# FACULTY OF LIFE SCIENCES

## SYLLABUS

## FOR

# M.Sc. (BIO-TECHNOLOGY)
# (For Colleges)
# (Semester: I - IV)

**Examinations: 2019-20**

# GURU NANAK DEV UNIVERSITY
# AMRITSAR

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER SYSTEM) (For Colleges)**

# SCHEME OF COURSE

## SEMESTER-I

| Code | Title of Course | Course Hours | | Max. Marks | |
|---|---|---|---|---|---|
| | | **T** | **P** | **T** | **P** |
| **BT 511** | Gene Structure, Function & Regulation | 3 | 4 | 75 | 25 |
| **BT 512** | Enzymology | 3 | 4 | 75 | 25 |
| **BT 513** | Cell Biology | 3 | - | 75 | - |
| **BT 514** | Introduction to Bioinformatics | 3 | 4 | 75 | 25 |
| **BT 515** | Biostatistics | 4 | - | 100 | - |
| **BT 516** | Computer Networking & Programming | 3 | 4 | 75 | 25 |
| | **Total** | **19** | **16** | **475** | **100** |
| | **Total** | **35** | | **575** | |

## SEMESTER-II

| Code | Title of Course | Course Hours | | Max. Marks | |
|---|---|---|---|---|---|
| | | **T** | **P** | **T** | **P** |
| **BT 521** | Principles of Biochemical Engg. | 3 | 4 | 75 | 25 |
| **BT 522** | Enzyme Technology | 3 | 4 | 75 | 25 |
| **BT 523** | Environmental Biotechnology | 3 | 4 | 75 | 25 |
| **BT 524** | Immunotechnology | 3 | 4 | 75 | 25 |
| **BT 525** | Structural Biology & Bioinformatics | 3 | 4 | 75 | 25 |
| **BT 526** | On job training | - | - | - | - |
| | **Total** | **15** | **20** | **375** | **125** |
| | **Total** | **35** | | **500** | |

## M.Sc. (BIO-TECHNOLOGY) (SEMESTER SYSTEM) (For Colleges)

### SEMESTER-III

| Code | Title of Course | Course Hours | Max. Marks |
|---|---|---|---|
| BT-631 | Genetic Engineering - Applications | 3 | 75 |
| BT-632 | Advances in Bioinformatics | 3 | 75 |
| BT-633 | Nanobiotechnology | 3 | 75 |
| BT-634 | Lab Techniques in Adv in Bioinformatics | 4 | 25 |
| BT-635 | Lab Techniques in Genetic Engineering-Applications | 4 | 25 |
| BT-636 | Seminars | 3 | 50 |
| BT-637 | Genomics & Functional Genomics | 3 | 75 |
| | | ---- | ----- |
| | **TOTAL** | **23** | **400** |
| | | ---- | ----- |

### SEMESTER-IV

| | | |
|---|---|---|
| **BT-638** | **Research Project** | **20** |

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-I) (For Colleges)**

**Course No. BT 511: Gene Structure, Function and Regulation**

**Time: 3 Hrs** **Marks: 75**

**Instructions for the Paper Setters:**
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

**SECTION-A**

Introduction to DNA structure, form andDNA supercoiling, renaturation and denaturation of DNA and Cotcurves, DNA Replication; prokaryotic and eukaryotic DNA replication mechanisms,DNA repair and recombinationmechanisms (FLP/FRT, Cre-lox), Transposons.

**SECTION-B**

Types of RNA and RNA polymerases in prokaryotes and eukaryotes, control of transcription in prokaryotes and eukaryotes, post transcriptional processing of m RNA, r RNA and t RNA.Sequential expression of gene in T4 phage.

**SECTION-C**

Genetic code, translational process in prokaryotic and eukaryotic organisms, checkpoints in translationpost-translational modifications,protein transport, protein trafficking and sorting, non-ribosomal polypeptide synthesis

**SECTION-D**

Regulation of gene expression in prokaryotes and eukaryotes; (operon concept; lac, trp and ara operons), RNA interference, Viral & cellular oncogenes, tumor suppressor genes from humans, structure, function & mechanism of action of p53, Molecular mechanism of antisense molecules, ribozymes, applications of antisense & ribozyme technologies.

**Books recommended:**


1. Damal. J, Lodish, H. and Baltimore, D. (2007). Molecular Cell Biology, 6th edition,Scientific American Books, Distributed by W.H. Freeman and Co., New York.
2. Bolsover, S.R., Hyams, J.S., S. Shephard, E.A. and White H.A. (1997) From Genes to Cells,John Wiley and Sons.
3. Lewin, B. (2007). Gene IX, 9th edition, Jones and Bartlett Publishers.
4. Nelson, D. L. & Cox, M. M. (2005). Lehninger Principles of Biochemistry, 4th ed., WorthPublishers, New York.
5. Freifelder, D. (2000). Microbial Genetics, Narosa Publishing House.
6. Research Papers.

**Course No. BT 511 Gene Structure, Function and Regulation (Practical)**

**Time: 3 Hrs** **Max. Marks: 25**

**Note: The question paper will be set by the examiner based on the syllabus.**

1. Isolation of DNA from blood.
2. Cloning of foreign DNA insert in plasmid.
3. Confirmation of the recombinants by restrictions mapping.
4. Isolation of RNA.
5. Electrophoresis of RNA.
6. Northern transfer
7. Native – PAGE
8. SDS – PAGE
9. Western Blotting

**Books Recommended:**

1. Sambrook, J. and Russel, D.W. (2001), Molecular Biology; A laboratory manual, Third edition, CSHL Press, Cold Spring Harbour, New York.
2. Ausubel, F.M., Brent, R, Kingston, R.E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. (2002), Short Protocols in Molecular Biology, Fifth edition, John Wiley and Sons, Inc.

