COURSE AT GLANCE FOR M Sc. LIFE SCIENCES (ZOOLOGY STREAM)

SUBJECT: LIFE SCIENCES (ZOOLOGY STREAM)

ACADEMIC SESSION: 2024-25

First Semester-**December, 2024**

Course Number	**Course Title**	**Credit Hours**	**Mark distribution**		**Maximum Marks**
			Mid term	**End term**	
LS-C-411	Fundamentals of Physical Sciences and Biophysics	4 CH	20	80	100
LS-C-412	Fundamentals of Biochemistry and Biophysical Chemistry	4 CH	20	80	100
LS-C- 413	Bio-instrumentation and Techniques	4 CH	20	80	100
LS-C-414	Fundamentals of Microbiology and Molecular Biology	4 CH	20	80	100
LS-C-415	Practical on Biophysics , Bio-instrumentation and Biochemistry	2 CH	00	50	50
LS-C-416	Practical on Microbiology and Molecular Biology	2 CH	00	50	50
ESDMS	**Environmental studies and disaster management**	**2 CH**	**40**	**60**	**100**
	Total Credit hour – First Semester	**22 CH**			**600**

Second Semester - **April,2025**

LS-C-421	Ecology, Biodiversity and Biostatistics	4 CH	20	80	100
LS-C-422	Cell Biology	4 CH	20	80	100
LS-C-423	Genetics	4 CH	20	80	100
LS-C-424	Immunology	4 CH	20	80	100
LS-C-425	Practical on LS-421 (Ecology, Biodiversity and Biostatistics)	2 CH	00	50	50
LS-C-426	Practical on LS-422, LS-423 & LS-424 (Genetics, Cell biology and Immunology)	2 CH	00	50	50
IDC (LS-Biof and vermin)	**Inter-disciplinary course (Open elective)**	**3 CH**	**40**	**60**	**100**
	Total Credit hour – Second Semester	**23 CH**			**600**

Third Semester- **December, 2025**

LS-C-511	Bioinformatics and Computer Application	4 CH	20	80	100
LS-C-512	Animal Taxonomy and Morphology	4 CH	20	80	100
LS-C-513	Animal Physiology and Development	4 CH	20	80	100
LS-E-514 (A, B, C, D)	Special Paper (E1)	4 CH	20	80	100
LS- C-515	Practical on LS-C- 512 and LS-C-513 (Animal Morphology, Taxonomy, Development, Physiology)	2 CH	00	50	50
LS-E-516	Practical on Special Paper I (E1)	2 CH	00	50	50
EDPS	**Entrepreneurship Development Programme**	**2 CH**	**40**	**60**	**100**
	Total Credit hour – Third Semester	**22 CH**			**600**

Fourth Semester, **April,2025**

LS-C-521	Genetic Engineering	4 CH	20	80	100
LS-E-522	Elective Papers (E2) [A, B, C, D,E F]	4CH	20	80	100
LS-E- 523	Special Paper- (E3) [A,B,C,D]	4 CH	20	80	100
LS-E-524	Practical on Special Paper - E3	2 CH	00	50	50
MOOCS	**MOOCS course/Alternative Course as opted by the students**	**3 CH**	**40**	**60**	**100**
LS-C- 525	Seminar	2 CH	00	50	50
LS-E-526	Project Work and Viva- voce	4 CH	25 (Viva)	75 (Thesis)	100
	Total Credit hour – Fourth Semester	**23 CH**			**600**
	Total Credit Hour-All Semesters (22+23+25+20)	**90 CH**			**2400**

C-Compulsory, E-Elective/Special

Elective I (E1)

A. Bioenergetics and Enzymology
B. Systems Ecology and Energetics
C. Microbial Physiology and Microbial Genetics
D. Cell and Radiation Physiology

Elective 2 (E2)

A. Cell culture Technique
B. Genomics and Proteomics
C. Medical Microbiology
D. Plant Metabolism
E. Vermitechnology
F. Hormonal Plant Physiology

Elective 3 (E3)

A. Structure, Metabolism and Metabolic Regulation
B. Environmental Microbiology and Sustainable Environmental Management
C. Industrial Microbiology and Virology
D. Stress and Crop Physiology

Signatures Chairman BOS, Signature of Head, School of Life Sc.

of School of Life Sciences (Zoology Stream)

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 and Biophysics**	**4CH**	**100 marks**

OBJECTIVE

This paper contains four units Fundamentals of Physical Sciences and Biophysics. 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 Fundamentals of Physical Sciences and Biophysics relating to M.Sc. degree in Life Sciences.
PEO2. Analyze the relationships among different concepts of Physical Sciences and Biophysics.
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 and Biophysics in the curriculum, students will be able to:

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

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: Concept of Physics, 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.

