouped Data, Graphic Methods, Obtaining Descriptive Statistics on the Computer, Case study. Introduction to probability and laws of probability, Random Events, Events-exhaustive, Mutually exclusive and equally likely (with simple exercises), Definition and properties of binomial distribution, Poisson distribution and normaldistribution. |
| Unit III<br>**Correlation and regression analysis, Statistical hypothesis**<br>10 lectures | Correlation, Covariance, calculation of covariance and correlation, Correlation coefficient from ungrouped data Spearson's Rank Correlation Coefficient, scatter and dot diagram, General Concepts of regression, Fitting Regression Lines, regression coefficient, properties of Regression Coefficients, Standard error of estimate. Making assumption, Null and alternate hypothesis, error in hypothesis testing, confidence interval, one-tailed and two-tailed testing, decision making. |
| Unit IV<br>**Tests of significance**<br>8 lectures | Steps in testing statistical significance, selection and computation of test of significance and interpretation of results; Sampling distribution of mean and standard error, Large sample tests (test for an assumed mean and equality of two population means with known S.D.), z-test; Small sample tests (t-test for an assumed mean and equality of means of two populations when sample observations are independent); parametric and Non parametric tests (Mann-Whitney test); paired and unpaired t-test, chi square test. |
| Unit V<br>**Experimental designs**<br>8lectures | Introduction to study designs: Longitudinal, cross-sectional, retrospective and prospective study, Principles of experimental designs, Randomized block, and Simple factorial designs, Analysis of variance (ANOVA) and its use in analysis of Randomized block Design, introduction to meta-analysis and systematic reviews, ethics in statistics. |

Recommended Textbooks and References:

1. Jaype Brothers, (2011), Methods in Biostatistics for Medical Students and Research Workers (English), 7thEdition
2. Norman T.J. Bailey, (1995), Statistical Methods in Biology, 3rd Edition, Cambridge UniversityPress.
3. P. N. Arora and P. K. Malhan, (2006), Biostatistics, 2nd Edition, Himalaya PublishingHouse.
4. Jerold Zar, Biostatistical Analysis, 4th Edition. PearsonEducation.
5. Biostatistics: a Foundation for Analysis in the Health Sciences, 7th Edition, Wiley.
6. ML Samuels, JA Witmer (2003) Statistics for the Life Sciences, 3rd edition. PrenticeHall.

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## Laboratory I: Biochemistry & Analytical Techniques

Credits 4

**Course Objectives**

The objective of this laboratory course is to introduce students to experiments in biochemistry. The course is designed to teach students the utility of set of experimental methods in biochemistry in a problem oriented manner.

**Student Learning Outcomes**

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

- To elaborate concepts of biochemistry with easy to run experiments;
- To familiarize with basic laboratory instruments and understand the principle of measurements using those instruments with experiments in biochemistry.

1. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Larrrbert's Law.
2. Titration of Amino Acids and separation of-aliphatic, aromatic and polar amino acids by thin layer chromatography.
3. Purification and characterization of an enzyme from a microbial source.
   a) Preparation of cell-free lysates
   b) Ammonium sulfate precipitation
   c) Ion-exchange Chromatography
   d) Gel Filtration
   e) Affinity Chromatography
   f) Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage methoc
   g) Generating a Purification Table
   i) Enzyme Kinetic Parameters: *Km*, *V*max and *K*cat.
6. Identification of an unknown sample as DNA, RNA or protein using available laboratory tools. (Optional Experiments)
7. Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy).
8. Determination of mass of small molecules and fragmentation patterns by Mass spectrometry.

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# LaboratoryII: Microbiology

Credits 2

**Course Objectives**

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

**Student Learning Outcomes**

Students should be able to:

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

## Syllabus

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

**Recommended Textbooks and References:**

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

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# Laboratory III: Plant and Animal Biotechnology

Credits 2

**Course Objectives**
Theobjectivesofthiscoursearetoprovide hands-on training in basic experiments of plant and animalbiotechnology.

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

**Syllabus**
**Plant Biotechnology**

1. Prepareculturemediawithvarioussupplementsforplanttissueculture.
2. PrepareexplantsofVallerianawallichiiforinoculationunderasepticconditions.
3. Attempt*invitro*androandgynogenesisinplants*(Daturastramonium)*.
4. Isolate plant protoplast by enzymatic and mechanical methods and attempt fusion by PEG (availablematerial).
5. Culture*Agrobacteriumtumefaciens*andattempttransformationofanydicotspecies.
6. GenerateanRAPDandISSRprofileof*Eremuruspersicus*and*Valerianawallichii*.
7. Preparekaryotypesandstudythemorphologyofsomaticchromosomesof*Alliumcepa, A.sativum,A.tuberosum*andcomparethemonthebasisofkaryotypes.
8. Pollenmothercellmeiosisandrecombinationindexofselectspecies (oneachiasmate, and the other chiasmate) and correlate with generation of variation.
9. Undertake plant genomic DNA isolation by CTAB method and its quantitation by visual as well as spectrophotometericmethods.
10. PerformPCRamplificationof'n'numberofgenotypesofaspeciesforstudyingthe geneticvariationamongtheindividualsofaspeciesusingrandomprimers.
11. Study genetic fingerprinting profiles of plants and calculate polymorphic informationcontent.

**Syllabus**
**AnimalBiotechnology**

1. Countcellsofananimaltissueandchecktheirviability.
2. Prepare culture media with various supplements for plant and animaltissueculture.
3. Prepare single cell suspension from spleenandthymus.
4. Monitor and measure doubling time ofanimalcells.
5. Chromosome preparations from cultured animalcells.
6. Isolate DNA from animal tissue bySDSmethod.
7. Attempt animal cell fusion usingPEG.

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## Semester Two

# Genetic Engineering

Credits

3

**Course Objectives**

The objectives of this course are to teach students with various approaches to conducting genetic engineering and their applicationsinbiologicalresearchaswell as in biotechnology industries. Genetic engineering is a technology that hasbeen developed based on our fundamental understanding of the principles of molecular biology and this is reflectedin the contents of thiscourse.

