COURSES OF STUDY

M.Sc. (Botany)

SEMESTER SYSTEM
(Effective from the Session 2021-2022 onwards)

RAVENSHAW UNIVERSITY
CUTTACK

SUMMARY OF THE COURSES OFFERED IN DIFFERENT SEMESTER

Paper No	Course title	Maximum marks/Credits
	1st Semester	
Paper 1.1.1	Microbiology	50/4
Paper 1.1.2	Genetics	50/4
Paper 1.1.3	Biochemistry	50/4
Paper 1.1.4	Plant Physiology	50/4
Paper 1.1.5	Practical relating to theory papers	100/8
	2nd Semester	
Paper 1.2.1	Plant Diversity	50/4
Paper 1.2.2	Cell Biology	50/4
Paper 1.2.3	Molecular Biology & Genetic Engineering	50/4
Paper 1.2.4	Instrumentation & Analytical Techniques	50/4
Paper 1.2.5	Practical relating to theory papers	100/8
	3rd Semester	
Paper 2.3.1	Ecology	50/4
Paper 2.3.2	Conservation Biology	50/4
Paper 2.3.3	Taxonomy & Plant Pathology	50/4
Paper 2.3.4	Plant Development & Tissue Culture	50/4
Paper 2.3.5	Practical relating to theory papers	100/8
	4th Semester	
	Elective (A) Environmental Biology	
Paper 2.4.1	Environment Toxicology and Waste Treatment	100/8
Paper 2.4.2	Waste Water and Modelling	100/8
Paper 2.4.3	Project on Elective Paper	100/8
	Elective (B) Industrial Microbiology	
Paper 2.4.1	Microbial technique, Microbial Physiology and Growth	100/8
Paper 2.4.2	Bioprocess Engineering & Technology	100/8
Paper 2.4.3	Project on Elective Paper	100/8
	Elective (C) Plant Biotechnology	
Paper 2.4.1	Tissue culture, Production and Utilization of Transgenic Plants	100/8
Paper 2.4.2	Techniques in Plant Biotechnology & IPR	100/8
Paper 2.4.3	Project on Elective Paper	100/8
	Elective (D) Plant Biochemistry	
Paper 2.4.1	Amino Acids, Nucleic Acids, Databases and Enzyme Kinetics	100/8
Paper 2.4.2	Metabolism and Plant Growth Regulators	100/8
Paper 2.4.3	Project on Elective Paper	100/8

Value Added and Add On Course (Optional), Total Course duration- 30 hours

Semester	Course	Course Title	Marks
Value Added Course (Optional)			
Any Semester	VA- 01	Chlorophyll Fluorescence Analysis	50
Any Semester	VA-02	Hydroponics For Soilless Organic Cultivation Of Plants	50
Any Semester	VA-03	Hairy Root Culture As A Source Of Secondary Metabolites	50
Add On Course (Optional)			
Any Semester	AO-01	Computational Bioinformatics	50
Any Semester	AO-02	Plant Tissue Culture	50
Any Semester	AO-03	Basics Of Microbiology	50

SEMESTER I

PAPER 1.1.1: MICROBIOLOGY

50 Marks (3 hours) (40 marks end semester and 10 marks mid semester examination)

Objectives

1. To learn the classification, diversity, growth and application of microorganisms.
2. To study the general features of Archaea, Eubacteria, and viruses.
3. To learn to the mechanisms of genetic recombination in bacteria and replication of viruses.
4. To learn about the microbial toxins and their health impacts.
5. To study the transmission and pathogenicity of different microbes.

Outcomes:

On completion of the course the students shall

1. Have a general idea on the microbial world and their importance to the mankind.
2. Learn about different pathogenic microbes and their pathogenicity.
3. A detailed knowledge about the viruses and viral diseases.
4. Have knowledge on physiology and metabolisms of diverse microorganisms and their application.
5. Be able to identify the toxins and toxin producing microbes.

UNIT –I

History and development of microbiology, Whittakar's five kingdom concept, Carl Woese's 3 domain classification, rRNA sequencing study, General features of Bergy's manual for classification of microbes, Isolation, culture and maintenance of microorganisms, Microbial growth, continuous culture (chemostat), Factors influencing growth of microbes, Role of microbes in agriculture and industry.

UNIT -II

General features of Archaea, Structure, Nutrition and Reproduction of Eubacteria, Genetic recombination in bacteria (Transformation, Conjugation and Transduction), General features and pathogenecity of mycoplasma, Rickttsia and Spirochaetes.

Cyanobacteria: Cell structure and reproduction. Heterocysts: Structure, development and function

UNIT-III

Virus: General characteristics and classification of viruses, nature, morphology and chemistry of virus, transmission of virus, virus-vector relationship, replication of Bacteriophage

Plant virus- TMV, structure, transmission, pathogenicity and replication

Animal viruses - HIV, structure, transmission, pathogenicity and replication

Treatment and prevention by anti-virals and vaccine

Viroids and Prions.

