**THIRUVALLUVAR UNIVERSITY**

**MASTER OF SCIENCE**

**M.Sc. BIOTECHNOLOGY**

**CBCS Pattern**

(With effect from 2020 - 2021)

**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** |  |  |  |  |
|  | Core | Paper-1 | 5 | 4 | Cell & Developmental Biology | 25 | 75 | 100 |
|  | Core | Paper-2 | 5 | 4 | Biochemistry | 25 | 75 | 100 |
|  | 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**  |
|  | CoreElective | Paper-1 | 3 | 3 | **(to choose one out of 3)**A. BioinstrumentationB. BioprospectingC. Aqua Culture Biotechnology | 25 | 75 | 100 |
| **External Elective for other major students (Inter/multidisciplinary papers)** |
|  | Open Elective | Paper-1 | 3 | 3 | **(to choose one out of 3)**A. Tools in BiotechnologyB. Medical BiotechnologyC. Food Biotechnology | 25 | 75 | 100 |
|  |  |  | **30** | **18** |  | **125** | **375** | **500** |
|  |
| **SEMESTER II** |  | ***CIA*** | ***Uni. Exam*** | ***Total*** |
|  | Core | Paper-4 | 4 | 4 | Microbial Technology | 25 | 75 | 100 |
|  | Core | Paper-5 | 4 | 4 | Immuno Technology | 25 | 75 | 100 |
|  | Core | Paper-6 | 4 | 3 | Genetic Engineering | 25 | 75 | 100 |
|  | Core Practical | Paper-1 | 3 | 3 | Lab in Cell & Developmental Biology and Microbial Technology | 25 | 75 | 100 |
|  | Core Practical | Paper-2 | 3 | 3 | Lab in Biochemistry and ImmunoTechnology | 25 | 75 | 100 |
|  | Core Practical | Paper-3 | 3 | 3 | Lab in Genetics & Molecular Biology and Genetic Engineering | 25 | 75 | 100 |
| **Internal Elective for same major students** |
|  | **CoreElective** | **Paper-2** | 4 | 3 | **(to choose one out of 3)**A. Omics TechnologyB. Pharmaceutical BiotechnologyC. Nanotechnology | 25 | 75 | 100 |
| **External Elective for other major students (Inter/multi disciplinary papers)** |
|  | **Open Elective** | **Paper-2** | 3 | 3 | **(to choose one out of 3)**A. Medicinal PlantsB. Tissue CultureC. Molecular Diagnostics | 25 | 75 | 100 |
|  | **\*Field Study** |  | - | 2 |  | 100 | - | 100 |
|  | **Compulsory Paper** | 2 | 2 | **Human Rights** | 25 | 75 | 100 |
|  |  |  | **30** | **30** |  | **325** | **675** | **1000** |
| **SEMESTER III** |  | ***CIA*** | ***Uni. Exam*** | ***Total*** |
|  | Core | Paper-7 | 6 | 5 | Ecology & Environmental Biotechnology | 25 | 75 | 100 |
|  | Core | Paper-8 | 6 | 5 | Plant Biotechnology | 25 | 75 | 100 |
|  | 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**  |
|  | CoreElective | Paper-3 | 3 | 3 | **(to choose one out of 3)**A. Cancer BiologyB. Industrial BiotechnologyC. Virology | 25 | 75 | 100 |
| **External Elective for other major students (Inter/multi disciplinary papers)** |
|  | Open Elective | Paper-3 | 3 | 3 | **(to choose one out of 3)**A. Forensic ScienceB. Dairy farmingC. Waste Water Management | 25 | 75 | 100 |
|  | **\*\*MOOC Courses** |  | - | - |  | - | - | 100 |
|  |  |  | **30** | **21** |  | **125** | **375** | **600** |
| **SEMESTER IV** |  | ***CIA*** | ***Uni. Exam*** | ***Total*** |
|  | Core | Paper-10 | 6 | 4 | Research Methodology | 25 | 75 | 100 |
|  | Practical | Paper-4 | 0 | 3 | Lab in Ecology & Environmental Biotechnology | 25 | 75 | 100 |
|  | Practical | Paper-5 | 0 | 3 | Lab in Plant Biotechnology | 25 | 75 | 100 |
|  | Core | Project  | 18 | 5 | Project with *viva voce***(Compulsory)** | 100(75 Project +25 viva) | 100 |
| **Internal Elective for same major students** |
|  | CoreElective | Paper-4 | 3 | 3 | **(to choose one out of 3)**A. Biosafety, Bioethics and IPRB. Systems BiologyC. Stem Cell Biology | 25 | 75 | 100 |
| **External Elective for other major students (Inter/multi disciplinary papers)** |
|  | Open Elective  | Paper-4 | 3 | 3 | **(to choose one out of 3)**A. Organic farmingB. EntrepreneurshipC. 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.

**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**

.

**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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