**Student Learning Outcomes**

Given the impact of genetic engineering in modern society, the students should be endowed with strong theoretical knowledge of this technology. In conjunction with the practicals in molecularbiology&geneticengineering, the students should be able to takeup biological research as well as placement in the relevant biotech industry.

| | |
|---|---|
| Unit I<br>**Introduction and tools forgeneticengineering**<br>6 lectures | Restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailihg; labeling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence in situ hybridization. |
| Unit II<br>**Different types of vectors**<br>7 lectures | Plasmids; Bacteriophages; Ml3 mp vectors; PUC19 and Bluescript vectors, Phagemids; Lambda vectors; Insertion and Replacement vectors; cosmids; Aftificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression, expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; Mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri as vectors. |
| Unit III<br>**Different types of PCR techniques**<br>7 lectures | Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR - cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics: viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP. |
| Unit IV<br>**Genemanipulation and protein-DNA interaction**<br>7 lectures | Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNasefootprinting; methyl interference assay, chromatin immunoprecipitation ; protein-protein interactions using yeast two-hybrid system; phage display. |
| Unit V<br>**Gene silencing and genome editing technologies**<br>13 lectures | Gene silencing techniques; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; Transgenics- gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS. |

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## Bioinformatics

Credits

3

**Course Objectives**

Theobjectivesofthiscoursearetoprovide theory and practical experience ofthe use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.

**Student Learning Outcomes**

Student should be able to :

- Develop an understanding of basic theory of these computationaltools;
- Gain working knowledge of these computational tools andmethods;
- Appreciate their relevance for investigating specificcontemporarybiologicalque stions;
- Critically analyse and interpretresults of theirstudy.

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| | |
|---|---|
| Unit I<br>**Bioinformatics basics**<br>5 lectures | 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 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<br>**DNA sequence analysis**<br>5 lectures | 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. |
| Unit III<br>**Multiple sequence analysis**<br>5 lectures | 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, updating submitted sequences, methods of phylogenetic analysis. |
| Unit IV<br>**Protein modelling**<br>5 lectures | Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; assigning secondary structures; sequence alignment- methods, evaluation, scoring |
| Unit V<br>**Protein structure prediction and virtual library**<br>6 lectures | Protein structure prediction: protein folding and model generation; secondary structure prediction; analyzing secondary structures; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; structure aided sequence techniques of structure prediction; structural profiles, alignment algorithms, sequence based methods of structure prediction, significance analysis, scoring techniques, protein function prediction; elements of in silico drug design; Virtual library |

**Recommended Textbooks and References:**

1. Lesk,A.M.(2002).*IntroductiontoBioinformatics*.Oxford:OxfordUniversityPress.
2. Mount,D.W.(2001).*Bioinformatics:SequenceandGenomeAnalysis*.ColdSpring Harbor, NY: Cold Spring Harbor LaboratoryPress.
3. Baxevanis,A.D.,&Ouellette,B.F.(2001).*Bioinformatics:aPracticalGuidetothe Analysis of Genes and Proteins*. NewYork:Wiley-Interscience.
4. Pevsner,J.(2015).*BioinformaticsandFunctionalGenomics*. Hoboken, NJ.:Wiley-Blackwell.
5. Bourne,P.E.,&Gu,J.(2009).*StructuralBioinformatics*.Hoboken,NJ:Wiley-Liss.
6. Lesk, A.M.(2004).*IntroductiontoProteinScience:Architecture,Function,and Genomics*. Oxford: Oxford UniversityPress.

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# Genomics and Proteomics

Credits

2

**Course Objectives**

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

**Student Learning Outcomes**

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

| | | |
|---|---|---|
| Unit I | **Basics of genomics** 3 lectures | Brief overview of prokaryotic and eukaryotic genome organization. Extrachromosomal DNA: bacterial plasmids, mitochondria and chloroplast DNA |
| Unit II | **Genome mapping** 4 lectures | 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** 3 lectures | Genome sequencing, methods for whole genome sequencing. Contig assembly, chromosome walking and characterization of chromosomes, gene identification, gene annotation, forward and reverse genetics. Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web. |
| Unit IV | **Comparative genomics** 5 lectures | Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; Transcriptome analysis, gene ethics; genomics as a tool for evolutionary studies, disease diagnosis and drug designing; Introduction to metabolomics, lipidomics, metagenomics and systems biology. |
| Unit V | **Proteomics** 5 lectures | Proteomics: Aims, strategies and challenges; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases, protein chips and functional proteomics; protein-protein and protein-DNA interactions, clinical and biomedical applications of proteomics |

**Recommended Textbooks and References:**

1. Primrose, S.B., Twyman, R.M., Primrose, S.B., & Primrose, S.B. (2006). *Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.
2. 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.

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# Molecular Diagnostics

Credits

2

**Course Objectives**

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

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

| | |
|---|---|
| Unit I<br>**Genome biology in health and disease**<br>4 lectures | Central dogma of molecular biology; human identity; chromosomal abbreviations and diseases; gene linked disorders; clinical variability and genetically determined adverse reactions to drugs. |
| Unit II<br>**Genome: resolution, detection & analysis**<br>8 lectures | PCR and its variants (Real-time; ARMS, Multiplex); In-situ hybridization; Fluorescence in-situ hybridization (FISH); Nucleic acid sequencing; Microarray; Molecular markers; Diagnostic proteomics |
| Unit III<br>**Detection of inherited diseases**<br>8 lectures | Direct detection and identification of pathogenic organisms (culturable and unculturable) Detection of inherited diseases, mutational mechanism of unstable triplet repeats, familial cancer syndromes. |
| Unit VI<br>**Molecular oncology**<br>6 lectures | Detection of recognized genetic aberrations in clinical samples from cancer patients; Predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma, targeted therapies |
| Unit VII<br>**Diagnostic metabolomics, Quality assurance and control**<br>4 lecture | Metabolite profile for biomarker detection in the body fluids/tissues in various metabolic disorders by using LCMS & NMR technological platforms.Quality oversight; regulations and approved testing. |

**Recommended Textbooks and References:**

1. Campbell,A.M.,&Heyer,L.J.(2006).*DiscoveringGenomics,Proteomics, and Bioinformatics*. San Francisco:BenjaminCummings.
2. Brooker,R.J.(2009).*Genetics:Analysis&Principles*.NewYork,NY:McGraw-Hill.

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3. Glick, B.R., Pasternak, J.J., & Patten, C.L. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. Washington, DC: ASM Press.
4. Coleman, W.B., & Tsongalis, G.J. (2010). *Molecular Diagnostics: for the Clinical Laboratorian*. Totowa, NJ: Humana Press.

