

**CVM UNIVERSITY**  
**MASTER OF SCIENCE**  
**BIOTECHNOLOGY (MEDICAL BIOTECHNOLOGY)**  
**PROGRAMME**

**Under Choice Based Credit Scheme**

**Structure with Effect From: 2021-22**



# CVM UNIVERSITY



## Programme M.Sc. Biotechnology (Medical Biotechnology) (Under the Choice based Credit Scheme)

### STRUCTURE WITH EFFECT FROM 2021-2022

Type of course	Course Code	Title	T/P	Credit	Exam Duration in Hrs	Component of Marks		
						Internal	External	Total
						Total / Passing	Total / Passing	Total / Passing
<b>Semester - I</b>								
Core Course	Core 1	Cell Communication & Cell Signalling	T	4	3	40/16	60/24	100/40
	Core 2	Molecular Diagnostic Techniques & Gene Therapy	T	4	3	40/16	60/24	100/40
	Core 3	Genetics of Mammalian Development	T	4	3	40/16	60/24	100/40
	Core 4	Practical Based on Core 1 & Core 2	P	4	3	40/16	60/24	100/40
	Core 5	Practical Based on Core 3 & Elective X	P	4	3	40/16	60/24	100/40
	Core 6	Comprehensive Viva-Voce		1			50/20	50/20
Elective Course (Any One)	Elective 1	Plant Biotechnology	T	4	3	40/16	60/24	100/40
	Elective 2	Microbial Technology	T	4	3	40/16	60/24	100/40
	Elective 3	Environmental Chemistry	T	4	3	40/16	60/24	100/40
	Elective 4	Clinical biochemistry	T	4	3	40/16	60/24	100/40
	<b>Total Credit</b>			<b>25</b>				

**MASTER OF SCIENCE – BIOTECHNOLOGY  
(MEDICAL BIOTECHNOLOGY), SEMESTER – I  
NAME OF COURSE: CELL COMMUNICATION AND CELL SIGNALING  
COURSE CODE: CORE 1  
SYLLABUS EFFECTIVE FROM: 2021-2022**

**Course Outcomes**

**At the end of this course, the student will be able to:**

1. Introduction membrane structure, transport across it, intracellular vesicular traffic
2. Cytoskeletal structures, cell cycle
3. Introduction to various signalling pathways in living system, types of receptors
4. Pathways of intracellular transduction

**UNIT I: Cell-cell and cell-matrix adhesion:**

Cell adhesive molecules, cell junctions, cadherins mediate cell-cell adhesion, Desmosomes, Tight junction

Integrins Mediate cell-ECM adhesion, Gap junction, Plasmodesmata

Basal lamina and extra cellular matrix.

Cell Cycle – Phases of Cell Cycle, functional importance of each phase, Molecular events during cell cycle, Check points.

General account on programmed cell death (Apoptosis)- intrinsic and extrinsic pathways

**UNIT II: Mechanisms of Cell communication:**

General principles of cell communication, Introduction to signaling Receptors (GPCRs, Ion Channel Coupled receptors, Enzyme coupled receptors) and ligands,

Signaling through G-protein coupled receptors (GPCRs) - Adenylyl Cyclase, Phospholipase C and small mediators, heterotrimeric G-proteins, effectors, Secondary messenger: NO, Calcium, cAMP

Tyrosine kinase receptors, Cytokine receptors, Src kinases

**UNIT III:**

**Pathways of intracellular transduction:** Wnt and Hedgehog Signaling, Notch/Delta signaling, ras/MAPK pathways, Mitogenic signaling Cytokine signaling/JAK-STAT/mTOR, NFkappa B signaling, TGF Beta signaling, PI3-kinase Lipid Signaling

**Unit IV: Host Parasite interaction:**

Recognition and entry process of different pathogens like bacteria, viruses into cells.

Alteration of host cell behavior by pathogens.

Cancer: Genetic rearrangement in progenitor cells, oncogenes, tumor suppressor genes

**REFERENCE BOOKS:**

1. Cell and Molecular Biology by E.D.P.DeRobertis and E.M.P.DeRobertis. 8th Edition, Reprinted -2007) B.I.Publications Pvt. Ltd.(Indian Edition).ISBN: 0-7817-3493-2.

2. Cell and Molecular Biology: Concepts and Experiments by Gerald Karp.5th Edition, Wiley International Edition, John Wiley&Sons,Inc. ISBN:0-471-65665-8.
3. Molecular Biology of THE CELL by Albert et al.4th Edition, 2002, Garland Science, Taylor & Francis Group. ISBN: 0-8153-3218-1
4. The Cell – A Molecular Approach By Geoffrey M. Cooper And Robert E. Hassman. 3rd Edition, 2004, ASM Press, Sinauer Associates, Inc.ISBN:0-87893-214-3.
5. Molecular cell Biology by Harvey Lodish, 5th Edition, (2004) W.H.Freeman and Company, New York.ISBN:0-7167-4366-3.
6. Cell Biology by C.B. Powar.(Reprinted-2004)Himalaya Publishing House, Mumbai.
7. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology by P.S. Verma and V.K. Agarwal(Reprinted -2007) Pub.S.Chand& Company Ltd.Ram Nagar, New Delhi.
8. Cytology by P.S. Verma and V.K. Agarwal (Reprinted -2006) Pub:S.Chand& Company Ltd.Ram Nagar, New Delhi-110055.ISBN: 81-219-0814-0.

**PRACTICALS:**

1. Mitosis preparation
2. Meiosis preparation
3. Histological localization of DNA and RNA
4. Histone protein localization
5. Nucleolus localization
6. Enzyme localization
7. Protein localization
8. Lipid localization
9. PAS reaction for GAG molecules

**MASTER OF SCIENCE – BIOTECHNOLOGY  
(MEDICAL BIOTECHNOLOGY), SEMESTER – I  
NAME OF COURSE: MOLECULAR DIAGNOSTIC TECHNIQUES & GENE  
THERAPY  
COURSE CODE: CORE 2  
SYLLABUS EFFECTIVE FROM: 2021-2022**

**Course Outcomes**

**At the end of this course, the student will be able to:**

- 1 Quality regulation and assurance in molecular diagnostic labs
- 2 Techniques used in molecular diagnostic labs
- 3 Various infectious diseases
- 4 Genetic disorders and inborn error of metabolism

**UNIT I: Molecular Diagnostic Laboratory**

Quality control, Record, investigation of epidemic and endemic diseases. Design and operation of the molecular Diagnostic laboratory: Introduction, Space and Design consideration, Operational consideration, Documents, Records, Sample retention, Result reporting, Quality assurance and Quality improvement.

