ANNAMALAI UNIVERSITY
MASTER OF SCIENCE
M.Sc. Biotechnology
(With effect from 2021 – 2022)

The Course of Study and the Scheme of Examination

Sl. No.	*Study Components*		*ins. hrs / week*	*Credit*	*Title of the Paper*	*Maximum Marks*		
	Course Title					*CIA*	*Uni. Exam*	*Total*
SEMESTER I								
1.	Core	Paper-1	5	4	Cell & Developmental Biology	25	75	100
2.	Core	Paper-2	5	4	Biochemistry	25	75	100
3.	Core	Paper-3	5	4	Genetics & Molecular Biology	25	75	100
	Practical	Paper-1	3	0	Lab in Cell & Developmental Biology	0	0	0
	Practical	Paper-2	3	0	Lab in Biochemistry	0	0	0
	Practical	Paper-3	3	0	Lab in Genetics & Molecular Biology	0	0	0
Internal Elective for same major students								
4.	Core Elective	Paper-1	3	3	**(to choose one out of 3)** A. Bioinstrumentation B. Bioprospecting C. Aqua Culture Biotechnology	25	75	100
External Elective for other major students (Inter/multidisciplinary papers)								
5.	Open Elective	Paper-1	3	3	**(to choose one out of 3)** A. Tools in Biotechnology B. Medical Biotechnology C. Food Biotechnology	25	75	100
			30	**18**		**125**	**375**	**500**
SEMESTER II						*CIA*	*Uni. Exam*	*Total*
6.	Core	Paper-4	4	4	Microbial Technology	25	75	100
7.	Core	Paper-5	4	4	Immuno Technology	25	75	100
8.	Core	Paper-6	4	3	Genetic Engineering	25	75	100
9.	Core Practical	Paper-1	3	3	Lab in Cell & Developmental Biology and Microbial Technology	25	75	100
10.	Core Practical	Paper-2	3	3	Lab in Biochemistry and ImmunoTechnology	25	75	100
11.	Core Practical	Paper-3	3	3	Lab in Genetics & Molecular Biology and Genetic Engineering	25	75	100
Internal Elective for same major students								
12.	**Core Elective**	**Paper-2**	4	3	**(to choose one out of 3)** A. Omics Technology	25	75	100

					B. Pharmaceutical Biotechnology C. Nanotechnology			
External Elective for other major students (Inter/multi disciplinary papers)								
13.	**Open Elective**	**Paper-2**	3	3	**(to choose one out of 3)** A. Medicinal Plants B. Tissue Culture C. Molecular Diagnostics	25	75	100
14.	***Field Study**		-	2		100	-	100
15.	**Compulsory Paper**		2	2	**Human Rights**	25	75	100
			30	**30**		**325**	**675**	**1000**
SEMESTER III						***CIA***	***Uni. Exam***	***Total***
16.	Core	Paper-7	6	5	Ecology & Environmental Biotechnology	25	75	100
17.	Core	Paper-8	6	5	Plant Biotechnology	25	75	100
18.	Core	Paper-9	6	5	Animal Biotechnology	25	75	100
	Core Practical	Paper-4	3	0	Lab in Ecology & Environmental Biotechnology	0	0	0
	Core Practical	Paper-5	3	0	Lab in Plant Biotechnology	0	0	0
Internal Elective for same major students								
19.	Core Elective	Paper-3	3	3	**(to choose one out of 3)** A. Cancer Biology B. Industrial Biotechnology C. Virology	25	75	100
External Elective for other major students (Inter/multi disciplinary papers)								
20.	Open Elective	Paper-3	3	3	**(to choose one out of 3)** A. Forensic Science B. Dairy farming C. Waste Water Management	25	75	100
21.	****MOOC Courses**		-	-		-	-	100
			30	**21**		**125**	**375**	**600**
SEMESTER IV						***CIA***	***Uni. Exam***	***Total***
22.	Core	Paper-10	6	4	Research Methodology	25	75	100
23.	Practical	Paper-4	0	3	Lab in Ecology & Environmental Biotechnology	25	75	100
24.	Practical	Paper-5	0	3	Lab in Plant Biotechnology	25	75	100
25.	Core	Project	18	5	Project with *viva voce* **(Compulsory)**	100 (75 Project +25 viva)		100

Internal Elective for same major students								
26.	Core Elective	Paper-4	3	3	**(to choose one out of 3)** A. Biosafety, Bioethics and IPR B. Systems Biology C. Stem Cell Biology	25	75	100
External Elective for other major students (Inter/multi disciplinary papers)								
27.	Open Elective	Paper-4	3	3	**(to choose one out of 3)** A. Organic farming B. Entrepreneurship C. Pollution Control	25	75	100
			30	**21**		**125**	**375**	**600**
			120	**90**				**2700**

*** Field Study**

There will be field study which is compulsory in the first semester of all PG courses with 2 credits. This field study should be related to the subject concerned with social impact. Field and Topic should be registred by the students in the first semester of their study along with the name of a mentor before the end of the month of August. The report with problem identification and proposed solution should be written in not less than 25 pages in a standard format and it should be submitted at the end of second semester. The period for undergoing the field study is 30 hours beyond the instructional hours of the respective programme. Students shall consult their mentors within campus and experts outside the campus for selecting the field and topic of the field study. The following members may be nominated for confirming the topic and evaluating the field study report.

(i). Head of the respective department
(ii). Mentor
(iii). One faculty from other department

****Mooc Courses**

Inclusion of the Massive Open Online Courses (MOOCs) with zero credits available on SWAYAM, NPTEL and other such portals approved by the University Authorities.

ANNAMALAI UNIVERSITY

MASTER OF SCIENCE

M.Sc. BIOTECHNOLOGY

DEGREE COURSE

UNDER CBCS

(With effect from 2021-2022)

SEMESTER I

CORE PAPER 1

Cell and Developmental Biology

Course Objectives

1. To understand better the cell and intracellular organelles.
2. Cells vital functions and biological developments of cells.
3. To get a knowledge in DNA replication and protein synthesis
4. To understand briefly about Developmental biology

Unit-1

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.

Unit-2

Cell signalling: Hormones and their receptors, Cell surface receptors, signaling through G – Protein, Coupled receptors, Signal transduction pathways, Second messengers, regulation of signaling pathways, Light signaling in plants. Ion Channel – Leaked receptors, Enzyme linked receptors, Cytoplasmic and Nuclear receptors.

Unit-3

DNA Replication: Prokaryotic & Eukaryotic replication. DNA damage and repair mechanisms.

RNA synthesis and processing – Transcription mechanism - Factors - Formation of initiation complex, Transcription activator and repressor, RNA polymerases, Capping, Elongation. RNA processing - RNA editing, Splicing and polyadenylation

Protein synthesis and processing – Genetic code, Ribosome, Formation of initiation complex, Initiation factors and their regulation complex, Elongation and elongation factors, Termination. Post-translational modification of proteins.

Unit-4

Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination.

Unit-5

Morphogenesis and organogenesis in animals: Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick; organogenesis – vulva formation in Caenorhabditis elegans, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.

References / Textbooks

1. Cell and Molecular Biology - P.K. Gupta
2. Cell and Molecular Biology - De Roberties and DeRoberties
3. Molecular Biology – Labfax, T.A. Brown, Bioscientific publishers Ltd, Oxford.
4. Molecular Biology of the Cell – Alberts, B *et al*
5. Developmental Biology by Scott F. Gilbert
6. Principles of Development by Lewis Wolpert, Cheryll Tickle
7. Molecular Biology - Channarayappa University Press India (P) Limited.
8. Molecular Biology and Biotechnology - J.M. Walker and R. Rapley, 2005 7.
9. Genomes – T.S. Brown
10. Frontiers in Celland Developmental Biology
11. Cell & Developmental Biology-Longdom publishing
12. https://ghr.nlm.nih.gov/primer/basics/cell
13. https://www.britannica.com/science/cell-biology
14. https://www.cellsignal.com/contents/science/cst-pathways/science-pathways
15. https://www.khanacademy.org/science/biology/cell-signaling/mechanisms-of-cell-signaling/a/introduction-to-cell-signaling
16. https://www.yourgenome.org/facts/what-is-DNA-replication
17. https://www.khanacademy.org/science/high-school-biology/hs-molecular-genetics/hs-rna-and-protein-synthesis/a/hs-rna-and-protein-synthesis-review
18. https://www.nature.com/scitable/topicpage/ribosomes-transcription-and-translation-14120660/
19. https://opentextbc.ca/biology/chapter/24-6-fertilization-and-early-embryonic-development/
20. https://courses.lumenlearning.com/boundless-biology/chapter/fertilization-and-early-embryonic-development/
21. https://www.eolss.net/Sample-Chapters/C03/E6-183-06-00.pdf
22. http://bio1520.biology.gatech.edu/growth-and-reproduction/animal-development-i/
23. https://opentextbc.ca/biology/chapter/13-2-development-and-organogenesis/

Course Outcomes

1. The students will be able to understand the cell and its basic functions
2. The students will be able to learn about the cell signaling and different pathways of cell signaling and types of receptors
3. The students will be able to learn the concept of DNA replication and central dogma of molecular biology
4. The students will be able to understand the gametes and its production, fertilization and formation of zygote and embryo
5. The students will be able to understand the morphogenesis and organogenesis in animals

SEMESTER I

CORE PAPER 2

Biochemistry

Course Objectives

1. To understand about metabolism of carbohydrates
2. To learn about the metabolism of lipids
3. To study about basic metabolism of in proteins
4. To learn about nucleic acid, vitamins and their types
5. To learn about biocatalyst
6. To know about functions of biomolecules

Unit-1

Carbohydrates – Introduction,Classification Significance - Carbohydrates - Structure and function. Metabolism of carbohydrates - Glycolysis, Citric acid cycle, Gluconeogenesis and Glycogenolysis. Electron Transport chain - oxidative and substrate level phosphorylation, Electron carriers of ETC.

Unit-2

Lipids – Classification- Structure and functions. Significance of PUFA, Cholesterol and its derivatives. Metabolism of fatty acids - β-oxidation. Fatty acid biosynthesis. Energetics of lipid metabolism.

Unit-3

Proteins - Classification – Structure and functions of essential and nonessential aminoacids, Properties of amino acids. General degradation of amino acids. Structure of protein - primary secondary, tertiary and quaternary. Conformation of protein (Ramachandran plot, secondary structure, domains, motif and folds).

Unit-4

Nucleic acids - Structure and function of DNA and RNA. Inborn errors of nucleotide metabolism. Vitamins - Structure, functions. Deficiency syndrome of vitamins (A, D, E, K, B12 & C).

Unit-5

Biocatalyst - Enzymes classification, Mechanism of action - allosteric enzymes, isoenzymes, coenzymes and cofactors. Michaelis – Menton equation. Bioenergetics - Concept of free energy, Entropy, Enthalpy & Redox Potential. High energy phosphate compounds - ATP, Phosphenol pyruvate, Creatine phosphate, phosphate potential. ATP-ADP Cycle.

References / Textbooks

1. Lehninger AL, Nelson DL and Cox MM (2002), Principles of Biochemistry. Mac Millan Worth Publishers Inc. (CBS Pub. & Distributors, New Delhi)
2. Martin DW, Jr., Mayer, PA and Rodwell, VW (2002). Harper's Review of Biochemistry 25th Edition, Maruzen Asian Ed: Lange Med. Pub.
3. Sunjay Jain, J L Jain & Nitin Jain, Fundamentals of Biochemistry, Chand Publications, New Delhi.
4. Stryer L (2002). Biochemistry, Freeman & Co.
5. Zubay, G. Biochemistry. Mac Millan Publication co. New York
6. Corn and Stump. Outline of Biochemistry.
7. Deb, A.C. Fundamentals of Biochemistry, New Central Book Agency-Kolkata
8. https://courses.lumenlearning.com/suny-ap2/chapter/carbohydrate-metabolism-no-content/
9. https://accesspharmacy.mhmedical.com/content.aspx?bookid=2492&sectionid=204926092

10. https://www.amboss.com/us/knowledge/Lipids_and_fat_metabolism
11. https://www.britannica.com/science/protein
12. https://www.toppr.com/guides/biology/biomolecules/proteins/
13. https://www.creative-enzymes.com/resource/enzyme-definition-and-classification_18.html

Course Outcomes

1. The students will be able to understand carbohydrates and their functions.
2. The students will be able to know metabolism of lipids.
3. The students will be able to understand important of proteins.
4. The students will be able to know nucleic acids and their functions.
5. The students will be able to understand enzymes and their functions.

SEMESTER I

CORE PAPER 3

Genetics and Molecular Biology

Course Objectives

1. To make the students familiar with the activity Genetics, mutation at the molecular level.
2. To Understand the Students about the mutation at the molecular level and Gene Expression.

Unit-1

Central dogma: Structure of DNA and RNA

DNA as the Genetic Material: Griffith's experiment, Hershey-Chase Experiment, Experimental Proof by Avery, McLeod and McCarty. RNA as genetic material. Basic Concept - Gene, Chromosome,DNA and RNA

Mendelian Principles: Introduction – Birth of Genetics, Mendelian principles –Mendel's experimental organism

DNA as the genetic material: Griffith's experiment, Hershey-Chase experiment, Experimental proof by Avery, McLeod and McCarty.

Unit-2

DNA Replication: Conservative, Semi conservative, Rolling circle. Mechanism of replication

Genetics of Bacteria and viruses: Transformation, Conjugation, F+, Hfr, Transduction- generalized and specialized.

Regulation of gene expression: Operon concept - lac and trp operons

Unit-3

Mutation: Spontaneous, Induced mutation, Radiation induced Mutation – (Ionizing and UV radiation),Molecular basis of Mutation. Point mutation. Chromosomal Abnormalities. Genetic basis of cancer – benign, malignant and metastatic cancer, Oncogenes and tumor suppressor genes.

Unit-4

Allelic variation and gene function–Completed Dominance, Incomplete Dominance, Pleotrophy, Penetrance and expressivity. Sex-linkage, sex limited and sex influenced characters.

Unit-5

Human genetics - Pedigree analysis, Twin studies–Mono zygotic, Di zygotic. Genetic testing–Prenatal genetic testing, Postnatal genetic testing. Transposable genetic elements – IS elements, composite transposons, Tn3, Tn5. Eukaryotes – Ac and Ds elements in maize, elements in drosophila. Retro transposons.

References / Textbooks

1. Textbook of population genetics by tomar
2. Textbook of Genetics by R.P. Meyyan (Saras Publication)
3. Text book of Genetics from Genes to Genomes–A joy Paul
4. Genetics–P.S. Verma,V.K. Agarwal
5. Essential of human genetics (5th Edn)–Manu L Kothari, Opa A Metha and Sadhana S Roy chodhury, Universities Press, Hyderabad.
6. Molecular Biology of Genes. 4th edition by Watson, Hopkins, Roberts, Steitz, Weiner.
7. The Cell – A molecular approach. 3rd edition by Geoffrey M. Cooper, Robert E. Hausman.
8. iGenetics (A Molecular Approach)- 2nd edition by Peter J. Russell

9. Genetics– A Conceptual Approach (2nd Edition)–Benjamin A. Pierce.W.H. Freeman Company
10. https://www.khanacademy.org/science/biology/bacteria-archaea/prokaryote-structure/a/genetic-variation-in-prokaryotes
11. https://www.ndsu.edu/pubweb/~mcclean/plsc431/mendel/mendel9.htm

Course Outcomes

1. The students will be able to explain DNA as a genetic material and mendelian principle
2. The students will be able to understand replication, genetics of bacteria and virus and gene regulation
3. The students will be able to know mutation, cancer and oncogene, tumour supression
4. The students will be able to know allelic variation and gene function
5. The students will be able to explain the human genetics and transposable elements

CORE ELECTIVE

PAPER-1

(to Choose either A or B)

Bioinstrumentation

Course Objectives

1. The overall objective of this paper is to enrich the student intelligentsia in all the biological observations which are explainable in terms of physical principles as biophysical phenomena.
2. Understand the canonical structure of biomedical instrumentation systems.
3. Through this course, students are introduced to basic biomedical engineering technology and introduce different biological signals, their acquisition, measurements and related constraints.
4. Students will have complete insight in these important techniques for the possible applications in various research areas of biological sciences.
5. On the successful completion of this course, the students would understand the analytical techniques and the principles of equipment used in biological and medical field.