# Research Methodology and Scientific Communication Skills

Credits: 2

**Course Objectives**

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

**Student Learning Outcomes**

Students should be able to:

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

| | |
|---|---|
| Unit I<br>**History of science and science methodologies**<br>8 lectures | Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology. |
| Unit II<br>**Preparation for research**<br>2 lectures | Choosing a mentor, lab and research question; maintaining a lab notebook. |
| Unit III<br>**Process of communication**<br>5 lectures | Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; barriers to effective communication; non-verbal communication-interpreting non-verbal cues; importance of body language, power of effective listening; recognizing cultural differences; Presentation skills-formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness. |
| Unit IV<br>**Scientific communication**<br>9 lectures | Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers- peer review process and problems, recent developments such as open access and non-blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct. |

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Department of Biotechnology, GGV

# Environmental Biotechnology

Credits 2

**Course Objectives**

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

**Student Learning Outcomes**

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

| | |
|---|---|
| Unit I<br>**Introduction to environment**<br>6 lectures | Introduction to environment; Pollution: air, water, soil, noise; pollution indicators; Climate change, Biodiversity and its conservation; bio geochemical cycles; microbial ecology. |
| Unit II<br>**Waste Management**<br>8 lectures | Waste management: domestic, industrial, and hazardous wastes (storage, transportation, treatment and disposal); solid waste management, wastewater characteristics and treatment, treatment strategies for effluent generated by distillery, paper and pulp industries, textile industries; waste to energy, recycling and reuse. |
| Unit III<br>**Bioremediation**<br>8 lectures | Bioremediation: Fundamentals, technological aspects and strategies, bioremediation of metals, radionuclides, organic pollutants/xenobiotic; Application of bacteria and fungi in bioremediation; Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration, phytostabilization). |
| Unit IV<br>**Biotechnology and agriculture**<br>11 lectures | Biopesticides, Bioinsecticides, Biofungicides, Bioherbicides: genetic modifications mode of actions; Biofertilizers: Symbiotic systems between plants–microorganisms, Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application. |
| Unit V<br>**Biofuels**<br>8 lectures | Biofuels: production of biogas; bioethanol; biodiesel; Utilizable biomass, microorganisms and biotechnological interventions for optimization of production, Microbial Fuel Cells, Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Bioplastic. |

Recommended Textbooks and References:

1. G.M. Evans and J. C. Furlong (2003), *Environmental Biotechnology: Theory*

**Recommended Textbooks and References:**

1. RajagopalVadivambal,DigvirS.Jayas.(2015).*Bio-Imaging:Principles,Techniques, and Applications*. ISBN 9781466593671 -CAT#K20618.
2. AlbertoDiaspro,MarcA.M.J.vanZandvoort.(2016).*Super-ResolutionImagingin Biomedicine*. ISBN 9781482244342 -CAT#K23483.
3. Taatjes,Douglas,Roth,Jürgen(Eds.).(2012).*CellImagingTechniquesMethodsand Protocols*. ISBN978-1-62703-056-4.

**Human Genomics**

**(Credits 2)**

**Unit I: Studying human chromosomes**

Chromosomes identification by size and staining pattern, Chromosome banding (G-banding, Q-banding, R-banding, T-banding, C-banding), Molecular cytogenetics (Chromosome fluorescence *in situ* hybridization (FISH), Chromosome painting and molecular karyotyping, Comparative genome hybridization (CGH)); Chromosome abnormalities (Numerical chromosomal abnormalities involve gain or loss of complete chromosomes: Polyploidy, Aneuploidy, Mixoploidy, Clinical consequences); Structural chromosomal abnormalities resulting from misrepair or recombination errors.

**Unit II: Analyzing the Structure and Expression of Genes and Genomes**

DNA library: Genomic DNA libraries, cDNA libraries, Library screening, Library amplification and dissemination. Sequencing DNA: Dideoxy DNA sequencing involving enzymatic DNA synthesis using base-specific chain terminators, Automation of dideoxy DNA sequencing, Iterative pyrosequencing, Massively parallel DNA sequencing for simultaneous sequencing of huge numbers of different DNA fragments. Genome structure analysis and genome projects, The linear ordering of genomic DNA clones in a contig and matching their original subchromosomal locations. The Human Genome Project as an international endeavor and biology's first Big Project, Major milestones in mapping and sequencing the human genome.

**Unit III: Basic gene expression analyses**

Different levels of expression mapping: tissue *in situ* hybridization, cellular *in situ* hybridization, northern blot hybridization, RNA dot-blot hybridization, ribonuclease protection assay, RT-PCR/qPCR, DNA microarray hybridization; Detection methods used in quantitative real time PCR: Nonspecific detection using SYBR Green I Dye, Specific detection by hybridization probes by Molecular Beacon probes and TaqMan double-dye probes.

**Unit IV: Organization of the Human Genome**

General organization of the human mitochondrial and nuclear genome, Distribution of genes within chromosomes, Duplication of DNA segments resulting in copy-number variation and gene families, Protein coding genes, The origins, prevalence, and functionality of pseudogenes, RNA genes (Ribosomal RNA genes, Transfer RNA genes, Spliceosomal small nuclear RNA (snRNA) genes, Non-spliceosomal small

nuclear RNA genes, Small nucleolar RNA (snoRNA) genes, Small Cajal body RNA genes, major classes of human noncoding RNA), Highly repetitive DNA: heterochromatin and transposon repeats

**Unit V: Human Genetic Variability and Its Consequences**

Types of variation between human genomes, Single nucleotide polymorphisms, Polymorphic variation in interspersed and tandem repeated sequences, Large-scale variations in copy number in human genomes, Common markers used in constructing framework DNA maps of complex genomes: Restriction fragment length polymorphism (RFLP), Microsatellite, Single nucleotide polymorphism (SNP); Sequence-tagged site (STS) Expressed sequence tag (EST).