**UNIT II: Techniques used in molecular Diagnostic Laboratory**

Gene Mutation Nomenclature, Detection of gene mutation: Hybridization-Based Methods- Single-Strand Conformation Polymorphism, Denaturing Gradient Gel Electrophoresis, Allele-Specific Oligomer Hybridization, Melt Curve Analysis, Inversion Probe Assay, Heteroduplex Analysis, Array Technology Sequencing (Polymerization)-Based Methods – Sequence-Specific PCR, Protein Truncation Test.

Cleavage Methods Restriction Fragment Length Polymorphisms, Heteroduplex Analysis With Single-Strand Specific Nucleases, Invader Assay, Chemical Cleavage.

**UNIT III: Infectious and Genetic disorders**

Bacterial-Tuberculosis; Viral-AIDS, Human Papilloma Virus, Herpes, Hepatitis-C; parasitic diseases- *Neiseriagonorrhoeae*, malaria, Cystic fibrosis, Triple repeat.

**UNIT IV: Genetic and Biomarker based disease diagnostics**

Polygenetic disorder – e.g. Diabetes.

Inborn error of metabolism: Lipidosis-, Lysosomal storage disorders-, glycogen storage disorders- Gaucher and Pompe, Tumor markers: Enzymes, Prostate Specific Antigen (PSA),

Hormones and protein markers, Biochemical, Molecular and cytogenetics test for Acquired disease.

**REFERENCE BOOKS:**

1. Buckingham L and Flaws (2007) *ML MOLECULAR DIAGNOSTICS: Fundamentals, Methods, & Clinical Applications* ISBN-13: 978-0-8036-1659-2
2. Nyhan William L, Barshop Bruce A, Ozand Pinar T. (2005) *Atlas of Metabolic Diseases* Second edition ISBN 0 340 809701
3. MousumiDebnath, Godavarthi B.K.S. Prasad, Prakash S. Bisen *Molecular (2010) Diagnostics: Promises and Possibilities* ISBN 978-90-481-3260-7
4. Burtis AC, Ashwood ER, Bruns DE (2006) *Tietz text book of Clinical Biochemistry and Molecular Diagnostics* 4th edition ISBN-13: 978-0-7216-0189-2 ISBN-10 0-7216-0189-8

**PRACTICALS:**

1. Collection of clinical infective samples
2. PCR based diagnosis – of Tuberculosis or HPV
3. PAGE: band detection of enzyme variants.
4. Screening of mucopolysaccharidosis by analysis of urinary glucoamenoglycanes.
5. Diagnosis of malaria using nested PCR

**MASTER OF SCIENCE – BIOTECHNOLOGY  
(MEDICAL BIOTECHNOLOGY), SEMESTER – I  
NAME OF COURSE: GENETICS OF MAMMALIAN DEVELOPMENT  
COURSE CODE: CORE 3  
SYLLABUS EFFECTIVE FROM: 2021-2022**

**Course Outcomes**

**At the end of this course, the student will be able to:**

- 1 Overview of embryogenesis, organogenesis and stem cells
- 2 Teratogenic agents and aging
- 3 Differential gene expression during development
- 4 Medical implications of developmental biology

**UNIT I: Overview of Embryogenesis in Mammals:**

Spermatogenesis, Oogenesis, structure of spermatozoa and ovum, Fertilization, Cleavage patterns, Blastulation, Gastrulation, Organogenesis

Basics of stem cells.

**UNIT II: Genetics of Axis Specification in Drosophila:**

Early Drosophila development- fertilization, cleavage

Genes that Pattern the Drosophila body plan- Anterior-posterior polarity in the oocyte, Dorsal-ventral patterning in the oocyte.

Generation the Dorsal-ventral pattern in the Embryo.

Segmentation and Anterior-Posterior body plan- segmentation genes; Gap genes, pair-rule genes & segmentation polarity genes.

Homeotic selector genes

**UNIT III: Cell Cell Communication In Development:**

Cell adhesion, cell migration

Cell signaling- induction and competence, reciprocal induction, regional specificity of induction, genetic specificity of induction.

Paracrine factors- Inducer molecules; FGF and RTK pathway, JAK-STAT pathway, Hedgehog pathway, Wnt pathway, SMAD pathway.

Juxtacrine signaling- Notch pathway

Extracellular Matrix as a source of developmental signals.

**UNIT IV: IV Birth Defects, Endocrine Disruptors and Aging:**

Genetic errors of human development, Teratogenic agents, Teratogenesis, Causes and genetic regulation of Aging. Sex determination in Mammals, Infertility, IVF

**REFERENCE BOOKS:**

1. Scott F Gilbert, Developmental Biology, 8<sup>th</sup> edition, Sinauer Associates Inc., USA. ISBN 0-87893-250-X
2. Shastry and Shukul, Developmental Biology, Rastogi Publications, ISBN 81-7133-734-1
3. Klug W. S. & Cummings M. R. Concepts of Genetics. Seventh edition. Pearson Education. ISBN 81-317-0811-X
4. Fundamentals of Genetics by B D Singh.
5. P. K. Gupta, Genetics. Rastogi Publications, Meerut, India, ISBN: 81-7133-842-9.
6. Gardner E. J., Simmons M. J. & Snustad D. P. Principles of Genetics. Eighth edition. John Wiley & Sons Inc. ISBN 9971-51-346-3.
7. Elements of Breeding and breeds of cattle and Buffalo- P Kanakraj, Jaypee Brothers Medical, ISBN: 978-8180618420

**PRACTICALS:**

1. To study different stages of embryogenesis.
2. To study different developmental stages of frog embryo.
3. To study different developmental stages of chick embryo.
4. To study the morphology and motility of sperm.
5. To study viability of sperm.
6. Acrosomal integrity test.
7. Teratogen activity test

**MASTER OF SCIENCE – BIOTECHNOLOGY  
(MEDICAL BIOTECHNOLOGY), SEMESTER – I  
NAME OF COURSE: PLANT BIOTECHNOLOGY  
COURSE CODE: ELECTIVE 1  
SYLLABUS EFFECTIVE FROM: 2021-2022**

**Course Outcomes**

**At the end of this course, the student will be able to:**

- 1 Tools and techniques of plant genetic engineering
- 2 Molecular biology of nitrogen fixation, nif gene transfer, herbicide resistant plants production
- 3 Transgenic plants for agriculture and commercial applications
- 4 Plant tissue culture techniques

**UNIT I:**

Plant biotechnology present scenario, Micropropagation and its application; Types of different organ culture and its application; Somaclonal variation: Introduction, Different pathways of somaclonal variation; factor affecting of somaclonal variation, Detection of somaclonal variation; Somaclonal variation its application in crop improvement.

