COURSES OF STUDIES

M.Sc. (LIFE SCIENCES)

(2019-2021)

SCHOOL OF LIFE SCIENCES
SAMBALPUR UNIVERSITY
JYOTI VIHAR-768 019
SAMBALPUR, ORISSA

OUTLINE COURSE STRUCTURE

Course	Course Title	Credit hours	Marks
SEMESTER- I			
LS-411	Fundamentals of Physical Sciences	3 CH	50
LS-412	Biochemistry	3 CH	50
LS-413	Biophysics and Biophysical Chemistry	3 CH	50
LS-414	Microbiology	3 CH	50
LS-415	Molecular Biology	3 CH	50
LS-416	Instrumentation and Techniques	3 CH	50
LS-417	Practical (Biochemistry and Instrumentation)	2 CH	50
LS-418	Practical (Microbiology)	2 CH	50
SEMESTER- II			
LS-421	Ecology	3 CH	50
LS-422	Cell Biology	3 CH	50
LS-423	Immunology	3 CH	50
LS-424	Genetics	3 CH	50
LS-425	Taxonomy, Biodiversity and Biostatistics	3 CH	50
LS-426	Advanced Techniques in Biology	3 CH	50
LS-427	Practical (Ecology and Biostatistics)	2 CH	50
LS-428	Practical (Genetics, Immunology, Advanced Technique)	2 CH	50
SEMESTER- III			
LS-531	Bioinformatics and Computer Application	3 CH	50
LS-532 (A or B) (Stream paper-I)	(A) Plant Morphology (B) Animal Morphology	3 CH	50
LS-533 (A or B) (Stream paper-II)	(A) Plant Developmental Biology (B) Animal Developmental Biology	3 CH	50
LS-534 (A or B) (Stream paper-III)	(A) Plant Physiology (B) Animal Physiology	3 CH	50
LS-535 (A – D) (Special Paper-I)	Biochemistry: (A) Bioenergetics Microbiology: (B) Microbial Physiology Ecology: (C) System Ecology Physiology: (D) Cell Physiology	3 CH	50
LS-536 (A – D) (Special Paper-II)	Biochemistry: (A) Enzymology Microbiology: (B) Microbial Genetics Ecology: (C)Ecological Energetics Physiology: (D) Crop Physiology	3 CH	50
LS-537 (A or B)	(A) Practical (Plant Morphology, Development and Physiology) (B) Practical (Animal Morphology, Development and Physiology)	2 CH	50
LS-538 (A – D)	Special Paper Practical- I (Special Paper-I and II) (A) Biochemistry (B) Microbiology (C) Ecology (D) Physiology	2 CH	50
LS-539	Practical (Bioinformatics and Computer Application)	2 CH	50
SEMESTER- IV			
LS-541	Genetic Engineering	3 CH	50
LS-542 (Elective Paper) (A - H) (Any one)	(A) Cell culture Technique (B) Genomics and Proteomics © Protein Engineering (D) Medical Microbiology (E) Vermitechnology (F) Hormonal Plant Physiology (G) Plant Metabolism	3 CH	50
LS-543 (A - D) (Special Paper-III)	Biochemistry: (A) Structure and Metabolism Microbiology: (B) Industrial Microbiology Ecology: (C) Microbial Ecology Physiology: (D) Stress Physiology	3 CH	50
LS-544 (A - D) (Special Paper-IV)	Biochemistry: (A) Metabolic Regulation Microbiology: (B) Virology Ecology: (C) Environmental Management Physiology: (D) Radiation Biology	3 CH	50
LS-545 (A-D)	Special Paper Practical- II (Special Paper-III and IV) (A) Biochemistry (B) Microbiology (C) Ecology (D) Physiology	2 CH	50
LS-546	Seminar	3 CH	50
LS-547	Project Work and Viva Voce	(3 + 2) CH	150
Total Course Credit		**90 CH**	**1700**

Preamble of Life Sciences Syllabus

Life Sciences is an advance and applied Biological Sciences course where the principles of Physics, Chemistry, Mathematics and other Physical Sciences are integrated together and applied and tested in the living systems. In other words, Life Science is the conglomeration of physical and natural sciences at the level of higher learning and is very important for Life Sciences students to understand the basic principles and theories of Physical sciences to solve Biological problems. So the major objective of the programme is to establish a fundamental foundation of understandings and skill based knowledge of Physical Sciences to be applied in living systems which will enable the students to pursue advance research in modern Life Sciences for solving upcoming critical problems.

M.Sc. Life Sciences syllabus has been designed to equip the students with subject domain knowledge and technical skills pertaining to both physical and biological sciences. The course also aims to train the students in all areas of Life Sciences with unique combination of some interdisciplinary courses, few compulsory papers, some elective papers and some specialization courses. Apart from this, students have the opportunity for exposure to cutting-edge technologies, modern equipment facilities and advance trainings to gear up their scientific aptitude to build their career and become part of Nation building. After completion of the course, students are made aware about the current social and environmental issues and how the living organisms including plants, animals and microbes are important for humanity and also for their relevance towards national economy and food security. After obtaining Post-graduate degree, the students may be quite competent and efficient to set up, design and execute research projects using various tools and techniques learned by them in the areas like modern instrumentation techniques, biophysical chemistry, biostatistics, computer applications, genetics, molecular biology, physiology, biochemistry, microbiology, ecology, radiation biology, developmental biology, genetic engineering etc. and develop Scientific temperament and research attitude for solving any sort of Life Sciences related problems.

Mission

M1.Sambalpur University shall strive to educate society for generations by providing transformative education with deep disciplinary knowledge and concern for environment.

M2. To develop problem solving, leadership and communication skill in student participants to serve the organization of today and tomorrow.

M3. To aim for the holistic development of the students by giving them value based ethical education with concern for society.

M4. To foster entrepreneurial skills and mindset in the students by giving lifelong learning to make them responsible citizens.

Programme Specific Outcomes (PSOs)

PSO1. Understand the nature and basic concepts of modern Life Sciences to solve the upcoming censorious problems.

PSO2. Analyse the relationships among different concepts of different branches of Life Sciences and their integration together for generation of useful products with societal relevance.

PSO3. Perform procedures and experiments as laid down in the areas of modern Life Sciences and find out leads for advance learning and also for new discovery.

PSO4. Apply the basic concepts learned from the course and execute them in real situations for the benefit of humanity.

Programme Outcomes (POs)

After completing the PG courses in Life Sciences, the student will be capable of

PO1. Critical thinking: Take informed actions after identifying the assumptions in the areas of Life Sciences that frame our thinking and actions.

PO2.Effective Communication: Speak, read, write and listen clearly in person and through electronic media in English and in one Indian language.

PO3. Social Interaction (Interpersonal Relation): Elicit views of others, mediate disagreements and prepared to work in a team.

PO4. Entrepreneurship Capability: Demonstrate qualities to be prepared through scientific experimentations to become an Entrepreneur in different branches of Life Sciences.

PO5. Ethics: Recognize different value systems, understand the moral dimensions and accept responsibility for them.

PO6.Environment and Sustainability: Understand the issues of environmental contexts and sustainable development.

PO7. Life-long Learning: Acquire the ability to engage in independent and life-long learning in the context of scientific and socio-technological changes.

FIRST SEMESTER

LS-411	**Fundamentals of Physical Sciences**	**3 CH**	**50 marks**

OBJECTIVE

This paper contains three units, namely basic physics, basic chemistry and basic mathematics. Each unit contains a description of the principles related to that unit, well-supported by mathematical derivations of equations, descriptions of laboratory experiments, historical background etc; with solved examples that explain equation just derived or the concept just discussed. These courses will help in fixing the Ideas firmly in student's mind. The examples discussed are used to encourage students for participation in discussions and motivate towards advance learning in the field.

PROGRAMME EDUCATION OBJECTIVES (PEOs): After studying Fundamentals of Physical Science in the curriculum, students will be able to:

PEO1. Understand the nature and basic concepts of Physical Sciences in Biology relating to M.Sc. degree in Life Sciences.

PEO2. Analyze the relationships among different concepts of Physical Sciences.
PEO3. Perform procedures as laid down in the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying Fundamental of Physical Sciences in the curriculum Students will be able to:

CO1. Remember and understand the basic concepts of Physical sciences.

CO2. Analyze the various concepts to understand them through laboratory experiments/case studies.

CO3. Apply the knowledge in understanding practical problems.

CO4. Execute/create the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE

Unit-I: Basic Physics: What is Physics? Physics and mathematics**,** Fundamental and Derived Quantities, Units and Dimensions, their conversions and their uses, Order of Magnitudes; The forces: Gravitational, Electromotive and Nuclear forces; Different forms of energies, Kinetic vs Potential energy, Mass-energy equivalence, Surface tension, Viscosity, Photoelectric effect, Basic characteristics of electricity, charge, current, voltage, resistance, capacitor, and electric field.

Unit-II: Basic Chemistry: Atomic structure – waves and wave functions, quantum numbers, Atomic orbitals, electronic configuration of atoms and periodic properties of elements, ionic radii's, ionization potential, electronic configuration of molecules. Bond lengths, Bond angles, bond order and bond energies, types of chemical bond (weak and strong), intermolecular forces, structure of simple ionic and covalent bonds, carboxylic acids, aldehydes and ketones, and amines.

Unit-III: Basic Mathematics: Logarithms, exponential series, factorials, graphs, Coordinate geometry – straight line and non-linear relationships. Differentiation– Rates and limits, Differential coefficients, Differentiation of a function. Integration – Basic concepts of integration, integration by substitution, integration by parts. Matrix algebra – linear transformation between vector spaces, Representation of linear transformation by matrices, Algebra of matrices, Eigen values and Eigen vectors of linear transformation.

SUGGESTED READING:

1. Text book of Physics by Barik, Das, Sharma.
2. Essentials of Physical Chemistry by Arun Bahl, B S Bahl & G.D. Tuli.
3. Text books in mathematics published by NCERT, India.
4. Concepts of Physics by H C Verma.
5. IIT Chemistry by O P Agarwal.
6. PMP Certification Mathematics by V Subramanian & R Ramachandran.

LS-412	Biochemistry	3 CH	50 marks

OBJECTIVE

The objective of this particular paper is to provide an advance understanding of course principles of biochemistry and their experimental basis. It will enable the students to understand the various aspects of biochemistry and its importance in daily life. Further it can be utilized for clinical diagnosis, manufacturing of biological products and treatment of diseases.

PROGRAMME EDUCATION OBJECTIVES (PEOs): After studying Biochemistry in the curriculum, students will be able to:

PO1. Understand the nature and basic concepts of Biochemistry.
PO2. Analyze the relationships among different concepts of Biochemistry.
PO3. Perform procedures as laid down in the areas of study.
PO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying biochemistry in the curriculum Students will be able to:

CO1. Remember and understand the basic concepts of Biochemistry.

CO2. Analyze the various concepts to understand them through laboratory experiments/case studies.

CO3. Apply the knowledge in understanding practical problems.

CO4. Execute/create the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE

Unit-I: Structure of Biomolecules: Polysaccharides, starch and glycogen as reserve fuel; Cellulose as structural polysaccharides; Lipids: triglycerides and spingosides, conjugated and complex lipids.Structure and conformation of nucleic acids. Proteins: molecular organization, protein structure (Primary, Secondary, Tertiary and Quaternary).

Unit-II: Metabolism and Bioenergetics: Glycogenesis and glycogogenolysis, HMP shunt, Gluconeogenesis and its physiological significance; Oxidation of fatty acids. Electron transport in mitochondria and chloroplast; Basic principles of oxidative and photophosphorylation.

Unit-III: Enzymes:Classification of enzymes, concept of active site and its analysis, Mechanism of enzyme catalysis (with examples), Michaelis-Menten, Linewever-Burke plot, Eddy-Hoftsee plot and Hans plot,Factors affecting enzyme catalysis, Enzymes inhibitions, Allosteric enzymes.

SUGGESTED READING:

1. Fundamental of Biochemistry by J. L. Jain.
2. IIT Chemistry by O P Agarwal.
3. Principles of Biochemistry by Lehninger, David L. Nelson and Michael M. Cox
4. Biochemistry by Jeremy M. Berg, John L. Tymoczko and Lubert Stryer
5. Principles of Biochemistry by Donald Voet, Judith G. Voet and Charlotte W. Pratt

LS-413	**Biophysics and Biophysical Chemistry**	**3 CH**	**50 marks**

OBJECTIVE:

Biophysics and Biophysical Chemistry is an advanced field of Biological sciences which uses the principles and techniques of physical science in the study of living systems. The course includes the fundamentals of weak electrostatic interactions and their significance in maintenance of the structural stability of biologically important macromolecules and diversified structures. The course also emphasizes the importance of light and other electromagnetic radiations in the regulation of different developmental activities in plants, animals and microbes. Additionally, biophysical chemistry enhances the knowledge on chemistry of life and its active involvement in different biological activities in the living organisms.

This paper contains three units, namely Inter-molecular interactions, Photo Biophysics, and Biophysical Chemistry. Each unit contains a description of the principles related to that unit, well-supported by different equations, descriptions of laboratory experiments, historical background etc. with solved examples. These will help in fixing the Ideas firmly in student's mind and motivate the students for higher study.

PROGRAMME EDUCATION OBJECTIVES (PEOs): After studying Biophysics and Biophysical Chemistry in the curriculum, students will be able to:

PEO1. Understand the nature and basic concepts of Biophysics and Biophysical Chemistry relating to M.Sc. degree in Life Sciences.
PEO2. Analyze the relationships among different concepts of Biophysics and Biophysical Chemistry.
PEO3. Perform procedures as laid down in the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying Biophysics and biophysical chemistry in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of Biophysics and Biophysical chemistry.
CO2. Analyze the various concepts to understand them through laboratory experiments/case studies.
CO3. Apply the knowledge in understanding practical problems.
CO4. Execute/ create projects or field assignment as per the knowledge gained in the course curriculum.

COURSE:

Unit-I: Molecular interactions: Dipole and dipole moments, induced and transient dipole, unit charge, charge-charge interaction, charge-dipole interaction, dipole-dipole interaction, hydrogen bonding, Van der Waal's interaction, role of weak electrostatic interactions in the stability of proteins (α-helix and β-pleated sheets), nucleic acids, bio-membranes, liposomes, micelles, artificial lipid bilayers and structure of water, protein folding.

Unit-II: Photobiophysics: Light absorption, emission and quantum transfer mechanism, laws of photochemistry, quantum yield and inductive resonance, photochemistry of photosynthesis and vision, UV-induced DNA damage and repair mechanisms, ionising and non-ionising radiations, effect of ionising radiations on biomolecules and cells and photo-protective mechanisms in plants during stress.

Unit-III: Biophysical chemistry: pH and Buffers, Ionic strength, Buffer strength, Buffering zone and preparation of buffers, Molecularity and kinetic order of reaction, Theories of reaction rate, Laws of thermodynamics and biology – Concept of free energy, Entropy, Q_{10} and Arrehnious equation.

SUGGESTED READING:

1. Modern College Chemistry by R C Acharya & Y R Sharma.
2. Essentials of Physical Chemistry by Arun Bahl, B S Bahl & G.D. Tuli.
3. Biophysical Chemistry By Upadhyay, Upadhyay & Nath.
4. Electrical Interactions in Molecular Biophysics: An Introduction. Raymond Gabler. Academic Press, New York.