**Recommended Textbooks and References:**


- Human Molecular Genetics By Tom Strachan and Andrew Read
- Brown TA. Genomes. 2nd edition. Oxford: Wiley-Liss; 2002. Chapter 1, The Human Genome. Available from: https://www.ncbi.nlm.nih.gov/books/NBK21134/

# Nano-biotechnology

Credits

3

**Course Objectives**

The course aims at providing a generaland broad introduction to multi-disciplinary field of nanotechnology. It will familiarize students with the combination ofthe top-down approach of microelectronics and micromechanics with the bottom-up approach of chemistry/biochemistry; a development that is creating new and excitingcross-disciplinaryresearchfields andtechnologies. Thecoursewillalsogive an insight into complete systems where nanotechnology can be used to improve our everydaylife.

**Student Learning Outcomes**

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

| | |
|---|---|
| Unit I<br>**Introduction to nanobiotechnology** | Introduction to Nanobiotechnology; Concepts, historical perspective; Classification of nanomaterials with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials |
| Unit II<br>**Nano – films** | Nano - films Thin films; Colloidal nanostructures; Self Assembly; Nanovesicles; Nanospheres; Nanocapsules and their characterisation. Nanomaterials for catalysis, development and characterization of nanobiocatalysts, applications of nanobiocatalysis in the production of drugs |
| Unit III<br>**Nano – particles** | Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers. |
| Unit IV<br>**Applications Of nano–particles** | Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development. Applications of nano-particles |
| Unit V<br>**Nano–toxicity**<br>5 lectures | Nano-toxicity: Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment; Ecotoxicity models and assays. |

Recommended Textbooks and References:

1. GeroDecher, Joseph B. Schlenoff,(2003); *Multilayer Thin Films: Sequential Assembly ofNanocompositeMaterials*,Wiley-VCHVerlagGmbH&Co.KGaA
2. DavidS.Goodsell,(2004);*Bionanotechnology:LessonsfromNature*;Wiley-Liss
3. NeelinaH.Malsch(2005),*BiomedicalNanotechnology*,CRCPress
4. GregT.Hermanson,(2013);*BioconjugateTechniques*,(3rdEdition);Elsevier
5. Recentreviewpapersintheareaof Nanomedicine.

| M.Sc Biotechnology PG Semester III | | | | | |
|---|---|---|---|---|---|
| Code | Course opted | Subjects | Hours/ semester | Hours/ week | Credits |
| MBT 301 T | Core -1 | Bioprocess Engineering and Technology | 48 | 03 | 3 |
| MBT 302T | Core -2 | Emerging Technologies | 32 | 02 | 2 |
| MBT 303T | Core -3 | Critical Analysis of Classical Papers | 32 | 02 | 2 |
| MBT 304T | Core-4 | Bioentrepreneurship | 32 | 02 | 2 |
| MBT 305T | Core -5 | Intellectual Property Rights, Biosafety and Bioethics | 32 | 02 | 2 |
| MBT 306T | Core -6 | Project Proposal Preparation and Presentation | 32 | 02 | 2 |
| MBT 307T | Core -7 | Research Seminar | 32 | 02 | 2 |
| MBT 308T | Elective | Microbial Technology | 48 | 03 | 3 |
| MBT 309 T | Elective | Animal Biotechnology | | | |
| MBT 310 T | Elective | Computational Biology | | | |
| MBT 311 T | Elective | Drug Discovery and Development | | | |
| MBT 312 T | Elective | Vaccines | | | |
| MBT 313 T | Elective | Protein Engineering | | | |
| MBT 314 T | Elective | Medical Microbiology and Infection Biology | | | |
| *MBT 315T | Elective | MOOCs course to be selected/opted from SWAYAM portal (SWAYAM-BIOTECH-1) | | | |
| | | Laboratory | | | |
| MBT 316L | Lab 01 | Laboratory VI: Bioprocess Engineering and Technology | 128 | 08 | 4 |
| MBT 317 L | Lab 02 | Laboratory VII: Bioinformatics | 64 | 04 | 2 |
| | | Total | 480 | 30 | 24 |
| M.Sc Biotechnology PG Semester IV | | | | | |
| Code | Course opted | Subjects | Hours/ semester | Hours/ week | Credits |
| MBT 401 | Core -1 | Dissertation | 512 | 32 | 22 |
| | | Total | 512 | 32 | 22 |
| Credits | | | | Total | 94 |

*M.Sc. Biotechnology students will select Massive Open Online Course (MOOCs)-SWAYAM course in the II and III semester available at http://ugcmoocs.inflibnet.ac.in/courses.php in consultation with Coordinator.

# Bioprocess Engineering & Technology

Credits 3

**Course Objectives**

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

**Student Learning Outcomes**

Students should be able to:

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

| | |
|---|---|
| Unit I<br>**Basic principles of biochemical engineering**<br>4 lectures | Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics. |
| Unit II<br>**Stoichiometry and models of microbial growth**<br>4 lectures | Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth. |
| Unit III<br>**Bioreactor design and analysis**<br>8 lectures | Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation v/s biotransformation; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters. |
| Unit IV<br>**Downstream processing and product recovery**<br>8 lectures | Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging. |
| Unit V<br>**Fermentation economics**<br>4 lectures | Isolation of micro-organisms of potential industrial interest; strain improvement; market analysis; equipment and plant costs; media; sterilization, heating and cooling; aeration and agitation; bath-process cycle times and continuous cultures; recovery costs; water usage and recycling; effluent treatment and disposal. |
| Unit VI<br>**Applications of enzyme technology in food processing**<br>4 lectures | Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions *e.g.* starch and sugar conversion processes; high-fructose corn syrup; interesterified fat; hydrolyzed protein etc. and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing. |
| Unit VII<br>**Applications of microbial technology in food process operations and production, biofuels and biorefinery**<br>4 lectures | Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria – production and applications in food preservation; biofuels and biorefinery |

# Emerging Technologies

Credits 2

**Course Objectives**

This course is broad-based in nature encompassingseveralnewtechnologies that current experimental researchers areemployingtoprobecomplexsystem biologyquestionsinlife-sciences.The objectivesofthiscoursearetoteachbasics of the new principles to students so as to appreciate current-day research tool-kit better.