**UNIT II:**

Chloroplast transformation: Structure of chloroplast; Plastid chromosome; Transformation methods-Agrobacterium mediated transformation, Particle gun method, Gene replacement, Gene insertion; Limitation of chloroplast transformation; Application of chloroplast transformation.

**UNIT III:**

Secondary metabolite: Role of secondary metabolites, Basic biosynthetic pathways, Techniques used in biosynthesis, Source of secondary metabolites; criteria for cell selection, factor affecting the culture of cells, Different bioreactors and their use in secondary metabolites production, Production of bioactive secondary metabolites by plant tissue culture.

**UNIT IV:**

Transgenic plants production: Development of abiotic (Insect, Disease, Herbicide) and biotic (Drought) resistant plants.  
Peptide production, biodegradable plastic and edible vaccine.  
DNA barcoding in plants its application.

**REFERENCE BOOKS:**

- An introduction to Plant Tissue culture by MK Razdan. M.K. 2003. Oxford & IBH Publishing Co, New Delhi, 2003.
- Plant Biotechnology: An Introduction to Genetic Engineering by Adrian Slater, Nigel W. Scott, Mark R. Fowler. Oxford University Press, 2008.

- Biochemistry & Molecular Biology of Plants. Bob Buchanan, Wilhelm Gruissem, Russell Jones. John Wiley & Sons, 2002.
- Plant biotechnology – J Hammond, et. al., Springer Verlag.
- Plant cell and tissue culture for production of food ingredients – T J Fu, G Singh, et. al.
- Biotechnology in crop improvement – H S Chawla.
- Practical application of plant molecular biology – R J Henry, Chapman & Hall. ¾ Elements of biotechnology – P K Gupta.
- An introduction to plant tissue culture – M K Razdan.
- Plant propagation by tissue culture: The technology (Vols. 1 & 2) – Edwin George.
- Handbook of plant cell culture (Vols. 1 to 4) – Evans et. al., Macmillan. ¾ Plant tissue and cell culture – H E Street, Blackwell Scientific.
- Cell culture and somatic cell genetics of plants (Vols. 1 to 3) – A K Vasil, A. Press.
- Plant cell culture technology – M M Yeoman.
- Plant tissue culture and its biotechnological applications – W Bary, et. al., Springer Verlag.
- Principles of plant biotechnology: An introduction to genetic engineering in plants – S H Mantel, et. al.
- Advances in biochemical engineering / Biotechnology – Anderson, et. al.
- Applied and fundamental aspects of plant cell tissue and organ culture edited by Reinert & Bajaj Y P S, Springer Verlag.
- Plant cell and tissue culture – S Narayanswamy, Tata Mc Graw Hill Co.
- Introduction of plant biotechnology – H.S. Chawla. Third Edition; Oxford and IBH publishing Co. Pvt. Ltd, New Delhi.

### **PRACTICALS:**

1. Preparation of MS media for inoculation
2. Micropropagation through nodal explants
3. Callus induction
4. Mass multiplication of banana
5. Agrobacterium tumefaciens mediated plant transformation
6. Protoplast isolation
7. Embryo dissection and culture
8. DNA isolation of plant material

**MASTER OF SCIENCE – BIOTECHNOLOGY  
(MEDICAL BIOTECHNOLOGY), SEMESTER – I  
NAME OF COURSE: MICROBIAL TECHNOLOGY  
COURSE CODE: ELECTIVE 2  
SYLLABUS EFFECTIVE FROM: 2021-2022**

**Course Outcomes**

**At the end of this course, the student will be able to:**

1. Exploitation microorganisms for industrial product production (primary metabolites)
2. Industrial production of secondary metabolites using microorganisms (e.g. antibiotics)
3. Steroid biotransformations and ergot alkaloids production, biofuels.
4. Food and dairy products production eg Cheese, yoghurt, Beer, Wine.

**UNIT I:**

Scope of Microbial biotechnology.

Microbial production and applications of primary metabolites: Citric acid, Ethanol, L-Glutamic acid, Vitamin B<sub>12</sub>

Industrially important microbial enzymes: Types, mode of action and industrial applications of microbial amylases and proteases

**UNIT II:**

Microbial production of therapeutically important products:-

Antibiotics: Penicillin, Streptomycin

Ergot alkaloids: Production by Saprophytic cultivation

Biotransformations of steroids: Hydroxylation and dehydrogenation,

Steroid biotransformations.

**UNIT III:**

Production of single cell protein from bacteria, fungi and algae, Characteristics, nutritional value and safety, substrates used, process examples, applications.

Cultivation of edible and medicinal mushrooms: Nutritional and medicinal properties

Production and applications of microbial exopolysaccharides: Classification, Biological functions, structure and biosynthesis of Xanthan and Alginate,

Factors affecting fermentative production of exopolysaccharides and downstream processing(recovery).

Production of bioplastics (Polyhydroxyalkonates)

**UNIT IV:**

Microbiology and technology of fermented dairy products:

Cheese making: Cheese varieties, manufacture of cheddar cheese,

Sources and properties of rennets.

Yoghurt making

Beer and Wine production

**REFERENCE BOOKS:**

1. Biotechnology - Rehm and Reid.
2. Comprehensive biotechnology - Murray Moo Young.

3. Microbial Technology Vol I & II - Henry J. Peppler&D.Pearlman
4. Microbiology & technology of fermented foods - Robert W. Hutkins. Blackwell publishing.
5. Modern Industrial Microbiology and Biotechnology 2nd edition - Nduka Okafor, Benedict C. Okeke - (2017, CRC Press)

**PRACTICALS:**

1. Production of cellulase enzyme by solid-state fermentation.
2. Saccharification of agro-waste by cellulase enzyme.
3. Bioassay of antibiotics
4. Production of citric acid by submerged fermentation
5. Production of protease by submerged fermentation.
6. Single cell oil production by Yeast
7. Production of Yoghurt
8. Downstream processing of penicillin

**MASTER OF SCIENCE – BIOTECHNOLOGY  
(MEDICAL BIOTECHNOLOGY), SEMESTER – I  
NAME OF COURSE: ENVIRONMENTAL CHEMISTRY  
COURSE CODE: ELECTIVE 3  
SYLLABUS EFFECTIVE FROM: 2021-2022**

**Course Outcomes**

**At the end of this course, the student will be able to:**

- 1 Structure and composition of atmosphere, green house effect
- 2 Water cycle, its pollutants, types of reactions in various water bodies
- 3 Organic and inorganic components of soil
- 4 Biochemical cycling of elements

**UNIT I:**

Atmospheric Chemistry and Air Pollution: Chemical processes for formation of inorganic and organic particulate matter, thermochemical and photochemical reactions in the atmosphere. Gaseous pollutants, sources, reactions, control and effects of air pollutants on living and non-living things. Effects of meteorological and topographical factors. Global Climate change: Ozone depletion, Acid Rain and Greenhouse effect. Formation and effects of Photochemical smog.