UNIT –IV

Microbial toxins: types, mode of actions and pathogenicity.

Bacterial toxins: Endo and exotoxins

Fungal toxins: toxins of *Aspergillus, Penicillium, Fusarium* and *Alternaria*

Algal toxins: cyanotoxins and dinotoxins

Chemotherapeutic agents: antibiotics and their mode of action; bacterial drugs (Penicillin, fluoroquinolones, tetracycline and aminoglycosides)

PAPER 1.1.2: GENETICS

50 Marks (3 hours) (40 marks end semester and 10 marks mid semester examination)

Objectives:

1. To know general organization, possible function, and frequency of genes and non-gene DNA sequences in a typical eukaryotic genome.
2. To know the principles and application of Mendelian laws (heavily reliant on problem solving).
3. To understand the extensions of Mendelian genetics, including different forms of allelic relationships.
4. To know the types of mutations and their expression in genes and the corresponding mRNAs and proteins.
5. Inheritance of linked genes and recombination mapping.

Outcomes:

On completion of the course the students shall

1. understand organization, and function, of genes in a cell.
2. Have detail knowledge on the principles of inheritance at the molecular, cellular and organismal levels.
3. Have an understanding on the relationships between molecule/cell level phenomena ("modern" genetics) and organism-level patterns of heredity ("classical" genetics)
4. Test and deepen their mastery of genetics by applying the knowledge of mutation in varietal development.
5. Understand the basis and application of inheritance of linked genes

UNIT-I

Mendel's experiments and laws of inheritance, gene interaction with epistasis or modified mendelian dihybrid ratios: masking gene action, supplementary gene action, duplicate gene action, complementary gene action

Multiple alleles in human (ABO blood group); eye colour in Drosophila, self incompatibility in plants; Polygenic inheritance, pleiotrophy

Maternal effects and cytoplasmic inheritance, mitochondrial & chloroplast genome

UNIT-II

Sex chromosomes, Chromosomal sex determination: XX-XY, XX-XO and ZZ-ZW systems, Compound sex chromosome,

Meiotic behavior of chromosomes: Primary & Secondary non-disjunction, Genic balance theory of sex determination, Sex determination in humans and Drosophila with special reference to SRY and sex lethal genes.

Sex linkage: Sex linked genes in man, sex chromosome disorders in man, Sex influenced dominance by sex-linked gene expression.

Sex determination in plants with special reference to *Melandrium.*

UNIT-III

Linkage groups: Complete and incomplete linkage

Crossing over: Relationship between genetic and cytological crossing over, Relationship between crossing over and chaisma formation, molecular mechanism of crossing over

Detection of linkage & Linkage maps: Test cross, test for linkage on the basis of F_2 generation, LOD score, gene mapping, three-point test cross in Drosophila, construction of linkage maps, identification of particular linkage groups with specific chromosome, physical distance and map distance

Interference and coincidence

Mitotic Recombination, Recombination within gene

Unit-IV

Chromosomal aberrations: Structural and numerical alterations/ variation in chromosomes

Mutation: Spontaneous and induced mutations, physical and chemical mutagens

Meiotic behavior of deletion, duplication, inversion and translocation. Euploids and aneuploids-classification, origin, induction, role of polyploidy in evolution and practical significance in crop improvement

Population genetics: Hardy-Weinberg's Law, genetics of quantitative traits in population.

PAPER 1.1.3: BIOCHEMISTRY

50 Marks (3 hours) (40 marks end semester and 10 marks mid semester examination)

Objectives:

1. To learn the structure and biosynthesis of amino acids and proteins.
2. To have an idea on the diversity of carbohydrates and their metabolism in cells.
3. To understand the enzymes and their mechanism of catalysis.
4. To know about the importance of inhibitors and regulation for function of enzymes.
5. To know about the structural variation of lipids and their importance in cellular energetics.

Outcomes:

On completion of the course the students shall

1. Understand the biological importance of amino acids and proteins.
2. Know about various carbohydrates and their role in cellular morphology and biochemistry.
3. Understand the kinetics of enzymatic action and have skill to determine the velocity of enzyme catalyzed reactions.
4. Understand the mechanism of action of representative enzymes and determine the role of catalytic amino acids.
5. Know about the coenzymes and vitamins, lipids and their cellular functions.

UNIT-I

Amino acids: Classification and properties, Acid–base properties, The Peptide bond, ionization behavior of peptides, biologically active peptides.