Unit-1

Physical techniques in separation of biomolecules: Centrifugation, Density Gradient Centrifugation and ultra-centrifugation. Chromatography Techniques: Theory and Application of Paper Chromatography, TLC, Gel Filtration Chromatography, Ion Exchange Chromatography, Affinity Chromatography, GC/GC-MS, HPLC, LC-MS, MALDI.

Unit-2

Theory and Application of PAGE, SDS PAGE, Agarose Gel Electrophoresis 2DE, Iso-electric Focusing, pulse field gel electrophoresis, Immuno diffusion, Immuno Electrophoresis, ELISA and RIA. Cell analysis: Principles and Applications of Light, Phase Contrast, Fluorescence Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, Confocal Microscopy.

Unit-3

Structural analysis of Biomolecules: Concepts, principle and applications of UV, IR, NMR, LASER Raman Spectroscopy, Mass Spectroscopy, Fluorescence Spectroscopy. X ray crystallography, X ray computer tomography and patch clamping

Unit-4

Principles of PCR, semi quantitative RT-PCR, Real Time PCR, Touch down PCR, Flow Cytometry, FACS, MACS and Microarray. Circular dichroism and optical rotatory dispersion, Polarography and Manometry – theory and application, Introduction Biosensors- Applications of Biosensors.

Unit-5

Tracer and other techniques – Radioactive decay, units of radioactivity, detection – Geiger Muller counter, Scintillation counter, Autoradiography. Applications and use of radio isotopes in biomedical sciences.

References / Textbooks

1. Anna Pratima G. Nikalje (2017). A Handbook of Chromatography. Scholar's Press Verlag Omniscriptam, Deutschland, Germany.
2. Wilson. K and Walker. J (2000). Practical Biochemistry – Principles and techniques. Cambridge University Press.
3. Reiner Westermeier (2004). Electrophoresis in Practice: A Guide to Methods and Applications of DNA and Protein Separations, Fourth Edition. Wiley Publishers.
4. Michael Hoppert (2003). Microscopic Techniques in Biotechnology. Wiley Publishers.
5. Gordon G. Hammes (2005). Spectroscopy for the Biological Sciences. Wiley Publishers.
6. Carmona, P., Navarro, R., Hernanz, A (1997). Spectroscopy of Biological Molecules: Modern Trends. Springer Publishers.
7. L Veerakumari (2015). Bioinstrumentation. MJP Publishers
8. Sarah Maddocks Rowena Jenkins (2016). Understanding PCR- A practical bench top guide. Elsevier Publishers.
9. Slater, Robert J (2005). Radioisotopes in biology (2nd ed.): Biochemistry and Molecular Biology Education. IUBMB Journals
10. Bell Z.W. (2012) Scintillation Counters. In: Grupen C., Buvat I. (eds) Handbook of Particle Detection and Imaging. Springer, Berlin, Heidelberg
11. P.K. Sharma (2014). Instrumental methods of chemical analysis. Krishna Prakashan Media Pvt Ltd.
12. Upadhyay., Upadhyay and Nath (2010). Biophysical chemistry. Himalaya Publishing House
13. Keith Wilson and Kenneth H. Goulding. A Biologist‟s guide to principle and techniques of practical biochemistry. Cambridge University Press.
14. Khandpur RS (2014). Handbook of Biomedical Instrumentation – R.S. Khandpur, McGraw Hill Education; Third edition
15. Wilson. K and Walker. J (2000). Practical Biochemistry – Principles and techniques. Cambridge University Press.
16. DonaldL.Pavia Gary M.Lipman, George S Kriz and Vyvyan JA (2015). Introduction to Spectroscopy- Cengage Learning India Private Limited; 5 edition
17. https://www.sciencedirect.com/topics/engineering/bioinstrumentation
18. https://cw.fel.cvut.cz/b172/_media/courses/a6m33zsl/microscopic_techniques.pdf

Course Outcomes

1. The students will be able to acquire knowledge about importance of various chromatographic techniques.
2. The students will be able to understand working principles and application of microscopes.
3. The students will be able to get insight into application of spectroscopy techniques.
4. The student will get knowledge about advanced instruments like qPCR, FACS etc.
5. The students will be able to learn about application of radio isotopes in biomedical sciences.

Bioprospecting

Semester: I **Credits: 3**

Hours of teaching: 3 **Paper type: Core Elective 1**

Course Objectives

1. To understand the bioreactors design and different types of bioreactors then its application in different field.
2. To depict the information in fermentation techniques and about the sterilization of bioreactors.
3. The course objectives are framed to give an adequate knowledge about fermentation process and types of fermentation process.
4. To learn about the physical, chemical and enzymatic methods used in the downstream processing.
5. To provide adequate knowledge in primary and secondary screening methods in drug designs.

Unit-1

Bioreactors Design of a basic fermenter, bioreactor configuration, design features, individual parts, baffles, impellers, foam separators, sparger, culture vessel, cooling and heating devices, probes for online monitoring, computer control of fermentation process, measurement and control of process. Reactors for specialized applications: Tube reactors, packed bed reactors, fluidized bed reactors, cyclone reactors, trickle flow reactors, their basic construction and types for distribution of gases.

Unit-2

Gas- liquid exchange and mass transfer, oxygen transfer, critical oxygen concentration, determination of Kla, heat transfer, aeration/agitation, its importance. Sterilization of Bioreactors, nutrients, air supply, products and effluents, process variables and control, scale-up of bioreactors.

Unit-3

Fermentation Process Growth of cultures in the fermenter, Importance of media in fermentation, media formulation and modification. Kinetics of growth in batch culture, continuous culture with respect to substrate utilization, specific growth rate, steady state in a chemostat, fed-batch fermentation, yield of biomass, product, calculation for productivity, substrate utilization kinetics. Fermentation process: Inoculum development. Storage of cultures for repeated fermentations, scaling up of process form shake flask to industrial fermentation.

Unit-4

Downstream Processing Biomass separation by centrifugation, filtration, flocculation and other recent developments. Cell disintegration: Physical, chemical and enzymatic methods. Extraction: Solvent, two phase, liquid extraction, whole broth, aqueous multiphase extraction. Purificationby different methods. Concentration by precipitation, ultra-filtration, reverse osmosis. Drying and crystallization.

Unit-5

Chemically creative fungi; screening for industrially useful fungal metabolites; drugs and pharmaceuticals from fungi; Ecotaxonomic approach in chemical screening; primary and secondary products of metabolism; classification of secondary metabolites; primary and secondary screening of antibiotic producers; auxanography; enrichment culture, techniques for strain improvement and Strain development; Industrial fungal strains preliminary and high throughput screening (HST); leads and lead optimization, IPR issues and patents.

References / Textbooks

1. Bioreactor design fundamentals (2013). Norton G. McDuffie. Butterworth- Heinemann.
2. Bioreactors analysis and design. Tapobrata Panda.
3. Practical manual on fermentation technology. S. Kuladaivelu and S. Janarthanan.
4. Bioreactors design, operation and novel applications edited by Carl-Fredrik Mandenius.
5. Fermentation, Biocatalysis and Bioseperation, Encyclopedia of Bioprocess Technology by Chisti, Y., Vol. 5, John Wiley and Sons, N,Y.
6. Fermentation biotechnology: Industrial perspectives by chand.
7. Downstream processing techniques in biotechnology (2018). Anuj Kumar Rana.
8. Reverse osmosis design, processes and applications 2nd edition (2015). Jane Kucera.
9. Antibiotic basics for clinicians choosing the right antibacterial agent second edition (2012). Alan R. Hauser.
10. Strain development in concrete under cyclic loading: theoretical and experimental investigations (2010). Marek Foglar.
11. Jagritisingh *et al*.,(2014) Bioreactors- Technology and design analysis. The Scitech Journal Vol. 01.
12. Jian-Jiang Zhong (2010) Recent advances in bioreactor engineering. Korean journal of chemical engineering.
13. Marcel Gutierrez-Correa and gritty K. Villena (2010) Characteristics and techniques of fermentation systems.
14. 4.Jungmin Kim *et al*., (2013) Methods of downstream processing for the production of biodiesel from microalgae. Biotechnology advances journal.
15. Gamal Osman Elhassa and Khalid Omer Alfarouk (2015) Drug development: stages of drug development. Journal of pharmacovigilance.
16. https://www.sciencedirect.com/topics/neuroscience/bioreactors
17. https://www.britannica.com/science/fermentation

Course Outcomes

1. The students will be able to gain knowledge of bioreactor.
2. The students will be able to understand the application and functioning of bioreactors.
3. The students will be able to understand the fermentation process growth of cultures in the fermentor.
4. The students will be able to understand the downstream procedure and fermenter waste treatment.
5. The students will be able to know the role of fungi in food and feed industries viz. Edible mushrooms, different cultivation and nutritional aspects of mushrooms.

Aquaculture Biotechnology

Semester: I **Credits: 3**

Hours of teaching: 3 **Paper type: Core Elective1**

Course Objectives

1. To understand the application of biotechnology in different aspects of aquaculture Feed, environmental management, diagnostic and pharmaceuticals.
2. To understand the use of biotechnology tools in application of tissue culturing etc.,

Unit-1

Introduction - Scope of biotechnology in fisheries and aquaculture research. Transgenics - Principles of transgenic technology and its application in fisheries, Synthetic hormones for induced breeding.

Unit-2

Feed biotechnology: Probiotics, single cell proteins, nutraceuticals. Commercial Recombinant protein - enzymes, hormones, bioactive compounds, therapeutic proteins. Antimicrobial peptides and their applications. Marine toxins.

Unit-3

Biotechnological approaches in environmental management: Bioremediation, biosensors, biofouling, treatment of waste water. Vaccination in fishes- DNA vaccines, sub UNIT vaccines and Biofilm Vaccines.

Unit-4

Applications of biotechnological tools - Recombinant DNA, Monoclonal antibodies, Cell lines, Stem cell culture, DNA markers and MAS. Application of tissue culture in sea weed and pearl production.

Unit-5

Molecular diagnostic technology in aquaculture: PCR protocol for white spot syndrome virus WSSV, Infectious hypodermal and hematopoietic necrosis virus IHHNV, Yellowhead disease YHD, Taura syndrome virus TSV. Electron microscopy in advanced fisheries research. Cryomicroscopy in aquaculture research.

References / Textbooks

1. Ramesh RC. (Ed.). 2007. Microbial Biotechnology in Agriculture and Aquaculture. Vol.II. Science Publ.
2. Nagabhushanam R, Diwan AD, Zahurnec BJ & Sarojini R. 2004.Biotechnology of Aquatic Animals. Science Publ.
3. Felix S 2007. Molecular diagnostic technology in aquaculture, Narendra Publishing House, Delhi, India
4. Pandian TJ, Strüssmann CA & Marian MP. 2005. Fish Genetics and Aquaculture Biotechnology. Science Publ. Primrose SB. 1989. Modern Biotechnology. Blackwell.
5. Glick BR & Pasternak JJ. 1999. Molecular Biotechnology: Principles and Applications of Recombinant DNA Technology. ASM Press.
6. Felix S. 2007. Molecular Diagnostic Biotechnology in Aquaculture. Daya Publ. House.
7. Fingerman M, Nagabhushanam R & Thompson MF. 1997. Recent Advances in Marine Biotechnology. Vols. I-III. Oxford & IBH.
8. Nair PR. 2008. Biotechnology and Genetics in Fisheries and Aquaculture. Dominant Publ.
9. Reddy PVGK, Ayyappan S, Thampy DM & Gopalakrishna. 2005. Text Book of Fish Genetics and Biotechnology. ICAR.

10. Singh B. 2006. Marine Biotechnology and Aquculture Development. Daya Publ. House.
11. Zhanjiang JL. 2007. Aquaculture Genome Technologies. Blackwell.
12. http://aquafind.com/articles/Aquaculture_Biotechnology.php
13. https://www.dfo-mpo.gc.ca/science/biotech-genom/publications/strategy-strategie/index-eng.htm
14. https://www.dfo-mpo.gc.ca/science/biotech-genom/publications/strategy-strategie/index-eng.htm
15. http://www.fao.org/3/i1140e/i1140e01.pdf

Course Outcomes

1. The students will be able to understand the scope of aquatic biotechnology as an emerging field
2. The students will be able to learn feed biotechnology, scp, active compounds and proteins
3. The students will be able to use of technology in environment management
4. The students will be able to understand and biotechnology in aquatic applications
5. The students will be able to molecular diagnostic technologies in aquatic biotechnology

Tools in Biotechnology

Semester: I **Credits: 3**

Hours of teaching: 3 **Paper type: Open Elective 1**

Course Objectives

1. Introduction to prokaryotic and eukaryotic genomes
2. Basic knowledge about cloning strategies
3. Technical knowledge of gene manipulation
4. Introduction to screening techniques
5. Application of biotechnology

Unit-1

Gene and Genomes: Prokaryotic and Eukaryotic Genomes - Structure of Gene - DNA as the genetic material; Extra chromosomal DNA: Plasmid, mitochondrial DNA and chloroplast DNA.

Unit-2

Cloning Vectors: Plasmid, phagemid, cosmid, Artificial Chromosomes (BAC) - Transformation techniques: Electroporation, CaCl2 method.

Unit-3

Tools for Gene Manipulation: Gel Electrophoresis: AGE and PAGE; Restriction Enzymes, Ligases, Modifying Enzymes - Markers for Selection: selectable and scorable - Examples.

Unit-4

Selection Strategy and Screening for Transformants: Selection of rDNA Clones: Blue-White Selection, Colony Hybridization, PCR, Molecular analysis: Western blotting, Southern Blotting and Northern Blotting.

Unit-5

Application of Cloning: Over expression of Biomolecules (Insulin) - Gene therapy– GMO – Application and Biosafety issues.

References / Textbooks

1. Primrose. S.B., Twyman R.M., Old. R.W. (2001) Principles of Gene Manipulation. 1. Blackwell Science Limited.

2. Molecular Biotechnology. S.B Primrose, Blackwell Scientific Publishers,Oxford, 1994.

3. Principles of Gene Manipulation. T.A.Brown

4. DNA Science – A first course in rDNA technology, D.A. MicklossndG.A.Freyar, Cold Spring Harbor laboratory Press, New York, 1990.

5. Molecular Cloning. Maniatis, Fritsch and Sambrook.

Course Outcomes:

1. The students will be able to obtain a comprehensive knowledge about concepts of gene and genomics.
2. The students will be able to gain an in-depth knowledge about vectors used in gene cloning.
3. The students will be able to apprehend about the principle tools that are used for gene manipulation.

4. The students will be able to know about the importance of selection and screening of transformants.
5. The students will be aware with the principal applications of gene cloning.