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-I) (For Colleges)**

**Course No. BT 512: Enzymology**

**Time: 3 Hrs** **Max. Marks: 75**

**Instructions for the Paper Setters:**
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

**SECTION-A**

Introduction to enzymes, classification of enzymes into six major groups with suitable examples, numerical classification of enzymes, mechanism of enzyme action, unit of activity, cofactors, coenzymes and prosthetic group, role of coenzymes.

**SECTION-B**

Types of Enzyme specificity, lock and key hypothesis, induced fit hypothesis, nature of active site, identification of functional groups at active site, Factors responsible for catalytic efficiency of enzymes i.e.proximity and orientation effects, enthalpy of intramolecular reactions, covalent catalysis, nucleophilic and electrophilic catalysis, strain and distortion theory.

**SECTION-C**

**Kinetics of Enzyme Catalysed Reactions:** Michaelis-Menten hypothesis, transformations of Michaelis-Menten equation and determination of Km and Vmax, Apparent Km & Vmax, Haldane relationship, substrate inhibition and activation, multireactant enzymes, King and Altman, method of deriving steady-state velocity equations, random ordered, Threol and Chance and Ping-pong mechanisms.

**SECTION-D**

**Regulation of Enzyme Activity:** Brief account of enzyme induction and repression, covalent modification, isoenzymes and allosteric regulation enzyme inhibition i.e. reversible and uncompetitive, Effect of temperature and pH on rate of enzyme catalysed reaction,.

**Books Recommended:**
1. Shultz, A.R. (1994). Enzyme Kinetics, Cambridge Press.
2. Trevor, P. (1995). Understanding Enzymes, 4th ed. Prentice Hall/Ellis Horwood, England.
3. Engel, P.C. (1996). Enzymology Labfax, Bios Scientific Publisher, Academic Press, U.K.
4. Price, N.C. and Strevens, L. (1999). Fundamentals of Enzymology, 3rd ed., Oxford University Press.
5. Palmer, T. (2001). Enzymes. Horwood Publishing, Chichester

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**Course No. BT 512 Enzymology (Practical)**

**Time: 3 Hrs.** **M. Marks: 25**

**Note: The question paper will be set by the examiner based on the syllabus.**

1. Estimation of absolute and specific activity of alkaline phosphatase from crude cell extract
2. Determination of activity in presence of activators.
3. Determination of activity in presence of inhibitors.
4. Determination of optimum pH
5. Determination of optimum temperature
6. Determination of Km & Vmax
7. Determination of Competitive, non-competitive inhibitor

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-I) (For Colleges)**

**Course No. BT 513 : Cell Biology**

**Time: 3 Hrs** **Max. Marks: 75**

**Instructions for the Paper Setters:**
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

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## SECTION-A

**Cell Structure and Function -** Cell classification, Structural organization and function of intracellular organelles: Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility.
**Membrane Structure and Function**: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, ion pumps, active transport, electrical properties of membranes.

## SECTION-B

**Cell Cycle**: Mitosis and meiosis, their regulation, steps in cell cycle, and control of cellcycle. Programmed cell death, aging and senescence.
**Cell Signaling:** Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component signaling systems, bacterial chemotaxis and quorum sensing.

## SECTION-C

**Cellular Communication:** Bacterial and plant two-component signaling systems, bacterial chemotaxis and quorum sensing Cellular Communication: Regulation of hematopoiesis, general principles of cell communication, celladhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.

## SECTION-D

**Techniques in Cell Biology:** Microscope and its modifications – Light, phase contrast and interference, Fluorescence, Confocal, scanning and transmission electron microscopy, freeze-etch and freeze-fracture methods for Electron Microscopy, Atomic force microscopy.

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**Books Recommended:**

1. Lodish et al., Molecular cell Biology, 4th Edition, W.H. Freeman & Company, 2000.

2. Smith & Wood, Cell Biology, 2nd Edition, Chapman & Hall, London, 1996.

3. Watson et al., Molecular Biology of the gene, 5th Edition, Pearson Prentice Hall. USA, 2003.

4. B. M. Turner, Chromatin & Gene regulation, 1st Edition, Wiley-Blackwell, 2002.

5. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-I) (For Colleges)**

**Course No. BT 514: Introduction to Bioinformatics**

**Time: 3 Hrs** **Max. Marks: 75**

**Instructions for the Paper Setters:**
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

**SECTION-A**

**Different Types of Biological Databases.** Nucleic acid andprotein databases: GenBank, EMBL, DDBJ, SWISS PROT, INTERPRO, UNIPROT.Resources at NCBI, PUBMED, MEDLINE etc Genome databases TIGR, PlasmoDB, SGD, Maize GDB Derived databases like Prints, Pfam, Prosite, Interpro.Structural databases: PDB, PDBsum, NDB etc.

**SECTION-B**

**Database Retrieval and Deposition Systems**: SRS, Entrez, Bankit, Seqin, Webin,AutoDep. Database Homology search: Scoring matrices, BLAST algorithms, Significance of alignments, BLAST variants, PSI and PHI BLAST Comparative genomics and Human Genome project

**SECTION-C**

**Primary Sequence Analysis:** Nucleotide and amino acid compositions, codon usage and statistics. AT and GC rich regions, Primer designing. Basics tools for determining flexibility, amphipathcity, antigenicity etc. in proteins.
**Pairwise and Multiple Sequence Alignment:** Global and local alignment, Scoring functions, Alignment representation and applications, ClustalW/ClustalX, Blast 2

**SECTION-D**

**Phylogenetic Trees:** Definition & description, various types of trees Phylogenetic analysis algorithm. Maximum Parsimony, Distance based methods, Clustering Methods, Boot strap analysis, Rooted and Unrooted trees, PHYLIP.