**UNIT II:**

Water Chemistry and Water Pollution: Chemistry of Natural Waters, Water resources, hydrological cycle, physical and chemical properties of water, complexion in natural and waste water, role of microorganisms, Water pollutants, Types, Sources, Heavy metals, Metalloids Organic, Inorganic, Biological and Radioactive. Types of reactions in various water bodies including marine environment, Eutrophication and ecological magnification due to water pollution.

**UNIT III:**

Biogeochemical cycling of elements: Gaia Hypothesis, The Carbon cycle-Carbon transfer through food webs-Carbon cycling within Habitats-Carbon Monoxide cycling. The Hydrogen Cycle, The oxygen Cycle. The Nitrogen Cycle-Ammonification, nitrification and denitrification. The Sulfur Cycle-Oxidative and reductive sulfur transformation. The phosphorus Cycle, Iron cycle, Manganese Cycle and Calcium Cycle.

**UNIT IV:**

Soil chemistry & soil composition: Soil profile: Organic & Inorganic components of soil, Physical and Chemical Properties, cation exchange capacity, soil pH, environmental properties of soils. Leaching and erosion. Reactions with acids and bases. Geochemical reactions that neutralize acidity. Biological Process that neutralize acidity, Pesticide and Polymer Pollution. Physiochemical control of soil pollution.

**REFERENCE BOOKS:**

1. Environmental Chemistry, a global perspective. Gary W. Valoon & Stephen J. Duffy, Oxford University Press.
2. Environmental chemistry, B. K. Sharma.
3. Mahajan, S.P., Pollution Control in Process Industries, Tata McGraw-Hill, 1985.

4. M. Arora, Environmental management of toxic and hazardous waste.
5. Tyagi, O. D. and M. Mehra, Text book of Environmental Chemistry.
6. A.K. de. Environmental Chemistry 2000 (4th edition). New age International (P) Ltd., New Delhi, India.
7. Kenneth Wark , Cecil F. Warner, Wayne T. Davis, Air pollution origin and its control work, 3rd Edition, Prentice Hall.
8. R. M. Atlas. (1993) Microbial Ecology Fundamentals and Applications. 4th edition Pearson education Pte. Ltd. ISBN: 81-297-0771-3.
9. Stanley E. Manohar, Environmental Chemistry, Williard Grant press, Beston, Massachutes

### **PRACTICALS:**

1. Spectrophotometric analysis of nitrate.
2. Spectrophotometric analysis of nitrite.
3. Analysis of ammonia.
4. Determination of sulphate by turbidometric method.
5. Determination of zinc by EDTA complexometric reaction.\
6. Analysis of Total Hardness,  $\text{Ca}^{+2}$  Hardness and  $\text{Mg}^{+2}$  Hardness.
7. Analysis of  $\text{Ca}^{+2}$  from egg shell.
8. Analysis of sulfite.

**MASTER OF SCIENCE – BIOTECHNOLOGY  
(MEDICAL BIOTECHNOLOGY), SEMESTER – I  
NAME OF COURSE: CLINICAL BIOCHEMISTRY  
COURSE CODE: ELECTIVE 4  
SYLLABUS EFFECTIVE FROM: 2021-2022**

**Course Outcomes**

**At the end of this course, the student will be able to:**

- 1 Specimen collection, preservation and transportation, composition of various body fluids
- 2 Acid base balance and disorders, types and functions of carbohydrates
- 3 Clinical enzymology, hemoglobin
- 4 General organ function tests

**UNIT I:**

Introduction to clinical biochemistry: Specimen collection, preservation and transportation (blood, urine, spinal fluid, saliva, synovial fluid, amniotic fluid).

Chemistry, composition & functions of lymph, CSF, ascitic fluid, pleural fluid & synovial fluid.

**UNIT II:**

pH and Acid base balance & disorders, Electrolytes balance & imbalance, Blood gases and blood buffers.

Types, function and importance of carbohydrates, proteins and lipid, Lipoproteins, Apolipoproteins, Lipoprotein metabolism and disorders.

**UNIT III:**

Clinical Enzymology: Principle of diagnostic enzymology, Liver, cardiac and skeletal enzyme, Digestive enzyme, Miscellaneous enzyme.

Hemoglobin (Biochemistry, synthesis and breakdown), Hemoglobinopathies, Thalessemia, Bilirubin metabolism, Jaundice, Vandenbergh test.

**UNIT IV:**

General Organ function tests: Liver function tests, , Thyroid function tests, Pancreatic function tests, Cardiac Function Test.

Biochemistry of Diabetes mellitus, Atherosclerosis, Fatty liver, and obesity.

**REFERENCE BOOKS:**

1. Tietz Textbook of Clinical Chemistry, Carl A. Burtis, Edward R. Ashwood, Harcourt Brace & Company AisaPvt. Ltd. ISBN-13: 978-0721656106
2. Commercial Biosensors: Graham Ramsay, John Wiley & Son, INC. (1998). ISBN-13: 978-0-471-58505-3
3. Essentials of Diagnostic Microbiology, Lisa Anne Shimeld.
4. Diagnostic Microbiology, Balley& Scott's. Eleventh Edition. ISBN 0-323-01678-2
5. Tietz Textbook of Clinical Chemistry and Molecular Diagnostics, 4th Edition By Carl A. Burtis, , Edward R. Ashwood, and David E. Bruns, - ISBN -9780721601892
6. The Science of Laboratory Diagnosis, Crocker Burnett. ISBN 1899066624
7. Text books of Medical Laboratory Technology – Dr. Praful B. Godkar
8. Henry's Clinical Diagnosis and Management by Laboratory Methods 2 Richard McPherson Matthew Pincus ISBN: 978-1-4160-0287-
9. Biochemistry for medical students: Vasudeven and Shreekumar Jay pee prakashan.
10. Practical Clinical biochemistry by Harold verly
11. Text book of medical biochemistry by- Chatterjea and Rana Shinde