Medical Biotechnology

Semester: I **Credits: 3**

Hours of teaching: 3 **Paper type: Open Elective 1**

Course Objectives

1. To understand about medical microbiology
2. To Learn about the bacterial infection
3. To Study about basics of viral infection
4. To Learn about parasitology
5. To Learn about clinical symptoms of various infections
6. To know about different characteristics of infectious agent

Unit-1

Medical Microbiology - Introduction and historical developments – Developments in medical bacteriology, developments in medical virology. Normal microbiota of human body – Host, microbe interactions. Classification of diseases.

Unit-2

Bacterial infection - Introduction, causative agents, characteristic features, virulence, pathogenesis, diagnosis, treatment and prevention of pneumonia, diphtheria, meningitis, whooping cough, Tb, leprosy, diarrhoea, cholera, typhoid, gonorrhea, syphilis, tetanus and gastroenteristis.

Unit-3

Viral infection - Introduction, causative agents, characteristic features, virulence, pathogenesis, diagnosis, treatment and prevention of small pox, common cold, influenza, measles, mumps, tubella, hepatitis, AIDS and polio.

Unit-4

Parasitology - General characteristics of parasites – Habitat, structure, life cycle, clinical manifestation, diagnosis, treatment and control of amoebiosis, malaria, ascariasis, enterobiasis, giardiasis, sleeping sickness.

Unit-5

Clinical symptoms - zoonotic infection, nosocomial infection, mycoplasma. Factors in Diseases - Environmental factor - physical injury, chemical injury, thermal injury, electrical injury. Developmental and genetic factors in diseases - gene defects. Abnormal fetal development – agenesis, dysgenesis, hypoplasia, aplasia, hypoplasia of mandibles, cleft palate.

References / Textbooks

1. Immunology by Roitt- (2006)
2. Immunology by Kuby-(2003)
3. Medical Physiology Guyton and Hall-(1996)
4. Medical Microbiology by Green
5. Fundamentals of Biochemistry- J. L. Jain-(2006)
3. Medical microbiology Mims Play fair Roitt, wekelin Williams.-(2009)
4. Biopharmaceuticals: Biochemistry and biotechnology, Harvard Academic publishers-(1998)
5. Human Genetics- Gangane –(2000)
6. Fundamentals of Biochemistry- J. L. Jain-(2006)
7. Text book of Biotechnology by R. C. Dubey - (2008)
8. Biotechnology by Satyanarayana- (2010)

6. https://jamanetwork.com/journals/jama/article-abstract/377575
7. https://www.verywellhealth.com/what-is-a-bacterial-infection-770565
8. https://www.healthline.com/health/signs-of-infection
9. https://www.betterhealth.vic.gov.au/health/ConditionsAndTreatments/infections-bacterial-and-viral
10. https://www.webmd.com/a-to-z-guides/bacterial-and-viral-infections
11. https://www.healthline.com/health/bacterial-vs-viral-infection

Course Outcomes

1. The students will be able to know medical microbiology
2. The students will be able to know bacterial infection
3. The students will be able to know viral infection
4. The students will be able to know parasitology
5. The students will be able to know clinical symptoms of various infections

Food Biotechnology

Semester: I **Credits: 3**

Hours of teaching: 3 **Paper type: Open Elective 1**

Course Objectives

1. To understand the basic concepts of food biotechnology in day to day life.
2. Students will get an idea about the process of quality control parameters related to different production process.
3. Thus the course objectives is framed- to impart adequate information regulatory guidelines related to genetically modified food.
4. To understand recent developments related to use and production of nutraceuticals.
5. Thorough knowledge gained after completing this course will help students to take up a career in fermentation and food processing. This course will also help students who are willing to take up the research in areas like food technology.

Unit-1

Important Industrial microorganism. Media for industrial fermentations, media composition – energy, carbon, nitrogen and other growth factors. Production of mass culture, maintenance and inoculum preparation. Single Cell Protein (SCP): Production and Process. Microbes as direct of nutritional food (chlorella, spirulina, mushrooms and Baker's yeast). Basics of Generally Recognized as Safe (GRAS).

Unit-2

Food Fermentation– Batch and continuous fermentation process for production of different food products or additives. Production process for alcoholic beverages: Beer, wine: Non -alcoholic beverages: tea, coffee, cocoa, Dairy products including cheese, yoghurt, acidophilus milk. Therapeutic value of fermented foods. Quality control process and parameters for fermented foods. Safety concerns.

Unit-3

Food additives: Introduction and basic concepts of food additives. Production of different additives - organic acids (lactic acid, acetic acid, succinic acid), amino acids, production of L- Glutamate, L-Lysine and other essential amino acids. Basic concepts pf food flavourants and pigments. Importance of nutraceuticals in daily life. Nutraceuticals from plants and bacteria.

Unit-4

Food spoilage and public health: Harmful effects of food borne bacterial and fungal toxins; Deterioration of foods. Food preservation: Principles and methods of preservation: Physical, irradiation, drying, heat processing, chilling and freezing, high pressure and modification of atmosphere); Chemical (Sodium benzoate Class I & II); Biological: Probiotics and bacteriocins.

Unit-5

Introduction to Genetically Modified (GM) foods. Ethical, legal and social issues concerning GM foods. current guidelines for the production, release and movement of GM foods; labeling and traceability; trade related aspects; biosafety and regulatory concerns related to GM food. Risk assessment and risk management. Public perception of GM foods. GMO Act.

References / Textbooks

1. E. M. T. El-Mansi, Jens Nielsen, David Mousdale, Ross P. Carlson (2019). Fermentation Microbiology and Biotechnology. Fourth Edition. CRC Press.

2. Single Cell Protein: Production and Evaluation for Food use. Bacha U and Nasir M (2011). LAP LAMBERT Academic Publishing.
3. Frazier And West Hoff (1995), Food Microbiology, Tata Mcgraw Hill Publishing Company Ltd, New Delhi.
4. Prescot (1987), Industrial Food Preservation, John Willey and Sons
5. Farshad Darvishi Harzevili, Hongzhang Chen (2015). Microbial Biotechnology - Progress and Trends. CRC press, Taylor and Francis Group.
6. Neelam Khetarpaul (2005). Food Processing and Preservation. Daya Publishing Group.
7. Neelam Khetarpaul (2007). Food Microbiology. Daya Publishing Group.
8. Tuteylan V (2013). Genetically Modified Food Sources. Safety Assessment and Control. Academic Press.
9. Safety Assessment of Genetically Modified Foods (2017). Huang K. Springer Publishers.
10. Bhunia A (2018). Foodborne Microbial Pathogens. Springer Publishers.
11. Doyle MP (2020). Food Microbiology and Food Safety. Springer Publishers.
12. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/---coop/documents/instructionalmaterial/wcms_628571.pdf
13. https://www.nature.com/scitable/topicpage/genetically-modified-organisms-gmos-transgenic-crops-and-732/

Course Outcomes

1. The students will be able to acquire knowledge about importance of microbes in food production.
2. The students will be able to understand QC and other safety guidelines related to production of fermented food.
3. The students will be able to get insight into process involved in production of organic acids, amino acids and nutraceuticals.
4. the student will be understanding the important role played by food preservatives in preventing spoilage.
5. The students will be able to learn about recent developments in GM food and related regulatory aspects.

Microbial Technology

Semester: II **Credits: 4**

Hours of teaching: 4 **Paper type: Core Theory**

Course Objectives:

1. To study about industrial products obtained from microbial fermentations.
2. To understand the fundamentals of the fermentation process, strain improvement and culture.
3. To understand the use of different microorganisms for manufacture of a variety of industrial products.

Unit-1

Introduction to DNA technology - Principles and tools of genetic engineering - Restriction enzymes, Cloning Vectors, gene library, DNA probe. Molecular techniques: Electrophoresis, Southern, Northern, Western & Slot blots. Polymerase Chain Reaction. Transgenic microbes.

Unit-2

Fermentation - Introduction – general information on microbial-based industries – substrates for industrial fermentation – strain improvement - an outline on fermentation and product recovery.

Unit-3

Pharmaceutical and related industries - Antibiotics- sources and types- production of Penicillin, Production of insulin and Hep B vaccine. Vitamins- Production of vitamin B12

Unit-4

Enzymes, Amino acids and Organic acids - Microbial sources, steps involved in production and product recovery and applications of amylase L- glutamic acid and Citric acid.

Unit-5

Food dairy, beverages and Agricultural industries - Single cell proteins (SCP) - SCP as food and feed – mass cultivation of Spirulina.cheese production. Alcoholic beverages – Beer and wine fermentation. Mushroom cultivation. Biofertilizers- mass production of Rhizobium. Biopesticides- Principles, production and application.

References / Textbooks:

1. Crueger,F. and Anneliese Crueger, 2000. Biotechnology: Industrial Microbiology Panima publishing Coporation New Delhi
2. Adams, M.R. and Moss, M.O. 1995. Food Microbiology New Age International Publishers New Delhi
3. Casida, L.E. Jr. 1996. Industrial Microbiology New Age International Publishers New Delhi
4. Alexander N. Glazer and Hiroshi Nikaido, 1994. Microbial Biotechnology: Fundamentals of Applied microbiology. W.H. Freeman and Co., New York.

Course Outcomes:

1. The students will able to Explain the principles and fundamentals of microbial technology.
2. The students will able to Elucidate the structure of fermentor.
3. The students will able to Understand the formulation of culture media.
4. The students will able to Describe the microbial processing in food and pharmaceutical industries.

5. The students will able to Summarize the methods used in industrial products such as microbial enzymes, organic acids etc.,

Immunotechnology

Semester: II **Credits: 4**

Hours of teaching: 4 **Paper type: Core Theory**

Course Objectives

1. To give an overview the basic concepts and principles of immune system and the techniques for developing diagnostics
2. To give an overview on Antigens and Antibodies
3. To give an overview on Immunoglobulins
4. To give an overview on cytokines
5. To give an overview on hypersensitivity

Unit-1

History and scope of immunology; Types of immunity - Innate and adaptive; Haematopoiesis and the cells of immune system; Organs of immune system. Structure and function of Primary and secondary lymphoid organs.

Unit-2

Antigens: properties and classes, haptens, mitogens, adjuvants and epitopes. T cell receptors - its organization and role in antigen recognition; MHC-general organization, antigen processing and presentation. T-cell: maturation, activation and differentiation; B-cell: maturation, activation, proliferation and differentiation; Clonal selection and immunological memory.

Unit-3

Immunoglobulin: Structure, classes, properties and functions; Organization and expression of immunoglobulin genes; Antigen- antibody interactions: Principles and applications of Precipitation and agglutination reaction, RIA, ELISA, Immunofluorescent microscopy; FACS. Hybridoma technology: monoclonal antibody production. Antibody engineering.

Unit-4

Cytokines: properties, structure and functions; Cytokine receptors; Therapeutic uses of cytokines and their receptors. Complement system: properties, activation pathways-classical, alternative and lectin. Transplantation: immunological basis of graft rejection and immunosuppressive therapy, immunological tolerance, clinical transplantations, molecular aspects of HLA typing.

Unit-5

Hypersensitivity reactions-Type I, II, III and IV. Autoimmune disorders- types, mechanism and treatment. Immune response to infectious diseases. Tumor immunology and cancer immunotherapy; Vaccines: Immunization schedule, traditional and novel strategies in designing vaccines.

References / Textbooks

1. Goldsby RA, Kindt TJ, Osborne BA, Kuby J. (2003). Immunology, 6th Edition, W.H. Freeman & Co. New York.
2. Kuby J. (2000). Immunology, 4 th Edition, W.H. Freeman & Co. New York.
3. Benjamini E, Coico R and Sunshine G. (2000). Immunology, 4th Edition, John Wiley & Sons, Inc.
4. Tizard IR. (1995). Immunology, 4th Edition. Saunders College Publishing Harcourt Brace College Publishers.
5. Ivan Riot and Peter I Delvis. (2004). Essentials of Immunology, 10th Edition, Blackwell Scientific Publications, Oxford

6. Abul K Abbas, Andrew H Litchman. (2004). Basic Immunology: Functions and disorders of the immune system, 2nd Edition, Elsevier Publications
7. Gerd Rudiger Burmester and Antonio Pezzuto. (2003). Color Atlas of Immunology, Thieme Stuttgart, New York
8. 2. Gabriel Virella. (1998). Introduction to Medical Immunology, 4th Edition, Marcel Dekker. Inc. New York
9. William E and Md. Paul. (2003). Fundamentals of Immunology, 5th Edition, Lippincott William and Wilkins Publishers.
10. 2. Myron M. Levine, James B Kaper, Rino Rappuoli, Margret A Liu, Michael F Good. (2004). New Generation Vaccines, 3rd Edition, Marcel Dekker, Inc. New York.
11. Rajasekara Pandian M and Senthilkumar B. (2007). Immunology and Immunotechnology. Panima Publishing Corporation, New Delhi. n L. nology: concepts, applications and perspectives, Wiley VCH publishers
12. Journal of immunology vol 204 issue 5
13. https://www.roswellpark.org/sites/default/files/thanavala_9-4-14_innate_immunity_part_1.pdf
14. https://www.slideshare.net/zamrankhan1/bth-203-immunology-and-immunotechnology

Course Outcomes

1. The students will be able to know the detailed description of the immune response made in humans to foreign antigens including microbial pathogens.
2. The students will be able to know about the cells involved in the immune response either innate or acquired and how the immune system recognizes self from non-self.
3. The students will be able to know about the b and t cell maturation and specific responses. Other topics covered will include the genetic basis of diversity of immune responses in mammals.
4. The students will be able to describe the cause and treatment for immune system pathologies and dysfunctions.
5. The students will be able to learn the importance techniques of immunodiagnosis.

Genetic Engineering

Semester: II **Credits: 3**

Hours of teaching: 3 **Paper type: Core Theory**

Course Objectives

1. To understand about gene cloning
2. To learn about the cloning vectors
3. To study about basics of cloning strategies
4. To learn about cloned genes
5. To learn about recombinant DNA technologies
6. To know about functions recombinant DNA technologies

Unit-1

Gene Cloning – Introduction, Basic tools - restriction enzymes, modifying enzymes, linker, Adaptor, Homopolymor tailing, DNA ligase, Polymerase enzyme – types, functions, applications. Core techniques in gene manipulation - Cutting and joining of DNA, Itroduction of DNA into cells

Unit-2

Cloning vectors - Bacteriophage vectors - pBr 322, PUC 18, M13. Bacterial vector - Cosmids, Phagemids, Phasmids, Bacterial Artificial Vector (BAC). Animal viral vectors - SV40. Plant vectors – CaMV, Ti-plasmid. Yeast vector - Yeast Artificial Chromosome. Gene transfer method - Transformation, Transduction, Particle bombardment, Electroporation, Liposome mediated gene transfer, Microinjection. Agrobacterium mediated gene transfer.

Unit-3

Cloning strategies - Construction – Genomic, rDNA libraries, Probe construction, methods of labeling gene probes - recombinant selection and screening, Molecular cloning. Strategies for identifying recombinant clones – gene mapping technique

Unit-4

Analysis of cloned genes - Restriction enzyme analyses, Southern blotting, Northern blotting, Western blotting, colony & plague hybridization. Factors affecting expression of cloned genes, Reporter genes, Fusion proteins. Cloning and expression of commercially useful proteins.

Unit-5

Application of r-DNA technology - production of recombinant proteins - insulin, Human growth hormone HGH, DNA vaccines. Transgenic plants - insect resistance, disease resistance. Transgenic animals – molecular pharming.