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### BT 514: Introduction to Bioinformatics (Practical)

**Time: 3 Hrs** **Max. Marks: 25**

- Phylogenetics tree analysis
- Using different type of Blast
- Using pair wise and multiple sequence alignment.
- Using Genome Daatabases
- Tools present at expasy.
- Various Databases at NCBI, EMBL, DDBJ
- To predict gene/ORF for genomic/DNA sequences of prokaryotic and eukaryotic origin

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-I) (For Colleges)**

**Course No. BT 515 : BIOSTATISTICS**

**Time: 3 hrs.** **Max. Marks: 100**

**Instructions for the Paper Setters:**
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

**SECTION-A**

Elementary Statistics: Representation of data- discrete data, continuous data, histogram, polygons, frequency curves. The mean Variability of data, Standard deviation. Median, Quantiles, Percentile, Skewness, Box and whisker diagrams (box plots), Introduction to statistical sampling from a population, Random Sampling.

**SECTION-B**

Probability: Experimental Probability, Probability when outcomes are equally likely, Subjective Probabilities, Probability laws Probability rules for Combined events, Conditional Probability and Independent Events, Probability trees, Bayes theorem. Probability Distribution Bernoulli Distribution, Binomial Distribution Poisson Distribution Uniform Distribution Normal Distribution, Normal approximation to binomial distribution, Central limit theorem.

**SECTION-C**

Multivariate Analysis: Regression and correlation:, Correlation & Regression, Scatter diagram, Regression function, Linear correlation and regression lines, Product moment correlation coefficient. Cluster analysis: Basics (Tree clustering), Distance Measures, Hierarchial tree, linkage rules (single and complete linkage, UPGMA), Two-way joining, k-means clustering and interpretation of results, expectation maximization. Principal Component Analysis (PCA): Principles and Applications to real life data.

**SECTION-D**

Random Variables Discrete and continuous Random variables Cumulative distribution function, Probability Mass function, Probability Density Function Expectation of random variables-experimental approach and theoretical approach. Expectation of X and variance of X, Expectation of function E[g(X)] . Hypothesis Testing: Fischer test, Chi Square test, Student t-test, ANOVA in reference to experimental deign.

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**Text Reference Books: -**

1. Brian S., Ripley D. and Venables W. N. (2002). Modern Applied Statistics. Springer Verlag
2. J. Crawshaw and J Chamber (2002) Advanced level Statistics, 4th Edition, Melson Thornes.
3. Kapoor V.K. and Gupta S.C. (2000) Fundamentals of Mathematical Statistics. Sultan Chand and Company, New Delhi
4. Gupta S.P. (2000). Statistical methods. Sultan Chand and Company, New Delhi.
5. Mendenhall W. and Sincich T. (1995). Statistics for engineering and sciences (IVth edition). Prentice Hall.
6. Elhance D.N. (1984). Fundamentals of Statistics. Kitab Mahal, Allahabad.

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-I) (For Colleges)**

**Course No. BT 516 Computers, Networking and Programming**

**Time: 3 Hrs** **Max. Marks: 75**

**Instructions for the Paper Setters:**
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

## SECTION-A

**Fundamentals of Computing:** Introduction to computer, Introduction to types of hardware and Software, Introduction to operating systems: Characteristics of Operating system like DOS, windows , UNIX/LINUX, Comparative advantages of security (hacking, cracking), Introduction to Computer Viruses.
Introduction to Internet, World Wide Web, Advantages of Web, Web Terminology, Accessing the Internet, Dedicated Access, Dial – up access, Concepts of Domain, Concept of Web Browser, Internet Services, Internet Tools. Telnet, FTP, Using E-Mail etc.

## SECTION-B

**Computer Networking and Internet:** OSI reference model, Network Topologies, Router, Switch, Data Communication (ISDN, Cable Modem), Communication Links (Coaxial Cables, Fiber Optics etc.), Optical vs. electronics networking, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network goals. Applications network, Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Concepts of client Server Architecture, Concept of search Engine, Database search engines.

## SECTION-C

**Elements of Programming in 'C' Language:** About C language, structure of a C program, character set, keywords, arithmetic operators, unary operators, relational and logical operators, hierarchy of operators, expressions, basic data types, constants and variables in C, type declaration, local and global variables, input function, output functions, formatted I/O, character I/O and string I/O functions, control statements, if statement, if-else statement, for statement, while statement, do-while statement, break and continue statements, switch statement, goto statement, ternary operators, Introduction to arrays, types of arrays, array declaration, array initialization, accessing data from array, character arrays, string variables.

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## SECTION-D

**Functions and Pointers:** Introduction to functions, library functions vs user-defined functions, advantages of functions, declaring a function, calling a function, passing arguments to a function, passing array to functions, recursion in functions, call by value and call by reference, introduction to pointers, pointer variables, declaring pointer variables, assessing values via pointers, pointer to string, passing arguments using pointers, structures and unions.