Unit-II: Photo-biophysics: 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: Physico-chemical Study of Matter: Atomic models of atom, Waves and wave functions, Quantum mechanics of Hydrogen atom, Nuclear Forces, Nuclear stability, basic concepts of radioactivity, Spectrum, Kinds of spectrum, UV & IR spectrum.

Unit-IV: 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.

SUGGESTED READINGS:

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.
7. Electrical Interactions in Molecular Biophysics: An Introduction. Raymond Gabler. Academic Press, New York.

LS-412	**Fundamentals of Biochemistry and Biophysical Chemistry**	**4 CH**	**100 marks**

OBJECTIVE

The objective of this particular paper is to provide an advance understanding of course principles in biochemistry, biophysical chemistry and their experimental basis. It will enable the students to understand the various aspects of biochemistry, biophysical chemistry 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 and Biophysical Chemistry in the curriculum, students will be able to:

PO1. Understand the nature and basic concepts of Biochemistry and Biophysical Chemistry.
PO2. Analyze the relationships among different concepts of Biochemistry and Biophysical Chemistry.
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 and Biophysical chemistry in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of Biochemistry and 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 the projects or field assignment as per the knowledge gained in the course curriculum.

COURSE

Unit-I: 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 Arrhenius equation.

Unit II: 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-III: 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-IV: 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 READINGS:

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	Bioinstrumentation and Techniques	4 CH	100 marks

OBJECTIVE:

Bioinstrumentation 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 Bionstrumentation and Techniques in the curriculum, students will be able to:

PEO1. Understand the basic concepts and principles of different instruments used in Life Sciences.
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 Bionstrumentation and Techniques in the curriculum,, students will be able to:

CO1. Remember and understand the basic concepts of Bionstrumentation and Techniques used in Life 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 projects or field assignment as per the knowledge gained in the course curriculum..

COURSE

Unit-I: Spectrophotometry – laws of absorption of light, absorption and action spectra, colorimeter and spectrophotometer, double and single beam spectrophotometer, visible and UV-spectrophotometry, applications of spectrophotometry, 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.

Unit-IV: Principle and application of the instrumental technique: X-ray crystallography, OD and CRD, Infra Red (IR), Nuclear Magnetic Resonance and Electron Spin Resonance spectroscopy. MALDI-TOF, MS-MS; Flow cytometry, Cytofluorometry and FACS; Atomic absorption spectroscopy (AAS); FISH, IRGA.

SUGGESTED READINGS:

1. Learning Radiology: Recognizing the Basic by William Herring
2. Handbook of HPLC-HPTLC (PB 2021) by R.K. Nema
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
7. Principles and Techniques of Biochemistry and Molecular Biology. Edited: Wilson and Walkers.

LS-414	Fundamentals of Microbiology and Molecular Biology	4 CH	100 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. 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):

PEO1. Understand the nature and basic concepts of Microbiology and Molecular Biology relating to M.Sc. degree in Life Sciences.
PEO2. Analyze the relationships among different concepts of Microbiology and Molecular 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 Microbiology and Molecular Biology in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of Microbiology and Molecular Biology.

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 cell wall, capsule, flagella, pilli, pronucleus, ribosomes, plasmid).

Unit-II: Bacterial nutrition and nutritional category, Bacterial culture: Synchronous 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: Genetic organization of Prokaryotes and Eukaryotes including nuclear genome and organellar genome; DNA as the genetic material; Central dogma of Molecular Biology; DNA replication: Models of DNA replication, Enzymes of DNA replication, 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-IV:, Translation: Genetic Code- Principle of translation, Translation machinery in Prokaryotes and Eukaryotes (t-RNA, Aminoacyl synthetase, Ribosome), Translation process (initiation, elongation and termination); DNA repairs mechanism, DNA recombination (site-specific and homologous) mechanisms and its significance. 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 READINGS:

1. Brock Biology of Microorganisms (12th edition) by Madigan and John M. Martinko, Paul V. Dunlap, David P. Clark Benjamin Cummings; 2008.
2. Microbiology. Sixth edition, International edition by Prescott, L. M., J. P. Harley and D. A. Klein. 2005., Mc Graw Hill.
3. Microbiology. Fifth edition by Pelczar, T. R. and M. J. Chan and N. R. Kreig. 2006, Tata Mc Graw-Hill INC. New York.
4. Fundamentals of Microbiology & Immunology by Ajit Banerjee and Nirmalya Banerjee 2008.. New Central Book Agency (P) Limited.
5. A Textbook of Microbiology, 4th Edn. by R C Dubey and D K Maheshwari , S. Chand Publishing.
6. Gene – VIII by B. Lewin, Pub: Jones and Barlett .
7. 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.
8. 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
9. The cell: A molecular Approach. by G.M. Cooper and R.E. Hausman

LS-415	**Practical on Bioinstrumentation, Biophysics and Biochemistry**	**2 CH**	**50 marks**
LS-416	**Practical on Microbiology and Molecular Biology**	**2 CH**	**50 marks**
	Total =	**20 CH**	**500 marks**

SECOND SEMESTER

LS-421	**Ecology, Biodiversity, and Biostatistics**	**4 CH**	**100 marks**

OBJECTIVE:

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. 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 EDUCATION OBJECTIVES (PEOs): After studying Ecology, Biodiversity and Biostatistics, the students will be able to:

PEO1. Remember and understand the basic concepts of Ecology, Biodiversity and Biostatistics.
PEO2. Analyze the relationships among different concepts of Ecology, Biodiversity and Biostatistics.
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 Ecology, Biodiversity and Biostatistics in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of Ecology, Biodiversity and Biostatistics.