LS-414	Microbiology	3 CH	50 marks

OBJECTIVE:

Microbiology is a broad discipline and students have a wide range of options for the study of microbiology including: microbial physiology, microbial genetics, microbial ecology, pathogenesis, immunology, virology, parasitology, epidemiology, evolution and diversity. Microbiology is a laboratory-based science, and as such, our curriculum supports laboratory components in most of the courses taught in the program.

PROGRAMME EDUCATION OBJECTIVES (PEOs):

PEO1. Understand the nature and basic concepts of Microbiology relating to M.Sc. degree in Life Sciences.
PEO2. Analyze the relationships among different concepts of Microbiology.
PEO3. Perform procedures as laid down in the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying Microbiology in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of Microbiology.

CO2. Analyze the various concepts to understand them through laboratory experiments/case studies.

CO3. Apply the knowledge in understanding practical problems.

CO4. Execute/ create projects or field assignment as per the knowledge gained in the course curriculum.

COURSE:

Unit-I: Historical resume of Microbiology, An overview of the microbial world (Bacteria, Archea, Eukaryote). Classification of Archea and Eubacteria as per Bergey's manual; Microbial phylogeny. Structural organization of prokaryotic cell (bacterial wall, capsule, flagella, pilli, pronucleus, ribosomes, plasmid).

Unit-II: Bacterial nutrition and nutritional category, Bacterial culture: Synchronomous and asynchronous culture, continuous culture and chemostat principle. Bacterial growth: phases of growth, Mathematical expression of growth, generation time, specific growth rate. Bacterial metabolism: Glucose dissimilation pathways, Bacterial respiration with organic and inorganic reductant, Chemolithotrophy. General principle of bacterial conjugation, transduction and transformation. Bacterial pathogenecity and anti-microbial compounds.

Unit-III: Virus**:** Generalproperties, structure, purification, cultivation, principle of viral taxonomy. Bacteriophage: structure, classification, one-step growth experiment. Production of DNA phage, RNA phage, Lytic cycle, Temperate phage and Lysogeny. Animal virus and its reproduction, viral infection (Presistent, Latent and Slow virus infection). Plant virus and their transmission. Anti-viral agents; M-13, Lambda, HIV, Influenza virus, Viriods and Prions.

SUGGESTED READING:

1. Brock Biology of Microorganisms (12th edition) by Madigan and John M. Martinko, Paul V. Dunlap, David P. Clark Benjamin Cummings; 2008.

2. Principles of Virology: Molecular Biology, Pathogenesis and Control of Animal Viruses by S.J. Flint, L.W. Enquist, V.R. Racaniello, and A.M. Skalka 2nd edition, ASM Press, Washington, DC, 2004.

3. Introduction to Modern Virology EPZ by Nigel Dimmock, Andrew Easton and Keith Leppard, 5th edition, Blackwell Publishing, 2005

4. Microbiology. Sixth edition, International edition by Prescott, L. M., J. P. Harley and D. A. Klein. 2005., Mc Graw Hill.

5. Microbiology. Fifth edition by Pelczar, T. R. and M. J. Chan and N. R. Kreig. 2006, Tata Mc Graw-Hill INC. New York.

6. Fundamentals of Microbiology & Immunology by Ajit Banerjee and Nirmalya Banerjee 2008.. New Central Book Agency (P) Limited.

7. A Textbook of Microbiology, 4th Edn. by R C Dubey and D K Maheshwari , S. Chand Publishing.

LS-415	Molecular Biology	3 CH	50 marks

OBJECTIVE:

Molecular biology deals with nucleic acids and proteins and how these molecules interact within the cell to promote proper growth, division, and development. It is a large and ever-changing discipline. This course will emphasize the molecular mechanisms of DNA replication, repair, protein synthesis.

PROGRAMME EDUCATION OBJECTIVES (PEOs): After studying Molecular Biology in the curriculum, students will be able to

PEO1. The course will help the students to understand basic concepts of Molecular Biology.

PESO2. At molecular level and there will be analysis of the interactions between the various systems of a cell, including the interrelationship of DNA, RNA and protein synthesis and learning how these interactions are regulated.

PEO3. The concepts discovered in this manner can be applied to mainstream biology, medicine, wildlife study and protection of endangered animals, food industry, pharmaceutical industry and environment protection.

OUTCOME

CO1. After studying the Molecular Biology curriculum, students will be able to understand the basic organization of genome through evolutionary process, transfer of the information for continuance of life and heredity at molecular level.

CO2. They can analyze the basic steps in transfer of genetic information and its regulation. and will have an insight into the natural process of repair mechanism and the recombination process which brings about variation in the genetic material.

CO3. They can construct and utilize predictive models to study and describe complex biological systems and apply concepts from other sciences in order to interpret biological phenomena.

CO4. The can execute project applying the basic principles of genetic engineering.

COURSE

Unit-I: Genetic organization of Prokaryotes and Eukaryotes including nuclear genome and organellar genome; DNA as the genetic material; Central dogma of Molecular Biology; Genome complexity; C-value paradox, Cot value, Repetitive DNA, Satellite DNA; Gene structure in Prokaryotes and Eukaryotes; Cistron, Recon, Muton; Variants of gene- Split genes, Pseudogenes, Overlapping genes and selfish DNA; DNA methylation.

DNA replication: Models of DNA replication, Enzymes of DNA replication, Process of DNA replication (initiation, elongation, termination), DNA replication at the telomere; Replication of Mitochondrial and Chloroplast genome.

Unit-II: DNA-Protein interaction, DNA repairs mechanism, DNA recombination (site-specific and homologous) mechanisms and its significance.

Transcription: Components of transcription machinery in Prokaryotes and Eukaryotes, Trancriptional factors, Transcription process (initiation, elongation and termination); Post-transcriptional processing, m-RNA stability, m-RNA editing; Gene silencing.

Unit-III: Translation: Genetic Code- Principle of translation, Translation machinery in Prokaryotes and Eukaryotes (t-RNA, Aminoacyl synthetase, Ribosome), Translation process (initiation, elongation and termination); Post-translational modifications of proteins.

Regulation of gene expression: Constitutive and Induced gene expression; Regulation of gene expression in Prokaryotes and Eukaryotes; Operon concept (Lac, Ara, Trp and His).

SUGGESTED READING:

1. Gene – VIII by B. Lewin, Pub: Jones and Barlett .
2. Molecular biology of the gene 5th Edn. by J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levine and R. Losick, Pub: Cold Spinger Harbr Laboratory Press.
3. Molecular Biology of the cell 4th Edn. by B. Alberts, D. Brey, J Lewis, M.Raff, K. Roberts and J.D. Watson, Pub: Garland Science
4. Molecular biology LabFax, by T.A. Brown.
5. Molecular Biology by T.A. Brown
6. The cell A molecular Approach by G.M. Cooper and R.E. Hausman

LS-416	Instrumentation and Techniques	3 CH	50 marks

OBJECTIVE:

Instrumentation and Techniques paper involves the principles and use of various instruments used to quantify various aspects of Biological materials. Cutting-edge instruments not only enable new discoveries but help to make the production of knowledge more efficient. Many newly developed instruments are important because they enable us to explore phenomena with more precision and speed.

PROGRAMME EDUCATION OBJECTIVES (PEOs): After studying Instrumentation and Techniques in the curriculum, students will be able to

PEO1. The course will help the students to understand basic principles of different instruments.

PEO2 Analyze the different biological materials using the instruments and techniques.
PEO3. Perform procedures as laid down in the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying Instrumentation and Techniques in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of Instrumentation and Techniques.

CO2. Analyze the various concepts to understand them through laboratory experiments/case studies.

CO3. Apply the knowledge in understanding practical problems.

CO4. Execute/ create projects or field assignment as per the knowledge gained in the course curriculum.

CO4. The can execute project applying the basic principles of genetic engineering.

COURSE

Unit-I: Spectrophotometry – laws of absorption of light, absorption spectra. Fluorescence and Flurometry. Centrifugation – Principles, Types: Density gradient and Differential centrifugation. Principle and types of chromatography (Paper, Column, Affinity and Ion-exchange).

Unit-II: pH metry, Bomb calorimetry, Flame photometry, Oxygen polarography, Principle and application of Gel Electrophoresis (Agarose, PAGE, SDS-PAGE and IEF).

Unit-III: Radioactivity; Principle and application of G.M. Counter and Liquid Scintillation counter, Microscopy (Compound, Phase contrast, Fluorescence, Confocal); Electron Microscopy (TEM, SEM and STEM); Remote sensing and its application.

SUGGESTED READING:

1. Principles And Techniques Of Biochemistry And Molecular Biology 8Ed by Wilson and Walkers
2. Learning Radiology: Recognizing the BasicsBook by William Herring
3. Modern Experimental Biochemistry by Rodney Boyer
4. Molecular Cloning: A Laboratory Mannual by Sambrook and Russell

LS-417	**Practical based on Biochemistry and Instrumentation**	**2 CH**	**50 marks**

LS-418	**Practical based on Microbiology**	**2 CH**	**50 marks**

SECOND SEMESTER

LS-421	**Ecology**	**3 CH**	**50 marks**

OBJECTIVE:

The Environment and Ecology is the paper to understand the nature of environmental influences on individual organisms, their populations and communities at the level of biosphere. It will also deal with the local distribution of animals in various habitats and the influence of the deterioration of habitats on the population and the community as a whole.

PROGRAMME EDUCATION OBJECTIVES (PEOs): After studying Environment and Ecology the students will be able to:

PEO1. To provide an understanding on the fundamentals of environment
PEO2. To analyze the relationship between various components of ecosystem
PEO3. Perform experiments to study various ecological parameters and biodiversity in laboratory/field conditions.
PEO4. Apply the basic concepts learned to execute them for environment protection.

COURSE OUTCOMEs (COs): After studying Environment and Ecology in the curriculum Students will be able to:

CO1: Remember and understand the basic principles of ecology and can judge how organism function, interact within and across trophic levels, influence the flow of energy and the movement and recycling of matter in communities and ecosystems

CO2: Analyze interactions within the context of specific habitats and judge how the habitat shapes the distribution and abundance of species. And can recognize that the distribution of organisms is a product of positive and negative interactions within and across trophic levels, including competition, mutualism, predation, and parasitism

CO3: Apply basic ecological principles to meet societal resource management and conservation goals.

CO4: Execute a productive role towards improving life and protecting the environment with due regard given to ethical values

COURSE:

Unit-I:
Concepts of environment and ecosystem: Biotic and abiotic interactions; Cybernetic nature of ecosystem; stability through feedback control and through redundancy of components; resistance and resilience stability, Gaia hypothesis; Concept of limiting factors- Liebig's law, Shelford's law; Ecological indicators. Energy in the environment: Laws of thermodynamics, energy flow in the ecosystem; Primary productivity and secondary productivity. Food chain, food web, trophic levels. Ecological pyramids, Ecological efficiencies, Bio-geochemical cycles- patterns and types (CNP).

Unit-II:
Population Ecology: Concept of population and population attributes: Density, natality, mortality, survivorship curves, life table, age structure, population growth forms, Concept of carrying capacity and environmental resistance, Life history strategies, r- and k- selection, Biological scaling (allometry), , Concept of community: concept of habitat and niche, Quantitative features and attributes of community, Community dynamics: trends and significance, Climax theory, Co-evolution of species populations in the community.

Unit-III:
Concepts of Resource: Biotic & Abiotic Resources, Renewable and Nonrenewable resources, Exhaustible and non-exhaustible resources. Resource Conservation and Management, Concept of Sustainable Development,
Concept of stress and Strain, Tolerance Hypothesis, Steno-and Eury species, Concept of limiting factors, Environmental Pollutants as stress factor: Sources/pathways of pollutants, metallic pollutants such as Mercury,Arsenic,CVadfmiun, Photochemical smog, Acid rain, Ozone hole, Eutrophication, Biological magnification, Fluoride as a pollutant, Global warming, Green house gases and climate change.

SUGGESTED READING:

1. Fundamentals of Ecology by Eugene P. Odum and Gary W. Barrett ,(2009) Amazon.in
2. Fundamentals of Ecology by S. Dash, M. Dash, 3rd Edition, Mcgraw Higher Ed
3. Concepts of Ecology by Concepts of Ecology (1995) by Edward J. Kormondy

LS-422	Cell Biology	3 CH	50 marks

OBJECTIVE: Membrane Biology associated with cellular transport along with cell signaling is key events in cell metabolism. Basic physiological processes in relation to different kinds of radiation largely influences cell dynamics and thus survival. This paper comprises of three units, namely Cell dynamics and Cell signaling, Cellular Transport, and Cellular Radiation Physiology. Each unit contains a description of the principles related to that unit, well-supported by different examples, descriptions of laboratory experiments, historical background etc. with solved equations that explain the concept. These courses will help in fixing the Ideas firmly in student's mind which will bring them to a habit of being excellent scientific temperament.

PROGRAMME EDUCATION OBJECTIVES (PEOs): After studying Cell Biology in the curriculum, students will be able to:

PEO1. Understand the nature and basic concepts of Cell Biology relating to M.Sc. degree in Life Sciences.
PEO2. Analyze the relationships among different concepts of Cell Biology.
PEO3. Perform procedures as laid down in the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying Biophysics and biophysical chemistry in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts/principles of Cell Biology.

CO2. Analyze the various concepts to understand them through scientific experimentations/ case studies.

CO3. Apply the knowledge in understanding practical problems.

CO4. Execute/create the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE:

Unit-I: Cell dynamics and Cell signaling: The dynamics of cell and its evolution, Architecture and life cycle of cells, Overview of cell to cell signaling at intercellular communications, Cell surface receptors and their role in signal transduction, G-protein coupled receptors and RTKs, 2nd messengers and signaling pathways, Regulation of signaling pathway.

Unit-II: Cellular Transport: Passive and active transport, co-transport and counter transport mechanisms, Diversity of transporter proteins in the cell membrane, diffusion and bulk flow, carrier mediated transport, Kinetics of transport, Concept of water potential, its components, units and measurement, Ion channel proteins and aquaporins.

Unit-III: Cellular Radiation Physiology: Basic radiation biophysics, UV and ionizing radiations, radiation effects on cell and sub-cellular components (nucleic acids and proteins), Dose response curves in prokaryotes and eukaryotes; Split dose technique and concept of dose LD_{50}.

SUGGESTED READING:

1. Essential Cell Biology by Albert et al.
2. Cell Biology by Gerald Karp
3. Fundamentals of Radiation Biology by P. Umadevi
4. Radiation Biology for Radiologist by Eric J. Hall
5. Molecular Cell Biology by Lodish et al.
6. A manual of Laboratory Experiences in Cell Biology by C E Gasque.
7. Cells by Lewin et al.

LS-423	Immunology	3 CH	50 marks

OBJECTIVE: This paper contains three units, namely Basics of Immunity, Immunoglobulins, Immunological techniques. Each unit contains a description of the principles related to that unit, well-supported by different examples, descriptions of laboratory experiments, historical background etc; with solved equations that explain the concept discussed. These will help in fixing the Ideas firmly in student's mind. The examples discussed in the class-room are used to encourage students to participate in discussions.