**Relation of Pointers with Arrays, Data Structures:** Arrays, Stacks, Simple queue, Circular queue, Binary trees, threaded binary trees, Linked List and implementation of above defined data structures in 'C'

**Object Oriented Concepts:** Objects, class, Polymorphism, Inheritance

**Recommended Books:**

**Programming in C**


1. Balagurusamy, E. (1992). Programming in ANSI C. Tata McGraw-Hill Publishing Company Limited, New Delhi
2. Kanetkar, Y. (2004). Let Us C - Fifth Edition. BPB Publications, New Delhi.
3. Schildt H. (2000). The Complete Reference. *McGraw-Hill, New Delhi.*


**Computing Fundamentals**


4. Norton's P. (2001). Introduction to Computing Fundamental. *McGraw HillEducation , New Delhi.*
5. Sinha P.K. (2001). Fundamental of Computers. *BPB Publication, New Delhi.*

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**Course No. BT 515 Computer Networking and Programming (Practical)**

**Time: 3 Hrs** **Max. Marks: 25**

**Note: The question paper will be set by the examiner based on the syllabus.**

**Write Programs:**

1. To show the use of standard input (scanf) and standard output (printf) functions
2. To show the use of variables and keywords.
3. To show the use of arithmetic operators, relational operators, logical operators, unary operators, assignment operator, arithmetic assignment operators and conditional operator.
4. To show use of library functions like sqrt, POW, tan, log etc.
5. To show the precedence of operators.
6. To show the use of getchar, putchar, gets, puts, getch, getche.
7. To Expertise branching statements like if, if-then, if-then-else.
8. To Expertise Looping Statement like while, do-while, for loops.
9. To show the utility of union and structures.
10. To create functions and to show different calls: Call by reference, Call by value.
11. To show the utility of pointers and various type of pointers like Pointer.
12. To a variable, Pointer to a function, Pointer to union and structures.
13. To show how to create and edit files.
14. To show the concept of binary trees, linked list, stack and queue.
15. To show the concept of objects, class, polymorphism and Inheritance

## M.Sc. (BIO-TECHNOLOGY) (SEMESTER-II) (For Colleges)

## BT 521 Principles of Biochemical Engineering

**Time: 3 Hrs** **Max. Marks: 75**

**Instructions for the Paper Setters:**
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

### SECTION-A

**Fundamental Principles of Chemical Engineering and Biochemical Engineering**: Application of Physical and Chemical Laws on biological systems. Stoichiometry of cell Growth, Growth Yield, Product Yield Growth Kinetics, Saturation Constant and Maintenance Energy.

### SECTION-B

**Bioreactor Designing and its Kinetics**: Basic concept of Bioreactor, batch, CSTR, packed bed, fluidized bed, plant and animal cell bioreactors. Solid state fermentation.
**Instrumentation and Controls of Bio Reactors**: Different in line, on line and off line instruments and controls used in bio reactors and its function.

### SECTION-C

**Sterilization and Scale Up**: Growth medium and air sterilization and its kinetics, Del factor and sterilization cycle, air filter and bed depth filtration, single fibre filtration efficiency. Scaling up of bioreactors.

### SECTION-D

**Transport in Bio Reactor**: Mass Transfer, KLa, Heat transfer, Newtonian and Non-Newtonian fluids.
**Products**: Growth linked and non growth linked product formation, Effect of inhibitors and activators.

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**Books**

1. Bailey J.E. 7 Ollis D.F. (2008) Biochemical Engineering Fundamentals McGraw Hills New York.
2. Stainbury P.F., Whitaker A & Hall S.J. (2008) Principal of Fermentation Technology, Aditya Book (P.) Ltd. New Delhi
3. S.J. Pirt (1985) Principles of microbes and cell cultivations. Blackwell Scientific Publication London.

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-II) (For Colleges)**

**BT 521 Principles of Biochemical Engineering (Practical)**

**Time: 3 Hrs** **Max. Marks: 25**

**Note: The question paper will be set by the examiner based on the syllabus.**

1. Study of the batch and CSTR fermentes.

2. Determination of mixing time in fermentes.

3. Sterilization of fermentes.

4. Standerization of pH and D.O. probes

5. Determination of Kla

6. Scale up of fermenter working volume on the basis of agitation and aeration.

7. To study the heat transfer in fermentes.

8. To study the solid state fermentation.

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-II) (For Colleges)**

**Course No. BT 522: Enzyme Technology**

**Time: 3 Hrs** **Max. Marks: 75**

**Instructions for the Paper Setters:**
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

**SECTION-A**

Monomeric, Oligomeric and multienzyme complexes, Extremozymes - thermostable, solventogenic and nonaqueous enzymes. Strategies of purification of enzymes, criteria of purity, molecular weight determination and characterization of enzymes.

**SECTION-B**

**The Design and Construction of Novel Enzymes**: artificial enzymes, abzymes, ribozymes, enzyme Vs fermentation. Biosensors - glucose oxidase, cholesterol oxidase, urease and antibodies asbiosensors.

**SECTION-C**

**Immobilized Enzymes and General Uses of Biocatalysts**: Methods of enzyme immobilization-ionic bonding, adsorption, covalent bonding (based on R groups of amino acids), microencapsulation and gel entrapment. Immobilized multienzyme systems, use of immobilized enzymes, bioreactors using immobilized enzyme.

**SECTION-D**

**Large Scale / Industrial Uses of Enzymes**: enzymes used in detergents, use of proteases in food, leather and wool industries, production of glucose syrup from starch using starch hydrolyzing enzymes, production of syrup containing maltose, enzymes in sucrose industry, glucose from cellulose, lactase in dairy industry, glucose oxidase and catalase in food industry, medical applications ofenzymes.

**Books Recommended:**
1. Shultz, A.R. (1994). Enzyme Kinetics, Cambridge Press.
2. Trevor, P. (1995). Understanding Enzymes, 4th ed. Prentice Hall/Ellis Horwood, England.
3. Engel, P.C. (1996). Enzymology Labfax, Bios Scientific Publisher Academic Press, U.K.
4. Price, N.C. and Strevens, L. (1999).