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.

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, Biogeochemical 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 habitat and niche, Quantitative features and attributes of community, Community dynamics: trends and significance, Climax theory, Co-evolution of species populations in the community. Concepts of Resource: Biotic & Abiotic Resources, Renewable and Nonrenewable resources, Exhaustible and non-exhaustible resources. Resource Conservation and Management, Concept of Sustainable Development,

Unit-III:
Biodiversity: Definition, importance, Magnitude and global accumulation of biodiversity; diversification through geological time scale; Levels of biodiversity. Measurement of biodiversity: Species richness & abundances, diversity indices – Shannon, Simpson & Fisher's Alpha. Biodiversity and various ecosystem services; Valuation of ecosystems and species:. Biodiversity prospecting and indigenous knowledge systems, community biodiversity registers. Attributes of biodiversity: keystone species, flag ship species, indicator species, rare species, vulnerable species, and endangered species; Latitudinal gradients of biodiversity and mega biodiversity. Methods of biodiversity conservation (i*n situ* and e*x situ,* and germplasm conservation)
Unit-IV:

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 READINGS:

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
4. Mayr, E. 1969. Principles of Systematic Zoology. McGraw Hill Book Company,Inc., NY. 24.
5. Biostatistics: Theory and Application by G.B.N Chainy, G. Mishra, P.k. Mohanty, Kalyani Publishers.
6. Introductory practical Biostatistics by B.N.Mishra, M.K. Mishra, Naya Prokash publication, Calcutta

LS-422	**Cell Biology**	**4 CH**	**100 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 influence cell dynamics and thus survival. This paper comprises of four units, namely Cellular organization and cell organelles, 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 Cell Biology 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 as the basic structural and functional unit of living system, prokaryotic and eukaryotic cells, plant and animal cells, organization of different organelles in the cell and their interaction, mitochondria, chloroplast, endoplasmic reticulum, Golgi bodies, lysosomes and peroxisomes. Role of cell organelles during cell division and cell cycle.

Unit-II: 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-III: 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-IV: 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 READINGS:

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	**Genetics**	**4 CH**	**100 marks**

OBJECTIVE

The objective of this study is to have an understanding of the inheritance and expression of genes. Students in M.Sc. Life Sciences should have a clear concept on various terminologies used in genetics. This course will help to understand the processes responsible for maintaining the stability of the genetic material and the processes that bring about variation in genetic pool.

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

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

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

CO1. Remember and understand the basic concepts and principles of Genetics.

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: Mendelian principles: Dominance, segregation, independent assortment; Extensions of Mendelian principles: Co-dominance, 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.

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

SUGGESTED READINGS:

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-424	**Immunology**	**4 CH**	**100 marks**

OBJECTIVE: This paper contains four 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. This paper 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 nature and 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: Primary lymphoid organs, Secondary lymphoid organs in the human body, Leucocyte in immune function, Antigen: Properties of antigen, Immunogenicity, Antigenicity, haptens, Adjuvants, B-cell epitopes, T-Cell epitopes, Antigen presenting Cells, Antigen processing and presentation

Unit – II: B-Cell activation and proliferation, T-Cell activation, maturation, Humoral immune response, Cell mediated immune response, Complement System: Complement components, Complement activation, Classical pathway, Alternative pathway, regulation of complement system

Unit-III: 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-IV: 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 READINGS:

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-425	**Practical on Ecology, Biodiversity and Biostatistics**	**2 CH**	**50 marks**
LS-425	**Practical on Genetics, Cell Biology and Immunology**	**2 CH**	**50 marks**

THIRD SEMESTER

LS-511	**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, BLAST, FASTA; Sequence Database:Nucleotide Sequence Database- GenBank, EMBL, DDBJ; Protein Sequence Databases:Uniprot-KB: SWISS-PROT, TrEMBL, UniParc; Structural Database:PDB, MMDB, CATH, FSSP, DALI, SCOP;Open access bibliographic resources and literature databases: PubMed, BioMed central, public library of sciences (PloS), CiteXplore.Retrieval System:Entrez, Information Retrieval System: SRS.