Levels of protein structure, Determination of primary structure of protein. Three dimensional structure of proteins (Secondary, tertiary and quaternary structures, structural patterns: motifs and domains), Ramchandran Plot

UNIT - II

Carbohydrates: Classification, configuration and conformation of monosaccharides, sugar derivatives, important disaccharides. Structural and storage polysaccharides, glucosaminoglycans, proteoglycans, glycoproteins and glycolipids

Carbohydrate metabolism: Glycolysis, TCA cycle, pentose-phosphate pathway. Gluconeogenesis, glycogen metabolism, regulation of carbohydrate metabolism, Oxidative phosphorylation, electron transport and ATP synthesis

UNIT –III

Enzymes: General properties, nomenclature and classification, extraction and assay

Michaelis-Menten kinetics and its significance, Brigg's-Halden modification, determination of V_{max} and K_m

Mechanism of enzyme action: general acid-base catalysis, covalent catalysis, metal catalysis

Mechanism of action of RNAse, Lysozyme and Chymotrypsin

Enzyme inhibition: competitive, non-competitive inhibition, determination of K_i, allosteric regulation, covalent modification

UNIT – IV

Lipids: Classification, storage lipids, structural lipids (glycerophospholipid and sphingolipids), signaling lipids, cofactors, terpenes, and pigments.

Coenzymes and vitamins

Biosynthesis and oxidation of fatty acids, regulation of fatty acid metabolism

PAPER 1.1.4: PLANT PHYSIOLOGY

50 Marks (3 hours) (40 marks end semester and 10 marks mid semester examination)

Objectives:

1. To educates students about the mechanism and physio-chemical activities happening in the life cycle of plants
2. To learn the plant nutrient uptake and translocation to different plant parts,
3. To learn the mechanism of photosynthesis, and the diversity of carbon fixation pathways
4. To learn the processes of nitrogen assimilation and transport mechanisms.
5. To understand plant responses towards biotic and abiotic signals.

Outcomes:

1. Be able to understand the governing principles behind various physiological life processes in plants.
2. Gain knowledge on the mechanism and energetic of membrane transport processes for nutrient uptake and transport.
3. Have knowledge on photosynthesis and the evolutionary significance of plurality of carbon pathways.
4. Learn about various uptake and transport mechanisms (water and solutes) in plants and correlation among these processes.
5. Be able to understand the role of various plant hormones, signaling compounds, thermodynamics, and stress responses.

UNIT-I

Water balance in plants, water absorption and transport through xylem, active and passive transport
Transport of ions across membrane barrier, membrane transport processes,
Membrane transport proteins: water channels, H^+ - ATPase and H^+- pyrophosphatase
Mechanism of solute accumulation in vacuoles, solute transport: Phloem loading & unloading

UNIT-II

Photochemistry and photosynthesis: General concept of photochemistry, Photosynthetic pigments and light harvesting complexes, Photo-oxidation of water, mechanisms of electron and proton transport & ATP synthesis.
Carbon assimilation: C_3, C_4 cycle and the CAM pathway
Photorespiration and its significance, the glyoxylate cycle
Biosynthesis of starch and sucrose

UNIT-III

Nitrogen metabolism: Overview, biological nitrogen fixation, mechanism of nitrate uptake and reduction, nitrate and ammonium assimilation, amino acid biosynthesis.

Stress Physiology: Responses of plants to biotic and abiotic stresses, mechanism of stress resistance and tolerance, water deficit and drought stress, salinity stress, metal toxicity, freezing and heat stress, HR and SAR, oxidative stress.

UNIT-IV

Plant growth regulators: Physiological effects and mechanism of action of auxins, gibberellins, cytokinins, ethylene and abscisic acid

Photoreceptors: phytochromes, cytochromes, UV-B and their role in regulation of plant morphogenesis

Flowering: Phenomenon of flowering, photoperiodism and its significance, endogenous clock

PAPER 1.1.5: PRACTICALS

100 marks (6 hours) (80 marks end semester and 20 marks mid semester examination)

Objectives:

1. To acquaint the students with the infrastructural requirements of a basic laboratory for conduct of practical.
2. To learn the methods of media preparation, isolation and culture of bacteria and cyanobacteria.
3. To understand the basic principles of spectrophotometry.
4. To learn the methods for estimation of enzyme kinetics.
5. To learn the procedure for extraction and quantification of photosynthetic pigments and biomelecules of plant samples.
6. To learn the procedure of SDS- PAGE.

Outcome:

After the completion of the course the students shall have

1. Knowledge on basic laboratory infrastructure for conducting experiments.
2. Skill to isolate, purify and inoculate microbial strains in plates, tubes and in liquid culture flasks.
3. Understanding of the principles of spectrophotometry and skill to use spectrophotometer in biological experiments.
4. Ability to extract and quantify photosynthetic pigments and biomolecules like carbohydrates, sugars, proteins and enzymes.
5. Proper understanding of the kinetics of enzyme activities and skill to quantify the common enzymes.
6. Knowledge on the application of electrophoretic techniques in biological research.