### **PRACTICALS:**

1. Preparation of standard solution, molar solution and other reagents
2. Analysis of normal and abnormal urine
3. Estimation of blood /serum glucose by various methods/ GTT
4. Glycosylated Hb, Hb Electrophoresis
5. Estimation Bilirubin , direct , total
6. Estimation of total protein and A/G ratio
7. Electrophoresis of plasma proteins
8. Estimation of total cholesterol and its fractions
9. Estimation of total lipids
10. Estimation of SGPT,SGOT
11. Hormone estimation: Determination of T3 or T4 by ELISA

**CVM UNIVERSITY**  
**MASTER OF SCIENCE**  
**BIOTECHNOLOGY (Medical Biotechnology)**  
**PROGRAMME**  
**Under Choice Based Credit Scheme**  
**Structure with Effect From: 2021-22**



# CVM UNIVERSITY



## Programme M.Sc. Biotechnology (Medical Biotechnology) (Under the Choice based Credit Scheme)

### STRUCTURE WITH EFFECT FROM 2021-2022

Type of course	Course Code	Title	T/P	Credit	Exam Duration in Hrs	Component of Marks		
						Internal	External	Total
						Total / Passing	Total / Passing	Total / Passing
<b>Semester - II</b>								
Core Course	Core 1	Immunotechnology	T	4	3	40/16	60/24	100/40
	Core 2	Regenerative Medicine	T	4	3	40/16	60/24	100/40
	Core 3	O'-mics	T	4	3	40/16	60/24	100/40
	Core 4	Practical Based on Core 1 & Core 2	P	4	3	40/16	60/24	100/40
	Core 5	Practical Based on Core 3 & ElectiveX	P	4	3	40/16	60/24	100/40
	Core 6	Comprehensive Viva-Voce		1			50/20	50/20
Elective Course (Any One)	Elective 1	Animal Biotechnology	T	4	3	40/16	60/24	100/40
	Elective 2	Bioseperation Technology	T	4	3	40/16	60/24	100/40
	Elective 3	Protein Engineering	T	4	3	40/16	60/24	100/40
	Elective 4	Environment Policy and Legislation	T	4	3	40/16	60/24	100/40
	<b>Total Credit</b>			<b>25</b>				

**MASTER OF SCIENCE – BIOTECHNOLOGY  
(MEDICAL BIOTECHNOLOGY), SEMESTER – II  
NAME OF COURSE: IMMUNOTECHNOLOG  
COURSE CODE: CORE 1  
SYLLABUS EFFECTIVE FROM: 2021-2022**

**Course Outcomes**

**At the end of this course, the student will be able to:**

- 1 learn about the mechanism of antibody diversity generation, technology for production of polyclonal and monoclonal antibodies
- 2 Knowledge about various techniques used in Immunology for diagnosis and research
- 3 Reasons for development of allergy, autoimmune disease etc.
- 4 Role of cytokines and other molecules in immunomodulation, tumor immunology

**UNIT I: Antibody production and Engineering:** Monoclonal antibody production: Hybridoma technology, Phage display library, High density cell culture technology and Microencapsulation.

**Antibody engineering:** Chimeric antibody, Human monoclonal antibody production and its limitations. Large scale polyclonal antibody production: antigen preparation and modification, dose and route of administration, selection of animal system, immunization, collection of sera and purification of antibody. Complement activation – Classical and alternative pathways

**UNIT II: Immunodiagnosics :** Precipitation reactions, measurement of affinity and avidity, immunoelectrophoresis, Agglutination, Radioimmunoassay, ELISA and its variants (Elispot Assay, chemiluminescence assay) Western blotting, Immunofluorescence techniques

**Immunohistochemistry:** Direct, indirect, PAP method, Avidin-Biotin complex method, labeled Streptavidin Biotin method, Multiple staining, electron microscopy, antibody microarray.

**Principle, construction and applications:** Fluorescence activated cell sorter, Surface Plasmon Resonance, Magnetic Activated Cell sorter, Assays of cell death. Animal models and transgenic animals in experimental immunology

**UNIT III: Cytokines:** Characteristics, families, receptors, associated diseases and cytokine therapy

**Immunopathology and Immunologic disorders**

**Hypersensitivity:** Types, mechanisms and disorders;

**Tolerance and Autoimmunity:** Tolerance, Organ specific and systemic autoimmune diseases, Mechanism of induction of autoimmunity, treatment.

**UNIT IV: Transplantation Immunology:** Types of graft, immunological basis of graft rejection, Graft Vs Host Reaction, HLA Typing, General Immunosuppression therapy

**Tumour Immunology-** Tumour Associated antigens and Tumour Specific Antigens; Evasion of immune system

**Immunity to infections:** Virus, Bacteria, Fungus

**Immunodeficiency diseases:** Primary and secondary immunodeficiency, few examples

**REFERENCE BOOKS:**

1. Essentials of Immunology (6th Edition): Ivan Roitt Blackwell Scientific Publications, Oxford, 1988.
2. Kuby- Immunology (6th Edition): R. A. Goldsby, T.J. Kindt, B.A. Osborne.
3. Fundamentals of Immunology: Paul W.E. (Eds.) Raven Press, New York, 1988.
4. Antibodies A laboratory Manual: Harlow and David Lane (1988), Old spring harbor laboratory
5. Cellular & Molecular Immunology: Abbas, Lichtman & Pober (Mc Graw Hill)
6. Basic immunology: Abbas & Lichtman (Saunders's Publication)

**PRACTICALS:**

1. Collection of blood by venipuncture, separation of serum and preservation of serum for short and long periods.
2. Differential leukocyte Count
3. Immunodiffusion in gels (Ouchterlony),
4. Counter- current immunoelectrophoresis.
5. Enzyme linked immunosorbant assay.
6. Latex and staphylococcal co-agglutination tests.
7. Separation of lymphocytes by centrifugation, gravity sedimentation etc.
8. Lymphocyte cell culture

**MASTER OF SCIENCE – BIOTECHNOLOGY  
(MEDICAL BIOTECHNOLOGY), SEMESTER – II  
NAME OF COURSE: REGENERATIVE MEDICINE  
COURSE CODE: CORE 2  
SYLLABUS EFFECTIVE FROM: 2021-2022**

**Course Outcomes**

**At the end of this course, the student will be able to:**

- 1 Basic biology of stem cells
- 2 Types of stem cells
- 3 Clinical applications of stem cells
- 4 tissue engineering: techniques and applications

**UNIT I: Basic Biology of stem cells:**

- Historical & Future Perspectives of Stem Cells.
- Definition and Properties of stem cells, types and sources of stem cells, Embryonic and Adult stem cells (Comparison of Embryonic and Adult stem cells)
- Embryonic Stem cells: Basic embryogenesis, properties, source, pluripotency and differentiation of ES cells.
- Molecular bases of Pluripotency, Mechanism of self-renewal, cell cycle regulation in stem cells.
- Adult stem cells: Characteristics, normal differentiation pathway, transdifferentiation (plasticity), Adult stem cells in different tissues; epithelial, skeletal, endothelial, Bone marrow & stromal, Hematopoietic etc.,
- Stem cell niches.