Unit-II:

Sequence Alignment:Similarity and Homology, Optimal Alignment, Global Alignment, Local Alignment, Pairwise and Multiple Sequence Alignment, Alignment Scoring Scheme, Quality of Sequence Alignment, Distance and Similarity, Hamming Distance, Edit Operation, Gaps & Insertions, Scoring Matrix (PAM, BLOSUM), Dot Plots; Dynamic Programming: The Needleman and Wunsch Algorithm, The Smith-Waterman Algorithm.

Unit-III:

Phylogenetics:Methods and steps of phylogenetic analysis; Classification of phylogeny: graphs, trees and cladograms.Concept of Molecular Modelling: Patterns, motifs and Profiles in sequences; Structure classification of proteins (Primary, Secondary, Tertiary, Quaternary). Protein structure prediction (Secondary & Tertiary), Protein databank (PDB), Homology Modelling, Model Validation - SAVES Server, Ramachandran Plot.Protein-Nucleic Acid interaction. Visualization Tools.

Unit IV

Prediction Tools: Phylogenetic Trees and Phylogenetic Analysis tools, Gene Prediction tools Protein Structure & Function Prediction tools. ModellingTools: Tools for 3D Protein Modelling. Visualization Tools : iCn3D, PyMol

SUGGESTED READINGS:

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-512	**Plant Taxonomy and Morphology**	**4 CH**	**100 marks**

OBJECTIVE

Knowledge of Plant taxonomy and 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 plants life like genetics, ecology, anatomy, etc.

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

PEO1. Understand the basic the basic nature and basic concepts of Plant Taxonomy and Morphology.
PEO2. Analyze the relationships among different concepts related to tools and techniques related to Plant Taxonomy and 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 Taxonomy and Morphology in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts Plant Taxonomy and Morphology.
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 assignments as per the knowledge gained in the course curriculum.

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 of Plants

(Artificial, Natural, Phylogenetic and Phenetic). Modern methods of taxonomy such as biochemical, molecular, serological and numerical.

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

Unit-III: 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-IV: 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; Angiosperm Phylogeny Group (APG) system; Range of floral structure affinities and phylogeny of Rannales, Mangolliales, Tubifloreae and microspermeae.

SUGGESTED READINGS:

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-513	**Plant Physiology and Development**	**4 CH**	**100 marks**

OBJECTIVE

Plant Physiology deals with the study of different life processes encompassing the dynamic mechanisms of growth, development, metabolism and reproduction in plants. It serves as a theoretical basis for increasing the total productivity of plants, improving their nutritional value, and raising the quality of their produce. In order to understand the plant way of life, knowing the structure and function is crucial. Plant development is the backbone of Plant Physiology and very important for understand the various conceptss of Plant Physiology. This paper will provide valuable information on the overall process of plant growth and deep insight of the underlying physiological mechanisms for improved productivity and yield.

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

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

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

CO1. Remember and understand the basic concepts of Plant Physiology and Development.

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 assignments as per the knowledge gained in the course curriculum.

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, micro and macronutrients and role of essential elements and their deficiency symptoms in plants.

Unit-II: Photosynthesis and respiration: 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, RQ, electron transport and oxidative phosphorylation.

Unit-III: Germination and Greening: Stored genetic message in seeds. Physiological and molecular changes during germination, Biosynthesis of chlorophylls, Synthesis, targeting and assembly of LHC. Synthesis of Rubisco subunits and their assembly. Leaf development and senescence, types of senescence, physiological significance and regulation of leaf senescence by genes.

Unit IV: Regulation of Plant growth and development: Biosynthesis, storage, transport and 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. Biological clock, Biochemical signals involved in flowering, Gene regulation of floral development, Transition of flowering, floral meristem and gene regulation of floral development.

SUGGESTED READINGS:

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

LS-514 (A - D)	**SPECIAL PAPER(Any one)**	**4 CH**	**100 marks**

LS-514 (A)	**Bioenergetics and Enzymology**	**4 CH**	**100 marks**

OBJECTIVE: This paper contains four units and 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. This paper 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 and Enzymology in the curriculum, students will be able to:

PEO1. Understand the basic nature and basic concepts of Bioenergetics and Enzymology in biological systems.
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 and Enzymology 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 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: Transduction of energy in cells and types of transducers, Concept of free energy, thermodynamic principles, 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: Mechanism of enzyme catalysis; Detailed mechanism of enzyme action (lysozyme, carboxy peptidase, chymotrypsin and RNAase); Coenzymes- their catalytic role and structure; lysozymes their evolutionary and adaptive significance; Ribozyme, Multi-enzyme complexes and concerted catalysis. Enzyme kinetics, Bisubstrate reaction kinetics for Binary Complex formation and ternary complex formation.

Unit-IV: 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 READINGS:

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-514 (B)	**System Ecology and Energetics**	**4 CH**	**100 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. 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 System Ecology and Energetics in the curriculum, students will be able to:

PEO1. Understand the application of general systems theory to ecology and to study an ecosystem as a complex system exhibiting emergent properties; and also to understand the concept of laws of thermodynamics in transfer of energy in ecosystem.