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**BT 522 Enzyme Technology (Practical)**

**Time: 3 Hrs** **Max. Marks: 25**

**Note: The question paper will be set by the examiner based on the syllabus.**

**Enzyme Purification**

Quantitation of activity of amylase /cellulase /acid phosphatase (salivary/ microbial/ animal/ plant source)

Ammonium sulphate precipitation

Gel permeation chromatography

Affinity chromatography

Ion-exchange chromatography

Native PAGE to check purity of enzyme

**Immobilization and Assay of Enzyme Activity**:

Adsorption of enzyme on inorganic carriers

Covalent immobilization of enzymes

Crosslinking of enzymes with glutaraldehyde

Entrapment of enzymes in polymeric gels

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-II) (For Colleges)**

**Course No. BT 523: Environmental Biotechnology**

**Time: 3 Hrs** **Max. Marks: 75**

**Instructions for the Paper Setters:**
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

**SECTION-A**

**Environmental Pollution and Management**: Types of pollution, sources, methods for the measurement of pollution and their control through Biotechnology; waste water treatments (physical, chemical and Biological). Microbiology of waste water treatments, aerobic and anaerobic process. Thin film techniques for waste water treatment using aquatic plants. Role of nanotechnology in environmental pollution control. Solid Waste Management with Vermicomposting, overall benefits, economics and marketing.

**SECTION-B**

**Biomass Production and Biofuels**: Introduction, plant biomass, sources of biomass,forest biomass, crop residues (cereals, leguminous crops, sugar cane etc.) aquatic biomass, wastes as a source of energy, composition of plant biomass(cellulose, hemicellulose and lignins), biomass conversion, biological and non- biological processes, useful products biomass (ethyl alcohol, methanol, methane), Application and future prospects, Recent trends in biofuel research.

**SECTION-C**

**Biological Nitrogen Fixation and Biofertilizer**: The range of nitrogen fixing organisms, biochemistry of nitrogenase, genetics of nitrogen fixation, regulation of *nif* gene expression, symbiotic nitrogen fixation, genetic analysis of *Rhizobium* bacteria, regulation of nod gene expression, transfer of *nif* genes from *Klebsiella pneumoniae* to other organisms, application and future prospects. green manuring, the blue green algae, algalization, *Azolla*, present status and improvements.

**SECTION-D**

**Bioremediation:** Types of bioremediation, use of fungi, algae and bacteria in biosorption, ecological considerations, biodegradation of oil spills, surfactants, TNT wastes, dye stuff wastes, insecticides, herbicides, antibiotics. plastic menace, biodegradable plastics, volatile toxic gases and biofiltration.

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**Recommended Books:**

1. Manahan, S. E. (2000), Environmental Science and Technology, Lewis Publishers, New York.
2. Anderson, D. & Conning, D.M. (1984). Experimental Toxicology, Royal Society of Chemistry.
3. Abbasi, S.A., and Ramasami, E. (1999). Biotechnological Methods of Pollution Control. Universities Press, Hyderabad.
4. Alexander, M.(1999). Biodegradation and Bioremediation. Acadamic Press, San Diego.
5. David, T.G. (1984). Microbial Degradation of Organic Compounds, Marcel Dekkar Inc., New York.
6. Omenn, G.E. (1987). Environmental Biotechnology, Plenum Press, New York.
7. Rittmann, D.E., McCarty, P.L. (2001). Environmental Biotechnology: Principles and Applications. McGraw Hill, New York.

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-II) (For Colleges)**

**Course No. BT 523 Environmental Biotechnology (Practical)**

**Time: 3 Hrs** **Max. Marks: 25**

**Note: The question paper will be set by the examiner based on the syllabus.**

1. Determination of drinking water quality
2. Determination of BOD and COD Sewerage samples
3. Isolation of Cellulolytic waste degrading microorganism
4. Isolation of Rhizobium from root nodule and mass cultivation
5. Study the technique of vermicomposting
6. Bioremediation of dyes using different fungal strain from soil

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-II) (For Colleges)**

**Course No. BT 524 Immunotechnology**

**Time: 3 Hrs** **Max. Marks: 75**

**Instructions for the Paper Setters:**
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

.

**SECTION-A**

**Introduction**
Induction and formation of antibodies, molecular basis of antibody diversity, hybridoma and its production; Immunization of animal, isolation of stimulated spleen cells, myeloma cell lines, methods for fusion of myeloma cells with antibody producing B-cells, selection and screening methods for positive hybrids, cloning methods, applications of monoclonal antibodies.

.

**SECTION-B**

**Vaccine Strategies**
Adjuvants, conventional vaccine, viral vaccines, bacterial vaccines, peptide vaccines, genetically engineered vaccines, DNA vaccines, concept of idiotype and anti-idiotypes, and their use as vaccines, evaluation of new vaccines-Phase I, II, III and IV clinical trials. Chimeric/bispecific antibodies, their construction by chemical methods, cell/fusion and recombinant DNA technology, applications of bispecific antibodies, humanized antibodies.
**Gene Therapy:** vector engineering, strategies of gene delivery, genereplacement/augmentation, gene correction, gene editing, gene regulation and silencing

**SECTION-C**

**Immunological Techniques**
Immunodiffusion and electro-immunodiffusion, ELISA, RIA, Western blotting, bacterial haemagglutination, haemagglutination inhibition, immunohistochemical staining methods(s), flow cytometry, CHIP.

**SECTION-D**

**Immunity and Immunoprophylaxis**
Immunity to virus, intracellular and extracellular bacteria, immunopathological consequences of parasitic infections, immune invasion, mechanism used by parasites, regulation of immune response in parasitic diseases. Vaccines against malaria, leishmaniasis, schistosomiasis and filariasis., Immunomudulation and immunosupression, *in vitro* screening for immunomodulation.