**UNIT II: Types of stem cells:**

- Hematopoietic stem cells- differentiation, marker identification, sources of HSCs, applications of HSCs.
- Mesenchymal stem cells- properties, sources, identification and characterization, Examples UCMSCs, ADMSCs.
- VSEL- isolation and identification
- Stem cells in Dental pulp
- SCNT- Somatic Cell Nuclear Transfer
- iPSCs- induced Pluripotent Stem Cells

**UNIT III: Clinical applications of stem cells**

- Stem cell therapies in Cardiac repair, Diabetes, Spinal cord injury, Auto immune disorders, Dermal wound healing- burns & skin ulcers, Neurodegenerative disease.
- Cancer stem cells- Stem cell origin in cancer, clonality and heterogeneity Tumor stem cells.
- Stem cells and ethics.

#### **UNIT IV:Tissue Engineering:**

- Historical perspective
- Scaffold materials- Natural, semi-synthetic & synthetic.
- Synthesis of TE scaffolds- Nanofiber assembly, Textile technology, Solvent casting & particulate leaching (SCPL), Gas foaming, Emulsification/Freezdrying.
- Cell Sources- Autologus, Allogenic, Xenogenic, syngenic. Stem cells in Tissue Engineering.

#### **REFERENCE BOOKS:**

- R. Lanza, J. Gearhart et al (Eds), Essential of Stem Cell Biology. (2009), Elsevier Academic press. ISBN: 978-0-12-088442-1.
- Adult stem cells; KursadTurksen: Human Press ISBN-1-58829-152-9.
- Animal Biotechnology- M.M.Ranga; AGROBIOS ISBN-81-7754-309-1.
- R. Lanza and I. Klimanskaya, Essential Stem Cells Methods. (2009), Academic Press
- J. J. Mao, G. Vunjak-Novakovic et al (Ed): Translational Approaches in Tissue Engineering & Regenerative Medicine 2008, Artech House, INC Publications.
- Robert Lanza et al. Principles of Tissue Engineering, 3rd Edition. Academic Press; 3rd edition.
- Stein et al. Human Stem Cell Technology and Biology: A Research Guide and Laboratory Manual.Wiley-Blackwell; 1 edition
- Lanza et al. Handbook of Stem Cells, Two-Volume Set: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal Stem Cells (v. 1).Academic Press.
- Regenerative Medicine and Cell Therapy (Hossein Baharvand, Nasser Aghdami. 2012)
- Principles of Regenerative Medicine 2nd Edition (Anthony Atala, Robert Lanza, James A. Thomson & Robert Nerem. 2010)
- <http://stemcells.nih.gov>

#### **PRACTICALS:**

1. Isolation and Culture of Hematopoietic Stem cells
2. Isolation and Culture of Mesenchymal Stem cells
3. Preparation of scaffolds
4. Cell culture on Scaffolds
5. Isolation of VSEL cells

**MASTER OF SCIENCE – BIOTECHNOLOGY  
(MEDICAL BIOTECHNOLOGY), SEMESTER – II  
NAME OF COURSE: O'-MICS  
COURSE CODE: CORE 3  
SYLLABUS EFFECTIVE FROM: 2021-2022**

**Course Outcomes**

**At the end of this course, the student will be able to:**

- 1 Introduction to genome and proteome, DNA microarray
- 2 Human genome project, Large scale sequencing methods, some model organisms and their genome projects
- 3 Protein structure and function, Methods to study protein-protein interactions
- 4 concept development about transcriptomics and metabolomics

**UNIT I:**

Introduction to the proteome and the genome, codon bias, gene expression, Genome size-C value paradox, DNA sequencing: Maxam-Gilbert, Sanger, Pyrosequencing, automated DNA sequencing. Other features of nucleic acid sequencing. Analysis and Annotation-ORF, Exon-intron boundaries

**UNIT II:**

Human genome project- Strategies for large-scale sequencing projects; landmarks on chromosomes generated by various mapping methods; BAC libraries and shotgun libraries preparation; Physical map-cytogenetic map, contig map, restriction map. Model organisms and other genome projects (*Arabidopsis*, *Caenorhabditis elegans*); Comparative genomics of relevant organisms such as pathogens and non-pathogens

**UNIT III:**

Relationship between protein structure and function, Identification and analysis of proteins by 2D analysis; Spot visualization and picking; Tryptic digestion of protein and peptide fingerprinting; Mass spectrometry: ion source (MALDI, spray sources); analyzer (ToF, quadrupole, quadrupole ion trap) and detector. Protein interaction maps. Protein arrays-definition, applications- diagnostics, expression profiling.

**UNIT IV:**

DNA Microarray technology: The generation of cDNA expression libraries, their robotic arraying, Complex hybridization on DNA chips. Transcriptomics: Comparative transcriptomics, Differential gene expression; Genotyping/SNP detection; Detection technology; Computational analysis of microarray data.

**REFERENCE BOOKS:**

1. Principles of Gene Manipulation and Genomics by Primrose

2. Genetics & Genomics By Csaba Szalai
3. Proteomics : From protein sequencing to function by S.R. Pennington and M.J. Dunn
4. Introduction to genomics by Arthur M Lesk

**PRACTICALS:**

1. Introduction to genome sequence databases
2. Protein and DNA sequence databases
3. Designing a primer
4. Total Protein profile of plant system using PAGE.
5. Determination of molecular weight and quantitation of separated proteins.
6. Demonstration of 2D gel electrophoresis

**MASTER OF SCIENCE – BIOTECHNOLOGY  
(MEDICAL BIOTECHNOLOGY), SEMESTER – II  
NAME OF COURSE: ANIMAL BIOTECHNOLOGY  
COURSE CODE: ELECTIVE 1  
SYLLABUS EFFECTIVE FROM: 2021-2022**