**Student Learning Outcomes**

Students should be to learn history, theoretical basis and basic understanding of latest technologies in area of biotechnology. They should also be able to learn about various applications of thesetechnologies.Thestudentsmayalso learn one application in depth through an assignment and/orseminar.

| | |
|---|---|
| Unit I<br>**Optical microscopy methods**<br>8 lectures | **Basic Microscopy:** Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Darkfield; Phase Contrast; Differential Interference Contrast; fluorescence and fluorescence microscopy: what is fluorescence, what makes a molecule fluorescent, fluorescence microscope; optical arrangement, light source; filter sets: excitation filter, dichroic mirror, and barrier, optical layout for image capture; CCD cameras; back illumination, binning; recording color; three CCD elements with dichroic beamsplitters, boosting the signal. |
| Unit II<br>**Mass spectroscopy**<br>4 lectures | Ionizationtechniques;massanalyzers/overviewMS;FT-ICRandOrbitrap,fragmentation ofpeptides;proteomics,nanoLC-MS;Phosphoproteomics;interactionproteomics,mass spectroscopy in structural biology; imagingmassspectrometry. |
| Unit III<br>**Systems biology**<br>3 lectures | High throughput screens in cellular systems, target identification, validation of experimental methods to generate the omics data, bioinformatics analyses, mathematical modeling and designing testable predictions. |
| Unit IV<br>**Structural biology**<br>3 lectures | X-raydiffractionmethods,solution&solid-stateNMR,cryo-electronmicroscopy,small-angle X-ray scattering, Atomic forcemicroscopy. |
| Unit V<br>**CRISPR-CAS**<br>6 lectures | History of its discovery, elucidation of the mechanism including introduction to all themolecularplayers,developmentofapplicationsfor*invivo*genomeengineeringfor geneticstudies,promiseofthetechnologyasanextgenerationtherapeuticmethod. |
| Unit VI<br>**Nanobodies**<br>4 lectures | Introduction to nanobodies, combining nanobody with phage-display method for development of antibody against native proteins, nanobody as a tool for protein structure-function studies, use of nanobodies for molecular imaging, catabolic antibodies using nanobodies. |

# Bioentrepre-neurship

Credits

3

**Course Objectives**

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

**Student Learning Outcomes**

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

| | |
|---|---|
| Unit I<br>**Innovation and entrepreneurship in bio-business**<br>8 lectures | Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (*e.g.* pharmaceuticals *vs.* Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies. |
| Unit II<br>**Bio markets - business strategy and marketing**<br>8 lectures | Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills. |
| Unit III<br>**Finance and accounting**<br>8 lectures | Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology. |
| Unit IV<br>**Technology management**<br>8 lectures | Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP). |

# Intellectual Property Rights, Biosafety and Bioethics

Credits 2

**Course Objectives**

The objectives of this course are:

- To provide basic knowledge on intellectual property rights and their implications in biological researchand product development;
- To become familiar withIndia's IPR Policy;
- To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products;
- To become familiar with ethical issues in biological research. This course will focus on consequences of biomedical research technologiessuch as cloning of whole organisms, genetic modifications, DNA testing.

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

- Understand the rationale for and against IPR and especiallypatents;
- Understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations;
- Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents;
- Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms, national and international regulations;
- Understand ethical aspects related to biological, biomedical, health care and biotechnology research.

**Unit I**
**Introduction to IPR**
5 lectures

Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art'; invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.

**Unit II**
**Patenting**
5 lectures

Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting-introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.

**Unit III**
**Biosafety**
5 lectures

Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools.

**Unit IV**
**National and international regulations**
5 lectures

International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).

**Unit V**
**Bioethics**
5 lectures

Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Humanand animal experimentation, animal rights/welfare, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.

# Project Proposal Preparation& Presentation

Credits

2

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

Students should be able to demonstrate the following abilities:

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

Syllabus

## Project Proposal Preparation

Selection of research lab and research topic: Students should first select a lab wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven.

Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources.

Writing Research Proposal: With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, *etc.* Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for dissertation.

Syllabus

## PosterPresentation

Students will have to present the topic of their project proposal after few months of their selection of the topic. They should be able to explain the novelty and importance of their research topic.

Syllabus

## Oral Presentation

At the end of their project, presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.

# Laboratory VI: Bioprocess Engineering & Technology

Credits

4

**Course Objectives**

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

**Student Learning Outcomes**

**Students should be able to:**

- **Investigate, design and conduct** experiments, analyze and interpret data, and apply the laboratory skills to solve complex bioprocess engineering problems;
- Apply skills and knowledge gained will be useful in solving problems typical of bio industries and research.

## Syllabus

1. Basic Microbiology techniques
   a) Scale up from frozen vial to agar plate to shake flask culture.
   b) Instrumentation: Microplate reader, spectrophotometer, microscopy.
   c) Isolation of microorganisms from soil samples.
2. Experimental set-up
   a) Assembly of bioreactor and sterilization.
   b) Growth kinetics.
   c) Substrate and product inhibitions.
   d) Measurement of residual substrates.
3. Data Analysis
   a) Introduction to Metabolic Flux Analysis (MFA).
4. Fermentation
   a) Batch.
   b) Fed-batch.
   c) Continuous.
5. Unit operations
   a) Microfiltrations: Separation of cells frombroth.
   b) Bioseparations: Various chromatographic techniques and extractions.
6. Bioanalytics
   a) Analytical techniques like HPLC, FPLC, GC, GC-MS *etc.* for measurement of amounts of products/substrates.

# Laboratory VII: Bioinformatics

Credits


## Course Objectives

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

## Student Learning Outcomes

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

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

## Syllabus

1. Using NCBI and Uniprot web resources.
2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt.
4. Similarity searches using tools like BLAST and interpretation of results.
5. Multiple sequence alignment using ClustalW.
6. Phylogenetic analysis of protein and nucleotidesequences.
7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8. Using RNA structure prediction tools.
9. Use of various primer designing and restriction site predictiontools.
10. Use of different protein structure prediction databases (PDB, SCOP, CATH).
11. Construction and study of protein structures using Deepview/PyMol.
12. Homology modelling of proteins.
13. Use of tools for mutation and analysis of the energy minimization of protein structures.
14. Use of miRNA prediction, designing and target predictiontools.