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-II) (For Colleges)**

**Books Recommended:**

1. Abbas, A.K., Litchman, A.H. and Pober, J.S. (2000). Immunology, 4th ed., Philadelphia, Pennsylvania: W.B. Saunders Company Publishers.
2. Benjamini, E., Coico, R. and sunshine, G. (2000). Immunology: A short course, 4th ed., New York, Wiley-Liss.
3. Roit, I.M., Delves, P. (2000). Essential Immunology, 10th ed., Oxford: Blackwell Scientific Publications.
4. Roitt, I., Brostoff, J. and Male, D. (2001). Immunology, 6th ed., Mosby.
5. Kanfmann S.H.E., Sher, A., Ahmed, R. (2002). Immunology of Infections Diseases, ASM Press, Washington.
6. Butler, M. (2004). Animal Cell Technology, 2nd ed., BIOS Scientific Publishers, U.K.
7. Goldsby, R.A., Kindt, T.J., Osborne, B.A. (2006). Kuby Immunology,4th ed., W.H. Freeman and Company, New York.

## M.Sc. (BIO-TECHNOLOGY) (SEMESTER-II) (For Colleges)

### Course No. BT 524 Immunotechnology (Practical)

**Time: 3 Hrs** **Max. Marks: 25**

**Note: The question paper will be set by the examiner based on the syllabus.**

1.Isolation of mononuclear cells from peripheral blood using ficoll gradient and viability test by dye exclusion method.
2. Blood film preparation for identification of cells.

3. Lymphoid organs and their microscopic organization

4. Raising of hyperimmune serum in experimental animals.

5. Purification of IgG from serum using protein A column

6. Immuno electrophoresis

7. Conjugation of antibodies with HRP or FITC

8. ELISA –Sandwitch

9. Immunohistochemical localization of proteins.

10. Growth and maintenance of Animal Tissue Culture cell line(s).

11. Doubling time of a given cell line

## M.Sc. (BIO-TECHNOLOGY) (SEMESTER-II) (For Colleges)

### Course No. BT 525 Structural Biology and Bioinformatics

**Time: 3 Hrs** **Max. Marks: 75**

**Instructions for the Paper Setters:**
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

### SECTION-A

Protein structure determination methods (principles of X-Ray diffraction, NMR and CD Spectroscopy), Conformational properties of proteins. Ramachandran plot- Hard sphere approach, primary, secondary, super secondary, tertiary and quaternary structures of proteins. Sequence and structure Motifs and Domains.
Anatomy of DNA; A, B, Z form of DNA . Principles of protein folding. Classification of three dimensional structure of protein in protein data banks (HSSP, SCOP, FSSP, CATH). Classification of proteins on the basis of families, superfamilies, classes, subclasses etc.

### SECTION-B

Secondary structure prediction methods: First, second, third and Fourth generation methods like CHOU-FASMAN, GOR , PHD, PSIPRED, JPRED, SOPM. Concepts, algorithms and their limitations. Benchmarking, CASP, CAFASP

**Methods for Prediction of Tertiary Structures of Proteins:**

1. Knowledge based or homology based structure prediction-Sequence alignment, Coordinate Assignment, Loop Prediction, Side chain Modeling, Validation of predicted models.

2. Fold recognition and Threading Methods
3. Ab-initio methods for structural predictions.

### SECTION-C

Methods to predict three dimensional structure of nucleic acids, rRNA, and their importance. RNA structure, structure of ribosome. Molecular interactions of protein-protein, protein-DNA, protein-carbohydrates. Case Studies. Fundamentals of intermolecular interactions as basis for docking studies.
Cambridge small molecular crystal structure data bank. Sequence to Structure and structure to function relationships- Some case studies

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**SECTION-D**

Coordinate systems and transformations amongst them. Basic principle 2D and 3D graphics and use of molecular graphics packages (e.g. Rasmol, MOLMOL, Chimera, Pymol, spdbviewer), Building small molecules using chemical information. Structure Visualization.

**Protein Structure Comparison and Alignment:** Introduction to Graph Theory,Distance Matrices, Structural alignment algorithms (CE, VAST, ALIGN, DALI, SSAP)

**Recommended books**:


1. C. Braden and C. Tooze (1991)Introduction to Protein Structure" *GarlandPublishing Inc., New York.*
2. Sheehan D. (2000). Physical Biochemistry. *WH Freeman Publishers*.
3. Bourhe P. E. and Weissig H. (2003). Structural Bioinformatics (Methods of structural Analysis). *Wiley-Liss.*
4. Orengo C.A., Jones D.T. and Thornton J.M. (2003). Bioinformatics: Genes Proteins and Computers. *Bios Scientific Pub.*
5. Friefelder D. M. (2004). Physical Biochemistry: Applications to Biochemistry and Molecular biology. *Blackwell Publishing.*
6. Eidhammer I., Jonassen I. and Taylor W. R. (2004). Protein Bioinformatics: An algorithmic approach to sequence and structure analysis. *Mathematics.*
7. Baxevais B.F. and Quellette F. (2004). Bioinformatics a Practical Guide to the Analysis of Genes and Proteins. *Wiley-Interscience*.
8. Mount D. W. (2004). Bioinformatics & Genome Analysis. *Cold SpringHarbor Laboratory Press.*
9. Creightons T.E. (2005). Proteins: Structures and Molecular Properties. *WHFreeman Publishers*

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-II) (For Colleges)**

**Course No. BT 525: Structural Biology and Bioinformatics (Practical)**

**Time: 3 Hrs** **Max. Marks: 25**

**Note: The question paper will be set by the examiner based on the syllabus.**

- ✓ To analyze protein sequence using Secondary Structure prediction Methods GOR, CHOU-FASMAN, PSIPRED, PHD JPRED SOPM etc.
- ✓ To retrieve various structures of Proteins from RCSB, their classification systems using CATH/SCOP etc
- ✓ To predict tertiary structure of protein by swill model and MGFM threading etc.
- ✓ Secondary structure of RNA using M fold.
- ✓ To down-load structures of proteins in software like RASMOL, SPDBV and
- ✓ To align, superimpose and compare three dimensional structures of the proteins
- ✓ To study the atomic co-ordinate files of various structures.
- ✓ Analysis of structures in these software. using 3D-alignment software