References / Textbooks

1. Principles of gene manipulation by RN old & S.B. Primrose (1996) Blackwell Scientific Publications
2. DNA cloning, I & II by DM Glover & BD. Hames (1995) IRL, Press
3. PCR strategies by MA. Innis, DH, Gelfand & JJ Sninskey (%), Academic press
4. Recombinant DNA by Watson JD, Gilman M. Witkowski, Zoller M. (1992), Scientific American Books
5. Diagnostic Molecular Microbiology by D.H. Persing, K T.F. Smith, F.c. Teower and T.J. While. ASM Press 1993
6. Recombinant DNA by Watson JD, Gilman M. Witkowski, Zoller M. (1992), Scientific American Books

7. Recombinant gene expression protocols by Tvan RS (1997) Humana Press.
8. https://www.khanacademy.org/science/biology/biotech-DNA-technology/DNA-cloning-tutorial/a/overview-DNA-cloning
9. https://studiousguy.com/cloning-vectors-types-characteristics/
10. https://plasmid.med.harvard.edu/PLASMID/cloningstrategies.jsp
11. https://www.thermofisher.com/in/en/home/life-science/cloning/cloning-learning-center/invitrogen-school-of-molecular-biology/molecular-cloning/cloning/common-applications-strategies.html
12. https://www.genscript.com/molecular-cloning-strategy.html
13. https://www.ncbi.nlm.nih.gov/books/NBK21505/
14. https://www.ncbi.nlm.nih.gov/books/NBK21450/
15. https://www.bio-rad.com/en-us/applications-technologies/introduction-gene-cloning-analysis?ID=LUSNKO4EH
16. https://www.hindawi.com/journals/ijg/2016/2405954/
17. https://medcraveonline.com/JABB/application-of-recombinant-DNA-technology-genetically-modified-organisms-to-the-advancement-of-agriculture-medicine-bioremediation-and-biotechnology-industries.html

Course Outcomes

1. The students will be able to know gene cloning.
2. The students will be able to understand cloning vectors.
3. The students will be able to know cloning strategies.
4. The students will be able to understand cloned genes.
5. The students will be able to know recombinant DNA technologies.

Omics Technology

Semester: II **Credits: 3**

Hours of teaching: 3 **Paper type: Core Elective 2**

Course Objectives

1. To make the students familiar with the eukaryotic and prokaryotic genomes and central dogma of molecular biology.
2. Students will get an idea about the new sequencing technologies and also to the development of database and their uses.
3. Thus the Course Objectives is framed to impact adequate knowledge about PCR and the types of PCR techniques.
4. To understand recent developments related to genomics and the genomics used in different field like plant and animal breeding and in recombinant protein.
5. To expose the students to understand the protein sequencing methods and proteomics tools.

Unit-1

RNA world hypothesis, Genetics to Genomics, Forward and revers genetics. Eukaryotic and prokaryotic genomes, Chromosome structure and function, Chromatin re-modeling/organization, DNA as genetic material, Central dogma of molecular biology.

Unit-2

Overview of conventional and new sequencing technologies, Strategies used in whole genome sequencing, NGS technologies, RNAseq, Genome annotation, Candidate gene discover and data mining, Transcription factor, Development of databases and their uses, Genome mapping by genetic and physical technique, Comparative genomics and SNP analysis.

Unit-3

Restriction and modifying enzymes, Various blotting techniques, PCR techniques, RT-PCR, qPCR, Digital PCR, Site directed mutagenesis, Genomic and cDNA libraries, Screening of libraries, DNA microarray, Antisense RNA, RNA interference, TALEN, CRISPR-Cas9.

Unit-4

Genomics in gene function analysis, Genomics in plant and animal breeding and improvement, Genomics in drug discovery, Genomics in valued added crops, Genomics in recombinant protein etc.

Unit-5

Proteomics basics, Forces that determine protein structure and physicochemical properties, Mechanisms of protein folding, Molten globule structure.Protein sequencing using various methods, Protein identification by mass spectrometry, Determination of post translation modification, Proteomics tools and databases.

References / Textbooks

1. Genome and Genomics: From Archaea to Eukaryotes 1sted 2019 Edition (2019), K. V. Chaitanya.
2. Molecular biology, Dr. P.S. Verma and Dr. V.K. Agarwal (2010) S Chand publisher.
3. Genome sequencing technology and algorithms 1st edition (2007) sun kim *et al*., Artech house publisher.
4. An introduction to database systems (8th edition) 2003, C. J. Date pearson publisher.
5. PCR Protocols third edition (2010), edited by Daniel J. Park.

6. Principles and technical aspects of PCR amplification, Alex van belkum *et al*.,
7. Bioinformatics methods and applications genomics, proteomics and drug discovery fourth edition, S.C. Rastogi *et al*.,
8. Genomics and proteomics principles, technologies and applications. DevarajanThangadurai, Ph.D, JeyabalanSangeetha, Ph.D (2015).
9. Principles of Proteomics, Twyman Richard.
10. Fundamentals of database system seventh edition, RamezElmasri, Shamkant B. Navathe.
11. Thomas Shafee and Rohan Lowe (2017). Eukaryotic and Prokaryotic gene structure. A Review. Wikijounal of medicine.
12. Chandra ShekharPareek *et al*., (2011). Sequencing technologies and genome sequencing. A Review. Journal of applied genetics.
13. Polymerase chain reaction: Theory, practice and application: A review. Sahel Medical Journal.
14. Sharma Neha and Harikumar S.L. (2013). Use of genomics and proteomics in pharmaceutical drug discovery and development: A Review. International journal of pharmacy and pharmaceutical sciences.
15. MohleddinJafari and All Masoudi- Nejad (2012). Proteomics databases and websites. Journal of Paramedical Sciences(JPS).
16. https://www.yourgenome.org/facts/what-is-the-central-dogma
17. https://microbiologyinfo.com/polymerase-chain-reaction-PCR-principle-procedure-types-applications-and-animation/

Course Outcomes

1. The students will be able to get the detailed characteristics of prokaryotes and eukaryotes genome as well as application of forward and reverse genetics.
2. The students will be able to get knowledge and design the experiments using various techniques of genome sequencing as well proper organization of generated biological data.
3. The students will be able to apply structural and functional genomics approaches on newly sequenced genome for functional characterization of genes.
4. The students will be able to develop capacity to pin point the strategies used for crop improvement and development of drug, recombinant proteins or value added crop.
5. The students will be able to handle a proteins and its characterization and demonstrate how various types of mass spectrometers can be used for proteome quantification, structure determination of proteins by various methods.

Pharmaceutical biotechnology

Semester: II **Credits: 3**

Hours of teaching: 3 **Paper type: Core Elective 2**

Course Objectives

1. Biotechnology has a long promise to revolutionize the biological sciences and technology.
2. Scientific application of biotechnology in the field of genetic engineering, medicine and fermentation technology makes the subject interesting.
3. Biotechnology is leading to new biological revolutions in diagnosis, prevention and cure of diseases, new and cheaper pharmaceutical drugs.

Unit-1

Introduction: Brief introduction to Biotechnology with reference to Pharmaceutical Sciences and pharmacology. History & principle of pharmacology. Drug names & classification systems. Routes of Drug administration, Absorption, Distribution and Metabolism. General principle of drug action – Pharmacokinetics, Pharmacodynamics. Measurement of drug action

Unit-2

Chemotherapeutic drugs – Protein Synthesis Inhibitors, Anti-Inflammatory, Antibacterial, Antifungal, Antiviral, Antihelminthic, Anticancer Drugs. Genetic recombination and drugs-Development of hybridoma for monoclonal antibodies. Human insulin, HGH, Erythropoietins, IFN, TNF, IL, Clotting factor VIII

Unit-3

Enzyme immobilization: Techniqes of immobilization, factors affecting enzyme kinetics. Study of enzymes such as hyaluronidase, penicillinase, streptokinase and streptodornase, amylases and proteases etc. Immobilization of bacteria and plant cells.

Unit-4

Micro-encapsulation: Types of microcapsules, importance of microencapsulation in pharmacy, microencapsulation by phase separation, coacervation, multi orifice, spray drying and other techniques, evaluation of micro capsules. Macro capsules: Advantages and disadvantages of capsule dosage form, material for production of hard and soft gelatin capsules.

Unit-5

Design and Development of Drugs: Drug discovery process: Principles, Techniques and Strategies used in new drug discovery. Regulations for laboratory animal care and ethical requirements. Bioassays: Basic principles of bioassays, official bioassays and experimental models. Pre-clinical and clinical models employed in the screening of new drugs

References / Textbooks

1. R.S. Satoskar, S.D. Bhandarkar, Nirmala N. Rege, R.R. Satoskar. Pharmacology and Pharmacotherapeutics 20th Revised Edition, Popular Prakashan (P) Ltd (2014)
2. S.S. Purohit, Kaknani, Saleja Pharmaceutical Biotechnology.
3. Torchilin, V. P. (2012). Immobilized enzymes in medicine (Vol. 11). Springer Science & Business Media.
4. Handbook of Encapsulation and Controlled Release by Munmaya Mishra first edition CRC Press
5. Pharmaceutical manufacturing handbook production and processes by Shayne Cox Gad, A John Wiley & Sons, Inc., Publication
6. Drugs: From Discovery to Approval by Rick NG, 3rd Edition, Wiley-Blackwell

7. The Journal of Pharmacology and Experimental Therapeutics by American Society of Pharmacology and Experimental Therapeutics
8. The Journal of Pharmacology & Pharmacotherapeutics (JPP), a publication of Phcog.Net, published by Medknow Publications and Media Pvt. Ltd.
9. H.P. Rang, M.M. Pale, J.M. Moore, Churchill Livingston. Pharmacology.
10. N.Murugesh, A concise Text Book of Pharmacology. Sixth edition. Sathya Publishers, Madurai.
11. R.C. Dubey, A Text Book of Biotechnology. S.Chand& Co Ltd, New Delhi.
12. Lynn Wecker, Lynn Crespo, George Dunaway, Carl Faingold and Stephanie Watts. Brody's Human Pharmacology, Elsevier 5th Edition 2010.
13. https://www.healthline.com/health/administration-of-medication#takeaway
14. http://howmed.net/pharmacology/routes-drug-administration/
15. https://www.nature.com/scitable/topicpage/genetic-recombination-514/
16. https://www.fda.gov/patients/drug-development-process/step-1-discovery-and-development
17. https://ebrary.net/18050/environment/application_immobilized_enzymes_pharmaceutical
18. https://wis-wander.weizmann.ac.il/space-physics/immobilized-enzymes-used-pharmaceutical-industry

Course Outcomes

1. The students will be able to learn about drugs and their action in our body
2. The students will be able to learn about chemotherapeutic drugs, genetic recombination and drugss
3. The students will be able to learn about enzyme immobilization and its application in pharmaceutical industry
4. The students will be able to learn about current trending microencapsulation technique
5. The students will be able to learn about designing and development of drugs

Nanotechnology

Semester: II **Credits: 3**

Hours of teaching: 3 **Paper type: Core Elective 2**

Course Objectives

1. The syllabus is designed in accordance with the latest industry trends and demands
2. The objective of this course is to train the students to have a strong of theoretical knowledge in the subject.
3. Covers the whole spectrum of nanomaterials ranging from overview, synthesis, properties, and characterization of nanophase materials to application including some new developments in various aspects.
4. Imparting the state of art of Nanotechnology to the society and to the environmental implication.
5. After completing this paper, student will be able to apply gained knowledge for various industrial applications of nanotechnology.

Unit-1

Introduction to Nanotechnology: Basic concepts of nanotechnology. definition & prospects. Importance of nanotechnology in biology. Classification of Nanostructures Bionanoparticles & nanocomposites. Types of biomaterials & biodegradable polymers.

Unit-2

Applications of nanomaterials – Importance of nanomaterials in chemical catalysis in dye & heavy metal removal, cosmetics, batteries, biosensor, food. Use of nanomaterials in agriculture. Application of nanoparticles in energy, tissue engineering (wound healing). Importance of nanobiotechnology in medicine and drug delivery.

Unit-3

Introduction to Nano-structured materials. Fullerenes - Properties and Characteristics. Carbon Nanotubes Characteristics and Applications. Basic concepts of Quantum Dots and Wires. Introduction to Gold and Silver Nanoparticles. Nanopores. Preparation and synthesis of gold and silver nanoparticles. Small Molecule-Protein Interactions. Micro-array and Genome Chips.

Unit-4

Microbial based synthesis of nanoparticles and its advantages. Synthesis of nanomaterials- Sol-Gel method for synthesis of nanoparticles, hydrothermal, Physical vapor deposition, chemical vapor deposition, ball milling, microfabrication, lithography-iron beam lithography. Concerns and Challenges of Nanotechnology.

Unit-5

Nanomedicine - Bio-Pharmaceuticals, Implantable Materials, Implantable Devices, Surgical Aids, Diagnostic Tools, Genetic Testing, Imaging, Nanoparticles Probe. Nanotechnology for Cancer Research and Therapy. Nanotechnology for Imaging and Detection. Environmental Nano Remediation Technology - Thermal, Physico-Chemical, and Biological Methods. Nano Filtration for the Treatment of Wastes, Removal of Organics, Inorganics and Pathogens. Nanotechnology for Water Purification.

References / Textbooks

1. Horst–Günter Rubahn (2008) Basics of Nanotechnology (3rd edition). Wiley Publishers.

2. Sengupta and Sarkar (2015). Introduction to Nano. Basics to Nanoscience and Nanotechnology. Springer Publishers.
3. Murty, B.S., Shankar P., Raj B., Rath B.B. and Murday, J (2013). Textbook of Nanoscience and Nanotechnology. Springer Publishers
4. K Raja and M Kannan Subramanian, K S (2018). Textbook on Fundamentals and Applications of Nanotechnology. Daya Publishing House.
5. Tuan Vo-Dinh (2019). Nanotechnology in Biology and Medicine: Methods, Devices, and Applications, Second Edition. CRC Press.
6. L Karthik, A. Vishnu Kirthi, Shivendu Ranjan, V. Mohana Srinivasan (2019). Biological Synthesis of Nanoparticles and Their Applications. CRC Press.
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9. Anming Hu and Allen Apblett (2014). Nanotechnology for Water Treatment and Purification. Springer Publishers.
10. Nanobiotechnology Concepts, Applications and Properties by Christef M. Niemeyer, C.A.Mirkin. Wiley – VCH Publishers
11. Mark Ratner and Daniel Ratner (2005). Nanotechnology a Gentle Introduction to the Next big idea. Pearson education. Inc.
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16. https://onlinelibrary.wiley.com/doi/pdf/10.1002/adma.200703183

Course Outcomes

1. The students will be able to acquire knowledge about importance of nanotechnology and nanomaterials.
2. The students will be able to understand application of nanomaterials in day to day life.
3. The students will be able to get insight into process involved in production of metal nanoparticles and its application.
4. The student will be understanding critical factors in synthesis of nanoparticles.
5. The students will be able to learn about recent developments and application of nanoparticles.

Medicinal Plants

Semester: II **Credits: 3**

Hours of teaching:3 **Paper type: Open Elective 2**

Course Objectives

Elementary treatment of various morphological uses in the identification and utilization of medicinal plants in general.

Unit-1

Introduction: Herbal Medicine–History of Traditional Medicine – History of Islamic Medicine, Siddha, Ayurveda, Homeopathy, Allopathy and Unani medicine.