PROGRAMME EUCATION OBJECTIVES (PEOs): After studying Immunology in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of Immunology
PEO2. Analyze the relationships among different concepts.
PEO3. Perform procedures as per the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying Immunology in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of Immunology.

CO2. Analyze the various concepts to understand them through case studies.

CO3. Apply the knowledge in understanding practical problems.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE:

Unit-I: Basics of immunity, Immunity related organs in the human body, Leucocyte in immune function, B cells and T cells – their structure and differentiation, antigen and antibody, properties of antigen, haptens, antigenicity, antigen processing and presentation, Complement activation.

Unit-II: Immunoglobulins – classification, structure and properties, primary and secondary immune response, Genetic basis of generation of antibody diversity, Antigen-antibody interaction. T-cell receptors, Major histocompatibility complex proteins. Interleukins.

Unit-III: Brief idea regarding Immunology of – Allergy, AIDS, Organ transplantation, Cancer and autoimmune diseases. Experimental techniques like – agglutination, precipitin formation, Immunodiffusion (SRID and DRID). Immunoelectrophoresis – types and uses, Radio Immuno Assay (RIA), ELISA, Western Blotting.

SUGGESTED READING:

1. Immunology by Ivan Roitt, Jonathan Brostoff and David Male
2. Immunology by Kuby et al.
3. Fundamentals of Immunology by Willium Paul.
4. Principles of Immunology by N V Shastri

LS-424	Genetics	3 CH	50 marks

OBJECTIVE

The objective of this study is to have an understanding of the inheritance and expression of genes. They will have a clear concept on various terminologies used in genetics. It will also help to understand the processes which help in maintaining the stability of the genetic material and the processes which bring about variation in genetic pool.

PROGRAMME EUCATION OBJECTIVES (PEOs): After studying Immunology in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of Immunology
PEO2. Analyze the relationships among different concepts.
PEO3. Perform procedures as per the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying Inheritance Biology in the curriculum, students will be able to:

CO1. Remember and understand Mendelian principles and the way of transfer of genetic material from one generation to another.

CO2. Analyze the various concepts to understand them through case studies.

CO3. Apply the knowledge in understanding extrachromosomal inheritance, the occurrence of variance in the gene pool and population genetics practical problems.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE

Unit-I: Mendelian principles: Dominance, segregation, independent assortment; Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.Extra-chromosomal inheritance: Inheritance of Mitochondrial and chloroplast genes, maternal inheritance.

Unit-II: Concept of gene: Allele, multiple alleles, pseudoallele, complementation tests. Gene mapping methods: Linkage maps, Tetrad analysis, Pedigree analysis, lod score for linkage testing, Mapping with molecular markers, Mapping by using somatic cell hybrids, Development of mapping population in plants. Quantitative genetics: Polygenic inheritance, Heritability and its measurements, QTL analysis.

Unit-III: The origin of genetic variability through mutation (Spontaneous and chemical mutation, Frame-shift mutation, point mutations and chromosomal abberations).Causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis. Structural & numerical changes of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications, Genetic diseases and

syndromes.Population Genetics: Gene pool, Gene frequency, Hardy Weinberg genetic equilibrium and the factors influencing it, Gene flow and Genetic drift.

SUGGESTED READING:

1. Genetics by Sinnot, Don, Dobjanasky.
2. Genetics by Strickberger.
3. Genetics by Gardner.
4. Concepts of Genetics by Klug and Cumming.
5. Applied Genetics by Emmanuel, Ignacimuthu and Vincentet
6. Molecular biology of the gene 5th Edn. by J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levine and R. Losick, Pub: Cold Spinger Harbr Laboratory Press.
7. Introduction to Genetic Analysis 12th Edn. by Griffith et. al.

LS-425	Taxonomy, Biodiversity and Biostatistics	3 CH	50 marks

OBJECTIVE:

Biosystematics will help in studying the biodiversity and its origins. In a broader sense, it is a science through which organisms are discovered, identified, named and classified with their diversity, phylogeny, spatial and geographical distributions. The objective of Biostatistics is to advance statistical science and its application to problems of biology including human health and disease, with the ultimate goal of advancing statistics. The role of biostatisticians is an important one, especially when it comes to designing studies and analyzing data from research problems.

PROGRAMME EUCATION OBJECTIVES (PEOs): After studying biosystematics and biostatistics in the curriculum, students will be able to:

PEO1. To understand the fundamental principles of systematic in which the animals/plants are classified according to their characters and what are the theories which have to be followed for classification. International rules of nomenclature and classification is studied. Also to understand the proper use and interpretation of significance levels (p values), recognize and understand the relevance of probability distributions such as the normal & binomial be able to formulate and test statistical hypotheses using 6 steps.

PEO2. To analyze the relationships between various taxa of organisms based in their evolutionary history and establishing their phylogeny

PEO3. To perform different tests of significance for getting a concrete conclusion in various aspects of biological experiments

PEO4. To apply the basic concepts of biosystematics and biostatistics to deal with kinds and diversity of organisms and any or all relationships among them and to deal with inferential statistics

COURSE OUTCOMEs (COs): After studying biosystematics and biostatistics in the curriculum, students will be able to:

CO1: Remember and understand the role in biology by providing the means for characterizing the organisms that we study.

CO2; Analyse the classifications that reflect evolutionary relationships that allows predictions and testable hypotheses

CO3: Apply the basic concepts for effective decision-making about conservation and sustainable use.

CO4: Execute the field based knowledge by providing a framework for systematic conservation planning for the management of biological diversity and natural resources.

COURSE

Unit-I: Taxonomy:Theories of evolution; Evidences in support of evolution (Morphology to Molecular level);Species concept and Speciation, Ranking and nomenclature, Types of classification (Artificial, Natural, Phylogenetic and Phenetic)of plants and animals, Modern methods of taxonomy such as biochemical, molecular, serological and numerical.

Unit-II: Biodiversity:Genetic diversity, Species diversity and Ecosystem diversity; Tools of diversity analysis (diversity, dominance, evenness and similarity indices); Relationship between diversity, dominance and productivity. ; Attributes of biodiversity (keystone species, flag ship species, indicator species, rare species, vulnerable species, endangered species); Latitudinal gradients of biodiversity and mega biodiversity. Methods of biodiversity conservation (i*n situ* and e*x situ*,and germplasm conservation)

Unit-III: Biostatistics: Concept of biostatistics, Measures of central tendency and dispersion; probability distributions (Binomial, Poisson and normal); Sampling distribution; Difference between parametric and non-parametric statistics; Confidence Interval; Errors; Levels of significance; Test of significance: Regression and Correlation; t-test; Analysis of variance; X^2 test; Basic introduction to Multivariate statistics.

SUGGESTED READING:

1. Mayr, E. 1969. Principles of Systematic Zoology. McGraw Hill Book Company,Inc., NY. 24.
2. Mayr, E.1997. This is Biology: The Science of Living world. Universities PressLtd.Biostatistics: Theory and Application by G.B.N Chainy, G. Mishra, P.k. Mohanty, Kalyani Publishers.
3. Stace, C. A. 1989. Plant Taxonomy and Biosystematics. Edward Arnold, London Introductory practical Biostatistics by B.N.Mishra, M.K. Mishra, Naya Prokash publication, Calcutta
4. Plant Systematics: Theory and Practice by Singh, Gurcharan. 2012 Completely revised and enlarged 3rd edition. Oxford & IBH, New Delhi.
5. Plant Taxonomy (Second Edition) by O.P. Sharma.

LS-426	Advanced Techniques in Biology	3 CH	50 marks

OBJECTIVE:

The paper on Advanced Techniques in Biology aims to introduce the applications of techniques like crystallography, cytometry etc which will help in understanding intricately the processes occurring inside the cell, tissues os the organism as a whole.

PROGRAMME EUCATION OBJECTIVES (PEOs): After studying Advanced Techniques in Biology in the curriculum, students will be able to:

PEO1. To understand the fundamental principles of various techniques like X-ray crystallography, OD and CRD, Infra Red (IR), Nuclear Magnetic Resonance and Electron Spin Resonance spectroscopy.

PEO2. To analyze the processes occurring inside the organisms using the techniques described in this paper.

PEO3. To perform experiments in various aspects of biological systems.

PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying Advanced Techniques in the curriculum, students will be able to:

CO1: Remember and understand the biological processes using various techniques.

CO2; Analyse the relationships between biochemical reactions and the biological processes.

CO3. Apply the knowledge in understanding practical problems.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE

Unit-I: Principle and application of the instrumental technique: X-ray crystallography, OD and CRD, Infra Red (IR), Nuclear Magnetic Resonance and Electron Spin Resonance spectroscopy.

Unit-II: MALDI-TOF, MS-MS; Flow cytometry, Cytofluorometry and FACS; Atomic absorption spectroscopy (AAS); FISH, IRGA.

Unit-III: Principle and application of HPLC, GLC; PCR and its variants; Application of PCR in Biology; DNA and Protein sequencing; Micro-array analysis (DNA and Protein).

SUGGESTED READING:

1. Learning Radiology: Recognizing the Basic by William Herring
2. Handbook of HPLC-HPTLC (PB 2021) by Nema R.K.
3. Applications of MALDI-TOF Spectroscopy 2013 Edition by Zongwei Cai, Shuying Liu , Springer
4. Physical Biochemistry by David Freifelder
5. Modern Experimental Biochemistry by Rodney Boyer
6. Molecular Cloning by Sambrook Russel

LS-427	**Practical based on Ecology and Biostatistics**	**2 CH**	**50 marks**

LS-428	**Practical based on Genetics and Immunology**	**2 CH**	**50 marks**

THIRD SEMESTER

LS-531	Bioinformatics and Computer Application	3 CH	50 marks

OBJECTIVE

They will learn storing the biological data, developing the tools that are essential to processing the data, and the important goal of this is to exploit the computational tools for analyzing the data that simply depicts the results. The computational education of biologists is changing to prepare students for facing the complex datasets of today's life science research.

PROGRAMME EUCATION OBJECTIVES (PEOs): After studying Bioinformatics and Computer Application in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of Bioinformatics and Computer Application

PEO2. Analyze the relationships among different concepts related to tools and techniques related to Bioinformatics and Computer Application.

PEO3. Perform procedures as per the areas of study.

PEO4. Apply the basic concepts learned to execute them to analyse different datasets.

COURSE OUTCOMEs (COs): After studying Bioinformatics and Computer Application in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts Bioinformatics and Computer Application.

CO2. Analyze the various concepts to understand them through case studies.

CO3. Apply the knowledge in understanding practical problems.

CO4. Execute the projects or field assignments as per the knowledge gained in the course curriculum.

COURSE

Unit-I: Major bioinformatics resources: NCBI, EBI, ExPASy, RCSB; open access bibliographic resources and literature databases: PubMed, BioMed central, Sequence databases formats, querying and retrieval; nucleic acid sequence databases: GenBank, EMBL, RAPDB, TAIR.

UNIT-II: Sequence Analysis using BLAST; Promoter architecture (TSS & TATA Box Prediction); transcription factor binding motifs (PLACE & Plant Pan); Gene Prediction (FGENESH, Genescan). Nucleotide polymorphism identification (Clustal Omega & MEGA); Primer Designing (gene specific; CDS specific; SNP and degenerate primer designing); Phylogenetic Analysis. Introduction to small RNA databases (miRBASE);

UNIT-III: Protein structure classification (SCOP & CATH); Protein secondary and tertiary structure prediction. Protein Conserved domain identification (NCBI CDD); Identification of Protein functional sites (Prosite); Protein localization (Protcomp); Protein phosphorelation (Musite); Protein-Protein Interaction network analysis (STRING).

SUGGESTED READING:

1. Essential Bioinformatics by Jin Xiong; Cambridge University Press (2006). ISBN-13 - 978-0521600828.

2. Bioinformatics: Sequence and Genome Analysis, David Mount, CBS Publishers & Distributors. ISBN-13: 9788123912417.

3. Problems and Solutions in Biological Sequence Analysis by Mark Borodovsky, Svetlana Ekisheva; Cambridge University Press (2006). ISBN-9780521612302.

4. RNA Sequence, Structure, and Function: Computational and Bioinformatic Methods by Jan Gorodkin & Walter L. Ruzzo (2014). ISBN-9781627037082

5. Protein Bioinformatics: An Algorithmic Approach to Sequence and Structure Analysis by Ingvar Eidhammer, Inge and Jonassen (2009) William R. Taylor Wiley India Pvt Ltd. ISBN-13- 978-8126522729

LS-532 (A - B)	STREAM PAPER-I (Any one)	3 CH	50 marks

LS-532 (A)	Plant Morphology	3 CH	50 marks

OBJECTIVE

Knowledge of morphology is essential for recognition or identification of plants. Certain important criteria for classification of plants are obtained from morphology. Knowledge of morphology is required for studying various aspects of plant life like genetics, ecology, anatomy, etc.

PROGRAMME EUCATION OBJECTIVES (PEOs): After studying Plant Morphology in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of Plant Morphology
PEO2. Analyze the relationships among different concepts related to tools and techniques related to Plant Morphology.
PEO3. Perform procedures as per the areas of study.
PEO4. Apply the basic concepts learned to execute them to analyse different datasets.

COURSE OUTCOMEs (COs): After studying Plant Morphology in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts Plant Morphology.

CO2. Analyze the various concepts to understand them through case studies.

CO3. Apply the knowledge in understanding practical problems.

CO4. Execute the projects or field assignments as per the knowledge gained in the course curriculum.

COURSE

Unit-I: Algae: Range of thallus structure and reproduction in Chlorophyceae, Phaeophyceae and Rhodophyceae. **Fungi:** Reproduction and degeneration of sexuality in Phycomycetes, Ascomycetes, Basidiomycetes.

Unit-II: Bryophytes: Gametophytic structure of Marchantiales, Anthoceretolales as the connecting link between bryophytes and pteridophytes, Mosses as the advanced group of bryophytes.Evolution of Saprophytes in Bryophytes. **Pteridophytes:**Origin and evolution in pteridophytes, Heterospory and its significance, Fillicales as an advanced group of pteridophytes, Range of reproductive structure and their evolution in pteridophytes.

Unit-III: Gymnosperm: Origin and outline classification, Cycadofilicales as an intermediate group between pteridophytes and gymnosperms, Cycadalesas the relic of ancient gymnosperms, Phylogenetic

position of Ginkgo,Angiospermic activity of Gnetum,Evolution of ovule in gymnosperm. **Angiosperms:** Origin and evolution of angiosperm, outline classification in orders according to Bentham and Hooker, Engler and Prantle, and Hutchinson system; Range of floral structure affinities and phylogeny of Rannales, Mangolliales, Tubifloreae and microspermeae.

SUGGESTED READING:

1. The structure and Reproduction of Algae Vol. I & II by Bishan Singh, Mahendra Pal Singh, Dehradun. Delhi.651 pp.1999.

2. Algae by O.P. Sharma. 2011, TATA McGraw-Hill, India.

3. Algae: A review, Prescott, G.W. 1984. Bishan Singh, Mahendra Pal Singh. Dehradun.

4. An introduction of Algae by Morris, I. 1986. Cambridge University Press U.K.

5. Botany for Degree students- Bryophyta by Vashishta. B.R., Sinha, A.K. and Adarsh Kumar, 2005. S. Chand and Company Ltd., New Delhi.