1. General idea on instruments used in microbiology laboratory.
2. Preparation and sterilization of media (Nutrient Agar, Nutrient Broth, Czapeck-Dox), Plating, Tubing, Slanting of media.
3. Gram staining and acid-fast staining of bacteria.
4. Isolation of bacteria in pure culture.
5. Study of commonly occurring cyanobacteria.
6. Measurement of length/breadth/diameter of microbial cell/spore using ocular and stage micrometer.
7. Study of principles of spectrophotometer and verification of Beer-Lambert's law.
8. Study of plant efficiency analysis under light and temperature stress
9. Effect of substrate concentration on activity of any enzyme and determination of Km value. (Acid Phosphatase, Peroxidase, Catalase)
10. Extraction of pigment from leaves and preparation of absorption spectra for chlorophylls and carotenoids.
11. Preparation of standard curves for quantification of protein, carbohydrate and reducing sugar.
12. Quantification of soluble and total protein and total carbohydrate contents of plant samples.
13. Isolation of Chloroplast and study of protein profile of RUBISCO by SDS-PAGE.

SEMESTER II

PAPER 1.2.1: PLANT DIVERSITY

50 Marks (3 hours) (40 marks end semester and 10 marks mid semester examination)

Objectives

1. To have an understanding about distribution, salient features and life cycle of different divisions of algae.
2. To have knowledge about algal biomass production, seaweed cultivation and environmental impacts of algal bloom.
3. To learn about origin, evolution, structure and reproduction in different orders of bryophytes.
4. To have knowledge about origin, evolution, structure and reproduction of different pteridophytes and gymnosperms.
5. To have an idea about structural diversity of lower plants.

Outcomes:

On completion of the course the students shall

1. Have an idea about distribution, salient features, pigment system, reserve food, structure and life cycle of different algal groups.
2. Have an understanding of methods used, problems and future prospects associated with algal biomass production and control.
3. Have a knowledge on origin, evolution of land plants and the theories associated with the assumptions.
4. Have an idea about origin, evolution, diversity of reproductive structures of pteridophytes and gymnosperms.
5. Have an understanding on origin, evolution, diversity and life cycles of gymnosperms.

UNIT - I

Algae: Marine, Freshwater and Terrestrial algae, Food reserve, Pigment and Thallus organization

Life cycles, salient features and reproduction in Prochlorophyta, Chlorophyta, Bacillariophyta, Xanthophyta, Dinophyta, Phaeophyta and Rhodophyta.

Algal biomass production and utilization, algal blooms and their environmental impacts. Cultivation of algae, value added algal products.

UNIT-II

Bryophyta: Theories of origin (algal and pteridophytean), Ecology, Evolution and Classification, Structure and reproduction of Anthocerotales, Marchantiales, Jungermanniales, Sphagnales, and Polytrichales

Evolution of gametophytes and sporophytes in Bryophytes

Phylogenetic relationships among Bryophytes, ecological and environmental significance.

UNIT-III

Pteridophyta: Theories of origin (algal and bryophytean), evolution and classification, Structure and reproduction of Psilophyta, Lycophyta, Sphenophyta and Pterophyta. Structural diversity of sori, Soral evolution in ferns, diversity and germination of spores, Structure, morphology, evolution and significance of sporocarp.

UNIT-IV

Gymnosperm: origin, evolution and classification, phylogenetic importance
Range of reproductive structures of Cycadales, Ginkgoales, Coniferales, and Gnetales, Structural diversity of pollens in Gymnosperms,
Evolution of male and female gametophytes in Gymnosperms.

PAPER 1.2.2: CELL BIOLOGY

50 Marks (3 hours) (40 marks end semester and 10 marks mid semester examination)

Objectives:

1. To understand the basic components of prokaryotic and eukaryotic cells
2. To understand the genetic basis of life and basic mechanism of DNA replication
3. Understand how energy is used and generated in cells
4. Understand how cells undergo mitosis & meiosis

Outcomes:

On completion of the course the students shall

1. Understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.
2. Learn the details of nucleic acid synthesis and regulation.
3. Learn how these cellular components are used to generate and utilize energy in cells.
4. Able to apply their knowledge of cell biology in cell division and growth regulation.

UNIT –I

Cell Theory, Variability, Size, Shape, Complexity and functions. Molecular organization of prokaryotic and Eukaryotic cells

Plasma membrane: Composition and dynamics, membrane carbohydrates and their role in cell recognition, membrane proteins and organization of lipids & proteins.

Social context of cells: Cell junction, cell adhesion and extra-cellular matrix.

Cell inclusions: pigments molecules & nutritive materials

Cell motility: Cilia and flagella of prokaryotes.

Cytoskeleton: Microtubules, intermediate filaments and microfilaments.

Cell Wall: Structure & functions, biogenesis, growth.