## Semester Four

### Dissertation

Credits

24

*(Semester III: 4 Credits; Semester IV: 20 Credits)*

**Course Objectives**

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

**Student Learning Outcomes**

Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments. Students should be able to demonstrate considerable improvement in the following areas:

- In-depth knowledge of the chosen area of research.
- Capability to critically and systematicallyintegrate knowledge to identify issues that must be addressed within framework of specific thesis.
- Competence in research design and planning.
- Capability to create, analyse and criticallyevaluatedifferenttechnical solutions.
- Ability to conductresearch independently.
- Ability to perform analytical techniques/experimentalmethods.
- Project managementskills.
- Report writingskills.
- Problem solvingskills.
- Communication and interpersonal skills.

| | |
|---|---|
| Syllabus<br>**Planning & performing experiments** | Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment. |
| Syllabus<br>**Thesis writing** | At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application. |

## Recommended Electives

### Biological Imaging

Credits: 2

**Course Objectives**

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

**Student Learning Outcomes**

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

capture images and the epi-fluorescence illumination source can be a mercury lamp, xenon lamp, LED's, etc. Each of light sources require carefully matched interference filters for specific excitation and emission wavelengths of your fluorophore of interest. With widefield microscopy, your specimen is only exposed to excitation light for relatively short time periods as the full aperture of emission light is collected by the objectives. Widefield fluorescence microscopy can be used in combination with other common contrast techniques such as phase contrast and differential interference contract (DIC) microscopy. This combination is useful when performing live-cell imaging to examine general cell morphology or viability while also imaging regions of interest within cells.

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| Unit II<br>**Confocal laser scanning microscopy (CLSM)**<br>3 lectures | CLSM has ability to eliminate out-of-focus light and information. It is also possible to obtain optical serial sections from thicker specimens. A conjugate pinhole in optical path of confocal microscope prevents fluorescence from outside of focal plane from being collected by photomultiplier detector or imaged by camera. In CLSM, a single pinhole (and single focused laser spot) is scanned across specimen by scanning system. This spot forms a reflected epi-fluorescence image back on original pinhole. When specimen is in focus, fluorescent light from it passes through pinhole to detector. Any out-of-focus light is defocused at pinhole and very little of this signal passes through to detector meaning that background fluorescence is greatly reduced. The pinhole acts as a spatial filter for emission light from the specimen. |
| Unit III<br>**Spinning discconfocal microscopy(SDCM)**<br>2 lectures | Thismethodutilisesa'NipkowDisc'whichisamechanicalopaquediscwhichhas aseriesofthousandsofdrilledoretchedpinholesarrangedinaspiralpattern.Each illuminated pinhole on disc is imaged by microscope objective to a diffraction-limited spot on region of interest on specimen. The emission from fluorophores passes back though Nipkow disc pinholes and can be observed and captured by a CCD camera. The effect of spinning disc is that many thousands of points on specimen are simultaneously illuminated. Using SDCM to examine a specimen means that real-time imaging (30-frames-per-secondorfaster)canbeachieved,whichisextremelyusefulifyouare lookingatdynamicchangeswithinlivingcellsoverawidespectrumoftime-scales. |
| Unit IV<br>**Light-sheet fluorescence microscopy (LSFM, or SPIM)**<br>2 lectures | Thismethodenablesonetoperformlive-cellimagingonwholeembryos,tissuesand cellspheroids*invivo* inagentle mannerwithhightemporalresolutionandinthree dimensions. One is able to track cell movement over extended periods of time and follow development of organs and tissues on a cellular level. The next evolution of light-sheet fluorescence microscopy, termed lattice light-sheet microscopy as developed by Eric Betzig (Nobel Prize Laureate 2014 for PALM super-resolution microscopy) will even allow live-cell imaging with super-resolved *in vivo* cellular localization capabilities. |
| Unit V<br>**Super-resolved fluorescence microscopy**<br>8 lectures | Super-Resolution in a Standard Microscope: From Fast Fluorescence Imaging to Molecular Diffusion Laws in Live Cells; Photoswitching Fluorophores in Super-Resolution Fluorescence Microscopy; Image Analysis for Single-Molecule Localization Microscopy Deconvolution of Nanoscopic Images; Super-Resolution Fluorescence Microscopy of the Nanoscale Organization in cells; Correlative Live-Cell and Super-Resolution Microscopy and Its Biological Applications; SAX Microscopy and Its Application to Imaging of 3D-Cultured Cells; Quantitative Super-Resolution Microscopy for Cancer Biology and Medicine. |

## Computational Biology

Credits

2

**Course Objectives**

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

**Student Learning Outcomes**

On completion of this course, the students are expected to:

- Develop an understanding of the basic theory of these computational tools;
- Develop required database extraction, integration, coding for computational tools and methods necessary for all Omics;
- Create hypothesis for investigating specific contemporary biological questions, provide help to experiment with or develop appropriate tools;
- Critically analyze and interpretresults of their study with respect to whole systems.

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| Unit I<br>**Introduction to computational biology basics and biological databases**<br>4 lectures | Computers in biology and medicine; Overview of biological databases, nucleic acid & protein databases, primary, secondary, functional, composite, structural classification database, Sequence formats & storage, Access databases, Extract and create sub databases, limitations of existing databases. |
| Unit II<br>**Pairwise and multiple sequence alignments**<br>5 lectures | Local alignment, Global alignment, Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots. Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman Algorithm, Hidden Markov Model: Viterbi Algorithm. Heuristic approach: BLAST, FASTA. Building Profiles, Profile based functional identification. |
| Unit III<br>**Genome analysis**<br>6 lectures | Polymorphisms in DNA sequence, Introduction to Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Probabilistic functional gene networks, Human genome project, Genomics and crop improvement. Study available GWAS, ENCODE, HUGO projects, extract and build sub databases; Visualization tools including Artemis and Vista for genome comparison; Functional genomics case studies. |
| Unit IV<br>**Structure visualization**<br>3 lectures | Retrieving and drawing structures, Macromolecule viewing platforms, Structure validation and correction, Structure optimization, Analysis of ligand-protein interactions; Tools such as PyMol or VMD. |
| Unit V<br>**Molecular modelling**<br>6 lectures | Significance and need, force field methods, energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; RMS fit of conformers and protein chains, assigning secondary structures; sequence alignment: methods, evaluation, scoring; protein curation: backbone construction and side chain addition; different types of protein chain modelling: ab initio, homology, hybrid, loop; Template recognition and alignments; Modelling parameters and considerations; Model analysis and validation; Model optimization; Substructure manipulations, annealing, protein folding and model generation; loop generating methods; loop analysis; Analysis of active sites using different methods in studying protein–protein interactions. |
| Unit VI<br>**Structure-based drug development**<br>6 lectures | Molecular docking: Types and principles, Semi-flexible docking, Flexible docking; Ligand and protein preparation, Macromolecule and ligand optimization, Ligand conformations, Clustering, Analysis of docking results and validation with known information. Extra-precision docking platforms, Use of Small-molecule libraries, Natural compound libraries for virtual high throughput screenings. |
| Unit VII<br>**Ligand-based drug development**<br>6 lectures | Quantitative structure activity relationships; Introduction to chemical descriptors like 2D, 3D and Group-based; Radar plots and contribution plots and Activity predictions, Pharmacophore modeling, Pharmacophore-based screenings of compound library, analysis and experimental validation. |