6. An Introduction of Fungi, 4th Edition by Dube, H.C 2013. Scientific Publisher, India.

7. Introductory Microbiology. 4th edition by Alexopoulous. C.J. Mims C.H and Black well, M., 2007. John Wiley and Sons, New York.

8. Fungi, I stEdition by Vashishta, B.R and sinha,A.K., 2011. Published by S. Chand and Company Ltd. New Delhi.

9. Plant Pathology. 5th Edition by George, N. Agrios, 2005, Academic Press.

10. Schumann, G.L., 2006. Essential Plant Pathology. APS Press.

11. Microbiology. 13th Edn. Pelezar,J.M., chan E.C.S and Kreig, R.N. 2008. Tata Mc. Graw Hill Publishing Company Ltd, New Delhi.

12. Botany for Degree students – Pteritophyta by Vashishta. P.C., A.K. Sinha and Adarsh Kumar. 2008. S. Chand and Company Ltd., New Delhi.

13. Gymnosperms by Vashishta, P.C. 1991. S. Chand & Company Ltd., Ram Nagar, New Delhi.

14. A text of Microbiology (Revised edition) by Dubey, R. C. and D. K. Maheswari. 2012. S. Chand and Company Ltd., New Delhi.

15. Plant Systematics: Theory and Practice by Singh, Gurcharan. 2012. Completely revised and enlarged 3rd edition. Oxford & IBH, New Delhi.

16. Plant Taxonomy (Second Edition) by O.P. Sharma.

LS-532 (B)	Animal Morphology	3 CH	50 marks

OBJECTIVE

The course will give an insight into morphology i.e. the study of the size, shape, and structure of animals and of the relationships of their constituent parts. They will learn about the the general aspects of biological form and arrangement of the parts of an animal.

PROGRAMME EUCATION OBJECTIVES (PEOs): After studying Animal Morphology in the curriculum, students will be able to:

PEO1. This course will help to the broader problems connected with the form of animals such as the phylogenetic evolution of form, the form-producing and form-maintaining factors.

PEO2. It will also help in analyzing the differences and similarities between organisms on the basis of their morphology.

PEO3. They will apply it to know how each group of organisms arose and how did they establish themselves in the environment with their special characteristics

OUTCOME:

CO1. After successfully completing this course, the students will be able todevelop an understanding on the diversity of animal life forms in general and group of animals on the basis of their morphological characteristics/ structures.
CO2. They can analyze the diversity and evolutionary history of different organ systems.
CO3. Also they will apply the knowledge in having an insight into the fact that how morphological change due to change in environment helps drive evolution over a long period of time.
CO4. They can execute the projects or field experiments as per the knowledge gained in the course.

COURSE

Unit-I: Segmentation and cepahalisation in animals; Larval forms in animals; Parasitism; Host-Parasite interaction with reference to *Sacculina* and *Bonelia*; Polymorphism in animals. Adaptive radiation and convergence in mammals; Minor phyla such as *Ectoprocta, Endoprocta, Bryozoa, Onychophora, Phornida*.
Unit-II: Neoteny and Paedogenesis in animals; Functional evolution of brain and digestive system in vertebrates; Living fossils and their significance. Zoogeography and distribution of animals; Migration in birds and celestial navigation; Anadromous and Catadromous migration in fishes.

Unit-III: Instinct vs acquiredbehaviour, Orientation in animals, Learning memory and intelligence, Social behaviour in animals; Neural basis of behaviour; Mimicry, Aestivation and hibernation in animals.

SUGGESTED READING:

1. The Invertebrata, by L.A.Borradaile and F.A.Potts
2. The Development of Animal Form: Ontogeny, Morphology, and Evolution by Alessandro Minelli Form and function by E.S.Russel
3. An introduction to animal morphology and systematic zoology by A. Maclistert
4. Animal Morphology by J.R.A.Davis
5. Concepts and approaches in animal morphology by P.Dullemeijer
6. Life of Vertebrates by Y.J. Young, Freeman Publication

LS-533 (A - B)	**STREAM PAPER-II (Any one)**	**3 CH**	**50 marks**

LS-533 (A)	**Plant Developmental Biology**	**3 CH**	**50 marks**

OBJECTIVE

The course help in understanding the basic life processes of plants. Research on plants enriches our intellectual life and adds to our knowledge about other life processes. The results of research on plant systems also can teach us how to approach problems in agriculture, health, and the environment.

PROGRAMME EUCATION OBJECTIVES (PEOs): After studying Plant Developmental Biology in the curriculum, students will be able to:

PEO1. This course will help to understand problems connected with the germination and fertilization and its regulation.

PEO2. It will also help in analyzing the floral development and phyllotaxy.

PEO3. They will apply it to know how each group of organisms arose and how did they establish themselves in the environment with their special characteristics

OUTCOME:

CO1. After successfully completing this course, the students will be able to develop an understanding on the diversity of animal life forms in general and group of animals on the basis of their morphological characteristics/ structures.

CO2. They can analyze the diversity and evolutionary history of different organ systems.

CO3. Apply the knowledge in understanding practical problems.

CO4. Execute the projects or field assignments as per the knowledge gained in the course curriculum.

COURSE

Unit-I: Germination and Greening: Stored genetic message in seeds. Physiological anad molecular changes during germination, Biosynthesis of chlorophylls, Synthesis, targeting and assembly of LHC. Synthesis of Rubisco subunits and their assembly. Leaf development and phyllotaxy.

Unit-II: Flowering and Senescence: Photoperiodism, Biological clock, Biochemical signals involved in flowering, Gene regulation of floral development, Transition of flowering, floral meristem and gene regulation of floral development. Types of senescence, Physiological significance and regulation of leaf senescence by genes.

Unit III: Regulation of Plant growth and development: Biosynthesis, storage, breakdown and transport, physiological response and mechanism of action of hormones (IAA, GA, Ethylene, cytokinin and ABA). Physical and chemical properties of photoreceptors: Phytochrome, Phototropin and Cryptochrome, and their mechanism of action on plants. Regulation of gene expression by photoreceptors.

SUGGESTED READING:

1. Plant Physiology and Development by L.Taiz and E. Zeiger
2. Plant Growth and Development-A Molecular Approach by Donald E. Fosket
3. Plant Development by by RF Lyndon
4. Mechanisms in Plant Development by Ottoline Leyser, Stephen Day
5. Plant Physiology by L.Taiz and E. Zeiger
6. Biochemistry and Molecular Biology of Plants by Bob B. Buchanan, W. Gruissem and Russel L. Jones

LS-533 (B)	Animal Developmental Biology	3 CH	50 marks

OBJECTIVE: This paper contains three units, namely Basics of Developmental Biology, Developmental Processes, and Morphogenesis. Each unit contains a description of the principles related to that unit, well-supported by different examples, descriptions of laboratory experiments, historical background etc; with solved equations that explain the concept discussed. These will help in fixing the Ideas firmly in student's mind. The examples discussed in the class-room are used to encourage students to participate in discussions.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Animal Development in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of Animal Development.
PEO2. Analyze the relationships among different concepts.
PEO3. Perform procedures as per the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying Immunology in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of Immunology.

CO2. Analyze the various concepts to understand them through case studies.

CO3. Apply the knowledge in understanding practical problems.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE:

Unit-I: Basics of developmental biology: Cell fate, potency, fate maps and mechanism of developmental commitment (cytoplasmic determinants, instructive and permissive induction, competence, mosaic vs regulative development); Maintenance of differentiation; Pattern formation, segmentation; Experimental developmental biology (model organisms, developmental mutants and transgenic organisms, cellular and microsurgical techniques).

Unit II: Developmental process: Gametogenesis; Ultrastucture of sperm and ovum, gamete recognition; Fertilization, sex determination; Cleavage; Cytological and biochemical changes during fertilization and cleavage; Blastula formation; Gastrulation; Germ layers formation.

Unit III: Morphogenesis and organogenesis: Mechanism of morphogenesis; cell aggregation and differentiation in *Dictyostelium*; Axes and pattern formation in *Drosophila*; Organogenesis; Vulva specification in *C. elegans*; Limb development and regeneration in vertebrates, Neurogenesis; Post-embryonic development: larva formation and metamorphosis.

SUGGESTED READING:

1. An Introduction to Embrylogy by Balinsky et al.
2. Chordate Embryology PS. Verma and V K Agarwal
3. Chordate Embryology by V B Rastogi.
4. Transition from embryology to developmental biology by Boris Balinsky
5. Developmental Biology 9th Edn. by Scoot F. Gilbert

LS-534 (A - B)	STREAM PAPER-III (Any one)	3 CH	50 marks

LS-534 (A)	Plant Physiology	3 CH	50 marks

OBJECTIVE

By revealing the dependence of the life processes on environmental conditions, plant physiology serves as the theoretical basis for increasing the total productivity of plants, improving their nutritional value, and raising the quality of their tissues and organs for use in industry. In order to understand the plant way of life, knowing the structure and functioning of is crucial. Plant Physiology provides information on how the plants survive. Therefore, studying the subject is necessary to get a deeper insight into the plants.

PROGRAMME EUCATION OBJECTIVES (PEOs): After studying Plant Physiology in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of water and solute translocation, photosynthesis and other physiological processes in plants.
PEO2. Analyze the relationships among different concepts related to tools and techniques related to Plant Physiology
PEO3. Perform procedures as per the areas of study.
PEO4. Apply the basic concepts learned to execute them to analyse different datasets.

COURSE OUTCOMEs (COs): After studying Plant Physiology in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts Plant Physiology.

CO2. Analyze the various concepts to understand them through case studies.

CO3. Apply the knowledge in understanding practical problems.

CO4. Execute the projects or field assignments as per the knowledge gained in the course curriculum.

COURSE

Unit-I: Water relations in plants and translocation of solutes: Absorption of water, Ascent of Sap, Transpiration, Stomatal mechanism, Translocation of organic solutes and its pathways, Pressure flow mechanism, Phloem loading and unloading,Synthesis of sucrose and starch.

Unit-II: Photosynthesis: Structure of photosynthetic apparatus, organization of light harvesting pigments, absorption spectrum and action spectrum; Mechanism of photosynthetic- electron and proton transport, cyclic and non-cyclic photophosphorylation, C_3, C_4 and CAM pathways of carbon fixation, photorespiration.

Unit-III: Respiration and mineral nutrition: RQ, electron transport & oxidative phosphorylation; Micro and macro nutrients; Role of essential elements and deficiency symptoms. Nitrogen cycle and fixation;Assimilation of nitrate, sulphur and ammonium ions; Nitrogen transformations.

SUGGESTED READING:

1. Plant Physiology and Development by L.Taiz and E. Zeiger
2. Introduction to Plant Physiology by William Hopkins
3. Plant Physiology by Frank B. Salisbury and C. W. Ross

LS-534 (B)	Animal Physiology	3 CH	50 marks

OBJECTIVE:

Animal physiology examines how biological processes function, how they operate under various environmental conditions, and how these processes are regulated and integrated. The proper studying of animal physiology is crucial for understanding and evaluating underlying biological processes, behavioral states and animal response to different biological, social and environmental stimuli.

PROGRAMME EUCATION OBJECTIVES (PEOs): After studying Animal Physiology in the curriculum, students will be able to:

PEO1. To understand the basic comparative physiology by introducing students to the principles of normal biological function in a wide range of organisms.

PEO2. To analyze the relationships existing between different physiological systems of animal body

PEO3. To perform laboratory experiment to know the basic physiological processes occurring in animals and to see how animals respond to changes in their environments

PEO4.To apply physiological concepts and principles at the basic and applied levels, to develop a working knowledge of the major physiological systems, and to associate anatomical areas with their specific function.

COURSE OUTCOMEs (COs): At the end of the course students can:

CO1: Remember and understand the functions of important physiological systems including the cardio-respiratory, renal, reproductive and metabolic systems;

CO2: Analyse and report on experiments and observations in physiology through case studies;

CO3: Apply the knowledge to integrate related topics from separate parts of the course.

CO4: Execute the project based on the knowledge gained from course material.

Unit-I: Electrical properties of neural membrane, Neurons, action potential, , central and peripheral nervous system, neural control of muscle tone and posture. Muscles as energy transducers, Muscles proteins and molecular mechanism of muscle contraction, Excitation – contraction coupling, Neural control of muscle contraction, Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above.

Unit-II: Enzyme secretion and motility of GI tract, digestion and absorption of nutrients. Respiratory pigments in animals, Oxygen equilibrium curve of HbA, HbF, Hill plot, Bohr and Root effect. Physiology of excretion, urine formation and concentration, Regulation of water balance, acid-base balance.

Unit-III: Hormones: General properties, sources and types, Molecular mechanism of steroid and non-steroid hormone action; Concept of hormonal control and feedback regulation, Pheromones.

SUGGESTED READING:

1. General and comparative animal physiology W.S. Hoar (3rd edn.1983)
2. Textbook of medical physiology by A.C. Guyton and J.E.Hall (11thedn. 2006)
3. Vander, Sherman, Luciano's Human Physiology: The Mechanisms of Body Function , Mcgraw-Hill (Tx); 9th edition (January 1, 2003)
4. Human physiology by C.C. Chattergee (2016)
5. Animal Physiology by R. Hill (2016)
6. Comparative animal physiology by C.L. Prosser (1973)

LS-535 (A - D)	SPECIAL PAPER- I (Any one)	3 CH	50 marks

LS-535 (A)	Bioenergetics	3 CH	50 marks

OBJECTIVE: This paper contains three units, namely Energy transduction in cells, Conversion of Light energy in Cells, Transformation of Energy in Mitochondria. Each unit contains a description of the principles related to that unit, well-supported by different examples, descriptions of laboratory experiments, historical background etc; with solved equations that explain the concept discussed. These will help in fixing the Ideas firmly in student's mind. The examples discussed in the class-room are used to encourage students to participate in discussions.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Bioenergetics in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of energetic in biological system.
PEO2. Analyze the relationships among different concepts.
PEO3. Perform procedures as per the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying in the Bioenergetics in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of Energy transduction, transformation of conversion in biological system.

CO2. Analyze the various concepts to understand them through case studies.

CO3. Apply the knowledge in understanding practical problems.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE:

Unit-I: Energy transduction in cells and types of transducers, Concept of free energy, Energetics of biochemical reactions, Redox system and redox potential, Phosphate transfer and phosphorylation potential, ATP as the energy rich compound.

Unit-II: Conversion of light energy to chemical energy during photosynthesis, Photo excitation, Photo induced electron transport and photophosphorylation, Dark reaction as the sink, Energetics of carbon fixation.

Unit-III: Energy transformation in mitochondria, Enzyme complexes and mobile electron carriers of mitochondrial membrane, Energetics of electron transfer reactins, Coupling factor, Coupling of oxidative phosphorylation and electron transport and mechanism of oxidative phosphorylation, Power transmission by proton gradients as the central motif of bioenergetics both in chloroplast and mitochondria.