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

PEO3. 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. 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 and Energetics 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. And to 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 pertaining to organism-environment complex, ecosystem productivity, quantitative ecology and Ecological modelling. And to analyze the various concepts of plant and animal energetics through case studies.

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 ecosystem and 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: 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.

Unit-III: 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. Energy flow at population level: Individual organisms and ecosystems, Energy flow studies in plant populations and animal populations;

Unit-IV: 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.

SUGGESTED READINGS:

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.
6. Ecological energetic by John Phillipson, St. Martin's Press, 1966 , pp57
7. 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
8. Energy Basis for Man and Nature by Howard T. Odum, McGraw Hill, 1981

LS-534 (C)	Microbial Physiology and Microbial Genetics	4 CH	100 marks

OBJECTIVE

Microbial Physiology and Microbial Genetics 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, genetics 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 and Microbial Genetics in the curriculum, students will be able to:

PEO1. Understand the basic the basic nature and basic concepts of Microbial Physiology and Microbial Genetics.
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 and Microbial Genetics 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 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: 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). 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).

Unit-III: 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 IV: 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. 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 READINGS:

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,4thEdition 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-534 (D)	**Cell and Radiation Physiology**	**4 CH**	**100 marks**

OBJECTIVE

Cell Physiology describes important cellular processes for sustenance of living systems. It comprises of four units such as cellular transport, cell cycle regulation, programme cell death and cellular radiation physiology. Students will study the structures and functions of basic components of animal and plant cells and understand how these cellular components are regulated in a programmed manner. How cellular components are integrated at the molecular level and how ionizing radiations influences living systems including human beings are important courses in this paper. This paper is suitable for students of both plant and animal sciences background.

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

PEO1. Understand 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, PCDin plants and animals and cellular radiation physiology.

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

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

CO4. Execute/create 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.

Unit-IV: Cellular response to ionizing radiation, target theory, single-hit and multi-hit phenomena, cell survival curves in prokaryotic and eukaryotic cells, kinetics of cell killing, Do, Dq and n, radio-sensitivity of synchronized cell populations, cell synchronized techniques, split dose technique and Elkind recovery mechanism, acute and delayed effects of radiation, radiation-exposed syndromes in human beings.

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-535	**Practical on Plant Morphology, Development, Physiology**	**2CH**	**50**

LS-536 (A - D)	**Special Paper Practical -I (A) Biochemistry, (B) Ecology, (C) Microbiology, (D) Physiology**	**2CH**	**50**

FOURTH SEMESTER

LS-541	**Genetic Engineering**	**4 CH**	**100 marks**

OBJECTIVE:

Genetic engineering basically involves recombinant DNA technology and 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. This paper is an advance level learning in Life Sciences and will help the students to make a career in modern Biology.

PROGRAMME EDUCATION OBJECTIVESS (PEOs): After studying Genetic Engineering in the curriculum, students will be able to:
PEO1. Understand the basic nature and basic concepts of Genetic Engineering.
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 Genetic Engineering in the curriculum, students will be able to:
CO1. Remember and understand the basic concepts of Genetic Engineering and their applications in Plants and animals.
CO2. Analyze the various concepts to understand them through scientific experimentations/ case studies.
CO3. Apply the knowledge in understanding practical problems in Genetic Engineering.
CO4. Execute/create 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

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; Polymerase Chain reaction, Blotting techniques: Southern, Northern, Western, Dot and Slot; Nucleic acid hybridization.

Unit- III: *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.

Unit-IV: 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). Selection and screening of transgenic plants using marker and reporter genes. Transgenic organisms and its advantages.

SUGGESTED READINGS:

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
4. Genes and Genomes by Singer and Berg
5. From genes to genome by J.Dale and M von Schantz
6. Molecular Biotechnology by Glick and Pasternak
7. Molecular Biology by Weaver
8. Molecular Cloning: A laboratory manual by J. Sambrook and E.F. Fritsch.
9. Protein Expression – A Practical Approach by Higgins and Hames

LS-542 (A - I)	**ELECTIVE PAPER (Any one)**	**4 CH**	**100 marks**

LS-542 (A)	**Cell Culture Technique**	**4 CH**	**100 marks**

OBJECTIVE: This paper contains four units and 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. This paper 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 and development of their career.

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 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: Animal cell culture: Fundamentals, Facilities and application of animal cell culture, culture media for animal cells; Properties of culture media, Advantages and disadvantages of serum in culture media; Biology & characterization of cultured cells.

Unit-II: Techniques for primary cell culture, Development and maintenance of cell lines, Monolayer vs Suspension culture, Advantages and limitations of animal cell culture; Stem cell culture & it's application.