**Course Outcomes**

**At the end of this course, the student will be able to:**

- 1 Introduction and scope of Animal Biotechnology
- 2 Basic techniques of animal cell culture
- 3 Applications of animal tissue culture
- 4 Techniques for producing transgenic animals

**UNIT I:**

- Introduction and scope of Animal Biotechnology
- Basic requirements for animal tissue culture: Infrastructure, necessary equipments and accessories for animal tissue culture lab.
- Culture Media: Different types of media-Natural media, Defined media, Serum free media  
Chemical, physical and metabolic functions of different constituents of culture media.
- Role of serum in tissue culture media
- Sterilization techniques
- Biohazards and Bioethics

**UNIT II:**

- Biology and characterization of cultured cells
- Basic techniques of animal cell culture: Primary culture techniques,
- Enzymatic and mechanical disaggregation techniques
- Sub culture methods
- Development of cell lines, nomenclature and types of cell lines.
- Explant culture, Organ culture – 3Dimensional culture
- Large scale culture of cells-suspension and monolayer culture
- Cell separation methods
- Cell cloning
- Transformation and immortalization

**UNIT III:**

- Application of animal tissue culture
- Contaminants- source, types and prevention
- Cell viability Cytotoxicity assays
- Cryopreservation of cultured cells
- Hybridoma technology – production of MAbs.
- Vaccine Production

**UNIT IV:**

- Transgenic Animal Technology:

- Techniques for producing transgenic Animals,
- Application of transgenic animals
- Artificial animal breeding, Artificial insemination,
- In vitro fertilization (IVF), Embryo Transfer, Embryo sexing
- Tissue Engineering- scaffold materials, synthesis of scaffold, cell sources and applications of Tissue engineering

### **REFERENCE BOOKS:**

- 1) Culture of animal cells: A manual of basic technique- R. Ian Freshney, Wiley Publication.
- 2) Animal cell culture & technology-M. Butler.
- 3) Animal cell culture techniques- M. Clynes, Springer.
- 4) Animal Biotechnology- M. M. Ranga. Agrobios (India).
- 5) Animal Biotechnology-Young, Murray, Moo. Pergamon Press, Oxford.
- 6) Methods in Cell Biology-Vol. 57, Animal cell culture methods- Mather, J.P., Academic Press.
- 7) Animal Cell Biotechnology-Spier, R.E. Academic press.
- 8) Animal biotechnology – P. Ramadass, MJP Publishers
- 9) Biotechnology- U.Styanarayan, Books and Allied (P) Ltd.

### **PRACTICALS:**

1. Introduction of animal tissue culture laboratory with necessary equipments & accessories.
2. Preparation of culture media
3. Sterilization of culture media
4. Primary culture from Chick embryo.
5. Cell counting using hemocytometer.
6. Cell viability
7. Organ culture – trachea culture
8. Short term lymphocyte culture.
9. Chromosome preparation from cultured cells.
10. Cytotoxicity test-MTT

**MASTER OF SCIENCE – BIOTECHNOLOGY  
(MEDICAL BIOTECHNOLOGY), SEMESTER – II  
NAME OF COURSE: BIOSEPERATION TECHNOLOGY  
COURSE CODE: ELECTIVE 2  
SYLLABUS EFFECTIVE FROM: 2021-2022**

**Course Outcomes**

**At the end of this course, the student will be able to:**

1. Students able to understand about various downstream processing
2. Product isolation and purification methods
3. Final Product Purification and Preparation

**UNIT I:**

Introduction to downstream processing, Characteristics of fermentation broth and its pretreatment, Separation of cells and suspended solids: Filtration: theory of filtration, use of filter aids, Batch filters, Continuous filters, cross flow filtration.

**Membrane processes** – Dialysis, ultrafiltration, Reverse osmosis and electrodialysis

**UNIT II:**

**Product isolation methods:**

Centrifugation: Cell aggregation and flocculation, Types of commercial centrifuges  
Cell disruption by physical and chemical methods,  
Liquid-liquid extraction-choice of solvent, co current and counter current extraction,  
Centrifugal extractor, Solvent recovery, Two-phase aqueous extraction system, Super critical fluid extraction.

**UNIT III:**

**Chromatography techniques for product isolation and purification:**

Adsorption chromatography, Gel permeation chromatography, Ion-exchange chromatography, Hydrophobic chromatography, Affinity chromatography, High performance chromatography (HPLC). FPLC, Expanded bed chromatography

**UNIT IV:**

**Final Product Purification and Preparation** Crystallization; Drying and lyophilisation; Formulation Strategies

Case studies: Recovery of Ethanol, Citric acid, Penicillin.

**REFERENCE BOOKS:**

1. Principles of Fermentation Technology – Peter F. Stanbury, Allan Whitaker and Stephen J. Hall.
2. Fermentation Microbiology and Biotechnology – E.M.T. El-Mansi and C.F.A. Bryee.
3. Comprehensive Biotechnology – Murray Moo Young
4. Biochemical Engineering Fundamentals – J.E.Bailey& D.F. Ollis.
5. Downstream industrial biotechnology : recovery and purification / edited by Michael C. Flickinger

**PRACTICALS:**

1. Determination of dry weight and wet weight of cells
2. Determination of total protein of cells by alkali lysis
3. Recovery and estimation of penicillin
4. Ammonium Sulphate fractionation of protein
5. Dialysis of fractionated proteins
6. Recovery of protein by acetone precipitation
7. Demonstration of chromatography techniques

**MASTER OF SCIENCE – BIOTECHNOLOGY  
(MEDICAL BIOTECHNOLOGY), SEMESTER – II  
NAME OF COURSE: PROTEIN ENGINEERING  
COURSE CODE: ELECTIVE 3  
SYLLABUS EFFECTIVE FROM: 2021-2022**

**Course Outcomes**

**At the end of this course, the student will be able to:**

1. Different tools and methods used in proteomic study.
2. The sources of protein, Industrial and medical application of proteins,
3. Different expression of proteins for large scale purifications,
4. Protein engineering strategy.

**UNIT I:**

Proteomics: Sample preparation, Gel-based proteomics - two-dimensional gel electrophoresis (2-DGE), two-dimensional fluorescence difference in-gel electrophoresis (DIGE), Staining methods, PF-2D, Tandem FPLC, Mass spectroscopy: basic principle, ionization sources, mass analyzers, different types of mass spectrometers (MALDI-TOF Q-TOF, LC-MS)

**UNIT II:**

Multidimensional proteomics: SELDI-TOF. Quantitative proteomics - stable isotope labeling by amino acids in cell culture (SILAC), isotope-coded affinity tag (ICAT), isobaric tagging for relative and absolute quantitation (iTRAQ); Label-free proteomics., Nuclear magnetic resonance spectroscopy (NMR), basic principles, chemical shift, spin-spin interaction, NOE, 2D-NMR, NOESY, COSEY.