UNIT-II

Nucleus: Origin, structure and function of nuclear envelope, nuclear pore complex, nucleolus & Chromatin organization and its packaging role of nuclear matrix in chromosome organization and function, matrix binding proteins.

Study of karyotype and its significance

Cell cycle: Molecular models and events. Regulators and checkpoints in cell cycle

Molecular mechanisms of cell division: Mitosis (Behavior of chromosomes, formation of mitotic spindle, Sister chromatid separation), Cytokinesis (Role of mitotic spindle in determining cytoplasmic cleavage site), Meiosis: Events & mechanism

UNIT – III

Plasmodesmata: Structure, role in movement of molecules & macromolecules, comparison with gap junctions.

Plant Vacuole: Tonoplast membrane, ATPases, transporters as storage organelle

Chloroplast: Biogenesis, structure, genome organization, gene expression, RNA editing, nucleo-chloroplastic interaction.
Mitochondria: Biogenesis, structure, genome organization.

UNIT – IV

Transport across cell membrane: Major types of membrane transport, Active transport, Co-transport, Symport, Antiport, Ion channels, Osmosis.
Macromolecular trafficking into and out of nucleus
Protein sorting: Transport of proteins into mitochondria and lysosomes.
Vesicular traffic: Coated and un-coated vesicles, Transport of secretory materials, Endocytosis.

PAPER 1.2.3: MOLECULAR BIOLOGY AND GENETIC ENGINEERING
50 Marks (3 hours) (40 marks end semester and 10 marks mid semester examination)

Objectives:

1. To understand the DNA replication mechanism.
2. To learn about the process of transcription and modification of RNA.
3. To have a critical understanding of the mechanism of translation, protein modification and gene regulation.
4. To learn about the basics of genetic engineering and its scope.

Outcome:

After the completion of the course the students shall have

1. An understanding of DNA replications and their cellular importance.
2. A clear concept about steps in transcription and post transcriptional modifications of RNA.
3. Knowledge on the mechanism of protein synthesis and protein modification.
4. Understanding of core concept of genetic engineering.

UNIT –I

DNA replication: Replication in prokaryotes, replication fork, initiation, elongation, termination, Replication in eukaryotes, D-loop model of DNA replication, DNA replication in single stranded DNA, rolling circle replication,

DNA synthesis by reverse transcription

DNA Repair: mismatch repair, base excision, nucleotide excision, direct repair, SOS repair

UNIT –II

Prokaryotic transcription: Mechanism of transcription.

Eukaryotic transcription and regulation: RNA polymerases structure and assembly, Eukaryotic promoters and enhancers, General and specific transcription factors, transcriptional repressors, mechanism of transcription regulation, Transcriptional and post-transcriptional gene silencing.

Modifications in RNA: 5'-cap formation, transcription termination, 3'-end processing and polyadenylation, splicing, editing, synthesis and processing of non-coding RNAs.

UNIT –III

Prokaryotic and eukaryotic translation: The translation machinery, mechanism of initiation, elongation and termination

Co- and post-translational modifications of proteins.

Principle of gene regulation, The Operon concept, lac- & trp-operon. Processing of tRNA and rRNA

Cell Signaling: Signaling molecules and signal receptors, second messengers, G protein coupled receptors, activation of gene transcription by G protein coupled receptors.

UNIT –IV

Scope of Genetic engineering, Milestones in genetic engineering

Molecular tools: Enzymes (Nucleases, Restriction endonucleases, Phosphomonoesterase, Alkaline

phosphatase, Polynucleotide kinase, DNA ligase, DNA polymerases, Reverse transcriptase, terminal deoxynucleotidyl transferase, Poly A polymerase), Hosts (*E. coli*, yeast, animal cells and Plant cells) and Vectors (Plasmids, Bacteriophages, Cosmids, Phagemids and artificial chromosomes).
DNA Sequencing: Sanger's technique, Maxam & Gilbert technique and automated sequencing.

PAPER 1.2.4: INSTRUMENTATION AND ANALYTICAL TECHNIQUES
50 Marks (3 hours) (40 marks end semester and 10 marks mid semester examination)

Objectives

1. To teach the students on microscopes of various complexities and their application in observation of biological samples.
2. To learn the principles and application of absorption and fluorescence spectrophotometry
3. To learn the basic principles and applications of centrifugation for separation of various macromolecules.
4. To understand the scope and utilities & various chromatographic techniques and the instrumentation thereof.
5. To Learn the methods of electrophoretic separation of biomelecules.
6. To learn the intrasample and intersample comparison of data using proper statistical methods.