SUGGESTED READING:

1. Fundamentals of Biochemistry by J L Jain.
2. Biochemistry by U Satyanarayan.
3. Lehninger Principles of Biochemistry.
4. Biochemistry by L Stryer.
5. Principles of Biochemistry by Donald Voet, Judith G. Voet and Charlotte W. Pratt

LS-535 (B)	Microbial Physiology	3 CH	50 marks

OBJECTIVE

Microbial physiology and metabolism provides information on sources of energy and its utilization by microorganisms. Microorganisms play important role in environment as producers, consumers and decomposers. To know the specific parameters it is important to understand physiology of these organisms in detail which will impart knowledge of the basic principles of bacteriology, virology, mycology, immunology and parasitology including the nature of pathogenic microorganisms, pathogenesis, laboratory diagnosis, transmission, prevention and control of diseases common in the country.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Microbial Physiology in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of Microbial Physiology
PEO2. Analyze the relationships among different concepts.
PEO3. Perform procedures as per the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying in the Microbial Physiology in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of microbial metabolism, normal microbiota in humans and therapeutic measures to control microbial infections.

CO2. Analyze the various concepts to understand them through case studies.

CO3. Apply the knowledge in understanding practical problems.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE:

Unit-I: Microbial metabolism, heterotrophic generation of ATP, Fermentation versus respiration, Respiratory metabolism, Oxidative phyosphorylation, autotrophic generation of ATP, Chemolithotrophy with reference to sulphur oxidizing, nitrifying and methanogenic bacteria. Anoxigenic bacterial photosynthesis. Fermentation pathways (ethanol, homo and hetero lactic fermentation, mixed acid fermentation, butandiol and propanic acid, amino acid fermentation), Biosynthesis of peptidoglycans.

Unit-II: Normal human microbiota (skin, gastrointerstinal tract, oral cavity, respiratory tract, genitourinary tract), Virulence factor of pathogens (toxin and toxigenicity, invaviveness, factors affecting phagocytocis), Host defence mechanism, inflammatory response).

Unit-III: Chemotherapy and antimicrobial agents: principles of chemotherapy, microbial structure and biochemical reactions as potential targets. Antimicrobial agents and their mode of action (sulfa drugs, β-lactum antibiotics, Aminoglycosides, Macrolides, Tetracycline, Chloramphenicol, Cycloserine, Isoniazid, antiviral durgs).

SUGGESTED READING:

1. Brock Biology of Microorganisms (12th edition) by Madigan and John M. Martinko, Paul V. Dunlap, David P. Clark Benjamin Cummings; 2008.

2. Microbiology: An Introduction by Gerard J Tortora, Berdell R Funke, Christine L Case Benjamin-Cummings Publishing Company ; 2008.
3. Microbial Physiology,4th Edition by Michael P. Sector, Albert G. Moat, John W. Foster, Michael P. Spector. Wiley.
4. General Microbiology 5e (Intern Ed) by Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. Palgrave Macmillan.
5. Fundamental Food Microbiology. 3rd edition by B. Ray., CRC press, 2006.
6. Microbiology. Sixth edition by Prescott, L. M., J. P. Harley and D. A. Klein. 2005. International edition, Mc Graw Hill.

LS-535 (C)	System Ecology	3 CH	50 marks

OBJECTIVE:

Ecology enriches our world and is crucial for human wellbeing and prosperity. It provides new knowledge of the interdependence between people and nature that is vital for food production, maintaining clean air and water, and sustaining biodiversity in a changing climate,. It will enable the scholar to understand how these relationships work. For example, humans breathe out carbon dioxide, which plants need for photosynthesis. Plants, on the other hand, produce and release oxygen to the atmosphere, which humans need for respiration.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying System Ecology in the curriculum, students will be able to:

PEO1. To understand the application of general systems theory to ecology and to study an ecosystem as a complex system exhibiting emergent properties;

PEO2. To analyze the interactions and transactions within and between biological and ecological systems; develop the ability to connect systems thinking and methods of application of general systems theory to identify the characteristics of ecosystems, using modern methods of ecological modelling;

PEO3. To perform practicals to acquire methodological skills for building a qualitative and quantitative ecological models that will allow them to acquire new knowledge about the behaviour of the studied ecosystems (models for interpretation);

PEO4. To apply the acquired skill to predict their behaviour (predictive models) and build models for the management of these systems (models decision support)

COURSE OUTCOMEs (COs): After studying in the System Ecology in the curriculum, students will be able to:

CO1: Understand the mutual and reciprocal relationships between different levels of ecological systems which will enable them to identify their responses (from species to ecosystem level) to changes in environmental factors.

CO2: Analyze the various concepts pertaining to organism-environment complex, ecosystem productivity, quantitative ecology and Ecological modelling.

CO3: Apply the knowledge of general systems theory to identify the characteristics of ecosystems, using modern methods of ecological modelling.

CO4: Execute the acquired methodological skills design the systemic measures to reduce or eliminate negative impacts on ecosystemand to develop new approaches that will help them to improve the condition of affected ecosystems.

COURSE

Unit-I: Organism- environment complex: Concept of stress and strain, biological adaptation and biological evolution, convergence and divergence, Concept of productivity: Primary production, Factors influencing primary productivity, Energy partitioning in food chain and web, Secondary productivity, secondary production from Indian ecosystems, Biological diversity and stability.

Unit-II: Quantitative Ecology: Quantification of diversity, dominance, evenness and species richness, Species area curve, Niche theory, Niche overlap, Population interactions: Inter-specific and Intra-specific interaction, Complexity theory and law of diminishing return.

Unit-III: Concept of Ecosystem modelling: Features of ecological modelling, model symbols. Modelling for environmental sciences and management, Types of models, Causal diagrams, System Dynamics, Population modelling, modelling of material flows through the systems (pollutants transfer, etc), Positive and negative feedback loops. Mathematical modelling, Classification: Deterministic model: matrix model, stochastic model: ANOVA model, Regression model, MARKOV model.

SUGGESTED READING:

1. Jorgensen, S. E. 2012. Introduction to systems ecology. New York. CRC Press: 320 pp.
2. Bertalanffy von, l. 1968. General System Theory. New York, George Braziller: 295 pp.
3. Jorgensen, S. E., Müller, F. (eds.). 2000. Handbook of Ecosystem Theories and Management. Boca Raton, London, New York, Washington D. C., Lewis Publishers: 600 pp.
4. Müller, F., Leupelt, M. (eds.). 1998. Eco Targets, Goal Functions, and Orientors. Berlin, Springer: 619 pp.
5. Jorgensen, S. E., Bendoricchio, G. 2001. Fundamentals of Ecological Modelling, Third edition. Elsevier, 530 pp.

LS-535 (D)	Cell Physiology	3 CH	50 marks

OBJECTIVE

Students will understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles. Students will understand how these cellular components are used to generate and utilize energy in cells. Cell physiology is a biological science in which you study live cells, tissues and the functions of organs and organ systems to learn how the body works.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Cell Physiology in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of Cell Physiology
PEO2. Analyze the relationships among different concepts.
PEO3. Perform procedures as per the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying in the Cell Physiology in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of cell transport, cell cycle and its regulation etc.

CO2. Analyze the various concepts to understand them through case studies.

CO3. Apply the knowledge in understanding practical problems in cell physiology.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE:

Unit-I: Cellular Transport: Passive and active transport, bulk flow and diffusion, organization of transport at plant membranes, diffusion of small molecules across phospholipid bilayer, pumps and carrier mediated transport, uniport, antiport and co-transport mechanisms, overview of membrane transport proteins, general properties of ion channels and their role in transport, water transport through water channel proteins.

Unit-II: Senescence and programmed cell death: Types of cell death in plants and animals, PCD in the life cycle of plants, pigments, proteins and nucleic acid metabolism during senescence, impact of senescence on photosynthesis and oxidative metabolism, role of endogenous plant hormones.

Unit-III: Cell cycle regulation: Plant and animal cells and their cell cycles, Over view of cell cycle and its control, DNA synthesis and replication during cell cycle, molecular mechanism of cell cycle control, regulation of cell cycle by intrinsic and extrinsic signals, cell cycle regulation in plant growth and development and check points in cell cycle regulation.

SUGGESTED READINGS:

1. **Molecular Cell Biology.** Lodish, Berk,Krieger, Bretscher,Ploegh, Amon and Martin. Freeman Macmillan Publishers (8^{th} Edition).
2. **Fundamentals of Plant Physiology**. Lincoln Taiz, Eduardo Zeiger, Ian Max Moller and Angus Murphy. Sinaur Associates Inc. publishers(Sixth Edition).
3. **Biochemistry and Molecular Biology of Plants**. B. B.Buchanan, W.Gruissem and R.L.Jones (Ed.), Wiley Blackwell Publishers (Second Edition).
4. Molecular Biology of The Cell. Bruce Alberts , Taylor & Francis.

LS-536 (A - D)	SPECIAL PAPER- II (Any one)	3 CH	50 marks

LS-536 (A)	Enzymology	3 CH	50 marks

OBJECTIVE:

The major learning objective of the course is to understand the theories of enzyme kinetics, the mechanisms of enzyme catalysis, and the mechanisms of enzyme regulation in the cell. Enzymes help speed up chemical reactions in the human body. They bind to molecules and alter them in specific ways. They are essential for respiration, digesting food, muscle and nerve function, among thousands of other roles. The study of the regulation of enzymes will help in regulating the cell and body function.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Enzymology in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of enzymes and their regulation.

PEO2. Analyze the relationships among different concepts of enzyme kinetics and regulation.
PEO3. Perform procedures as per the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying in the Cell Physiology in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of cell kinetics and its regulation etc.

CO2. Analyze the various concepts to understand them through case studies.

CO3. Apply the knowledge in understanding practical problems in enzymology.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE:

Unit-I: Mechanism of enzyme catalysis; Detailed mechanism of enzyme action (lysozyme, carboxy peptidase, chymotrypsin and RNAase); Coenzymes- their catalytic role and structure; Isozymes- their evolutionary and adaptive significance; Ribozyme, Multi-enzyme complexes and concerted catalysis.

Unit-II: Enzyme kinetics and significance of Km and Vmax; Effect of temperature and pH on enzyme catalysis. Mechanism and kinetics of competitive, non-competitive and uncompetitive inhibition; Allosteric inhibition; Bi-substrate reactionskinetics and mechanism; Kinetics of the Ping-pong catalysis.

Unit-III: Enzyme regulation and its significance; Covalent modification, Allosteric regulation of enzymes with reference to Aspartic transcarbamylase. Enzyme purification: extraction and purification; Enzyme immobilization and its significance.

SUGGESTED READING:

1. Fundamentals of Enzymology by Nicholas C. Price and Lewis Stevens
2. Enzyme Technology by S. Shanmugam, T.Sathishkumar, M. Shanmugaprakash
3. Outlines of Biochemistry by Eric E.Conn, Paul K. Stumph,George Bruening, Roy H. Doi
4. A Study of Enzymes: Enzyme Catalysts, Kinetics, and Substrate Binding by Stephen Allen Kuby
5. Introduction to Proteins: Structure, Function, and Motionby Amit Kessel and Nir Ben-Tal
6. Enzyme Technology: Pacemaker of Biotechnology by Prasad Nooralabettu Krishna

LS-536 (B)	Microbial Genetics	3 CH	50 marks

OBJECTIVE:

Microbial genetics is also important for understanding molecular techniques used to modify genes and proteins, manipulate bacteria, archaea, and eukaryotic organisms for fundamental research as well as practical applications in diverse areas of medicine and biotechnology. Microbial genetics will play a unique role in developing the fields of molecular and cell biology and also has found applications in medicine, agriculture, and the food and pharmaceutical industries. Hereditary processes in microorganisms are analogous to those in multicellular organisms.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Microbial Genetics in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of microbial genetics.
PEO2. Analyze the relationships among different concepts of enzyme kinetics and regulation.
PEO3. Perform procedures as per the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying in the Microbial Genetics in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of genetic transformation etc.

CO2. Analyze the various concepts to understand them through case studies.

CO3. Apply the knowledge in understanding practical problems in Microbial Genetics.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE:

Unit-I: The study of microbial genes: The inheritance of characteristics and variability, Phenotypic and genotypic changes: Types of mutation; Mutagenic age mechanism of mutagenesis; Mechanisms of suppression of non-sense and frame shift mutations; Repairing mechanism of mutations. Oncogenes: Transformation of normal cells to Tumor cells; Oncogenes; Oncogenic DNA and RNA viruses.

Unit II: Genetic transformation in Microbes: Introduction to Microbial genomes; Gene transfer in bacteria: Modes of gene transfer, phages, yeast and fungi, Molecular genetics of conjugation, transduction and transformation; Genetic mapping of bacteria. Genetics and life cycle of phages-lambda, T4, pi, Mu and Ml3. Restriction and modification systems in bacteria.

UNIT- III: Gene Expression and regulation: Genetic switches; Regulation of transcription and translation, post-translational modifications. Transposable elements: structure and classification of bacterial and yeast transposons, Mechanisms of transposition.

SUGGESTED READING:

1. Molecular Genetics of Bacteria by Larry Snyder and Wendy Champness, 3rd edition; ASM press; 2007.
2. Brock Biology of Microorganisms (12th edition) by Madigan and John M. Martinko, Paul V. Dunlap, David P. Clark Benjamin Cummings; 2008.
3. Microbiology : An Introduction by Gerard J Tortora, Berdell R Funke, Christine L Case Benjamin- Cummings Publishing Company ; 2008.
4. Medical Microbiology and Immunology by Levinson W, Jawetz E: Lange publication; 2001.
5. Microbial Physiology, 4th Edition by Michael P. Sector, Albert G. Moat, John W. Foster, Michael P. Spector Wiley.
6. General Microbiology 5e (Intern Ed). By Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. Palgrave Macmillan.
7. Microbiology. Sixth edition, International edition by Prescott, L. M., J. P. Harley and D. A. Klein. 2005. Mc Graw Hill.

LS-536 (C)	ECOLOGICAL ENERGETICS	3 CH	50 marks

OBJECTIVE:

The primary objective of studying Ecological Energetics is to understand the rates of flow of energy and rates of movement of nutrients are measured. In this section we will learn how energy flow and nutrient cycling can provide insight into ecological systems and provide tools to manage our world.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Ecological Energetics in the curriculum, students will be able to:

PEO1. To understand the concept of laws of thermodynamics in transfer of energy in ecosystem

PEO2. To analyze solar energy available to earth surface and environmental influences on the energy availability for ecosystem productivity

PEO3. To performlaboratory studies on ecological efficiency of animal and plant populationthat can be broadly accessible to field ecologists

PEO4. To apply the concept of ecological energetics on human being

COURSE OUTCOMEs (COs): After studying in the Ecological Energetics in the curriculum, students will be able to:

CO1: Remember and understand the energetic costs in ecological processes that are crucial to an animal's growth, survival, and reproductive fitness

CO2: Analyze the various concepts of plant and animal energetics through case studies

CO3: Apply the knowledge to address real-world questions at many spatial and temporal scales.