## Drug Discovery and Development

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

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

Credits: 2

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| Unit I<br>**Target identification and molecular modelling**<br>7 lectures | Identification of target or drug leads associated with a particular disease by a number of different techniques including combinations of molecular modeling, combinatorial libraries and high-throughput screening (HTS); Conceptualizing the automation of the HTS process and the importance of bioinformatics and data processing in identification of lead compounds; Rational drug design, based on understanding the three-dimensional structures and physicochemical properties of drugs and receptors; Modelling drug/receptor interactions with the emphasis on molecular mechanisms, molecular dynamics simulations and homology modelling; Conformational sampling, macromolecular folding, structural bioinformatics, receptor-based and ligand-based design and docking methods, in silico screening of libraries, semi-empirical and ab-initio methods, QSAR methods, molecular diversity, design of combinatorial libraries of drug-like molecules, macromolecular and chemical databases. |
| Unit II<br>**Lead optimization**<br>5 lectures | Identification of relevant groups on a molecule that interact with a receptor and are responsible for biological activity; Understanding structure activity relationship; Structure modification to increase potency and therapeutic index; Concept of quantitative drug design using Quantitative structure–activity relationship models (QSAR models) based on the fact that the biological properties of a compound are a function of its physicochemical parameters such as solubility, lipophilicity, electronic effects, ionization, stereochemistry, *etc.*; Bioanalytical assay development in support of *in vitro* and *in vivo* studies (LC/MS/MS, GC/MS and ELISA). |
| Unit III<br>**Preclinical development**<br>5 lectures | Principles of drug absorption, drug metabolism and distribution - intestinal absorption, metabolic stability, drug-drug interactions, plasma protein binding assays, metabolite profile studies, Principles of toxicology, Experimental design for preclinical and clinical PK/PD/TK studies, Selection of animal model; Regulatory guidelines for preclinical PK/PD/TK studies; Scope of GLP, SOP for conduct of clinical & non clinical testing, control on animal house, report preparation and documentation Integration of non-clinical and preclinical data to aid design ofclinical studies. |
| Unit IV<br>**Drug manufacturing**<br>4 lectures | Requirements of GMP implementation, Documentation of GMP practices, CoA, Regulatory certification of GMP, Quality control and Quality assurance, concept and philosophy of TQM, ICH and ISO 9000; ICH guidelines for Manufacturing, Understanding Impurity Qualification Data, Stability Studies. |
| Unit V<br>**Clinical trial design**<br>4 lectures | Objectives of Phase I, II, III and IV clinical studies, Clinical study design, enrollment, sites and documentation, Clinical safety studies: Adverse events and adverse drug reactions, Clinical PK, pharmacology, drug-drug interaction studies, Statistical analysis and documentation. |
| Unit VI<br>**Fundamentals of regulatory affairs and bioethics**<br>4 lectures | Global Regulatory Affairs and different steps involved, Regulatory Objectives, Regulatory Agencies; FDA guidelines on IND and NDA submissions, Studies required for IND and NDA submissions for oncology, HIV, cardiovascular indications, On-label *vs.* off-label drug use GCP and Requirements of GCP Compliance, Ethical issues and Compliance to current ethical guidelines, Ethical Committees and their set up, Animal Ethical issues and compliance. |

# Protein Engineering

Credits

2

**Course Objectives**

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

**Student Learning Outcomes**

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

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

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| Unit I<br>**Introduction to protein engineering**<br>5 lectures | Protein engineering – definition, applications; Features or characteristics of proteins that can be engineered (definition and methods of study) – affinity and specificity; Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, *etc.* Protein engineering with unnatural amino acids and its applications. |
| Unit II<br>**Stability of protein structure**<br>5 lectures | Methods of measuring stability of a protein; Spectroscopic methods to study physicochemical properties of proteins: far-UV and near-UV CD; Fluorescence; UV absorbance; ORD; Hydrodynamic properties–viscosity, hydrogen-deuterium exchange; Brief introduction to NMR spectroscopy – emphasis on parameters that can be measured/obtained from NMR and their interpretation. |
| Unit III<br>**Applications**<br>5 lectures | Forces stabilizing proteins – Van der waals, electrostatic, hydrogen bonding and weakly polar interactions, hydrophobic effects; Entropy – enthalpy compensation; Experimental methods of protein engineering: directed evolution like gene site saturation mutagenesis; Module shuffling; Guided protein recombination, *etc.*, Optimization and high throughput screening methodologies like GigaMetrix, High throughput microplate screens *etc.*, Application to devices with bacteriorhodopsin as an example; Engineering antibody affinity by yeast surface display; Applications to vaccines, Peptidomimetics and its use in drug discovery. |
| Unit IV<br>**Computational approaches**<br>5 lectures | Computational approaches to protein engineering: sequence and 3D structure analysis, Data mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles and thermophiles *vis-à-vis* those from mesophiles; Proteindesign, Directed evolution for protein engineering and its potential. |
| Unit V<br>**Case studies**<br>1 lecture | Case Studies. |

# Vaccines

Credits

2

**Course Objectives**

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

**Student Learning Outcomes**

By the end of this course, students should be able to:

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

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| Unit I<br>**Fundamentals of immune system**<br>6 lectures | Overview of Immune system; Human Immune system: Effectors of immune system; Innate & Adaptive Immunity; Activation of the Innate Immunity; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Correlates of protection. |
| Unit II<br>**Immune response to infection**<br>9 lectures | Protective immune response in bacterial; viral and parasitic infections; Primary and Secondary immune responses during infection; Antigen presentation and Role of Antigen presenting cells: Dendritic cells in immune response; Innate immune response; Humoral (antibody mediated) responses; Cell mediated responses: role of CD4+ and CD8+ T cells; Memory responses: Memory and effector T and B cells, Generation and Maintenance of memory T and Bcells. |
| Unit III<br>**Immune response to vaccination**<br>8 lectures | Vaccination and immune response; Adjuvants in Vaccination; Modulation of immune responses: Induction of Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems - Microbial adjuvants, Liposomal and Microparticles as delivery systems; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and Mucosal Immunity. |
| Unit IV<br>**Vaccine types & design**<br>3 lectures | History of vaccines, Conventional vaccines; Bacterial vaccines; Viral Vaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; PeptideVaccine. |
| Unit V<br>**Vaccine technologies**<br>4 lectures | NewVaccineTechnologies;RationallydesignedVaccines;DNAVaccination;Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination;Vaccinesfortargeteddelivery(VaccineDeliverysystems);Diseasespecific vaccine design: Tuberculosis Vaccine; Malaria Vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola,Zika). |

# Medical Microbiology and Infection Biology

Credits 3

**Course Objectives**

This course will provide a perspective and exposure to medical aspects of bacteriology, virology, mycology, parasitology and infectious diseases along with concepts of symptoms, pathogenesis, transmission, prophylaxis and control, a conceptual understanding of host – pathogen interactions using well characterized systems as examples. The student should have a good grasp of disease causing microbes and their interactions with host.

**Student Learning Outcomes**

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

- Compare and contrast different microbial diseases, including properties of different types of pathogens, and mechanisms of pathogenesis;
- Summarize role of host in infectious disease, including natural barriers to infection, innate and acquired immune responses to infection, and inflammation;
- Compare and contrast experimental approaches for identifying virulence genes and advantages/disadvantages of each approach for specificpathogens.

## Unit I
### Bacterial diseases
8 lectures

Normal microflora (microbiome) of human body and its role – Skin, mouth and respiratory tract, intestinal tract, urogenital tract; Pathogenesis and virulence factors - Koch's postulates, Adherence and invasion, Toxins, Enzymes, Antiphagocytic factors, Antigenic heterogeneity, Iron acquisition; *Bacillus anthracis, Clostridium* spp., *Corynebacterium diptheriae; E. coli, Vibrio cholerae, Helicobacter pylori, Salmonella typhi and paratyphi, Shigella dysenteriae; Listeria monocytogenes, Mycobacterium* spp., Rickettsial diseases; *Haemophilus influenzae, Bordetella pertussis*, Brucellosis, Streptococcal and Staphylococcal infections; Antibacterial chemotherapy (with examples of antibiotics) - Inhibition of cell wall synthesis, inhibition of cell membrane function, inhibition of protein and nucleic acid synthesis, antimetabolites; Drug resistance - origin (genetic and non-genetic), mechanisms, antimicrobial activity *in vitro* and *in vivo*, Multi-drug resistance and its mechanisms *e.g.* MDR-TB.

## Unit II
### Viral diseases
7 lectures

Viral Pathogenesis - Routes of entry, Viral spread (local and systemic infection), Viral persistence (chronic and latent infection); Polio, Chicken pox, Mumps, Measles, Rubella; Viral hemorrhagic fever, viral encephalitis, Dengue and Yellow fever; Influenza virus infection (emphasis on Avian and swine flu), Rabies and Prion diseases; Hepatitis and Human Cancer viruses; Emerging viral diseases – Ebola, Marburg, SARS, Hanta, Chikungunya, Zika, Chandipura; Antiviral chemotherapy and Viral vaccines; Nucleotide and nucleoside analogs, Reverse transcriptase inhibitor, protease inhibitor, fusion inhibitor *etc.*, Interferons, Killed and attenuated vaccines.

## Unit III
### Fungal and protozoan infections
7 lectures

Types of Mycoses (with specific example of causative fungi) – Superficial, Cutaneous, Sub-cutaneous; Types of Mycoses (with specific example of causative fungi) - Endemic and Opportunistic; Mycotoxins and Antifungal chemotherapy – Mycetismus, Aflatoxins, classes of currently available drugs and new inhibitors in the pipeline; Protozoan diseases - Giardiasis, Amoebiasis; Leishmaniasis, African sleeping sickness; Malaria, Cryptosporidiosis; Infection by Helminths – Nematodes, Trematodes, Cestodes.

## Unit IV
### Sexually transmitted diseases and congenital infections
6 lectures

Syphilis and Gonorrheal infections; AIDS and Lentiviral infection; Herpes infections; Chlamydial infections *(Chlamydia trachomatis)*; Mycoplasma and Ureaplasma infection; Toxoplasmosis; Congenital viral infections – Cytomegalovirus, Varicella zoster, HBV, Enterovirus, Parvovirus B19 *etc.*

## Unit V
### Host-pathogen interaction
6 lectures

Intracellular and extracellular pathogens, Principles of microbial pathogenesis, host damage, inflammatory responses, adaptation strategies of pathogen- impact of host and pathogen metabolism on immunity and pathogen survival; Chronic pathogens and mechanisms of persistence; Evasion mechanisms of pathogens; Bacterial – host interaction- *Mycobacterium tuberculosis, Borrelia burgdorferi*; Viruses – host interaction: HIV, Influenza; Protozoan – host interaction: *Plasmodium* spp., *Leishmania major.*

# Course: Animal Biotechnology

**Course Code: MBT 309T**

**Course Credit: 3**

**Unit I**

Introduction to the balanced salt solutions and simple growth medium. Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium, Serum & protein free defined media and their applications.

**Unit II**

Primary and secondary cell culture, Development of cell lines, Biology and characterization of the cultured cells. Basic techniques of mammalian cell cultures in vitro.

**Unit III**

Maintenance of cell culture, Cell Passaging, Measuring parameters of growth, Measurement of viability and cytotoxicity.

**Unit IV**

Cell synchronization, Cell transformation, Apoptosis, Cryopreservation, Common cell culture contaminants.

**Unit V**

Applications of animal cell culture: cell culture based products, vaccines, Hybridoma technology and monoclonal antibodies, stem cells and their applications, Animal cloning, IVF technology, Organ, organotypic and histotypic cultures.

**Suggested Readings**

1. Culture of Animal Cells: Freshney
2. Animal Cell Culture: John RW Masters
3. Animal Cell Culture Techniques: Martin Clynes
4. Transgenic Animals: Generation and Use: Louis-Marie Houdebine