Unit-III: Introduction: history & scope of plant cell and tissue culture, Laboratory requirements, media preparation, Somatic embryogenesis; Synthetic seeds; Haploid production (anther & pollen) & triploid production.

Unit-IV: 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 READINGS:

1. Biotechnology by B D Singh.
2. A textbook of Biotechnology by R C Dubey.
3. Plant Tissue Culture: Theory and Practice, a Revised Edition by S.S. Bhojwani and M.K. Razdan
4. Introduction To Plant Tissue Culture 3Ed by M.K. Razdan
5. Biotechnology by J E Smith.
6. Biotechnology by U Satyanarayana.
7. Plant Tissue Culture: Techniques and Experiments by Roberta H. Smith.

LS-542 (B)	**Genomics and Proteomics**	**4 CH**	**100 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 Genomics and Proteomics 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 Genomics and Proteomics in the curriculum, students will be able to:

CO1. Remember and understand the basic concepts of genetic organization and Genomics and Proteomics.
CO2. Analyze the various genome sequencing projects to understand them through Scientific experimentations/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 Genomics: Organization of Prokaryotic and Eukaryotic Genomes, C – value paradox, Organelle genomes and Endosymbiont theory, Extraction of DNA, Methods of preparing genomic DNA for sequencing, DNA sequence analysis methods-Maxam & Gilbert Method, Sanger Di-deoxy method, Fluorescence method, shot-gun approach. NGS – different methods and principles. Genome projects on E.coli., Arabidopsis and rice; Human genome project

Unit – II: Genome Analysis: Genetic and physical maps: Breeding requirements for mapping. Molecular markers - RFLP, RAPD, AFLP, SCAR, CAPS, microsatellites and SNPs, ESTs. Methods of molecular mapping, Marker assisted selection. Map-based cloning, T-DNA and transposon tagging. Differential display via RT-PCR. Micro-array in functional genomics. . Interference RNA, RNA silencing, SiRNA: Applications in Functional genomics, Medicine and Gene Knockdown. Gene Editing - Crispr Cas9

Unit – III: Protemics: Protein hierarchy, protein folding, Large scale preparation of proteins and peptides, Synthesis of peptides, use of peptides as probes. Detection of proteins on SDS gels, Protein cleavage, Edman degradation of protein . Protein extraction, Isolation, Ammonium sulphate precipitation, Protein Purification by Size exclusion chromatography, Ion-exchange Chromatography, Affinity chromatography

Unit – III: Proteome Analysis: Two-dimensional polyacrylamide gel electrophoresis, Sample Preparation, Solubilization, Reduction, Resolution, Reproducibility of 2-DE Detecting proteins in polyacrylamide gels, Image analysis of 2-DE gels. Mass spectrometry based methods for protein identification- De novo sequencing using mass spectrometric data- Correlative mass spectrometric based identification strategies, 2-DE gel electrophoresis coupled with mass spectrometry, Micro array techniques- Types of micorarrays, Designing a microarray experiment, Microarray Technology in Treating Disease. , Proteomics in drug Discovery in human

SUGGESTED READINGS:

1. Data Mining for Genomics and Proteomics: Analysis of Gene and Protein Expression Data Book by Darius M. Dziuda
2. Introduction to genomicsBook by Arthur M. Lesk
3. Genetics and Genomics in Medicine Book by Judith Goodship, Patrick Chinnery, and Tom Strachan.
4. Principles of Genome Analysis and Genomics by S. B. Primrose and R.M. Twyman, 7 th Edition, Blackwell Publishing, 2006.
5. Discovering Genomics, Proteomics and Bioinformatics by AM Campbell, LJ Heyer and Benjamin Cummings 2nd Edition. CSH Press, NY. 2007

LS-542 (C)	Medical Microbiology	4 CH	100 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 mechanisms 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 Medical Microbiology.

CO2. Analyze the various concepts to understand them through scientific experimentations/ case studies.
CO3. Apply the knowledge in understanding practical problems in Medical Microbiology.

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

COURSE:
Unit I

Basics of microbial infections: Nosocomial bacterial infections (Types of HAI, sources andreservoirs of HAI, microorganisms causing nosocomial infections), Clinicalbacterial infections (MRSA, VRE, ESBL producing bacilli, Carbapenem resistant Enterobacteriaceae, CPE),Fungal infections (Dermatomycoses: Trichophyton sp. Epidermophyton sp.), Systemic Fungal infections (Coccidiodomycetes, Candidiasis, Cryptococcosis), Opportunistic fungal infections. Emerging and Re-Emerging Viral diseases (*Bunyaviridae, Flaviviridae, Paramyxoviridae, Picornaviridae, Togaviridae, Hepadnavirida, Coronaviridae).*

Unit II

Microbial diagnostics: Bacteriology: Staining procedures in clinical microbiology, Typingmethods: Biotyping, Antibiogram typing, Bacteriocin typing, Bacteriophage typing, Nucleic acid based typing: PCR typings, Ribotyping,Plasmid profile based typing, Optical map typing, WGS typing.Mycology: Culture methods: Specimencollection, Direct microscopy, Culture of filamentous and yeast like fungi, laboratorydiagnostic tools, Non culture methods: PCR based identification of DNA from bodyfluids, Detection of glucan in blood, Galactomannan Ag testing.Virology: Sampling, Cell culture, Seropyting, Diagnostics assays, Cytopathic effect test, Genome sequencing, Isolation and identification of structural and non-structural proteins.