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-II) (For Colleges)**

# Course No. BT 526 On job Training

## M.Sc. (BIO-TECHNOLOGY) (SEMESTER-III (For Colleges)

### BT-631 Genetic Engineering - Applications

**Time: 3Hrs** **Max marks 75**

**Instructions for the Paper Setters:**

Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

### SECTION-A

Plant Transformation technology: The basis of tumour formation, hairy root, features of T1 and R1 plasmids, mechanisms of DNA transfer, role of virulence genes, use of T1 and R1 as vectors, binary vectors, use of 35S and other promoters, genetic markers, use of reporter genes, reporter gene with introns, methods of nuclear transformation, viral vectors and their applications, multiple gene transfers, vectorless or direct DNA transfer, particle bombardment, electroporation, microinjection. Transgene stability and gene silencing. *In planta* transformation, transgene validation.

### SECTION-B

Applications of plant transformation for productivity and performance: Herbicide resistance for phosphoinothricin, glyphosate, sulfonylurea, atrazine; Insect resistance: Bt Genes, non-Bt like protease inhibitors, alpha amylase inhibitor; Virus resistance: coat protein mediated, nucleocapsid gene; Disease resistance; chitinase, 1-3 beta glucanase, RP antifungal proteins, thionines, PR proteins; Nematode resistance, abiotic stress adaptation, Long shelf life of fruits and flowers: use of ACC synthase, poly-galactouranase, ACC oxidase; Male sterile lines: bar and barnase systems; Carbohydrate composition and storage: ADP glucose pyrophosphatase, terminator gene technology.

### SECTION-C

Molecular pharming (farming): edible vaccines, therapeutic proteins, Nutritional quality: golden rice, protein, vitamins. T-DNA & transposon tagging, promoter trapping, activation tagging. Chloroplast transformation: advantages, vectors, success with tobacco and potato;

### SECTION-D

Molecular marker-aided breeding: RFLP maps, linkage analysis, RAPD, SSLP markers, STS, microsatellites, SCAR (sequence characterized amplified regions), TE anchors, SSCP (single strand conformational polymorphism), AFLP, QTL, map-based molecular marker assisted selection, Application of RFLP in forensic, disease prognosis, genetic councelling, pedigree, varietal analysis, etc., animal trafficking and poaching, germplasm maintenance, taxonomy and biodiversity.

**Books Recommended:**

1. Gupta, P. K. (1996). Elements of Biotechnology, Rastogi and Co., Meerut.
2. Henry, R. J. (1997). Practical Applications of Plant Molecular Biology, Chapman and Hall.
3. Chawla, H. S. (1998). Biotechnology in Crop Improvement, International Book Distributing Company.
4. Research Papers.

## M.Sc. (BIO-TECHNOLOGY) (SEMESTER-III) (For Colleges)

### BT-632 Advances in Bioinformatics

**Time: 3 Hrs** **Max Marks: 75**

**Instructions for the Paper Setters:**
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

**SECTION-A**

**Sequence Alignment:** scoring matrices, PAM, BLOSUM, Local and global alignmentconcepts; Dot matrix sequence comparison; Dynamic programming; Needleman-Wunch algorithm, Smith-Waterman algorithm; Statistics of alignment score.

**SECTION-B**

**Multiple Sequence Alignment:** progressive alignment, scoring MSA, CLUSTALW,database searches for homologous sequences:FASTA and BLAST, PSSM searching, PSI-BLAST and PHI-BLAST.

**SECTION-C**

Gene prediction in prokaryotic genomes, gene prediction in eukaryotes, evaluation of gene prediction methods, promoter prediction in *E.coli* and promoter prediction in eukaryotes.

Protein structure prediction, use of sequence patterns for protein structure prediction, prediction of protein secondary structure from the amino acid sequence- Chou-Fasman/GOR method, PHD, JPred. Prediction of three-dimensional protein structure.

**SECTION-D**

DNA and protein microarrays. functional proteomics, oligosaccharide microarrays for glycomics, pharmacogenomics, introduction to metabolomics.

**Books Recommended:**


1. C. Braden and C. Tooze (1991), Introduction to Protein Structure" *Garland PublishingInc., New York.*
2. Bourhe, P. E. and Weissig H. (2003), Structural Bioinformatics (Methods of structural Analysis). *Wiley-Liss.*
3. Orengo, C.A., Jones, D.T. and Thornton, J.M. (2003), Bioinformatics: Genes Proteins and Computers. *Bios Scientific Pub.*
4. Eidhammer, I., Jonassen, I. And Taylor, W. R. (2004), Protein Bioinformatics: An algorithmic approach to sequence and structure analysis. *Mathematics.*
5. Baxevais, B.F. and Quellette, F. (2004), Bioinformatics a Practical Guide to the Analysis of Genes and Proteins. *Wiley-Interscience*.
6. Mount, D. W. (2004), Bioinformatics & Genome Analysis. *Cold Spring HarborLaboratory Press.*

## M.Sc. (BIO-TECHNOLOGY) (SEMESTER-III) (For Colleges)

### Course No. BT 633: NANOBIOTECHNOLOGY

**Time: 3 Hrs** **Marks: 75**

**Instructions for the Paper Setters:**

Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

**SECTION-A**

Introduction and Land Marks in the Evolution of Nanobiotechnology: Technologiesfor visualization of biological structure at nanoscale: atomic force microscopy, scanningprobe microscopy, Introduction tonanoparticles and nanoshellsPure metal and bimetallic nanoparticles, quantum dots, magnetic nanoparticles,nanocrystals, self assembly molecules

**SECTION-B**

Application of Nanobiotechnology in Molecular Diagnostics: Nanoparticles formolecular diagnostics – Nanobiotechnology for identification of SNPs via DNA hybridizationand proteins,Detection of biomarkers bynanotechnologies, *invtiro*imaging for disease diagnostics via different nanoparticles

**SECTION-C**

Nanobiosensors and their Applications :lipoparticles and dendrimers based biosensors Carbon nanotube biosensors, electronicnanobiosensors, nanosensors for glucose monitoring, biosensors for environmental monitoring and food contanimation,.