**UNIT III:**

X-ray Crystallography: Principle of X-ray diffraction, scattering vector, structure factor, phase problem, reciprocal lattice and Ewald sphere, Miller indices, Zone axes, crystal lattice, Lane Equations, Bragg's law, special properties of protein crystals, model building, refinement and R-factor.

**UNIT VI:**

Protein Engineering: Protein sources, Industrial and medical application of proteins, different expression of proteins for large-scale purifications, protein engineering strategy, rational and random mutagenesis. Applications of protein engineering protein in Chemical and Medical Industries: Generation of heat stable, pH stable enzymes, application in vaccine development, drug development, sensor development. Practicals, Protein electrophoresis-1D+2D, HPLC, FPLC, MALDI-TOF & LC-MS

**REFERENCE BOOKS:**

1. Principles of Protein X-Ray Crystallography [3rd ed.] by Jan Drenth
2. Protein engineering in industrial biotechnology by L Alberghina, Net Library, Inc.

3. Protein Engineering Protocols [1 ed.] by Kristian Müller, Katja Arndt
4. Protein Engineering by C Kohrer, U Rajbhandary
5. Protein Engineering Handbook Volume 3 [1 ed.] by Stefan Lutz, Uwe Theo Bornscheuer
6. Protein Engineering by P. Kaumaya
7. Protein Structure Prediction: Methods and Protocols by Webster, David (Southern Cross Molecular Ltd., Bath, UK)
8. Essential Bioinformatics by JinXiong

**PRACTICALS:**

1. To perform protein extraction.
2. Determine an importance of various electrophoresis techniques in protein engineering.
3. A study an application of liquid chromatographic technique.
4. To understand the importance of gas chromatographic techniques with demonstration.
5. Understanding of principles and applications of MALDI-TOF and SELDI TOFF

**MASTER OF SCIENCE – BIOTECHNOLOGY  
(MEDICAL BIOTECHNOLOGY), SEMESTER – II  
NAME OF COURSE: ENVIRONMENT POLICY AND LEGISLATION  
COURSE CODE: ELECTIVE 4  
SYLLABUS EFFECTIVE FROM: 2021-2022**

**Course Outcomes**

**At the end of this course, the student will be able to:**

1. Legal structure of India and fundamentals of environmental legislation and policy making.
2. Understand the environmental performance including compliance with environmental legislation.
3. Implementation of environmental policies and practices and raise awareness about the emerging environmental issues.
4. Study of various acts, laws and rules related to air, water, environment and wastes in India.

**UNIT I:**

**International Law and Environmental Protection:** Fundamental Principles of International Environmental Law. United Nations Conference on Human Environment, 1972 (Stockholm Conference) – Aims and Objectives of the Conference, Stockholm Declaration. UNEP- Vienna Convention & Montreal Protocol, World Charter for Nature, 1982. WCED – The Brundtland Commission, Brundtland Report 1987. United Nations Conference on Environment and Development (UNCED/Earth Summit) – Aims and Objectives of Conference, Rio Declaration 1992, Agenda 21, Convention on Biological Diversity. Earth Summit Plus Five - Kyoto Protocol, 1997; Millennium Development Goals. Johannesburg Conference 2002 (WSSD) - Johannesburg Declaration & Major Outcomes.

**UNIT II:**

**History and Development of Environmental Law in India:** Environmental Protection in Ancient Indian Tradition and Culture - Protection of Environment in Ancient India and During Medieval Period. Protection of Environment during British Period – Major Legislations. Protection of Environment during Post Independence Period – Pitambar Pant Committee, Tiwari Committee, NCEP, Department of Environment, MOEF Guidelines and Notifications, Appellate Authority Act, Other related Notifications.

**UNIT III:**

**Protection of Environment under the Indian Constitution:** Introduction – Indirect Provisions, International Obligations, 42<sup>nd</sup> Constitution Amendment Act, 1976. Directive Principles of State Policy - Fundamental Duties. Development of Fundamental Right to Environment - Judicial Role, Expansion of Locus Standi, PIL, Constitutional Remedy for Protection of Environment, Dynamic Interpretation of Article 21, 14 & 19 of the Constitution. Right to Wholesome Environment – Right to Clean and Pollution-free Environment, Right to Sweet Water. Incorporation of International Principles under Indian

Constitution – Sustainable Development - Precautionary and Polluter Pays Principles, Absolute and Strict Liability.

#### **UNIT IV:**

##### **Protection of Water, Air and Environment in India:**

EP Act 1986, Air (Prevention and Control of pollution) Act, Water (Prevention and Control of pollution) Act, Mines and Mineral Act, Factories Act, Pesticides Act, Indian Forest Act, Wildlife Act, Ancient Monuments and Archaeological Sites and Remains Act, Hazardous Waste Management and Handling Rules / Biomedical Rules / Solid Waste Management Rules, Environment Tribunal Act, Climate change Protocols and Conventions,

#### **REFERENCE BOOKS:**

1. S.C. Shastri, *Environmental Law*, (3<sup>rd</sup>Edn.), Eastern Book Company, Lucknow, 2008.
2. Maheshwara Swamy, *Textbook on Environmental Law*, (2<sup>nd</sup>Edn.), Asia Law House, Hyderabad, 2008.
3. Shyam Divan and Armin Rosencranz, *Environmental Law and Policy in India*, Oxford University Press, New Delhi, 2005.
4. Amod S. Tilak, *Environmental Law*, (1<sup>st</sup>Edn.), Snow White Publication, Mumbai, 2009.
5. I.A. Khan, *Environmental Law*, (2<sup>nd</sup>Edn.), Central Law Agency, Allahabad, 2002.
6. P Leelakrishnan, *Environmental Law in India*, (2<sup>nd</sup>Edn.), Lexis Nexis, New Delhi, 2005.
7. S. Shantakumar, *Introduction to Environmental Law*, (2<sup>nd</sup>Edn.), Wadhwa & Company, Nagpur, 2005.

#### **PRACTICALS:**

1. Bio-ethanol production from waste materials.
2. Production of biodiesel from vegetable oil.
3. Production of biofuel from algae.
4. Physico-chemical analysis soil.
5. Isolation of *Actinomyctes* from soil.
6. Demonstration of Lab scale biogas production plant.
7. Saponification value of an oil sample.