Unit-2

Ethano botany:*Withania somnifera* (Amukkara) *Glycyrrhizaglabra* (Athimathuram), *Myristica fragrans* (Jathikkai), *Gymnemasylvestre* (Cakkaraikkolli), *Pongamiapinnata* (Punkam)-PropertiesandMedicinaluses.

Unit-3

Common medicinal plants: Family, Local Name, Common name, Medicinal uses–*Ocimumsanctum, Solanumtrilobatum, Cardiospermumhalicacabum, Adhatodavasica, Catharanthusroseus, Ecliptaalba.*

Unit-4

Parts of Medicinal plants: Fruit –Amla, Bulb – Garlic, Rhizome – Ginger, Seed –Castor, Bark – Cinchona, Leaves –Neem and Flower – Clove.

Unit-5

Cultivation methods– crop protection – Harvesting– Storage and Protection–Marketing utilization– Export of medicinally important plant (General aspects).

Course Outcomes

1. The student will be able to gain knowledge on traditional medicine
2. The student will be able to study some important medicinal plants
3. The student will be able to know the common herbal plants
4. The student will be able to know the preservation of herbal medicine
5. The student will be able to learn cultivation methods of herbal plants

References / Textbooks

1. Gokhale, S.S,C.K.Kokate and A.P.Purohit (1994). Pharmacognosy. Niraliprakashan, Pune.
2. Faroogi, A.A. and B.S.Sreeramu (2004), Cultivation of Medicinal and Aromatic crops. University Press (India) P. Ltd., Hyderabad.
3. Pal. D.C and S.K. Jain (1998), Tribal medicine, Naya Prakash, 206, Bidhan Sarani, Calcutta.
4. Thirugnanam, Akbarsha and Krishnamurthy (2010), Indian Medicinal plants and Home Remedies, Selvi Pathipagam, Trichy.

Tissue Culture

Semester: II **Credits: 3**

Hours of teaching: 3 **Paper type: Open Elective 2**

Course Objectives

1. To understand the techniques for tissue culture environment
2. To understand the laboratory rules.
3. To know that propagation techniques and plant nutritional perspectives.
4. To develop the knowledge of commercial applications and techniques.

Unit-1

The Tissue Culture Environment- Media Types -Filter Bridge, Agar, Liquid - Nutrient Media Composition – Cleanliness - Light and Temperature – Hormones - Artificial Light - Water Quality - Water Treatments - Carbon Dioxide Effects – Greenhouses.

Unit-2

Plant Nutrients - Major Elements - Minor (Trace) Elements -Total Salts - How Plants Grow - Factors Affecting Nutrient Uptake - Nutrient Solution Preparation - Hydroponic Nutrients – Chelates - Growing Media for Tissue Culture - Water in Tissue Culture - Chemical Analysis

Unit-3

The Laboratory - The Tissue Culture Laboratory - Preparation Area - Transfer Chamber - Culture Growing Area - Siting a New Lab - Equipment Requirements for a Lab – Chemicals

Unit-4

Micropropagation Techniques - Stock Plants -selection, planting, management - Uses for Tissue Culture - Problems with Tissue Culture – Procedures – Explants – Sterilization - Nutrient Media - Shoot Induction and Proliferation - Rooting and Planting Out - Stages in Plant Development - Treating Plant Tissue with Sterility

Unit-5

Commercial Applications - Understanding Genetics and Plant Breeding – Biotechnology - Cell Fusions - Overcoming Pollination Incompatibility - Pollination Biology - Taking Plants out of Culture - Hardening off Plants - Growing Rooms or Chambers.

References / Textbooks

1. An introduction to Plant Tissue culture by MK Razdan. M.K. 2003. Oxford & IBH Publishing Co, New Delhi, 2003.
2. Plant Biotechnology: An Introduction to Genetic Engineering by Adrian Slater, Nigel W. Scott, Mark R. Fowler. Oxford University Press, 2008.
3. Plant tissue culture by Bhojwani. S.S and Razdan. M.K 2004.
4. Plant Propagation by Tissue Culture: Volume 1 & 2. EF George. Exegetics Limited, 1999.
5. Plant cell culture, A Practical approach, 2nd Edition, Edited by R.A. Dixon and R.A. Gonzales.

Course Outcomes

1. The students will gain knowledge on tissue culture environment
2. The students will be able to learn about the nutritional properties and requirements for tissue culture.

3. The students will learn about the design of a tissue culture laboratory and its requirements
4. The students will be able to grow plants at controlled conditions in laboratory
5. The students will be able to understand plant breeding techniques and transfer lab-grown plants to environmental conditions in hardening facility

Molecular Diagnostics

Semester: II **Credits: 3**

Hours of teaching: 3 **Paper type: Open Elective 2**

Course Objectives

1. To provide an advanced understanding for students about the molecular basis of the pathogenesis, diagnosis and treatment of human diseases.
2. To describe and discuss topics related to infectious diseases, chronic diseases, genetic diseases, and diseases arising from abnormal immune responses.
3. To have precise diagnosis of diseases are of paramount importance to overcome false diagnosis based on symptoms
4. The main objectives of this paper is to introduce students to different techniques that are commercially used in molecular diagnosis of diseases and give an account of different diseases that are routinely diagnosed using molecular testing.
5. At the end of the course work, students should have idea about molecular diagnosis and the methods to implement the challenges that health care field faces very often.

Unit-1

Introduction to molecular diagnostics Definition - History – Diseases- infectious, physiological and metabolic errors, and inherited diseases. Biomarkers- types, potential uses and limitations. Diagnostics – types and importance in clinical decision making. Benefits of molecular diagnostics over conventional diagnostics. Ethical issues related to molecular diagnostics. Personal safety and laboratory safety. GLP for handling highly infectious disease samples and documentation.

Unit-2

DNA based molecular techniques for diagnosis DNA based molecular techniques: SNP chromosomal microarrays, relative-quantitative PCR, methylation analysis, MLPA, mutation screening panels (xTAG, Luminex), and SNP testing. PCR-based SNP detection: single-stranded conformational polymorphism analysis, heteroduplex analysis, allele-specific and multiplex PCR.

Unit-3

Proteomic assays for diagnostics Proteomics- introduction to clinical proteomics. Gel based techniques: 1D and 2D PAGE. High throughput multidimensional protein identification technology: Protein microarray, Immunoassays –Immunohistochemistry.

Unit-4

Applications of molecular diagnostics Major Histocompatibility Complex (MHC), HLA typing. Role of Molecular diagnostics in bone marrow transplantation and organ transplantation. Diagnosis of genetic diseases- Thalassemia, Cystic Fibrosis. Neonatal and Prenatal disease diagnostics- Prenatal and pre-implantation diagnosis. Molecular diagnosis for early detection of cerebral palsy, Down's syndrome

Unit-5

Molecular diagnosis of degenerative diseases and infectious disorders Muscular Dystrophy, Cardiovascular diseases. Pharmacogenomic testing for cardiovascular diseases. Malignant diseases: Molecular oncology testing in malignant disease- Acute and Chronic leukemias. Circulating tumour cell testing (CTC). Molecular diagnostic of various viral diseases: Dengue, Chickgungunya, Ebola and Influenza(H1N1), Corona, SARS.

References / Textbooks

1. George Patrinos Wilhelm Ansorge Phillip B. Danielson (2016). Molecular Diagnostics (3rd Edition) Academic Press.
2. Nader Rifai A. Rita Horvath Carl T. Wittwer Jason Park (2018). Principles and Applications of Molecular Diagnostics. Elsevier Publishing Group.
3. Wayne W. Grody and Frederick L. Kiechle (2010). Molecular Diagnostics Techniques and Applications for the Clinical Laboratory. Elsevier Publishing Group.
4. Jim Huggett and Justin O'Grady (2014). Molecular Diagnostics – Current Research and Application. Academic Press.
5. William B. Coleman and Gregory J. Tsongalis (2005). Molecular Diagnostics for the Clinical Laboratorian. Humana Press.
6. Jonathan L. Haines Margaret A. Pericak Genetic Analysis of Complex Disease (2005). John Willey
7. Lela Buckingham (2011). Molecular Diagnostics: Fundamentals, Methods, & Clinical Applications. FA Davis Publishers.
8. Carl Burtis, Edward Tietz (2011). Textbook of clinical chemistry and molecular diagnostics. Ashwood, David Bruns, Elsevier Publishing Co
9. Juluri R Rao, Colin Craig John E Moore (2006). Molecular Diagnostics: Current Technology and Applications. Taylor and Francis.
10. https://researchadvocacy.org/system/files/MolecularDiagnosticsTutorialFinal_0.pdf?file=1&type=node&id=152&force=0
11. https://academic.oup.com/clinchem/article/49/2/348/5639602

Course Outcomes

1. The students will be able to acquire knowledge about importance of molecular diagnostic methods over conventional methods.
2. The students will be able to understand application of DNA based detection methods.
3. The students will be able to get insight into application of proteomic diagnostic methods.
4. The student will be understanding critical factors diagnosis of various genetic and immune disorders.
5. The students will be able to learn about recent developments and application of molecular diagnosis in cancer therapy and viral disease.

Lab in Cell and Developmental biology

Semester: I& II **Credits: -**

Hours of teaching: 3 **Paper type: Core Practical**

1. Observation of prokaryotic and eukaryotic cells and cell types - Living Cells / Temporary / Permanent Preparations.
2. Squash preparation of onion root tip, testis and anther lobes.
3. Preparation of buccal smear.
4. Isolation, determination, purification and separation of protein, carbohydrates, lipids, DNA and RNA.

Lab in Biochemistry

Semester: I& II **Credits: -**

Hours of teaching: 3 **Paper type: Core Practical**

1. Estimation of protein by – Lowry method, Bradford method
2. Estimation of glucose by Ortho-toluidine method,
3. Total sugars by Anthrone method
4. Determination of glycine (Sorensen formal titration),
5. Separation of Amino acids by TLC method
6. Determination of physical factors (temperature and pH) affecting enzyme activity
7. Immobilization of enzyme

Lab in Genetics and Molecular Biology

Semester: I & II **Credits: -**

Hours of teaching: 3 **Paper type: Core Practical**

1. Isolation of plant DNA by CTAB method
2. Isolation of DNA from the buccal cells / animal tissue
3. Estimation of DNA by diphenylamine method
4. Observation of Mendelian traits in student population
5. Bacterial conjugation/ Transformation

Lab in Microbial Technology

Semester: II **Credits: 3**

Hours of teaching: 3 **Paper type: Core Practical**

1. Sterilization, media preparation.
2. Isolation of Industrially important microorganisms.
3. Product recovery – Paper chromatography.
4. Demonstration of Fermenter operation.
5. Batch culture Technique a) Still culture & b) Shake culture.
6. Cultivation of yeast – biomass production.
7. Mushroom cultivation – demonstration.
8. Ethanol production.

9. Wine fermentation.
10. Citric acid production.
11. Glutamic acid production.
12. Biofertilizers
    a) Bacterial: Rhizobium.
13. Visit to Biotech Industries.

Lab in Immunotechnology

Semester: II **Credits: 3**

Hours of teaching: 3 **Paper type: Core Practical**

1. Study on Blood Cells Identification of blood cells Differential count of white blood cells and red blood cells.
2. Agglutination test a) ABO Blood grouping b) Widal test for typhoid fever
3. Agglutination inhibition test - Pregnancy test for detection of HCG
4. Precipitation test
    a) Ouchterlony's Double Immunodiffusion Technique (ODD)
    b) Radial Immuno Diffusion (RID)
    c) Rocket Immuno Electrophoresis (RIE)

Lab in Genetic Engineering

Semester: II **Credits: 3**

Hours of teaching: 3 **Paper type: Core Practical**

1. Plasmid DNA extraction from E. coli
2. Isolation of plasmid DNA
3. Restriction digestion

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SEMESTER III

PAPER - 7

Ecology & Environmental Biotechnology

Course Objectives

1. To understand the basic concepts of ecology, biogeochemical cycles and harmful effects of greenhouse gases.
2. Students will get an idea about the hazards to our environment and solutions to protect for sustainable development
3. Thus the Course Objectives is framed- to impart adequate information to the students about water treatment and solid waste management.
4. To understand recent developments related to bioremediation using transgenic organisms.
5. Thorough knowledge gained after completing this course will help students to take up a career in tackling industrial pollution and also who is willing to take up the research in areas like development of biological systems for remediation of contaminated environments

Unit-1

Basic concepts ecology: Interaction between environment and biota; Concept of habitat and ecological niches; Limiting factor; Energy flow, food chain, food web and tropic levels. Ecological pyramids and recycling. Oxygen, Nitrogen, Phosphorous, Carbon and Sulphur cycles in nature. Population ecology. Ecosystem dynamics and management: Stability and complexity of ecosystems. Principles of conservation; Conservation strategies; sustainable development. Global environmental problems: ozone depletion, UV-B greenhouse effect and acid rain.

Unit-2

Environmental pollution: Types of pollution and pollution analysis – noise, air and gaseous pollution. Noise pollution: Source, measurement, impact on ecosystem and control. Air pollution: Types, source, method of sampling, measurement, impact on ecosystem and control. Methods for controlling noise and air pollution. Gaseous pollutants and odours: General sources, methods of control; fundamentals of adsorption, mechanism of adsorption, equilibrium isotherms regeneration of adsorbent, application of adsorption for control of gaseous and odour emission.

Unit-3

Water pollution: Impurities in water, water pollution by industrial waste and effluents, examination of water, collection of water samples, water analysis – physical, chemical and biological. Standards of water quality. Water treatment processes: Primary treatment, screening, skimming with coagulants, flocculation, filtration, aeration and disinfection; Secondary treatment: Aerobic processes – activated sludge, oxidation ditches, trickling filter, towers, rotating discs, rotating drums, oxidation ponds. Anaerobic digestion, anaerobic filters, Up flow anaerobic sludge blanket reactors; Tertiary treatment: Activated carbon treatment, reverse osmosis and electro dialysis.

Unit-4

Solid waste management: sewage sludge treatment and utilization, excreta disposal in unsewered area; composting and vermiculture.; biodegradation of non-cellulosic wastes for environmental conservation and fuel; bioconversion of cellulosic wastes into protein and fuel; biodegradation of xenobiotics; bioremediation of contaminated soils and waste lands; radioactive product waste disposal.

Unit-5

Bioleaching of metals, mechanisms of bioleaching, factors affecting bioleaching and current biomining processes. Biobeneficiation of gold ores. Transgenic microbes and plants for remediation. Microbially enhanced oil recovery. Biodesulfurization of coal: Removal of organic and inorganic sulfur from coal.