Outcome:

After the completion of the course the students shall be able to

1. Understand the basic principles and operation of microscopes and learn the techniques of preparation of samples for observation under electron microscope.
2. Understand the basic principles of operation and instrumentation of absorption and fluorescence spectrophotometers and knowledge to use the techniques for analysis of biological samples.
3. Learn the methods of centrifugation and application of various types of centrifugation techniques for cell fractionation.
4. Skill to prepare, operate and interprete various types of chromatograms and blotting methods.
5. Skill to apply the knowledge of electrophoresis in biomolecules separation.
6. Skill to apply proper statistical procedure for interpretation of date and reaching an inference.

UNIT –I

Principle of operation and Instrumentation of Light, Fluorescence and Electron Microscopes

Ultraviolet-visible absorption spectroscopy: Principle, Instrumentation and application,

Fluorescence spectrophotometry: Principle, Instrumentation and application

Radioisotope techniques: Nature of radioactivity, isotopes in biochemistry, measurement of radioactivity (carbon dating, Geiger-Muller counting and liquid scintillation counting).

UNIT –II

Principles of electrochemical techniques: Electrochemical cells and reactions, potentiometry and voltametry, the pH electrode

Centrifugation techniques: Basic principles of sedimentation, Types of centrifuges, Types of rotors, Methods in preparatory ultracentrifugation (differential and density gradient centrifugation).

Chromatographic techniques: Principles of chromatography (Adsorption and Partition chromatography), Planar chromatography (Paper and Thin-layer chromatography), Column

chromatography (Gas chromatography, Gel exclusion/permeation chromatography, Ion exchange chromatography, Affinity chromatography, HPLC).

UNIT III

Electrophoretic techniques: General principles, support media, electrophoresis of proteins (SDS-PAGE, native gels, gradient gels, isoelectric focusing gels and two dimensional gels), electrophoresis of nucleic acids (Agarose, pulse-field and sequencing gels).

Blotting techniques (Southern, northern and western blotting)

UNIT –IV

Statistical Methods: Sampling methods, sampling distribution, measures of central tendency and dispersion,

Probability distribution: normal, binominal and poisson distribution. Sample homogeneity and heterogeneity analysis by binomial and poisson distribution,

Parametric and nonparametric statistics: paired and unpaired t-test and χ^2 test, analysis of variance: one factor and two factor ANOVA, linear and non-linear regression and correlation

PAPER 1.2.5: PRACTICALS

100 Marks (6 hours) (80 marks end term and 20 marks mid term evaluation)

Objectives:

1. To learn the procedure for collection and preparation of temporary and permanent slides of lower plants and their microscopic observation.
2. To learn the method of squashing and staining of mitotic and meiotic cells and determination of stages mitotic meiotic cell division
3. To learn the techniques of use of camera lucida and prepare the diagram of chromosomes and other microscopic materials.
4. To understand the statistical methods and their application for comparison among samples.
5. To learn the techniques of isolation, quantification and separation of nucleic acids.

Outcome:

After the completion of the course the students are expected to

1. Have an idea on habitats of lower plants through field survey and learn the techniques of sample collection, staining and structural differentiation of the vegetative and reproductive parts.
2. Have skill for preparing the microscopic slides taking dividing cells and identify the stages of division.
3. Learn the use of camera lucida and skill to draw diagrams of materials in the microscope of the microscopic preparation.
4. Have an understanding on the application of recommended statistical procedures and in comparison of data in samples.
5. Have ability to use different laboratory procedures for extraction, quantification and analysis of nucleic acids.

1. Study of micro and macro algae in the field and in the laboratory (preparation of temporary and permanent materials and identification).
2. Study of morphology and reproductive structures of algae belonging to different classes through permanent microscopic preparations and preserved specimens.
3. Study of temporary & permanent preparation for microscope observation of external and internal features of vegetative and reproductive structure of important genera of Bryophytes.
4. Study of temporary and permanent preparation of vegetative and reproductive structure of Pteridophytes.
5. Study of temporary and permanent preparation of vegetative and reproductive structure of Gymnosperms.
6. Squashing techniques for study of mitosis and meiosis in onion root tip and flower bud. Use of camera lucida to study chromosomes & calculating the magnification.
7. To find out mitotic index of dividing cells of Allium cepa root tips.
8. Comparative karyotypic analysis of two species of a genus.
9. Measurement of Dispersion, [Standard Deviation (SD), Standard Error of Mean (SEM), Variance] of the given plant sample

10. Statistical analysis of biological samples and study of test of significance by t-test, $\chi 2$ test, and F-test
11. Isolation of plant DNA and quantification of extracted DNA by spectrophotometric method.
12. Separation of DNA by gel electrophoresis.

SEMESTER III

PAPER 2.3.1: ECOLOGY

50 Marks (3 hours) (40 marks end semester and 10 marks mid semester examination)

Objectives:

1. To introduce the students about interaction between biotic and components of an ecosystem.
2. To learn about the nature of various natural ecosystems and their influence on the stability and diversity of species.
3. To learn the experimental and field test for estimating the diversity and satiability of an ecosystem.
4. To study the models and mechanisms of succession in natural communities.
5. To study to the characteristics and dynamism of population and the population interaction.