CO4: Execute the project and field studies as the knowledge gained in the course

Unit-I: Energy in ecological system: Concept, Laws of thermodynamics, Solar radiation and the energy in environment; Solar flux, Photo-synthetically active radiation, Attenuation of radiation, Attenuation coefficient. Reception of radiance by leaves: reflectance, absorbance and transmittance.

Unit-II: Energy transformation in nature: Concept of productivity and productivity efficiency; photochemical reaction, environmental influences on photosynthetic capacity, seasonality of photosynthesis, and ecological consequences of different photosynthetic pathways. Laboratory studies and ecological efficiency. Field studies and ecological efficiency.

Unit-III: Energy flow at population level: Individual organisms and ecosystems, Energy flow studies in plant populations and animal populations; Productive pattern of biotic communities in different geographical regions; Implication of ecological energetics on human being.

SUGGESTED READING:

1. Ecological energetic by John Phillipson, St. Martin's Press, 1966 , pp57

2. Maximum Power: A Festschrift on Ecology, Energy and Economy in Honor of H. T. Odum, Charles A. S. Hall (Editor) University Press of Colorado, 1995
3. Energy Basis for Man and Nature by Howard T. Odum, McGraw Hill, 1981

LS-536 (D)	Crop Physiology	3 CH	50 marks

OBJECTIVE:

The major learning objective of the course Crop physiology is concerned with the processes and functions of the crops at cellular, sub-cellular and whole plant levels in response to environmental variables and growth. In short, physiology is the study of functional aspects of crop plants. Thus, physiological understanding of crop plants provides the fundamental scientific base about various aspects of metabolism, growth and development. This is immensely important for crop improvement or technology improvement in agriculture or horticulture.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Crop physiology in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of crop growth and yield.
PEO2. Analyze the relationships among different concepts of enzyme kinetics and regulation.
PEO3. Perform procedures as per the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying in the Crop Physiology in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of cell kinetics and its regulation etc.

CO2. Analyze the various effects of environmental factors to understand them through case studies.

CO3. Apply the knowledge in understanding practical problems in crops.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE:

Unit-I: Dynamics of Crop growth and yield, harvest index, induction of flowering, genetic manipulation of fruit ripening, modification of product traits like starch, vitamin and mineral contents, engineering plant protein composition, manipulation of crop yield through photosynthesis, metabolic engineering of lipids and molecular farming.

Unit-II: Effect of light and hormones (IAA,GA,ABA and Ethylene) on crop growth and yield, agricultural productivity through GM crops, regulations for GM crops and their products, greener genetic engineering, biotechnology of nitrogen fixation, in crop plants, incorporation of *Nod*, *Nif*, *Hup* genes for better crop production.

Unit-III: Water and mineral use efficiency and their manipulation for crop improvement, use of pesticides and herbicides in modern agriculture, physiological and biochemical mode of their action, strategies for engineering herbicides resistance and herbicide resistant crops, environmental impact of herbicides resistance and super-weeds, plant-pathogen interaction, biotechnological approaches to disease resistance for increased crop production.

SUGGESTED READING:

1. **Plant Physiology and Development**. Lincoln Taiz, Eduardo Zeiger, Ian Max Moller and Angus Murphy. Sinaur Associates Inc. publishers(Sixth Edition) 2015.
2. **Fundamentals of Plant Physiology**. Lincoln Taiz, Eduardo Zeiger, Ian Max Moller and Angus Murphy. Sinaur Associates Inc. publishers(Sixth Revised Edition) 2018.
3. **Plant Physiology**. F.B. Salisbury and C.W. Ross. Thomson Information Publising Group (5^{th} Edition)1991.
4. Physicochemical and Environmental Plant Physiology. Park S. Nobel, Elsevier Science, (5^{th} Edition) 2020.
5. Introduction to Plant Physiology. Huner NPA and Hopkins, WG. Wiley publishers, (4^{th} Edition) 2013.
6. **Biochemistry and Molecular Biology of Plants**. B. B.Buchanan, W.Gruissem and R.L.Jones (Ed.), Wiley Blackwell Publishers (Second Edition) 2015.

LS-537 (A – B)	**Practical (Any one)**	**2 CH**	**50 marks**
LS-537 (A)	**Practical based on Plant Morphology, Development and Physiology**	**2 CH**	**50 marks**
LS-537 (B)	**Practical based on Animal Morphology, Development and Physiology**	**2 CH**	**50 marks**

LS-538 (A – D)	**Special Paper Practical – I (Any one)**	**2 CH**	**50 marks**
LS-538 (A)	**Practical based on Bioenergetics and Enzymology**	**2 CH**	**50 marks**
LS-538 (B)	**Practical based on Microbial Physiology and Microbial Genetics**	**2 CH**	**50 marks**
LS-538 (C)	**Practical based on System Ecology and Ecological Energetics**	**2 CH**	**50 marks**
LS-538 (D)	**Practical based on Cell Physiology and Crop Physiology**	**2 CH**	**50 marks**

FOURTH SEMESTER

LS-541	**Genetic Engineering**	**3 CH**	**50 marks**

LS-541GENETIC ENGINEERING

OBJECTIVE:

Genetic engineering, also called recombinant DNA technology, involves the group of techniques used to cut up and join together genetic material, especially DNA from different biological species, and to introduce the resulting hybrid DNA into an organism in order to form new combinations of heritable genetic material.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Genetic Engineering in the curriculum, students will be able to:

PEO1. The students will understand the basic concepts in genetic engineering.

PEO2. They will get acquainted with the versatile tools and techniques employed in genetic engineering and recombinant DNA technology.

PEO3.They will be appraised about applications genetic engineering

PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOME (COs): After studying the Genetic Engineering in the curriculum, students will be able to:

CO1. On completion of the genetic engineering course the students will have an understanding of basic concepts in genetic engineering.

CO2.They can analyse the tools for genetic manipulation.

CO3. They will have an insight into basic means of gene isolation, insertion in proper hosts and the manipulations for appropriate expression of heterologous genes.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE

Unit-I: Scope and milestones in Genetic engineering**,** Molecular tools: Enzymes (Nucleases, Restriction endonucleases, Phosphomonoesterase, Alkaline phosphatase, Polynucleotide kinase, DNA ligase, DNA polymerases, Reverse transcriptase, terminal deoxynucleotidyltransferase, Poly A polymerase), Hosts (E. coli, yeast, animal cells and Plant cells) and Vectors (Plasmids, Bacteriophages, Cosmids, Phagemids and Artificial Chromosome Genetic Engineering: Restriction endonuclease, Ligase and other modifying enzymes; Linker, Adapter and MCS; Gene cloning vectors- Plasmid, bacteriophage, cosmid, BAC, YAC; Expression vectors: basic concept, bacteria and yeast based expression vector; Gene library- genomic and c-DNA; Polymerase Chain reaction, Blotting techniques: Southern, Northern, Western, Dot and Slot; Nucleic acid hybridization.

Unit-II: Basic concept of gene cloning: Cloning of interacting gene: two hybrid and three hybrid assay; DNA finger printing and DNA foot printing; DNA Sequencing; Site directed mutagenesis; *In vitro* transcription and translation; RNA interference: Antisense RNA, siRNA and miRNA; Ribozyme Technology; Genetic engineering regulations and safety guidelines. Expression Strategies for Heterologous genes: Saccharomyces cerevisiae expression systems (S. cerevisiae vectors, intracellular cellular production of heterologous proteins, secretion of heterologous proteins by S. cerevisiae), Baculovirus-insect cell expression systems, mammalian cell expression systems.

Unit-III: Cell and tissue culture: Primary and secondary culture, cell lines, callus culture, protoplast culture, cell fusion and somatic hybridization.
Gene transfer methods in plant and animal cells (calcium phosphate method, electroporation, biolistic, liposomal bag, microinjection and *Agrobacterium* mediated).Genome editing using CRISPER. Selection and screening of transgenic plants using marker and reporter genes.Preparation of transgenic organisms and its advantages.

SUGGESTED READING:

1. Genome by T.A. Brown.
2. DNA Science. A First Course in Recombinant Technology by Mickloss and Freyer
3. Molecular Biotechnology by S.B. Primrose From genes to genome by J.Dale and M von Schantz
4. Molecular Biotechnology by Glick and Pasternak
5. Molecular Biology by Weaver
6. Molecular Cloning: A laboratory manual by J. Sambrook and E.F. Fritsch.
7. Protein Expression – A Practical Approach by Higgins and Hames

LS-542 (A - I)	ELECTIVE PAPER (Any one)	3 CH	50 marks

LS-542 (A)	Cell Culture Technique	3 CH	50 marks

OBJECTIVE: This paper contains three units, namely Animal Cell culture, Plant Cell culture, Somatic Hybridization. Each unit contains a description of the principles related to that unit, well-supported by different examples, descriptions of laboratory experiments, historical background etc; with solved equations that explain the concept discussed. These will help in fixing the Ideas firmly in student's mind. The examples discussed in the class-room are used to encourage students to participate in discussions.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Cell Culture Technique in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of Cell Culture Technique.
PEO2. Analyze the relationships among different concepts.
PEO3. Perform procedures as per the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying in the Cell Culture Technique in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of Cell and tissue culture.

CO2. Analyze the various concepts to understand them through case studies.

CO3. Apply the knowledge in understanding practical problems.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE

Unit-I: Animal cell culture: Natural vs artificial culture media, Properties of culture media, Advantages and disadvantages of serum in culture media; Techniques for primary cell culture, Development and maintenance of cell lines, Monolayer vs Suspension culture, Advantages and limitations of animal cell culture; Application of animal cell culture, Stem cell culture.

Unit-II: Introduction: history & scope of plant cell and tissue culture, media preparation, culture of plant cell and tissue; Somatic embryogenesis; Synthetic seeds; Haploid & triploid production.

Unit-III: Somatic hybridization and cybridization, Methods of gene transfer in plant cells; Somaclonal and gametoclonal variant selection, Application of tissue culture technique in horticulture, forestry and industry; Germplasm conservation.

SUGGESTED READING:

1. Biotechnology by B D Singh.
2. A textbook of Biotechnology by R C Dubey.
3. Biotechnology by J E Smith.
4. Biotechnology by U Satyanarayana.

LS-542 (B)	Genomics and Proteomics	3 CH	50 marks

OBJECTIVE:

Genomics, study of the structure, function, and inheritance of the genome (entire set of genetic material) of an organism. A major part of genomics is determining the sequence of molecules that make up the genomic deoxyribonucleic acid (DNA) content of an organism. The major learning objective of the course proteomics is to analyze the varying proteomes of an organism at different times in order to highlight differences between them. Put more simply, proteomics analyzes the structure and function of biological systems.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Crop physiology in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of genomics and proteomics.
PEO2. Analyze the relationships among different concepts of genomes and regulation.
PEO3. Perform procedures as per the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying in the Cell Physiology in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of genetic organization and its regulation etc.

CO2. Analyze the various genome sequencing projects to understand them through case studies.

CO3. Apply the knowledge in understanding practical problems in genome and varying proteomes.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE:

Unit-I: Genetic organization of prokaryotes and eukaryotes; Genome sequencing: principle and methodology; Recognition of coding and non-coding sequences and genetic annotation; Tools of genome analysis- Linkage analysis including pedigree, Genetic mapping using molecular markers (RFLP, RAPD, SSR, STS); Physical mapping. Genome analysis using 16s rRNA sequencing, ESTs and SNPs; Concept of TILLING, DNA microarray technology.

Unit-II: Genome sequencing projects (Microbes, plants and animals); Assessing and retrieving genome project information from the web; Reverse Genetics; Basics of Structural genomics and Comparative Genomics; High throughput screening in genome for drug discovery and identification of gene targets; Pharmoco-genomics and Drug development.

Unit-III: Proteomics: Protein analysis (measurement of concentration, amino acid composition, N-terminal sequencing); 2-D electrophoresis; IEF; Micro-scale solution; Peptide fingerprinting; MALDI-TOF; SAGE and Differential display proteomics; Protein-Protein interactions, Yeast-two hybrid and Three-hybrid system; Protein microarray; Proteomics and Drug discovery.

SUGGESTED READING:

1. Data Mining for Genomics and Proteomics: Analysis of Gene and Protein Expression DataBook by Darius M. Dziuda
2. Introduction to genomicsBook by Arthur M. Lesk
3. Genetics and Genomics in MedicineBook by Judith Goodship, Patrick Chinnery, and Tom Strachan

LS-542 (D)	Medical Microbiology	3 CH	50 marks

OBJECTIVE:

Medical Microbiology laboratory plays an important role in patient care by providing the cause of infection and antimicrobial susceptibility data to physicians. Rapid diagnosis of pathogens is important for initiating effective antibiotic administration and improving the outcomes of treatment. The major importance of medical microbiology is that it helps in the identification, isolation, diagnosis and treatment of pathogenic microorganisms and also produces beneficial organisms such as yeasts and some antibiotics. Biologists use microbiology to develop new methods for preventing illness.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Medical microbiology in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of disease biology and nature of pathogens..
PEO2. Analyze the relationships among different categories of pathogens and their of mechanism of action.
PEO3. Perform procedures as per the areas of study.
PEO4. Apply the basic concepts learned to execute them.

COURSE OUTCOMEs (COs): After studying in the Medical Microbiology in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of genetic organization and its regulation etc.

CO2. Analyze the various genome sequencing projects to understand them through case studies.

CO3. Apply the knowledge in understanding practical problems in genome and varying proteomes.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE:

Unit I: Concept of diseases: Harmful microbial interactions with humans: Entry of pathogen into the host, colonization and growth; Virulence factors and toxins: Exotoxins, Enterotoxins, Endotoxins. Host defense mechanisms: Nonspecific innate resistance, Inflammation and fever.

Unit II: Pathogens: Enteric pathogens: *Vibrio, Salmonella, Shigella, E. coli*. Gram positive cocci; *Staphylococcus, Micrococcus* and *Streptococcus*. Gram positive rods: *Coryneforms, Listeria, Mycobacterium* and *Nocardia*. Gram negative rods-*Klebseilla, Salmonella, Shigella, Neisseria, Haemophilus* and *Pseudomonas*. Anaerobic bacteria: *Clostridium*. Opportunistic fungal pathogens. Virus-Host interactions: Pathogenesis of viral infections.

Unit III: Antimicrobial agents, therapy and resistance: Antibacterial agents and their mechanism of action, Resistance to antimicrobial drugs, Basis of resistance, Antibiotic sensitivity testing, Antibacterial assays, Antiviral and Antifungal agents, and susceptibility test.

SUGGESTED READING:

1. Medical Microbiology E-Book Book by Ken S. Rosenthal, Michael A. Pfaller, and Patrick R Murray
2. Medical Microbiology & Immunology Book by Ernest Jawetz and Warren E. Levinson

3. Sherris Medical Microbiology: An Introduction to Infectious Diseases by Kenneth J. Ryan

LS-542 (E)	Vermitechnology	3 CH	50 marks

OBJECTIVE:

The branch of science that studies the importance and utilization of different earthworm species to answer problems related to ecology and environment is known as Vermitechnology. Use of vermicompost has been found effective for improving soil aggregation, structure, and soil fertility, increasing soil microbial population and enzymes, improving moisture-holding capacity of soil, increasing cation exchange capacity, and crop yield.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Vermitechnology in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of soil profile and the role of earthworms in soil fertility.
PEO2. Analyze the relationships among different categories of earthworms and their of mechanism of action.
PEO3. Perform procedures as per the areas of Vermitechnology like Vermiculture, Vermicompost and vermiconservation.
PEO4. Apply the basic concepts learned to execute them in improving the soil condition.