References / Textbooks

1. Fundamentals of Ecology Eugene P. Odum and Gary W (2007). Barrett. Saunders Publishers.
2. Instant Notes in Ecology Aulay MacKenzie, Andy Ball and Sonia Virdee (2001). Taylor & Francis Publishers.
3. Environmental Biotechnology by Alan Scragg (2005). II nd edition. Pearson Education Limited, England.
4. Environmental Biotechnology by S.N. Jogdand. (1995). Ist edition. Himalaya Publishing House.Bombay
5. Wastewater Engineering – Treatment, Disposal and Reuse. Metcalf and Eddy (2017). Tata Mc Graw Hill, New Delhi.
6. Environmental chemistry by A.K. De (2007). New Age international Publishers.
7. Introduction to Biodeterioration by D. Allsopp and K.J. Seal, (2004). Cambridge University Press.
8. Natarajan KA, Biotechnology of Metals (2018). Elsevier publishing group.
9. Igiri *et al*. (2018). Toxicity and Bioremediation of Heavy Metals Contaminated Ecosystem from Tannery Wastewater: A Review. Journal of Toxicology.
10. Marques *et al*. (2018). Extremophilic Microfactories: Applications in Metal and Radionuclide Bioremediation. Frontiers in Microbiology
11. Sikosana *et al* (2018). Municipal wastewater treatment technologies: A review. Procedia Manufacturing.
12. Gupta *et al* (2015). A review on current status of municipal solid waste management in India. Journal of Environmental Sciences.
13. Bertrand *et al*. (2015) Environmental Microbiology: Fundamentals and Applications. Springer Publishers
14. http://www.fao.org/3/t0551e/t0551e05.htm
15. http://www.fao.org/fcit/environment-health/solid-waste/en/

Course Outcomes

1. The students will be able to acquire a complete knowledge about ecosystem and global environmental problems.
2. The students will be able to understand harmful effects of environmental pollution and its methods of control and management.
3. The students will be able to get insight into process involved in wastewater treatment.
4. The student will be understanding the recent developments in solid waste management.
5. The students will be able to learn about bioremediation and use of recombinant organisms for the process.

PAPER - 8

Plant Biotechnology

Course Objectives

1. To provide the knowledge of various aspects of plant biotechnology including micro propagation
2. Genetic improvement of plants through hybridization
3. Somatic hybridization
4. Genetic transformation
5. Bio chemistry and molecular biology
6. Plant transformation

Unit-1

Genomic interaction–Protoplasmic fusion, cyto plasmid male sterility. Genetic engineering in plants-Pest resistance, Herbicide resistance. Resistance to fungi and bacteria. Delay of fruit ripening. Somaclonal variation, valuable germ plasm.

Unit-2

Plant tissue culture -tot potency, cytodifferentiation, callus culture, anther culture, cell suspension culture, micro propagation, organogenesis, somatic embryo genesis, protoplast culture.

Unit-3

Bio chemistry and molecular biology -Nitrogen fixation in legumes by Rhizobium.

Molecular biology of plant stress response (a biotic).Genetic modification-transgenic plants and its application, ecological impact of transgenic plants. Genetic Engineering in Food industry–back ground, history, controversies over risks, applications.

Unit-4

Hybridization-Isolation, purification and culture of protoplast. Identification and characterization of somatic hybrids, hybrids- applications. Haploid Plants from Anther Culture-In Vitro propagation for commercial production of ornamentals.

Unit-5

Plant transformation – Vectors- Agro bacterium mediated transformation, particle bombardment, electro oration. Conformation of transgene expression by molecular techniques-PCR, Northern, Southern and Western blot analysis.

References / Textbooks

1. Basic Biotechnology, S. Ignachimuthu. 1995. Tata McGraw Hill Publishers, New Delhi
2. Text book of biotechnology by U.Satyanarayana
3. Grierson, D., and S.N. Covey.1988. Plant Molecular Biology. Blackie & Sons. Ltd. Glascow.
4. Marks. J.L. (Ed.).1989. A Revolution on Biotechnology. Cambridge Univ. Press, Cambridge.
5. Dodds J.H.1985. Plant Genetic Engineering. Cambridge Univ. Press, Cambridge..
6. Text book of biotechnology by V.Kumaresan
7. Applied Plant biotechnology by N.Arumugam
8. Robert N.Trigiano, Dennis J.Gray, 1996, Plant Tissue Culture Concept and Laboratory Exercises, CRC Press, London.
9. P.S.Srivasta, 1998, Plant Tissue Culture and Molecular Biology, Narosa Publishing House, New Delhi.

10. https://link.springer.com/article/10.1007/s40502-013-0039-6
11. https://www.microscopemaster.com/cell-culture.html
12. https://www.sciencedirect.com/topics/nursing-and-health-professions/anther-culture
13. https://www.qiagen.com/us/service-and-support/learning-hub/molecular-biology-methods/animal-cell-culture/

Course Outcomes

1. The students will be able to know about genomic interaction
2. The students will be able to understand plant tissue culture techniques
3. The students will be able to know bio chemistry and molecular biology
4. The students will be able to know hybridization technique.
5. The students will be able to understand plant transformation.

PAPER - 9

Animal Biotechnology

Course Objectives

To gain a spectrum of understanding of various aspects of animal cell culture and gene transfer technology.

Unit-1

Animal Cell Culture lab– Introduction. Lab design and equipments - Sterile area, Laminar flow hood, CO2 incubator, Cryostorage (liquid Nitrogen flask), Refrigerated centrifuges freezers (- 800C), Inverted microscope, Hemocytometer, pH meter, Magnetic stirrer, Micropipettes and pipette aid.

Unit-2

Animal cell culture: Fundamentals, facilities and applications. Media for Animal cells. Types of cell culture - Primary, secondary. Cell transformation, cell lines, Insect cell lines, stem cell cultures, cell viability and cytotoxicity.Biology of cultured cells, measurement of growth, cell synchronization, senescence and apoptosis organ culture.Cryopreservation.

Unit-3

Genetic engineering in animals - methods of DNA transfer into animal cells – calciumphosphate co precipitation, micro-injection, electroporation, liposome encapsulation.Biological vectors.Hybridoma technology, Vaccine production.

Unit-4

Gene therapy - Mapping of human genome.RFLP and applications.DNA finger printing and Forensic science.Molecular diagnosis of Genetic disorders. Transgenics: Transgenic animals - Merits and demerits - Ethical issues in animal biotechnology. Production and recovery of products from animal tissue.

Unit-5

Cytotoxicity - Estimation of viability by Dye exclusion, cell proliferation assays, MTT-based cytotoxicity assay. Cultures - Cytokines, Plasminogen activators, Blood clotting factors, Growth hormones.

References / Textbooks

1. Culture of Animal cells: A Manual of Basic Techniques (2004) R. Ian Freshney.
2. Animal Cell Biotechnology: Methods and Protocols (Methods in Biotechnology) 1st Edition, Nigel Jenkins.
3. Textbook of Animal Biotechnology, B Singh, S K Gautam and M S Chauhan, Teri Press,
4. Animal Cell Culture: Concept and Application, Sheelendra M. Bhatt, 2013
5. Animal Cell Biotechnology: Methods and Protocols, Pörtner, Ralf (Ed.), 2014.
6. Animal Cell Biotechnology, Vol. 1, by R. E. Spier (Author), J. B. Griffiths (Editor).
7. https://www.intechopen.com/books/biomedical-tissue-culture/culture-conditions-and-types-of-growth-media-for-mammalian-cells

Course Outcomes

1. The students will be able to study basic needs of cell culture
2. The students will be able to implant knowledge on media
3. The students will be able to describe genetic engineering in animals
4. The students will be able to know ethical concerns over the use of animal biotechnology.
5. The students will be able to know various biotechnologies available to the animal related fields.

CORE ELECTIVE

PAPER - 3

(to choose one out of 3)

A. Cancer Biology

Course Objectives

1. To get a firm foundation in the fundamentals of Cancer Biology
2. To have an insight into molecular mechanism of cancer
3. To understand the cancer and its immunology
4. Prevention and diagnosis of cancer

Unit-1

Introduction to cancer biology: Incidence and etiology of cancer, gene expression and chromosome separation, cell division, differentiation and death. Oncogene and tumor suppressor. Genetics of cancer - Two Hit hypothesis and genomics instability. Introduction to metastasis and metastatic process, TNM staging, Imaging - types and clinical oncology.

Unit-2

Molecular mechanism of cancer: Macromolecules in cancer - protein structure and function, lipid signaling and metabolism in cancer. Membrane trafficking in cancer - Dysregulated vesicles trafficking system in cancer cells. Oncogene and cell signaling - protein kinase association, G-protein coupled receptor, hormonal signaling, calcium signaling and metastasis. Tumor suppressors and the cell cycle regulations - retinoblastoma gene, DNA Damage. Metastasis and cytoskeleton. Extracellular Matrix and the tumor Microenvironment (EMM). Cellular mechanism and Warburg effects.

Unit-3

Overview and elements of cancer immunology: Role of immune system in cancer cell. Immune cell types against cancer. Cytokines and its role in immune cell programming against cancer.

Unit-4

Cancer antigen and antibody development Source of cancer antigens – clonal (viral)/mutational origin – detection and processing by immune cell types through MHC – T-cell receptor – B-cell receptor and cytokines involved – cancer cell death strategies induced by immune cells. Roles and mechanism of immune self-tolerance machinery and Immune surveillance. Risk factor/potential target towards autoimmune disorders and cancer.

Unit-5

Cancer pharmacological studies: Cancer prevention and diagnosis - Epidemiology of cancer cell, Genome screening, Infectious agents that cause cancer. Cancer treatment strategies - cancer resistance to chemotherapy, immunological suppression of cancer, cancer drug discovery, literature review on cancer treatment.

References / Textbooks

1. An Introduction To Cellular And Molecular Biology of Cancer" by Peter J Selby Margaret A Knowles.
2. "Introduction to the Cellular and Molecular Biology of Cancer" by L M Franks.
3. "The Biology of Cancer" by Robert A Weinberg, "Principles of Cancer Biology" by Kleinsmith.
4. "The Emperor of All Maladies: A Biography of Cancer (Old Edition)" by Siddhartha Mukherjee.
5. "Cancer Biology" by Raymond W Ruddon, "Biology of Cancer (Pearson Special Topics in Biology)" by PALLADINO and PHILLIS.
6. "Cancer: Principles and Practice of Oncology: Primer of the Molecular Biology of Cancer" by Vincent T DeVita and Theodore S Lawrence.
7. "Cancer Cell Signaling (Methods in Molecular Biology)" by Martha Robles-Flores.
8. "The Biology of Cancer: A New Approach" by P R Burch

Course Outcomes:

1. The students will be able to develop a comprehensive knowledge about basics of cancer biology.
2. The students will be able to understand an in-depth knowledge about molecular mechanism of cancer.
3. The students will be able to able to relate and understand the role of immune system in cancer.
4. The students will be able to know about the importance of immune process, selection and tolerance of cancer.
5. The students will be able to gain the knowledge about the diagnosis and treatment strategies of cancer.

CORE ELECTIVE

PAPER - 3

B. Industrial Biotechnology

Course Objectives

1. To impart knowledge in microbial production of industrial products.
2. Industrial products and their separation techniques.
3. Media formulation

Unit-1

Industrial Biotechnology – Introduction - General information on microbes based industries – Major classes of commercial products using microbes –Amino acids, Vitamins, Antibiotics, Food and Beverages.

Unit-2

Industrial use of microorganisms – isolation, preservation and maintenance of microorganisms. screening methods. Strain improvement

Unit-3

Medium requirement for fermentation process – Carbon sources, Nitrogen sources, and growth factors. media formulation. Fermenter – Design, Functions and Types.

Unit-4

Microbial enzymes in food processing – Industrial production of enzymes, Food products – cheese, yoghurt, jelly. Beverages – Alcoholic and Non – alcoholic beverages.

Unit-5

Mass cultivation of Spirulina, Single Cell Proteins (SCP), Biofertilizers – Azospirillum, Azolla, Rhizobium, Mass production of phosphate solubilizing bacteria.

References / Textbooks

1. Manual of industrial microbiology and Biotechnology, Demain A.L. Solomon, J.J., 1986. ASM press.
2. Biotechnology, Satyanarayana, U., 2006. Books and Allied (P) Ltd.
3. Industrial Microbiology, Reed C., Prescott and Dann's, 1982. Macmillan publishers.
4. An introduction to Genetic Engineering, Desmond, S.T., Nicholl, 1994. Cambridge press.
5. Text book of biotechnology by V.Kumaresan
6. Industrial biotechnology by N.Arumugam
7. Principles of Gene Manipulation. 4th edition, Old R.W. and S.B. Primrose, 1994. Blackwell scientific publication London.
8. Fundamentals of Biotechnology, P.Prave, P.Faust, V. Sitting, word sukatasch D., 1987. VCH verlasgetell Schafor MBH, Weinhkeim.
9. http://www.biologydiscussion.com/biotechnology/biotechnology-introduction-scope-and-applications-of-biotechnology/11608
10. https://courses.lumenlearning.com/boundless-microbiology/chapter/industrial-microbiology/
11. http://www.biologydiscussion.com/biotechnology/downstream-processing/stages-in-downstream-processing-5-stages/10160

Course Outcomes

1. The students will be able to know about introduction to biotechnology and major classes of commercial products using microorganisms.
2. The students will be able to understand introduction to biotechnology and major classes of commercial products using microorganisms.
3. The students will be able to know the bioreactors / fermentor: types and microbial culture and its types
4. The students will be able to know microbial enzymes in food processing 5. The students will be able to understand plant transform biofertilizers and its types

CORE ELECTIVE

PAPER - 3

C. Virology

Course Objectives

1. To make the students to understand the history and principle of virology and also to maintenance and handling of laboratory animals.
2. Students will get an idea about the how to cultivate and purification of viruses by various methods.
3. To provide adequate knowledge on vaccines and different types of vaccines and mechanisms of action of viruses.
4. To depict the information to diagnosis the different types of diseases like cancer, viral enteric disease etc., and treatment for this disease.
5. To understand the information about drugs and diagnosis of infectious diseases.

Unit-1

History and principles of virology, virus taxonomy, introduction to replication strategies. Structure and morphology of animal and plant viruses, Infrastructure for virology: principles of bio-safety, containment facilities, maintenance and handling of laboratory animals and requirements of virological laboratory.

Unit-2

Estimation of yields, methods for purification. Diagnostic methods: Immunodiagnosis, haemagglutination and haemagglutinationinhibition tests, complent fixation, flow-cytometry and immune-histochemistry. Microscopic techniques. Fluorescence, confocal and electron microscopic techniques principles and applications. Nucleic acid based diagnosis: Nucleic acid hybridization, polymerase chain reaction, Real time PCR, RT-LAMP microarray and nucleotide sequencing.

Unit-3

Conventional vaccines killed and attenuated, modern vaccines- recombinant proteins, subunits, peptides, DNA vaccines. Antiviral: Interferons, designing and screening for antivirals, mechanisms of action, antiviral libraries, antiretrovirals – mechanisms of action and drug resistance. Modern approaches of virus control: Antisense RNA, siRNA, ribozymes, in silico approaches for drug designing.

Unit-4

Viral cancers (HPV &EBV), viral hepatitis (HAV,HBV,HCV& HEV), Respiratory viral diseases (Influenza, Bird Flu, RSV and PIV), Viral Haemorrhagic Fevers (Dengue &Chikungunya), Viral Encephalitis (JEV & WNV), Viral Enteric Diseases (Rota virus & Polio), Rabies and HIV/AIDS.

Unit-5

Molecular mechanism of drug resistance (MDR) Anti-viral chemotherapy. Antifungal chemotherapy. Hospital- acquired infections (nosocomial), immune compromised states Modern approaches for diagnosis of infectious diseases: basic concepts of gene probes, dot hybridization and PCR assays.