**SECTION-D**

Clinical Application of Nanobiotechnology : role of nano- technology in drug discovery and applications of nanoparticles in drug delivery w.r.t. ADME concept, nanotechnology for earlydetection of cancers,monitoring of cardiovascular diseases, agents, safety and toxicity aspects of nanoparticles.

**Books recommended**


1. Nanobiotechnology: Concepts,Applications andPerspectives (2004), Christ of M.Niemeyer (Editor), ChadA. Mirkin (Editor), Wiley VCH.
2. Nanobiotechnology - II more concepts and applications.(2007) - Chad A Mirkin and Christof M. Niemeyer (Eds),Wiley VCH.
3. Nanotechnology in Biology and Medicine: Methods,Devices, and Applications.
4. BioNanotechnology by Elisabeth S. Papazoglou, AravindParthasarathy, DOI: 10.2200/S00051ED1V01Y200610BME007Morgan & Claypool Publishers

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-III) (For Colleges)**

**BT-634 Lab Techniques in Advances in Bioinformatics (Practical)**

**Time : 4 Hrs. Max.** **Marks : 25**

**Note: The question paper will be set by the examiner based on the syllabus.**

1. To Study & analyse various biological databases
2. NCBI, EBI, Expasy, NBRF-PIR
3. To Study and analyse various other databases like
4. BAC's, STS's, EST databases
5. Study of Protein Databases RCSB, SWISSPROT etc.
6. Study of Nucleic acid databases like Gene Bank, EMBL etc.
7. To retrieve sequences from NCBI/EBI/ExPasy and submit in BLAST/FASTA/CLUSTALW/ PRFs (Protein Research Foundation)
8. Study of Biodiversity Informatics using various tools GBIF (Global Biodiversity Information Facility) Species 2000, IOB
9. Taxonomic Browser at NCBI etc.

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-III) (For Colleges)**

**BT-635 Lab Techniques in Genetic Engineering – Applications**

**Time: 4 Hrs** **Max Marks: 25**

**Note: The question paper will be set by the examiner based on the syllabus.**

1. Isolation of Ti plasmid from Agrobacterium tumefaciens.

2. Electrophoresis of Ti plasmid.

3. Agrobacterium mediated transformation of any plant system with any reporter gene.

4. Confirmation of transformation by PCR.

5. Confirmation of transformation by Southern hybridization.

6. Analysis of reporter gene expression in transformed plant cells.

7. Expression of fusion protein His-Tag in E.coli.

8. Purification of the fusion protein by column chromatography.

9. Expression studies using reverse transcription - PCR

10. Expression studies using Northern Hybridization.

**M.Sc. (BIO-TECHNOLOGY) (SEMESTER-III) (For Colleges)**

## BT-636 : Seminar

**Time: 3Hrs** **Max Marks: 50**

Each candidate will deliver seminar of one and half hours each on recent developments in Biotechnology. Presentation of Seminars will carry 25 marks. An objective type common paper of 25 marks on all the seminars will be taken at the end of the session. The question paper will be set and evaluated by a board of three internal examiners from the concerned department of college.

## M.Sc. (BIO-TECHNOLOGY) (SEMESTER-III) (For Colleges)

### BT-637 Genomics & Functional Genomics

**Time : 3Hrs** **Max Marks:75**

**Instructions for the Paper Setters:**

Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

### SECTION-A

**Whole Genome Analysis :** Preparation of genomic library in vectors, ordered cosmid libraries, BAC libraries, shotgun librarie.Conventional sequencing (Sanger, Maxam and Gilbert methods),automated sequencing, Pyrosequencing.

### SECTION-B

**DNA Microarray:** Chemical DNA synthesis, Printing of oligonucleotides and PCR products on glass slides, nitrocellulose paper. Genome analysis for global patterns of gene expression using fluorescent-labelled cDNA or end-labelled RNA probes. Analysis of single nucleotide polymorphism using DNA chips.

### SECTION-C

**Proteome Analysis:** Two dimensional separation of total cellular proteins, isolation and sequence analysis of individual protein spots by mass spectroscopy,MALDI- TOF, MALDI-Q, ESI-TOF, ESI-Q, REFLECTRON. Protein microarrays.

### SECTION-D

**Metablome Analysis**: Introduction to metabolomics.Techniques and instrumentation used for metablomics, LC-MS, Applications of metablomics. Advantages and disadvantages of DNA and protein microarrays. Total expression vs functional proteomics, introduction to pharmacogenomics,

**References:**


1. Peruski, L.F. Jr. and Peruski, A.H. (1997). The Internet and New Biology: Tools for Genomic and Molecular Research ASM.
2. Schena, M.ed. (1999). DNA Microarrays: A practical approach. Oxford University Press.
3. Hunt, S. and Livesey, F. ed. (2000). Functional Genomics: A practical approach. Oxford University Press.
4. Recent articles in journals

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# BT-638: Research Project: 20 Hrs.