COURSE OUTCOMEs (COs): After studying in the Vermitechnology in the curriculum, students will be able to:

CO1. Remember and understand the basic aspects of vermitechnology.

CO2. Analyze the various soil types and to improve them through case studies.

CO3. Apply the knowledge in understanding practical problems in soil fertility and vermiremediation.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum in soil conditioning.

COURSE:

Unit-I: Fundamental concepts and strategies: Concept of pedosphere , Diversity soil biota and their role in soil fertility, General idea on earthworms, Identification of functional category of worms, extraction and sampling methods of earthworms, Concept of endemic and exotic worms, General principles of soil and manure testing.

Unit-II: Processes: General idea of decomposition and composting processes, Impact of functional category of earthworms on soil properties, Biofertilization, Biotransformation, Bioremediation, Biomagnification, Biodegradation, Bioturbations with earthworms, Prospects of vermitechnology in reducing methane gas emission, Organic farming and protein production.

Unit-III Technology: Small and vermicomposting technology, Advantages of vermicomposting over composting, Vermiconservation, Restoration/ reclamation of degraded terrestrial environment through

integrated vermitechnology, Case studies on vermitechnology, WINDROW models, SOVADEC computerized model, Prospects and problems of vermitechnology.

SUGGESTED READING:

1. Charles Darwin's Plough: Tools for Vermitechnology. Dash M. C. (2012). IK International Publishers. ISBN 9381141274 ISBN 978-9381141274.
2. Vermitechnology (English, Paperback, Violet A Mary Christy
3. Vermitechnology (English, Paperback, Yadav Shweta)

LS-542 (F)	Hormonal Plant Physiology	3 CH	50 marks

OBJECTIVE:

This paper aims to give an view of various hormones regulating various plant processes and their regulation.The physiological effects of these hormones and mode of their action will be the main focus.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying **Hormonal Plant Physiology** in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of hormones and the role plant development
PEO2. Analyze the different categories of hormones and their mechanism of action.
PEO3. Perform procedures as per the areas of hormonal effect on plant growth with specific case studies.
PEO4. Apply the basic concepts learned to execute them in improving the crop growth and yield.

COURSE OUTCOMEs (COs): After studying in the **Hormonal Plant Physiology** in the curriculum, students will be able to:

CO1. Remember and understand the basic aspects of hormones related to plants.

CO2. Analyze the various mechanisms of hormonal actions and to improve them through case studies.

CO3. Apply the knowledge in understanding practical problems in hormonal control.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum in plant development.

COURSE:

Unit-I: Concept of hormones and their action, Auxin: the principal growth regulators in plants, Biosynthesis and degradation of auxins, Auxin transport to different plant parts, Extraction and measurement of auxins, Physiological effects of auxins on root and shoot growth, Phototropism and Gravitropism, Auxin signal transduction pathways, Auxin as herbicides.

Unit-II: Gibberlins and Cytokinins: Discovery of Gibberlins, Biosynthesis and metabolism of gibberlins, Physiological roles of gibberlins, Mechanism of gibberlin action, Gibberlin signal transduction pathway. Discovery and properties of cytokinins, Cytokinins and cell division, Sites of cytokinin biosynthesis and transport, Cytokinin metabolism, Physiological role of cytokinins, Cellular and molecular modes of cytokinin action.

Unit-III: Ethylene and ABA: Structure, biosynthesis and measurement of ethylene, Developmental and physiological effects of ethylene, Cellular and molecular modes of ethylene action. ABA: a stress hormone, Occurrence and chemical structure of ABA, Biosynthesis, metabolism and transport of ABA, ABA induced stomatal closure, Physiological role of ABA, Cellular and molecular modes of ABA action.

SUGGESTED READING:

1. **Fundamentals of Plant Physiology**. Lincoln Taiz, Eduardo Zeiger, Ian Max Moller and Angus Murphy. Sinaur Associates Inc. publishers(Sixth Edition) 2018.
2. **Plant Physiology**. F.B. Salisbury and C.W. Ross. Thomson Information Publising Group (5^{th} Edition)1991.
3. Physicochemical and Environmental Plant Physiology. Park S. Nobel, Elsevier Science, (5^{th} Edition) 2020.
4. Introduction to Plant Physiology. Huner NPA and Hopkins, WG. Wiley publishers, (4^{th} Edition) 2013.
5. **Biochemistry and Molecular Biology of Plants**. B. B.Buchanan, W.Gruissem and R.L.Jones (Ed.), Wiley Blackwell Publishers (Second Edition) 2015.

LS-542 (G)	Plant Metabolism	3 CH	50 marks

OBJECTIVE:

This paper aims to give an view of various hormones regulating various plant processes and their regulation.The physiological effects of these hormones and mode of their action will be the main focus.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Plant Metabolism in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of photosynthesis and metabolism of biomolecules.
PEO2. Analyze the the different categories of biomolecules and their mechanism of action.
PEO3. Perform procedures as per the areas of plant metabolism with specific case studies.
PEO4. Apply the basic concepts learned to execute them in engineering new lipids and proteins etc.

COURSE OUTCOMEs (COs): After studying in the Plant Metabolism in the curriculum, students will be able to:

CO1. Remember and understand the basic aspects of biomolecules and their synthesis.

CO2. Analyze the various mechanisms of plant metabolism and to improve them through case studies.

CO3. Apply the knowledge in understanding practical problems in plant metabolism.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum in plant development.

COURSE:

Unit-I: Carbohydrate Metabolism: Photosynthesis, C_3 and C_4 pathways, CAM metabolism, Photorespiration, Metabolism of polysaccharides such as starch, cellulose, lignin and pectin. Metabolism of sucrose, Various phosphate pools and their interaction. Integration of carbohydrate metabolism in plant cell, Electron transfer in plant mitochondria, Interaction between chloroplast and mitochondria.

Unit-II: Lipid Metabolism: Fatty acid biosynthesis, Desturation and elongation of fatty acids, Synthesis of unusual fatty acids, Metabolism of phospholipids, Synthesis and catabolism of storage lipids, Engineering of new lipids.

Unit-III: Secondary Metabolites: Types and distribution of secondary metabolites, Terpenoids: biosynthesis and function of terpenoids in higher plants. Alkaloid localization and biosynthesis,

Flavonoid biosynthesis, Shikimic acid pathway, Acetate-Malonate pathway, Function of flavonoids, Cyanogenic glycosides and non-protein amino acids.

SUGGESTED READING:

1. **Fundamentals of Plant Physiology**. Lincoln Taiz, Eduardo Zeiger, Ian Max Moller and Angus Murphy. Sinaur Associates Inc. publishers(Sixth Edition) 2018.
2. **Plant Physiology**. F.B. Salisbury and C.W. Ross. Thomson Information Publising Group (5^{th} Edition)1991.
3. Introduction to Plant Physiology. Huner NPA and Hopkins, WG. Wiley publishers, (4^{th} Edition) 2013.
4. **Biochemistry and Molecular Biology of Plants**. B. B.Buchanan, W.Gruissem and R.L.Jones (Ed.), Wiley Blackwell Publishers (Second Edition) 2015.

LS-543 (A – D)	SPECIAL PAPER- III (Any one)	3 CH	50 marks

LS-543 (A)	Structure and Metabolism	3 CH	50 marks

OBJECTIVE:

The course aims to provide an advanced understanding of the core principles and topics of Biochemistry and their experimental basis, and to enable students to acquire a specialised knowledge and understanding of selected aspects by means of a stem/branch lecture series and a research project.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Structure and Metabolism in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of Structure and Metabolism of biomolecules.
PEO2. Analyze the the different categories of biomolecules and their microbial production.
PEO3. Perform procedures for deeper understanding of biomolecules with specific case studies.
PEO4. Apply the basic concepts learned to execute them in regulation and synthesis etc.

COURSE OUTCOMEs (COs): After studying in the Structure and Metabolism in the curriculum, students will be able to:

CO1. Remember and understand the basic aspects of biomolecules and their synthesis.

CO2. Analyze the various mechanisms of biomolecule synthesis with specific case studies.

CO3. Apply the knowledge in understanding practical problems in biomolecule regulation.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum in biomolecules.

COURSE:

Unit I: Carbohydrates and Lipids: Structural organization of polysaccharides; Metabolic pathways and energetics of carbohydrates: Glycolysis, HMP shunt, Glycogen metabolism; Calvin cycle and C_4 pathway; Photorespiration; ED pathway. Structural organization of complex lipids and steroids; Lipid biosynthesis; α, β, ω oxidation of fatty acids; Energetics of lipid oxidation and regulation; Cholesterol biosynthesis.

Unit II: Nucleic acid and Proteins: *De novo* and Salvage pathway of nucleic acid biosynthesis. Molecular organization and hierarchy of proteins; Ramchandran plot and establishment of higher order structures; Proteolysis.

Unit III: Amino acid, Vitamins and Hormones: Amino acid metabolism: transamination, deamination, decarboxylation; Urea cycle. Vitamins and Hormones: absorption and transport; Biochemical functions of vitamins: A, D, E , K, B and C.

SUGGESTED READING:

1. Principles of Biochemistry by AL Lehninger, David L. Nelson and Michael M. Cox
2. Biochemistry by Jeremy M. Berg, John L. Tymoczko and Lubert Stryer
3. Principles of Biochemistry by Donald Voet, Judith G. Voet and Charlotte W. Pratt

LS-543 (B)	Industrial Microbiology	3 CH	50 marks

OBJECTIVE:
The aim of the course is to give the students broad theoretical and practical skills in industrial microbiology.The students will be able to discuss the role of microorganisms in industry, as well as to carry out experiments to produce microbial metabolites. Industrial microbiology uses different microorganisms, such as naturally occurring organisms, laboratory selected mutants, or even genetically modified organisms, to produce a very large variety of industrial products in large quantities.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Industrial Microbiology in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts in designing and operations of bioreactors.
PEO2. Analyze the the different categories of bioreactors and commercial enzyme production.
PEO3. Perform procedures for deeper understanding of bioproductions with specific case studies.
PEO4. Apply the basic concepts learned to execute them in regulation and synthesis etc.

COURSE OUTCOMEs (COs): After studying in the Structure and Metabolism in the curriculum, students will be able to:

CO1. Remember and understand the basic aspects of bioreactors.

CO2. Analyze the various mechanisms of enzyme synthesis in bioreactors with specific case studies.

CO3. Apply the knowledge in understanding practical problems in bioreactor designing.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum in commercial production and mass culture of cell in bioreactors.

COURSE:

Unit-I: Design and operation of conventional bioreactor (design, sterilization, inoculation, sampling, aeration and control system); Solid substrate fermentation; Variation in bioreactor design (Batch, Fed-batch, CSTR, Tubular flow and Packed Bed). Residence time distribution (E-curve, F-curve and C-curve). Diauxic growth and substrate inhibition kinetics.

Unit-II: Commercial production of microbial enzymes, industrial chemicals (alkanes, butanol, ethanol, amino acid, hydrogen, organic acids, exo-polysaccharides), antibiotics, sterols, therapeutic peptides and proteins. Microbial technology for alcoholic beverages production (beer, wine and cider), vinegar production; Dairy fermentation (butter and cheese); SCP.

Unit-III: Mass culture of cell in bioreactor system; Immobilized cell culture; Enzyme immobilization and its application in bioreactor; Biofilm; Strategies for maximizing productivity (Amino acid and SCP). Downstream processing of product/enzyme recovery: case study.

SUGGESTED READING:

1. Microbial Ecology By Atlas R.M., Bartha R., Benjamin Cummings Publishing Co, Redwood City, CA., 1993.
2. Principles of Fermentation Technology by P.F. Stanbury, W. Whitaker &S.J. Hall, Aditya Books (P) Ltd., New Delhi, 1997.
3. Industrial Microbiology: An Introduction by Waites, Morgan, Rockey & Highton, Blackwell Science, 2001.
4. Fundamental Food Microbiology , 3rd edition by B. Ray., CRC press, 2006.
5. Food Microbiology by M.R. Adams & M.O. Moss., Royal Society of Chemistry, 2000.
6. Molecular Biology of the Gene by James Watson, Tania Baker, Stephen Bell, Alexander Gann, Michael Levine & Richard Losick , 6th Edition; CSHL Press; 2007.
7. Principles of Microbiology by R.M. Atlas , Mosby publishers, St. Louis; 1995.

LS-543 (C)	Microbial Ecology	3 CH	50 marks

OBJECTIVE:

Analyze the causes of climate change and see how human activities affect the climate. See the consequences of global climate change for ecosystems and human society. Recognize the moral principles, goals, and virtues needed for making sound policy and lifestyle responses to global climate change.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Atmosphere and Climate Change in the curriculum, students will be able to:

PEO1. To understand the basic concept of atmospheric properties and to educate the students about the new concept of climate change.

PEO2. Analyze the impact of climate change on agriculture, forest, water resources, and monsoon system of India

PEO3. Perform procedures to lower the impact of climate change on the environment at home

PEO4. To apply the scientific background for research and other careers across a broad spectrum of atmosphere related science, focusing particularly on the links between the atmosphere and the land surface environment.

COURSE OUTCOMEs (COs): After studying in the Atmosphere and Climate Change in the curriculum, students will be able to:

CO1: Remember and understand the basic concept of atmospheric properties, its dynamic nature and variability in turns of the global energy balance.

CO2: Analyze the concepts related to the fundamentals of climatology, pollution climatology, and the phenomenon of climate change with emphasis on India.

CO3:Apply the knowledge in understanding the effects due the imbalance of the atmospheric processes such as global warming, air pollution, climate change etc.

CO4: Execute the field assignment as per the knowledge gained in the course.

COURSE

Unit I: Basic atmospheric properties, climatic controls, climatic classifications and variability. Movement in the atmosphere: global scale, regional scale, local scale. Wind, stability and turbulence; Energy balance in atmosphere, Atmospheric moisture: Forms of cloud condensation; Precipitation, Thunderstorms, floods and droughts, Indian monsoon, El Nino, La Nina effect, and western disturbances,

Unit II: Natural climate changes: Records of climate change (glacial cycles, ocean sediments, corals, tree rings). Indian climate through ages; impact of the Himalayan mountain building and the Indian Summer, Monsoon. Drivers of climate change- greenhouse gases, aerosols – reflective and black carbon, land use changes. Energy balance, feed-back processes in climate system, concepts of global warming potential (GWP), radiative forcing.

Unit III: Climate change scenarios of India: impact of climate change on agriculture, forest, water resources, monsoon system of India. Causes and consequences of Global warming: Greenhouse effect; Global and regional trends in greenhouse gas emissions; Sea level rise; role of oceans and forests as carbon sinks; Ozone depletionstratospheric ozone shield; Ozone hole. Impacts of Climate change: Effects on organisms including humans; effects on ecosystems and productivity; species responses in terms of distribution ranges, adaptation; spread of diseases; Extinction risk for temperature-sensitive species; UV effects.