References / Textbooks

1. Virology principles and application John Carter and Venetia Saunders (2007) John Wiley and sons publishers.
2. Principles of Virology 4th edition Jane Flint.
3. Real –Time PCR: Current technology and applications 1st edition (2009) edited by Julie Logan *et al*.,
4. Analytical techniques in DNA sequencing edited by Brian K. Nunnally

5. Medical Microbiology: with student consult by Patrick R. Murray phD (Author), Ken S. Rosenthal PhD Saunders; 7th edition.
6. Antiviral Agents, Vaccines and Immunotherapies. Stephen K. Trying. October 2004. Marcel Dekker.
7. Diagnostic procedures for Viral, Rickettsial, and Chlamydial Infections. Edwin H. Lennette (Editor), David A. Lennette, Evelyne T. (Eds.) Lennette, Evelyne T. Lennette (Editor). January 1995. American public health association publications.
8. Antiviral drug discovery for emerging diseases and bioterrorism threats. Paul F. Torrence (editor). July 2005. John Wiley and sons, Incorporated. 4. Viral hepatitis and liver disease, A.J. Zuckerman.
9. Evolution by means of hybridization (1916) Johannes P. Lotsy.
10. Rapid cycle real - time PCR methods and applications Udoreischi *et al*.,
11. R. Vinothkumar *et al*., complexity of begomovirus and betasatellite populations associated with chill leaf curl disease in India. Journal of general virology.
12. S E Atawodi *et al*., (2010) Polymerase Chain Reaction: Theory, practice and application: A Review. Sahel Medical Journal.
13. Anthony R Mawson *et al*., (2017) Pilot comparative study on the health of vaccinated and unvaccinated 6 to 12- year- old U. S. children. Journal of translational science.
14. AkankshaRathi (2018) The evolution of NACP: India's attempt at controlling the HIV/AIDS epidemic. International journal of scientific research.
15. RuwaliPushpa *et al*., (2013) Antiviral potential of medicinal plants: An overview. International research journal of pharmacy.
16. https://www.sciencedirect.com/science/article/pii/b978044453488000002X
17. https://www.yourgenome.org/facts/what-is-PCR-polymerase-chain-reaction

Course Outcomes

1. The students will be able to gain knowledge about the basic concepts of virology.
2. The students will be able to learn the virological techniques for diagnosis.
3. The students will be able to understand the various viral groups and also about the vaccines to treat that viral groups.
4. The students will be able to learn clinical features, epidemiology, diagnosis and treatment of viral group.
5. The students will be able to get an idea about the various diagnostic techniques such as PCR.

OPEN ELECTIVE

PAPER - 3

(to choose one out of 3)

A. Forensic Science

Course Objectives

1. To know the sociological aspects, molecular mechanisms and its application in forensic science.
2. To know about different forensic examination types and techniques.
3. To acquires knowledge about Instrumentation techniques.
4. To know about personal identification techniques.
5. To understand the molecular identifications.

Unit-1

Crime Scenario in India: Introduction to crime and history, Sociological aspects of crime and criminals in society, Types of crime and its causes – property crimes, public order crimes, violent crimes, cyber-crimes.

Unit-2

Forensic Examination of Body and Semen Fluids: Molecular mechanisms for identification of the evidences from the criminal.

Unit-3

Forensic Examination of Hair and Tissue: Molecular mechanisms for identification of the evidences from the criminal.

Unit-4

Personal Identification: Personal identification techniques as somatoscopy, somatometery, osteometery and craniometery their importance in determination of age and sex.

Unit-5

Instrumentation & Investigation Techniques: Crime Detection Devices –Microscopy – Chromatography – Documents – Ballistics - Fingerprints Examination. New and future technologies - DNA chips - SNPs and limitations of DNA profiling. Application of Molecular techniques to Forensic.

References / Textbooks:

1. Dr. Rukmani Krishnamurthy. Introduction to Forensic Science in Crime Investigation. Selective and scientific books publishers and distributors, New Delhi. (2005).
2. Kirby, LT. DNA Fingerprinting Technology. Palgrave Macmillan UK. (2009).
3. Richard Saferstein. Criminalistics: An Introduction to Forensic Science, 9th Ed. (2001).
4. Sharma, B.R., Forensic Science in Criminal Investigation and Trial, 4th Ed. (2008).
5. Stern C, Principles of Human Genetics, Freeman, California. (2012).

Course Outcomes

1. The students will be able to understand various aspects of crimes
2. The students will be able to do forensic examination of body and semen fluids to identify criminals
3. The students will be able to do forensic examination of hair and tissue to identify criminals
4. The students will learn personal identification techniques to determine age and sex
5. The students will be able to gain knowledge about different advanced investigation and instrumentation techniques

OPEN ELECTIVE

PAPER - 3

B. Dairy Farming

Course Objectives:

1. To get a firm knowledge on Dairy farming
2. To have an insight of husbandry and dairy management
3. To understand the concept of dairy chemistry and microbiology
4. To learn the dairy processing
5. To know the quality assurance of dairy products

Unit-1

General Description of Dairy: Introduction to dairy and dairy farming, history of dairy farming, national and inter status of dairy farming, dairy developmental strategies in India, quality and biosafety in dairy industry, entrepreneurship development and industrial consultant.

Unit-2

Dairy Husbandry: Anatomy, Nutrition, Physiology, Genetics and Breeding of Cattle in dairy farming. Frozen Semen Technology. Dairy cattle management. Health and Hygiene. Vaccination schedule. Common starter cultures in dairy industry-their classification, characteristics and propagation.

Unit-3

Dairy Chemistry and Microbiology: Introductory Dairy chemist, -Milk production and physician chemical properties of milk, environmental factors influencing the milk composition - Milk lipids, proteins, sugar, minerals, vitamins and their biosynthesis classes and significance. Thermal stability of milk, Freezing point depression of milk. Milk microbes - spoilage and fermentation of milk, milk borne disease, clean milk production and health publication.

Unit-4

Dairy processing and engineering technology: dairy processing and production- principle, operation and design, methodology of standardization, pasteurization and pasteurizer, Homogenization and homogenizer, freezer, evaporator, boiler. Milk packaging, cleaning, cleaning agent and sanitation. Dairy technology - manufacturing of fat rich products (cream butter ghee ice cream), dried milk products (cheese), fermented products (dahi, yogurt, shrikand), indigenous milk products. Effective utilization of dairy by products.

Unit-5

Dairy management and technology: Food safety and Quality assurance strategies, Implementation of HACCP/ ISO and certification, Packaging of Market Milk and Milk products, Advancements in Liquid Milk and Milk Products Packaging. Quality and sensory analysis of milk - interpretation, significance, determination of specific gravity, fat, SNF, TS, acidity and pH of milk, MBR test, SPS, Phosphate activity. Common adulterants in milk and their detection techniques. Advanced analytical techniques in milk and milk products.

References / Textbooks

1. “Fundamentals of Dairy Chemistry” by Noble P WongWong.
2. “Modern Technology of Food Processing and Agro Based industries” by NIIR Board.
3. “Enzymes in Food Processing: Fundamentals and Potential Applications” by Parmjit S Panesar and Satwinder S Marwaha.

4. “Novel Thermal and Non-Thermal Technologies for Fluid Foods (Food Science & Technology International (Hardcover Academic))” by PJ Cullen and Brijesh K Tiwari.
5. “Modern Technology of Milk Processing and Dairy Products” by NIIR BOARD.
6. “Production Processing and Marketing of Milk and Milk Products” by Rajendra Kumar Pandey.
7. “High Temperature Processing of Milk and Milk Products” by Hilton C Deeth and Michael J Lewis.
8. “The Untold Story of Milk, Revised and Updated: The History, Politics and Science of Nature’s Perfect Food: Raw Milk from Pasture-Fed Cows” by Ron Schmid.
9. “Improving the Safety and Quality of Milk: Milk Production and Processing: 1 (Woodhead Publishing Series in Food Science, Technology and Nutrition)” by M Griffiths, 10. “Milk Processing and Quality Management (Society of Dairy Technology)” by Adnan Y Tamime.

Course Outcomes:

1. The students will be able to develop a comprehensive knowledge about basics of dairy farming
2. The students will be able to understand the physiology and management aspect of dairy farming
3. The students will be able to discuss the chemistry and microbiology of dairy
4. The students will be able to know about the processing technologies of dairy products
5. The students will be able to gain knowledge on quality management of dairy products

OPEN ELECTIVE

PAPER - 3

C. Waste Water Management

Course Objectives

1. To make the students to understand industrial wastewater and the impact that causes to environment and also to the human health.
2. To provide the knowledge to prevent and control the industrial pollution.
3. To learn about the various methods used to treat the industrial wastewater.
4. To depict the information on wastewater reuse and residual management.
5. To understand the design of industrial manufacturing process and waste treatment flow sheet for textiles and other industries.

Unit-1

Industrial scenario in India– Industrial activity and Environment - Uses of Water by industry – Sources and types of industrial wastewater – Nature and Origin of Pollutants - Industrial wastewater and environmental impacts – Regulatory requirements for treatment of industrial wastewater – Industrial waste survey – Industrial wastewater monitoring and sampling -generation rates, characterization andvariables –Toxicity of industrial effluents and Bioassay tests – Major issues on water qualitymanagement

Unit-2

Prevention and Control of Industrial Pollution – Benefits and Barriers – Waste management Hierarchy - Source reduction techniques – Periodic Waste Minimization Assessments – Evaluation of Pollution Prevention Options – Cost benefit analysis – Pay-back period – Implementing and Promoting Pollution Prevention Programs in Industries.

Unit-3

Flow and Load Equalisation – Solids Separation – Removal of Fats, Oil and Grease- Neutralisation – Removal of Inorganic Constituents – Precipitation, Heavy metal removal , Nitrogen and Phosphorous removal, Ion exchange, Adsorption, Membrane Filtration, Eletrodialysis and Evaporation – Removal of Organic Constituents – Biological treatment Processes - Chemical Oxidation Processes - Advanced Oxidation processes – Treatability Studies.

Unit-4

Individual and Common Effluent Treatment Plants – Joint treatment of industrial and domestic wastewater - Zero effluent discharge systems - Quality requirements for Wastewater reuse – Industrial reuse, Present status and issues - Disposal on water and land – Residuals of industrial wastewater treatment – Quantification and characteristics of Sludge – Thickening, digestion, conditioning, dewatering and disposal of sludge – Management of RO rejects.

Unit-5

Industrial manufacturing process description, wastewater characteristics, source reduction options and waste treatment flow sheet for Textiles – Tanneries – Pulp and paper – metal finishing – Oil Refining – Pharmaceuticals – Sugar and Distilleries

References / Textbooks

1. Industrial Scenario in India Nishi Sinha (1997). APH publishers.
2. Industrial waste treatment 1st edition contemporary practice and vision for the future Nelson Nemerow (2006).

3. Industrial pollution prevention Shen, Thomas T. (1999)
4. Waste Management Practices: Municipal, Hazardous, and Industrial, Second edition John Pichtel (2014).
5. Industrial Waste Treatment Handbook 2nd edition Woodard and Curran, Inc. (2005).
6. Biological Treatment Processes volume 3 Wang *et al*., (1986).
7. An applied guide to water and effluent treatment plant design 1st edition Sean Maran (2018).
8. Wastewater treatment for pollution control and reuse third edition. Soli J Arceivala. Shyam R Asolekar.
9. Industrial Engineering and management, O.P. Khanna.
10. The Industrial Wastewater systems handbook. Ralph L. Stephenson, James B. Blackburn.Jr.
11. Rohitkanda (2015), Indian Manufacturing Sector: A Review on the Problems and Declining Scenario of Indian Industries, International Journal of Science and Research (USR).
12. TaherehMoghtaderi, Potentially toxic elements pollution, source apportionment and ecological risk assessment in soils of agricultural and industrial areas, Bandar abbas-south of Iran, journal of pollution effects and control.
13. Viktoria Pitas and BenceFazekas (2012), studies on the biological treatment of industrial wastewater streams, environmental engineering and management journal.
14. Anupam Khajuria (2015), application on reuse of wastewater to enhance irrigation purposes, universal journal of environment research and technology 2015 volume 5, issue2: 72-78.
15. Sunil S. Pattanshetti and Sagar M. Gawande (2015), characteristics study of wastewater in gadhinglaj, international journal of current research.
16. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/industrial-pollution
17. https://www.yourhome.gov.au/water/wastewater-reuse

Course Outcomes

1. The students will be able to get the concepts of industrial scenario in india and major issues on water quality management.
2. The students will be able to understand the methods that are used for the control and prevention of industrial pollution.
3. The students will be able to learn the fundamental scientific processes underlying the design and operation of wastewater treatment.
4. The student will get the knowledge of the management of residues from water and wastewater treatment.
5. The student will understand about the wastewater treatment.

SEMESTER IV

PAPER - 10

Research Methodology

Course Objectives

1. To inculcate the research methods and designing.
2. To access various data sources for research and also to write a thesis, research articles and project proposals.

Unit-1

Research – Meaning, Purpose, Types. Steps in Research -Identification, selection and formulation of research problem.Formulation of hypothesis- types, testing of the hypothesis.

Unit-2

Literature Survey - sources of information - primary, secondary, tertiary. Journals, reviews, books, monographs, bibliography. Web resources - E-Journal, Journal access, TOC alerts, Citation index, Impact factor, H-Index, E-Consortium, UGC infonet, E-Books, Internet discussion groups and communities, Scirus, Pubmed, Google Scholar, ChemIndustry, Wiki Databases, Science Direct, Sci Finder, Scopus.

Unit-3

Research proposal - Purpose and scope, Sponsor identification, Format, Proposal development, Structure of research proposal - style of write up. Research Report - Types of reports -Technical report, Popular report. Contents - Styles of reporting, Steps in drafting reports, Editing the final draft. Evaluating the final draft.

Unit-4

Scientific papers – Short communication, Research articles, Review articles, book reviews, justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style.

Unit-5

Synopsis - Thesis writing, Presentations - Oral and poster, publications of scientific works in journals, proceedings and chapters in book.

References / Textbooks

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS
2. Kothari, C.R.,1985, Research Methodology- Methods and Techniques, New Delhi
3. Writing the doctoral dissertation.Barrons Educational series, 2nd edition, Davis, G.B. and C.A. Parker, 1997.pp 160.
4. MS office, Sexena, S. 2001.Vikas Publishing House Pvt. Ltd., New Delhi M
5. Kothari, C.R.,1985, Research Methodology- Methods and Techniques, New Delhi
6. Authoring a PhD, thesis: how to plan, draft, write and finish a doctoral dissertation, Duncary, P. 2003. Macmillan, pp 256.
7. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS
8. https://bbamantra.com/research-methodology/
9. https://www.researchgate.net/publication/329736173_Research_Methodology_Msc_notes_of_Dr_Judu_illavarasusvyasa_univ

Course Outcomes

1. The students will be able to understand the research and its types.
2. The students will be able to understand the collection of reviews from various journals.
3. The students will be able to learn about writing research proposals.
4. The students will be able to know about scientific papers.
5. The students will be able to know about the thesis writing and oral and poster presentation.

CORE ELECTIVE

PAPER - 4

(to choose one out of 3)

A. Biosafety, Bioethics and IPR

Course Objectives

1. To create awareness regarding safety and ethical issues about
2. To create awareness regarding genetic modifications, stem cell research, patents and copy rights aspects of the biotechnological products and process.

Unit-1

Biosafety – Introduction, biosafety issues in biotechnology, historical background. Introduction to Biological Safety Cabinets - Primary Containment for Biohazards, Biosafety Levels, Biosafety Levels of Specific Microorganisms. Recommended Biosafety Levels for Infectious Agents and Infected Animals.

Unit-2

Biosafety Guidelines - Biosafety guidelines and regulations - National and International. Operation of biosafety guidelines and regulations of Government of India, Definition of GMOs & LMOs. Roles of Institutional Biosafety Committee - RCGM, GEAC for GMO applications in food and agriculture. Environmental release of GMOs, Risk Analysis, Risk Assessment, Risk management and communication.Overview of National Regulations and relevant International agreements including Cartagena Protocol.