Outcomes:

On completion of the course the students shall

1. Have knowledge on species' geographical range and how ecosystem characteristics are influenced by the various components.
2. Understand the factors that influence geographic patterns of abundance in an ecosystem.
3. Understand the concept of ecological functioning which would certainly help students to maintain the local ecosystems.
4. Have a comprehensive idea on succession changes in natural communities.
5. Have a detailed knowledge on the population interaction from micro to macro scale and how to manipulate beneficial interactions for improving ecosystem production.

UNIT-I

Abiotic and biotic components;

Primary and secondary production, methods of measuring productivity, pattern of primary production and biomass in the major ecosystem of the world

Energy flow: sources and pattern; food chain and food web in terrestrial and aquatic ecosystems

Biogeochemical cycles - Carbon, Nitrogen, Sulphur, Phosphorus.

UNIT-II

Community ecology: nature, structure and gradient analysis, structural analysis of plant and animal community

Niche and Random Niche model of species association

Species diversity in ecological gradient, Experimental and field test of diversity-stability Hypothesis, Ecotone and edge effect

Competition theory and coexistence

Succession - models of succession (monoclimax and polyclimax theories), Mechanism of succession in natural communities - facilitation, tolerance, and inhibition

Plant communities association

UNIT-III

Population ecology: Basic concept, population characters, biotic potential.
Kinetics of population growth, population growth curves, laws of population growth, regulation of population density, limiting factors of population growth, population fluctuation
r & k selection,
Population interactions: positive and negative interactions, interspecific relationship
Population regulation: competitive exclusion, density dependent and independent regulation

UNIT-IV

Environmental pollution: Kinds and sources of pollutants, classification of pollutants,
Soil pollutants: sources, types, and effects; modification of plant productivity by soil pollution, effects on soil microflora.
Water & Air pollutants: fates and effects, role of plants for pollution control,
Global climate change, green house effect, ozone depletion- causes and effects.

PAPER 2.3.2: CONSERVATION BIOLOGY

50 Marks (3 hours) (40 marks end semester and 10 marks mid semester examination)

Objectives:

1. To understand the concept and values of plant biodiversity.
2. To know about the status and causes of biodiversity loss.
3. To have a clear knowledge about the IUCN categories of threat to biodiversity.
4. To study and understand the various strategies for conservation of biodiversity.
5. To understand the biodiversity act.
6. To understand the origin, evolution and domestication of cultivated plants and to know their wild relatives.
7. To create awareness about importance of plants and plant products in daily human life and value of ethnobotany.

Outcome:

After the completion of the course the students shall be able to

1. Develop understanding of the concept and scope of plant biodiversity.
2. Identify the causes and consequences of loss of biodiversity.
3. Utilize skills to manage plant biodiversity.
4. Apply various strategies for the conservation of biodiversity.
5. Have critical understanding on the provisions of Biodiversity Act.
6. Develop the understanding about distribution and importance of wild relatives in crop improvement.
7. Conceptualize the role of plants in human welfare and have skill to prepare strategies for biodiversity conservation.

UNIT -I

Biodiversity: Concepts and level (α, β, γ), importance of biodiversity, status of biodiversity in India, assessment of biodiversity, major causes of biodiversity loss and its impact, biodiversity hot spots of India and world, IUCN categories of threat, red data book, convention of biological diversity (CBD), salient features of biodiversity Act.

Agrobiodiversity: Concept of diversity in domesticated species (land races, advanced cultivars, wild relatives of cultivated plants, wild plants), Economic value of agrobiodiversity. Causes of erosion and management for food security, Governance of agrobiodiversity

UNIT-II

Conservation: Strategies for *in situ* Conservation: Protected areas, wildlife sanctuaries, national parks, biosphere reserve, strategies for *ex situ* conservation: botanical gardens, field gene banks, seed banks, *in vitro* conservation, DNA banks, national and international strategies for conservation of plant genetic resources, sustainable development in biodiversity, Biodiversity and the 2030 Agenda for Sustainable Development.

UNIT-III

Plant resource and utilization: Origin and domestication of cultivated plants, world centres of diversity of domesticated plants, plant introduction, primary, secondary centres of origin and diversity of crop plants, origin, evolution and wild relatives of food crop (rice and pigeon pea), fibre (cotton & jute) and oil-yielding crops (groundnut), sugar and biomass crop (sugarcane), fruits (mango).

UNIT-IV

Ethnobotany and forest products: basic principles and scope, uses of medicinal and aromatic plants, cultivation and trade of medicinal plants, important firewood and timber yielding plants, collection, trade and management of non-wood forest products, plants used as avenue trees for shade, and aesthetics, plants used in sericulture and biodiesel production, joint forest management and stake holders responsibility.