SUGGESTED READING:

1. Hardy, J.T. 2003. Climate Change: Causes, Effects and Solutions. John Wiley & Sons.
2. Harvey, D. 2000. Climate and Global Climate Change. Prentice Hall.
3. Barry, R. G. 2003. Atmosphere, Weather and Climate. Routledge Press, UK
4. Mitra, A.P., Sharma, S., Bhattacharya, S., Garg, A., Devotta, S. &Sen, K. 2004. Climate Change and India. Universities Press, India.

LS-543 (D)	Stress Physiology	3 CH	50 marks

OBJECTIVE:

The importance of studying the effects of stress on individual organisms is addressed by considering the use of individual-level information to: elucidate the mechanistic bases of inter-population variation; predict population-level effects; and monitor stress in natural communities.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Stress Physiology in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts stress and its effect in nature.
PEO2. Analyze the different types of stresses and their effects.

PEO3. Perform procedures for deeper understanding of stress management in organisms with specific case studies.
PEO4. Apply the basic concepts learned to execute them in management of both abiotic and biotic stresses.

COURSE OUTCOMEs (COs): After studying in the Stress Physiology in the curriculum, students will be able to:

CO1. Remember and understand the basic aspects of stresses encountered in nature.

CO2. Analyze the various mechanisms of stress effect with specific case studies.

CO3. Apply the knowledge in understanding practical problems in stress and its management.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum in stress effect study.

COURSE:

Unit-I: Abiotic stresses and organismal responses; Biological stresses and strain; Stress injury and resistance and their classification; Physiology of acclimation and acclimatization; Molecular approaches to study stress response in plants; Gene expression and signal transduction in response to stress signals.
Unit-II: High and low temperature stresses; Organismal response to chilling, Freezing and high temperature stresses; Molecular mechanisms of adaptation to high temperature stress; HSPs, AFPs and their expression; Molecular response to drought; drought injury and resistance, expression of stress resistant genes in plants; LEA proteins, aquaporins and water use efficiency.

Unit-III: Salinity stress in plants; Salt stress injury and resistance mechanisms, Salt regulated genes expression; ABA responsive genes and osmotin; ABA dependent and ABA independent pathways of stress response; Role of *cis*-acting and *trans*-acting factors in stress resistance; Heavy metal stress and phytochelatin response; Engineering stress resistant genotypes.

SUGGESTED READING:

1. **Plant Physiology and Development**. Lincoln Taiz, Eduardo Zeiger, Ian Max Moller and Angus Murphy. Sinaur Associates Inc. publishers(Sixth Edition) 2015.
2. **Fundamentals of Plant Physiology**. Lincoln Taiz, Eduardo Zeiger, Ian Max Moller and Angus Murphy. Sinaur Associates Inc. publishers(Revised Sixth Edition) 2018.
3. **Plant Physiology**. F.B. Salisbury and C.W. Ross. Thomson Information Publising Group (5^{th} Edition)1991.
4. Physicochemical and Environmental Plant Physiology. Park S. Nobel, Elsevier Science, (5^{th} Edition) 2020.
5. Introduction to Plant Physiology. Huner NPA and Hopkins, WG. Wiley publishers, (4^{th} Edition) 2013.
6. **Biochemistry and Molecular Biology of Plants**. B. B.Buchanan, W.Gruissem and R.L.Jones (Ed.), Wiley Blackwell Publishers (Second Edition) 2015.
7. **Physiological Plant Ecology,** Walter Larcher
8. **Plant Physiological Ecology,** Hans Lambers and Reffel S. Oliviera.

LS-544 (A – D)	**SPECIAL PAPER- IV (Any one)**	**3 CH**	**50 marks**

LS-544 (A)	**Metabolic Regulation**	**3 CH**	**50 marks**

OBJECTIVE:
Metabolic regulation enables the balance between substrate and product of enzyme-catalyzed reactions to be maintained so that ordered metabolic flow can occur in response to developmental requirements and environment.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Metabolic Regulation in the curriculum, students will be able to:

PO1. Understand the basic the basic nature and basic concepts in regulation of metabolic processes.
PO2. Analyze the Molecular mechanism of hormone action.
PO3. Perform procedures for deeper understanding of bio-productions with specific case studies.
PO4. Apply the basic concepts learned to execute them in regulation and synthesis etc.

COURSE OUTCOMEs (COs): After studying in the Structure and Metabolism in the curriculum, students will be able to:

CO1. Remember and understand the basic aspects of bioreactors.

CO2. Analyze the Signal response coupling in metabolic processes with specific case studies.

CO3. Apply the knowledge in understanding practical problems metabolic regulation

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE:

Unit-I: Metabolic regulation: Glycolysis, Phosphofructokinase and pyruvate kinase as control points in glycolysis; Pasteur effect; TCA cycle and its control; Glyoxalate cycle and its regulation; Regulation of glycogen metabolism.

Unit-II: Molecular mechanism of hormone action: Epinephrine, Insulin, Thyroxine, Estrogen, Phytohormones namely cytokinin and ethylene.

Unit-III: Signal response coupling in metabolic processes: Sugar sensing signal transduction; Hexokinase as sugar sensor; Ca-Calmodulin signaling system; cAMP as 2^{nd} messenger; GTP binding protein and kinase/phosphatase cascade.

SUGGESTED READING:

1. Principles of Biochemistry by AL Lehninger, David L. Nelson and Michael M. Cox
2. Biochemistry by Jeremy M. Berg, John L. Tymoczko and Lubert Stryer
3. Principles of Biochemistry by Donald Voet, Judith G. Voet and Charlotte W. Pratt
4. Harpers Illustrated Biochemistryby Victor Rodwell , David Bender

LS-544 (B)	Virology	3 CH	50 marks

OBJECTIVE:
Virology is the study of understanding viruses – from more common infections such as chicken pox to new and emerging infections like Zika and Ebola. Virologists are medical doctors that oversee the diagnosis, management and prevention of infection. By studying viruses, we can learn about the biology of host cells and organisms, develop strategies against viral disease and manipulate viruses for our own purposes. Some viruses are only a single self-replicating gene, while others can encode almost a thousand proteins and be the size of a bacterium.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Industrial Virology in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of viral structure and taxonomy.
PEO2. Analyze the different categories of virus and their reproduction.
PEO3. Perform procedures for deeper understanding of viral physiology and genetics.
PEO4. Apply the basic concepts learned to execute them in regulation of virus.

COURSE OUTCOMEs (COs): After studying in the Virology in the curriculum, students will be able to:

CO1. Remember and understand the basic aspects of viruses.

CO2. Analyze the various mechanisms of reproduction and infection with specific case studies.

CO3. Apply the knowledge in understanding practical problems in viral infections.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum viral processes.

COURSE:

Unit-I: Definitive properties of viruses, Virus structure (capsid, nucleic acid, viral envelope and enzyme); Viral diversity: classification of virus and taxonomy; Viral cultivation, detection and enumeration. Viral evolution and emergence of new virus.

Unit-II: Viral attachment and entry into the host cell; Genomic replication of DNA viruses and RNA viruses; Viral translational strategy; Viral assembly, maturation and exit of viruses. General features of TMV, HIV, Poliovirus, Rhabdovirus, Reovirus, Retrovirus, Adenovirus, Poxvirus).

Unit-III: Classification of bacteriophage; One step growth experiment; Reproduction of dsDNA, ssDNA and RNA phage; Lytic cycle; Temperate bacteriophage and Lysogenic cycle; Choice of lysis and lysogeny. Viral pathogenesis, prevention of viral diseases (vaccines & antiviral drugs).

SUGGESTED READING:

1. Principles of Virology: Molecular Biology, Pathogenesis and Control of Animal Viruses by S.J. Flint, L.W. Enquist, V.R. Racaniello, and A.M. Skalka 2nd edition, ASM Press, Washington, DC, 2004.
2. Introduction to Modern Virology EPZ by Nigel Dimmock, Andrew Easton and Keith Leppard, 5th edition, Blackwell Publishing, 2005
3. Basic Virology by Edward K. Wanger, Martinez Hewiett, David Bloom and David Camerini, 3rd edition, Blackwell Publishing, 2007Medical Microbiology and Immunology by Levinson W, Jawetz E: Lange publication; 2001.
4. Virology: Principles and Applications. Dr John Carter and Prof Venetia Saunders .John Wiley & Sons.1st edition.
5. A. Maharajan. 2011. Virology. Daya Publishing House. ISBN: 9788170356813.
6. Plant pathology by George N. Agrios: 4th ed., Academic press, New York, 1969.
7. Plant pathology by R.S. Mehrotra: Tata McGraw –Hill publishing company limited. New Delhi.
8. Human Virology by John Oxford (Author), Paul Kellam (Author), Leslie Collier

LS-544 (C)	Environmental Management	3 CH	50 marks

OBJECTIVE:

Objectives and Guiding Principles of Environmental Management is creating the awareness about environmental problems among people; imparting basic knowledge about the environment and its allied problems and Developing an attitude of concern for the environment.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Industrial Microbiology in the curriculum, students will be able to:

PEO1: To understand the population dynamics, the use of natural resources and environmental pollution.

PEO2: To analyze the fundamentals of cost-benefit, environmental planning, and economic development.

PEO3: To perform procedures to develop managerial skills that allows the quality control of the environmental programs.

PEO4: To apply the scientific planning strategies required for environmental problem analysis

COURSE OUTCOMEs (COs): After studying in the Structure and Metabolism in the curriculum, students will be able to:

CO1: Remember and understand the rationale behind the exploitation of natural environments. It provides you with detailed knowledge and understanding of the important relationships between sustainable environmental management and natural ecosystems and the value of adopting an integrated approach to studying both.

CO2: Conduct research and present findings on selected environmental sustainability topics.

CO3: Apply the knowledge to develop controls to reduce or eliminate risk

CO4: Execute the study in managerial, technological and policy approaches to natural resource management

Unit-I: Degradation of environment and its management: Impacts of developmental projects on environment; Land, water, air pollution: Definition, Sources and types, causes, effects, and management; Loss of biodiversity; Principles of environment management; Concept of carbon trading, carbon capture and storage.

Unit-II: Environmental management techniques and standards: Life cycle assessment and SWOT analysis, municipality solid waste management, Air quality management, Water quality management, Biodiversity and its management, Environmental Management Plan(EMP), Applications of GIS and Remote sensing in environmental management. Environment management system standards: ISO 14000, CPCB.

Unit-III: Environmental management policies: Environmental Economics, Environmental monitoring programme, Ecosystem Services; Conventions and Summits: Kyoto Protocol, 1997, Cartagena Protocol, 2003, Rio Declaration 1992, Montreal Protocol, 1987, Stockholm Declaration, 1972, Ramsar Convention, 1971, IPCC Report 2008, Bali Summit on Climate; Indian Acts on Environment: Indian Forest Act 1927, The National Forest Policy, 1952, Water Act, 1974, The Forest (Conservation) Act, 1980, The Air (Prevention and Control of Pollution) Act, 1981, Environment Protection Act, 1986, The Biological

Diversity Act 2002, New Environmental Impact Assessment, 2006 . National Environment Appellate Authority Act, 1997.

SUGGESTED READING:

1. T. V. Ramachandra and Vijay Kulkarni, Environmental Management (2009), TERI press
2. Mary K. Theodore, Louis Theodore, Introduction to Environmental Management (2009), CRC press
3. I.V Murali Krishna Valli Manickam, Environmental Management 1st Edition (2017), Elsevier
4. Environmental Engineering First Editionby Gerard Kiely (Author) (1996), McGraw-Hill

LS-544 (D)	Radiation Biology	3 CH	50 marks

OBJECTIVE:

Radiation biology (also known as radiobiology) is a medical science that involves the study of biological effects of ionizing radiation on living tissues. Whether the source of radiation is natural or man-made, whether it is a large dose of radiation or a small dose, there will be some biological effects. The study also aims to know the limits on the exposure to radiation are designed to avoid unnecessary damage to health. These limits need to be continually assessed in the light of new scientific discoveries. Limits that are set too low may create unacceptable morbidity for individuals.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Radiation Biology in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of radiation in nature.
PEO2. Analyze the cellular response to radiation.
PEO3. Perform procedures for radiation exposure and recovery mechanism with specific case studies.
PEO4. Apply the basic concepts learned to execute them in regulation of radiation damage.

COURSE OUTCOMEs (COs): After studying in the Radiation Biology in the curriculum, students will be able to:

CO1. Remember and understand the basic aspects of radiations – ionizind and non-ionizing.

CO2. Analyze the various mechanisms of cellular response to radiation exposure with specific case studies.

CO3. Apply the knowledge in understanding practical problems in related to radiation application.

CO4. Execute the projects or field assignment as per the knowledge gained in the course curriculum in kinetics of radiation influences.

COURSE:

Unit-I: Fundamentals of radiation biology: Types of radiation, Interaction of ionizing radiation with matter; Photoelectric effect; Compton scattering and pair production; Direct and indirect effects of ionizing radiation; Detection and measurement of radiation; Radiation chemistry and free radicals; Radiolysis of water; Radiation effects at sub-cellular and molecular level.

Unit-II: Cellular responses to ionizing radiation: Target theory and cell survival curves in prokaryotic and eukaryotic cells; Single hit and multi hit phenomena; Do, Dq and n; Kinetics of cell killing; Oxygen effect and cell survival curves; Radio-sensitivity of synchronized cell population, Cell synchronization techniques; Factors influencing the effects of ionizing radiation.

Unit-III: Radiation injury and recovery mechanisms: Radiation induces chromosomal aberrations and gene mutation; DNA damage and repair; Acute radiation effect and delayed effects; Effects on cell cycle; Split dose technique; Elkind recovery patterns; Dq as measure of repair; Effects of hypoxia on the repair

of sub-lethal radiation damage; High LET radiations in cancer therapy; Radiolabelled compounds in biology and medicine.

SUGGESTED READING:

1. P. Uma Devi, A. Nagarathnam and B.S. Satish Rao. Introduction to Radiation Biology. B.I. Churchil Livingstone Pvt.Ltd.
1. Prasad, K.N., *CRC Handbook of Radiobiology*, CRC Press, Florida
2. Eric J Hall, Amato J Giaccia. *Radiobiology for the Radiologist*. Lippincott : Williams & Wilkins.
3. A.H.W. Nias. *An Introduction to Radiobiology*. John Wiley and sons
4. Alison P Casarette. *Radiation Biology*. Prentice Hall Inc.

LS-545 (A – D)	**Special Paper Practical – II (Any one)**	**2 CH**	**50 marks**
LS-545 (A)	**Practical based on Structure and Metabolism and Metabolic Regulation**	**2 CH**	**50 marks**
LS-545 (B)	**Practical based on Industrial Microbiology and Virology**	**2 CH**	**50 marks**
LS-545 (C)	**Practical based on Microbial Ecology and Environmental Management**	**2 CH**	**50 marks**
LS-545 (D)	**Practical based on Stress Physiology and Radiation Biology**	**2 CH**	**50 marks**

LS-546	**SEMINAR**	**3 CH**	**50 marks**
LS-547	**PROJECT WORK (3 CH) & VIVA VOCE (2 CH)**	**5 CH**	**150 marks**