Unit III

Prevention and control of diseases: Principles and measures taken for infectious diseases,Biotechnologically produced vaccines, Mabs, Antibiotics, anti-metabolites, Genomeknock out programmes using CRISPER/Cas 9.

Unit IV

Microbiology and serology: Identification of microbes in specimen and culture.Serological techniques: widal, weilfelix, VDRL, HIV, HBV, CRP, RF, ASO, ELISA and CLIA, medical imaging techniques: RT-PCR, ELISA, Immunofluorescence, CT scan, PET Scan, MRI, Xray, ultrra Sound.

SUGGESTED READINGS:

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 (D)	Plant Metabolism	3 CH	50 marks

OBJECTIVE:

This paper aims to give an overview 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, Fatty acid synthase, Desaturation and elongation of fatty acids, Synthesis of unusual fatty acids, Synthesis of membrane lipids, Function of membrane lipids, Synthesis and function of extracellular lipids, Synthesis and catabolism of storage lipids, Genetic engineering of lipid

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.

Unit –IV Amino acid, Nitrogen and Sulfur Metabolism: Biosynthesis of amino acid, Catobolism of amino acid, Transamination reactions, Ammonia uptake and transport, Nitrate uptake and transport, Nitrate reduction, Nitrite reduction, Nitrate signalling, Interaction between nitrate assimilation and carbon metabolism, Sulfate uptake and transport, The reductive sulfate assimilation pathway, Regulation of sulfate assimilation and interaction with nitrogen and carbon metabolism

SUGGESTED READINGS:

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-542 (E)	**Vermitechnology**	**4 CH**	**100 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, Prospects and problems of vermitechnology.

Unit IV: Harvesting of vermicompost - quality, properties and advantages over chemical fertilizers. Packaging and marketing- cost benefit analysis. Vermiwash and its applications.Natural enemies of earthworms: Pests, parasites and pathogens affecting earthworms. Uses of earthworms in food and medicine - ayurvedic and unani. Recycling of food wastes in vermitechnology.

SUGGESTED READINGS:

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 overview of various hormones regulating to various plant processes and their regulation. The physiological effects of these hormones and mode of their action for improvement of crop yield and plant productivity will be the main focus in this paper.

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: Structure, biosynthesis and measurement of ethylene, developmental and physiological effects of ethylene, ethylene inhibitors and promoters, ethylene in seed germination and dormancy, Cellular and molecular modes of ethylene action, ethylene perception and signaling and its influence in crop growth and productivity.

Unit-IV: ABA: ABA as 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 in plants, ABA signaling and crop productivity under stressful environments.

SUGGESTED READINGS:

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 (5th Edition)1991.
3. Physicochemical and Environmental Plant Physiology. Park S. Nobel, Elsevier Science, (5th Edition) 2020.
4. Introduction to Plant Physiology. Huner NPA and Hopkins, WG. Wiley publishers, (4th 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 (D)	**Plant Metabolism**	**3 CH**	**50 marks**

LS-543 (A – D)	**SPECIAL PAPER- II (Any one)**	**4 CH**	**100 marks**

LS-543 (A)	**Structure, metabolism and Metabolic Regulation**	**4 CH**	**100 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 specialized knowledge and understanding in the regulation of Biochemical metabolism in living organisms.

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

PEO1: Understand the basic the basic nature and basic concepts of Structure, metabolism and Metabolic Regulation.

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 the Structure, metabolism and Metabolic Regulation in the curriculum, students will be able to:

CO1: Remember and understand the basic concepts of Structure, metabolism and Metabolic Regulation.

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

Unit II: 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.

Unit-III: Regulation of carbohydrate Metabolism: Reciprocal regulation of Glycolysis and gluconeogenesis, Role of Phosphofructokinase and pyruvate kinase, Pasteur effect; Cori cycle, Reciprocal regulation of Glycogenesis and Glycogenolysis, Allosteric control & covalent modification, Hormonal control by epinephrine and glucagon.

Unit-IV: Regulation of Lipid Metabolism: Reciprocal regulation of fattyacid biosynthesis and fattyacid breakdown, Role of Acetyl CoA carboxylase and insulin in fattyacid biosynthesis, Role of epinephrine and glucagon in inhibiting fattyacid biosynthesis, allosteric regulation by citrate and palmitoyl CoA.