Unit-3

Bioethics- What is bioethics - legal and socioeconomic impacts of biotechnology, Public education of the process of biotechnology, making ethical concerns of biotechnology research and innovation.

Unit-4

Intellectual property rights - TRIPS, GATT. International conventions patents and methods of application of patents - Legal implications - Biodiversity and farmer rights

Unit-5

Patents and patent laws - Objectives of the patent system, Basic principles and general requirements of patent law. Biotechnological inventions and patent law.Legal development - Patentable subjects and protection in biotechnology.The patenting living organisms.

References / Textbooks

1. Hoosetti, B.B.2002. Glimpses of Biodiversity.Daya, New delhi.
2. Ethics in engineering, Martin.M.W. and Schinzinger.R. III Edition, Tata McGraw-Hill, New Delhi. 2003.
3. Bare Act, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007
4. Beier, F.K., Crespi, R.S. and Straus, T. Biotechnology and Patent protection-Oxford and IBH Publishing Co. New Del
5. Hoosetti, B.B.2002. Glimpses of Biodiversity.Daya, New delhi.
6. Senthil Kumar, Sadhasivam and Mohammed, Jaabir. 2008. IPR, Biosafety and Biotechnology Management. Jasen Publications, Tiruchirapalli, India.
7. http://www.cbd.int/biosafety/background.shtml
8. http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section 3.html.

Course Outcomes

1. The students will be able to understand the basics of biosafety and biodiversity.
2. The students will be able to understand the guidelines of biosafety.
3. The students will be able to learn about bioethics and socio economics.
4. The students will be able to know about patent and intellectual rights.
5. The students will be able to know about the patent and patent laws.

CORE ELECTIVE

PAPER - 4

B. Systems Biology

Course Objectives

To imbibe the information to the students, computational cell biology and fabrication of data base of genetic apparatus of the biological system.

Unit-1

Principles of Systems Biology- Systems Biology and modeling, Properties of models, Variables, parameters and constants.Model development, Data integration. Techniques – Elementary and Advanced - Standard models and approaches in systems biology. Elementary flux models and extreme pathways - Flux balance analysis, Metabolic control analysis.

Unit-2

Metabolomics- Digestion of proteins and protein metabolism, Urea Cycle, Transport metabolism, Carbohydrate metabolism – metabolism of glucose – glycolysis, TCA cycle, glycogenesis, Pentose phosphate shunt, Electron transport.Lipid metabolism - beta oxidation.Interconnection of pathways, metabolic regulations.Phylogeny, RNA secondary Structure, Gene Prediction.

Unit-3

Computational Cell Biology - Principle and levels of simulation – Virtual Erythrocytes, Pathological analysis. Flux Balance Analysis, Graphical Biological Network Editor and Simulator (Cell Designer).

Unit-4

Location Proteomics - Protein subcellular location - Pattern Recognition. Predicting ligand binding function, Use of gene cluster, detecting protein – protein interaction.Methods for Protein-Protein Interaction Analysis- Yeast Two Hybrid System (Y2H), Peptide Mass Fingerprinting (PMF).

Unit-5

Creative Bioinformatics - Novel use for database. Use of EST database, Unigene, Gene discovery, Primer design, Restriction mapping, Position specific cloning, KEGG, SNP database, Target identification, Epitope identification. Spatial Signalling Dynamics – Methods and Quantification of receptor signaling.

References / Textbooks

1. Foundation of Systems Biology – Hi Roaki Kitano
2. Introduction to Systems Biology – Sangdun Choi
3. The underlying pathway structure of biochemical reaction networks. Christopher H. Schilling et. al. 1998.PNAS. 95:4193-8
4. Whole cell simulation: a grand challenge of the 21st Century. Masaru Tomita, 2001. Trends in Biotechnology. 19: 205-210
5. Shanmughavel, P. 2005. Principles of Bioinformatics, Pointer Publishers, Jaipur, India.
6. Shanmughavel, P. 2006. Trends in Bioinformatics, Pointer Publishers, Jaipur, India.
7. The underlying pathway structure of biochemical reaction networks. Christopher H. Schilling et. al. 1998. PNAS. 95:4193-8
8. Cluster Analysis and Display of Genome – wide expression patterns. Michael B.Eisenet. al. 1998, Proc. Natl. Acad. Sci. USA. 95: 14863 – 14868.
9. Molecular Classification of Cancer: Class Discovery and Class prediction by Gene Expression Monitoring. Golub TR. et. al. 1999. Science, 286: 531 – 537.

10. The Escherichia coli MG. 1655 in silico metabolic genotype: its definition, characteristics and capabilities. Jeremy S. Edwards et. al. 2000. PNAS. 97:5528-33.
11. http://www.biologydiscussion.com/notes/quick-notes-on-systems-biology/38338
12. https://www.ias.ac.in/article/fulltext/reso/015/02/0131-0153

Course Outcomes

1. The students will be able to understand the basic principles of systems biology.
2. The students will be able to understand the metabolism of carbohydrates, proteins and glucose.
3. The students will be able to learn about cell designer and virtual of cells.
4. The students will be able to know about protein interaction and gene cluster and databases.
5. The students will be able to know about the bioinformatics and biological databases.

CORE ELECTIVE

PAPER - 4

C. Stem Cell Biology

Course Objectives

To impart knowledge to the student's basics of stem cells – culture and application.

Unit-1

Stem Cells– Introduction – History - Concepts in stem cell biology - Germline stem cells and germ line derived pluripotent - Embryonic Stem cells - Induced pluripotent stem cells & direct differentiation cells.

Unit-2

Types of Stem cells:Chromatin in stem cell biology - Cardiac Stem cells - Hematopoietic Stem cells – Notch – Regeneration - Prostate and Mammary Stem cells; TGFß and GPCRs

Unit-3

Telomeres in Stem cell Biology- Neuro stem cells - Mesenchymal SCs - Intestinal and skin stem cells - Cancer and stem cells; RTKs, TGFß

Unit-4

Stem cell culture - Embryonic stem cell, therapeutic uses of stem cell, disease recovery of stem cell, isolation and preservation of stem cell, clinical application of placenta in offspring - Ethical issues associated with stem cell biology.

Unit-5

Stem cell based treatment of diseases - stem cell used organogenesis in animals and human, clinical diagnosis of stem cell. Assisted reproductive technology - IUI, IVF, ICSI.Isolation of sperm and ova, role of sperm bank and ova bank, cryopreservation.

References / Textbooks

1. Essentials of Stem Cell Biology (Second Edition) Edited by: Robert Lanza, John Gearhart, Brigid Hogan, Douglas Melton, Roger Pedersen, E. Donnall Thomas, James Thomson and Sir Ian Wilmut
2. Essentials of Stem Cell Biology, Third Edition 3rd Edition by Robert Lanza (Editor), Anthony Atala (Editor)
3. Stem Cells: A Short Course 1st Edition by Rob Burgess (Author), John Wiley publisher, New Jersey.
4. Principles of stem cell biology and cancer future application and therapeutics edited by TarikRegad, Thomas J. Sayers and Robert C. Rees.
5. Stem cell biology edited by Daniel R. Marshak, Richard L. Gardner and David Gottlieb published by cold sprig laboratory press.
6. Stem Cells: Basics and Applications, Kaushik D Deb and Satish M Totey, Tata McGraw-Hill Education, 2009.
7. Stem Cells, Anna M. Wobus, Kenneth Boheler Springer Berlin Heidelberg, 02-Dec-2005
8. https://www.britannica.com/science/stem-cell
9. https://www.closerlookatstemcells.org/learn-about-stem-cells/types-of-stem-cells/

Course Outcomes

1. The students will be able to know the history of stem cell and its basics.
2. The students will be able to learn about the different types of stem celland how they are derived and extent of their plasticity.
3. The students will be able to learn abouttumor stem cell and telomeres in stem cell biology.
4. The students will be able to understand stem cell culture and ethical issues.
5. The students will be able to learn about stem cell based diseases and assisted reproductive technology.

OPEN ELECTIVE

PAPER - 4

(to choose one out of 3)

A. Organic Farming

Course Objectives:

To expose students to principles of agriculture and agricultural practices. To have a basic understanding on agriculture in India with relation to soil types, climatic conditions etc.

Unit-1

Introduction - Principles of Organic Farming- Farming Models-Natural Farming, Fukuoka-Japan, Parma Culture, Billmollyson, Australian Organic Farming, Ecological Farming, Palekar Model. Advantages and disadvandages of Organic farmic. Organic certification and the USDA-NOP.

Unit-2

Soil Factor - Physical, chemical and biological properties - Classification of Indian soils - Mineral and organic constituents of soils and their role in maintaining soil productivity. Essential plant nutrients and other beneficial elements in soils and plants

Unit-3

Composting Technique - Introduction- history of composting – compost - composting processes - microbiology of composting - fate of pathogens - ingredients in composting - various methods of composting: vermi- composting and home composting - steps in composting.

Unit-4

Biofertilizers and their Production - Introduction - Types: Microbes as biofertilizer, green manure, green leaf manure, importance of macronutrients; Biofertilizers vs Chemical fertilizers; Nitrogen fixers – types and examples; Phosphate solubilizers – role of bacteria and Mycorrhizae - Mass cultivation and Application of the following biofertilizers: i) Rhizobium ii) Azospirillum, iii) Cyanobacteria iv) Mycorrhizae.

Quality control; Challenges and opportunities; Biofertilizer Entrepreneurship

Unit-5

Agricultural practices - Implements, Seed bed preparation, ploughing, harrowing, sowing, irrigation, weeding, leveling, transplantation. Inter-cultivation, Crop rotation, harvesting, Post- harvest methods - Cultivation of paddy, ground nut, sugarcane, vegetable and fruits.

References / Textbooks

1. Shovan Ray (Ed). 2007. Handbook of Agriculture in India. Oxford University Press. New
2. Delhi.
3. Kumar Arvind, 2006. Concepts of Tropical Agriculture.Eastern Books Coprporation. India.
4. Sreenivas, Y.S. 2009. Advances in Agricultural Research in India, Oxford Book
5. Company.Jaipur.
6. RamanandSagar 2009.Advances in Agricultural Biotechnology. Cyber Tech Pub. New Delhi.
7. HemantRawat. 2008. Agricultural Biotechnology. Oxford Book Company. Jaipur.
8. Panda, S.C. 2005.Agronomy. Agrobios. Jodhpur.
9. Rajendra Reddy and J.P. Abhay Shankar. 2007. Encyclopaedia of Agriculture.
10. Commonwealth Pub., New Delhi.

Course Outcomes

1. The students will able to understand the various models of organic farming
2. The students will able to explain the role of soil health in organic crop production.

3. The students will able to identify the fundamentals of cultural practices and biological processes for successful establishment of organic farming.
4. The students will able to provide consultation and make awareness to the society about needs of organic farming for their routine life.
5. The students will able to set their own business, marketing and to compete with entrepreneurs.

OPEN ELECTIVE

PAPER - 4

B. Entrepreneurship

Course Objectives

1. To get an introductory knowledge about business concept
2. To know about the Entrepreneurship
3. To understand the concept Enterprise
4. To understand the concept behind the growth of business
5. To know about the various schemes announced by government

Unit-1

Small Business Small Business - Introductory frame work - Concept and Definition - Nature and Characteristics - Relationship between small and large business - Scope and types of small business - Rationale and objectives - Small business as seed bed of Entrepreneurship.

Unit-2

Entrepreneurship Concept Entrepreneur and Entrepreneurship concept - Distinction between entrepreneur and Manager - Entrepreneurial competency - Functions and Types.(Including women and rural)

Unit-3

Establishing a small enterprise Establishing a small enterprise - Steps - Project identification and selecting the product - Generation and screening the project ideas - Market analysis and Technical analysis (up to cost of production) Project formulation - Assessment of project feasibility -Preparation of project report- Dealing with basic and initial problems of setting up of Enterprises.

Unit-4

Growth Strategy Growth Strategy for small business - Need for growth - Types of growth strategy - Expansion and Diversification and Sub contracting.

Unit-5

Incentives and subsidies Incentives and subsidies - Central and State Government Schemes

References / Textbooks

1. “Entrepreneurial Development” by Khanka S S
2. “Entrepreneurial Development and Small Business Management” by Dr P T Vijayashree & M Alagammai.
3. “Entrepreneurial Development” by Desai.
4. “Dynamics of Entrepreneurial Development and Management” by V Desai.
5. “Business Development for Dummies” by Anna Kennedy.

Course Outcomes

1. The students will be able to develop a basic knowledge of business
2. The students will be able to understand about entrepreneurship concept and management
3. The students will be able to understand the concept of enterprise and market analysis
4. The students will be able to gain technical knowledge about the growth of business
5. The students will be able to gain the knowledge various government schemes supporting entrepreneurship

OPEN ELECTIVE

PAPER - 4

C. Pollution Control

Semester: IV **Credits: 3**

Hours of teaching: 3 **Paper type: Open Elective 4 (Non-Major)**

Course Objectives

1. To create awareness on the entire pollution problem
2. Know about different pollutions, consequences in the environment and its mitigation.
3. The student acquires knowledge about Marine Pollution types, sources, need for conservation, human impact, role of global institutions and NGO's role.
4. To manage, control and utilize alternative fuels

Unit-1

Air Pollution -Causes of Air pollution suspended particulate matter, Acid rain, Radiation pollution, Noise pollution, Thermal pollution

Unit-2

Soil Pollution - Causes of Soil Pollution: Industrial effluents, agricultural pollution, plant residues, insecticides, pesticides, fungicides, herbicides. Biological treatment of wastes and pollutants- solid waste disposal treatment of liquid waste

Unit-3

Water Pollution: Pollution and its control: Water pollution – Industrial effluents (Tannery, Textile, Sugar mill, Paper mill). Marine pollution.

Unit-4

Alternate Applications: Carbon banking – carbon foot print – industrial, institutional, governmental policies and rules. Alternative fuels – biofuels – wind, solar, hydrothermal, geothermal sources of energy.

Unit-5

Environmental Management: Environmental education (Awareness program, Environmental Audit) – participatory approach to reduce pollution.

References / Textbooks

1. Kumar, H. D. General Ecology, Vikas Publishing House Pvt. Ltd Delhi, 1997.
2. Sharma, P. D. Ecology and Environment, Rastogi Publications, Meerut, India, 2000.
3. Verma V. Plant ecology, Ane books Pvt Ltd, 2011.

Course Outcomes

1. The students will learn about the sources and different aspects of air pollution
2. The students will gain knowledge on soil pollution and methods to control pollutants
3. The students will learn about water and marine pollution and effective ways to control
4. The students will be able to learn about government policies and find alternative sources for fuels
5. The students will be able to spread awareness among public to reduce pollution

Core Practical

Semester: III & IV

Lab in Ecology & Environmental Biotechnology

Estimation of coliforms by MPN in water

1. Quantitative estimation of iron in water
2. Quantitative estimation of chromium in water
3. Determination of BOD of effluent
4. Determination of COD of effluent
5. Production of methane from sewage sludge

Core Practical

Semester: III& IV

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Lab in Plant Biotechnology

Tissue culture methods-media preparation, sterilization, inoculation of explants, callus culture, suspension cultures, anther and ovule cultures.

1. Isolation of protoplasts, viability test for protoplasts, protoplast culture.
2. Plant DNA isolation and analysis of electrophoretic gels.
3. Quantification of DNA/RNA in plant tissues by spectrophotometer method.

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