SUGGESTED READINGS:

1. Fundamentals of Biochemistry by J L Jain.
2. Biochemistry by U Satyanarayan.
3. Lehninger Principles of Biochemtry.
4. Bichemistry by L Stryer.

LS-543 (B)	**Environmental Microbiology and Sustainable Environmental management**	**4 CH**	**100 marks**

OBJECTIVE

Students learn to integrate science with society for the overall development of the Nation. Students Are charged with the concepts to take up higher studies, set up small scale industries, develop confidence to take up challenging tasks of research in the field of Microbiology.

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

PEO1. Understand the Basic concepts of Microbiome: Microbes in terrestrial, aquatic, atmospheric and biological environments

PEO2. Analyze the significance of bioflim reactor, biotransformation, bioremediation, bioaugmentation, bioleaching etc.
PEO3: Perform procedures to develop managerial skills that allows the quality control of the environmental programs.
PEO4: Apply the scientific planning strategies required for environmental problem analysis

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

:
CO1: Remember and understand the basic concept of microbial ecology and its importance for existence of various species on the planet.
CO2: Conduct research and present findings on selected environmental sustainability topics.
CO3: Apply the knowledge for sustainable development by maintaining soil health. Besides this, they will be acquainted with the biofertilizer production technology and the bottlenecks in the technology
CO4: Execute the study in managerial, technological and policy approaches to natural resource management.

Unit I

Microorganisms as an important component of environment; Methods in Microbial Ecology (sampling, enrichment, isolation, identification and molecular analysis); Measurement microbial biomass and activity. Biofertilizers – history of biofertilizers, sources of nitrogen and the importance of biofertilizers, description and characteristics of biofertilizers. Biofertilizer production technology-strain selection, sterilization, growth and fermentation, standards and quality control, biofertilizer application technology, constraints in the commercialization of biofertilizer technology

Unit II

Plant Growth , Promotory Rhizobacteria and their metabolites. Mechanism of action for biotic and abiotic stress management, Biological Nitrogen Fixation, Biochemistry of nitrogen fixation-nitrogensae, ammonia, assimilation and transport, physiological aspects of nitrogen fixation, nodulation-early and late events, molecular biology of nitrogenase activity, Microbial interaction with plants (Rhizosphere, Mycorrhiza and root-nodule bacteria). Microbial remediation and Xenobiotic degradation. Microbial leaching

Unit III

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, 14011

Unit-IV

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 READINGS:

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 Edition by Gerard Kiely (Author) (1996), McGraw-Hill

5. Hardy, J.T. 2003. Climate Change: Causes, Effects and Solutions. John Wiley & Sons.
6. Harvey, D. 2000. Climate and Global Climate Change. Prentice Hall.
7. Barry, R. G. 2003. Atmosphere, Weather and Climate. Routledge Press, UK
8. Mitra, A.P., Sharma, S., Bhattacharya, S., Garg, A., Devotta, S. &Sen, K. 2004. Climate Change and India. Universities Press, India.
9. Soil Microbiology: Soil Microorganisms and Plant Growth by NS Subba Rao
10. Recent Advances in Plant Biochemistry by SL Mehta, ML Lodha and PV Sane

LS-543 (C)	Industrial Microbiology and Virology	4 CH	100 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: Industrial Microbiology: 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. 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.

Unit-III: Virology: 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. General features of TMV, HIV, Poliovirus, Rhabdovirus, Reovirus, Retrovirus, Adenovirus, Poxvirus). Viral evolution and emergence of new virus. 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.

Unit-IV: 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 READINGS:

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 (D)	**Stress and Crop Physiology**	**4 CH**	**100 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, water use efficiency and its manipulation for crop improvement.

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.

Unit-IV: Dynamics of crop growth and yield, harvest index, improvement of crop yield through manipulation of photosynthesis and induction of flowering, role of florigen and antiflorigen in flowering for crop productivity, modification of product traits like vitamins and iron contents, engineering plant protein composition, molecular farming of lipids, use of herbicides for crop improvement, physiological and biochemical mode of their action and strategies for engineering herbicides resistant crops, plant-pathogen interaction, biotechnological approaches to disease resistance for increased crop production.

SUGGESTED READINGS:

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-545 (A – D)	**Special Paper Practical – II (Any one)** **(A) Biochemistry, (B) Ecology, (C) Microbiology, (D) Physiology**	**2 CH**	**50 marks**

LS-546	**SEMINAR**	**2 CH**	**50 marks**
LS-547	**PROJECT WORK (3 CH) & VIVA VOCE (2 CH)**	**4 CH**	**100 marks**

Environmental studies and disaster management (In First semester)	**2 CH**	**50**
Inter-disciplinary course (Open elective) (In Second Semester)	**3 CH**	**75**
Entrepreneurship Development Programme (In third Semester)	**2 CH**	**50**
MOOCS course (One paper in Second or Third Semester)	**3 CH**	**75**