PAPER 2.3.3: **TAXONOMY AND PLANT PATHOLOGY**

50 Marks (3 hours) (40 marks end semester and 10 marks mid semester examination)

Objectives:

1. To know the general basis of taxonomy and the rules of ICN for correct nomenclature of taxa.
2. To know about the modern techniques for identification and classification of plants
3. To learn phonetic, phylogenetic and molecular classification of plants.
4. To learn the taxonomic diversity through knowledge on representative families
5. To have a basic understanding on the fungi and fungal diseases.

Outcomes:

On completion of the course the students shall

1. Be able to correctly identify the taxa and make correct nomenclature following ICN
2. Have an idea on the importance of both morphology and modern systems for classification of plants
3. Have an understanding on the modern tools of taxonomy for building the taxonomic hierarchy.
4. Have skills to identify plants on the basis of the morphological characters.
5. Be able to know the general bases of plant diseases caused by biotic agents and major infective crop diseases with severe economic impact.

UNIT-I

Nomenclature: The species concept, delimitation of taxa and attribution of ranks, salient features of ICN, Typification, Priority and its limitations, effective and valid publications, herbarium methodology, modern tools for herbarium specimen repository, specimen digitization, important herbaria of the world.

Phenetic and phylogenetic systems of classification, relative merits and demerits of major system of classification (Benthem & Hooker, Engler-Prantl, Hutchinson, APG system)

UNIT –II

Cladistics in taxonomy: Conceptual lineage, parallelism and convergence, cladistics in classification of plants

Embryology, cytology and phytochemistry as taxonomic tools.

Molecular taxonomy: Molecular markers in phylogenetic studies, ideal marker genes, nuclear, mitochondrial and chloroplast markers.

UNIT- III

Plant families: Phylogenetic relationship

Range of floral structures in major dicot groups: Ranales, Asterales, Lamiales, and Leguminales

Range of floral structures in monocot groups: Poales, Scitaminae and Orchidales

UNIT-IV

Fungi: Structure and reproduction of Phycomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes. Mitosporic fungi, Degeneration of sexuality in fungi, Fungal nutrition, heterothallism, heterokaryosis. Application of fungi in industries, agriculture and medicine.

Plant Pathology: Disease symptoms, modes of infection and dissemination, disease resistance and defense – morphological and biochemical basis, host-parasite relationship.

PAPER 2.3.4: PLANT DEVELOPMENT AND TISSUE CULTURE

50 Marks (3 hours) (40 marks end semester and 10 marks mid semester examination)

Objectives:

1. To understand the mechanism of shoot, root, leaf, flower and fruits development in plants.
2. To get knowledge about the development of pollen and ovule and pollen-pistil relation.
3. To have an in-depth knowledge about fertilization, and development of embryo and endosperm.
4. To understand various techniques of plant tissue culture.
5. To have an understanding of methods for gene transfer in plants.

Outcome:

After the completion of the course the students are expected to

1. Develop an understanding of concepts and fundamentals of differentiation and development of different plant organs.
2. Have in-depth knowledge of reproductive biology of angiosperms.
3. Have an understanding on the process of embryo development.
4. Learn the methodology of tissue culture and its importance.
5. Have knowledge about the production of transgenic plants.

UNIT – I

Differentiation and development: Plant cell development with its unique features.

Development of shoot and root apical meristem, leaf development and phyllotaxy, vascular tissue differentiation of root, shoot & leaf, transition to flowering, floral development & homoeotic mutants in *Arabidopsis* Fruit development and ripening process.

Metabolic changes associated with senescence and its regulation.

UNIT – II

Male gametophyte: Structure of anthers, microsporogenesis, pollen development, male sterility, pollen germination, pollen tube growth and guidance, pollen storage, pollen embryos.

Female gametophyte: Ovule development, megasporogenesis, structure and organization of the embryo sac, pollination mechanisms and vectors.

UNIT -III

Structure of pistil, pollen - pistil interactions,

Self incompatibility in plants: cytological, biochemical and molecular aspects,

Double fertilization and endosperm development: types, development and maturation

Embryogenesis: structure and development of monocot, dicot and grass embryos

UNIT-IV

Plant tissue culture: Laboratory requirements and general techniques involved tissue culture, plant regeneration by axillary shoot proliferation of nodal explants, direct adventitious organogenesis, callus mediated organogenesis, somatic embryogenesis, artificial seeds, protoplast isolation, culture,

techniques of fusion, and production of somatic hybrids, methods for gene transfer in plants (*Agrobacterium* - mediated & direct gene delivery).

PAPER 2.3.5: PRACTICALS

100 Marks (6 hours) (80 marks end term and 20 marks mid term evaluation)

Objectives:

1. To make the anatomical sections of plant parts and their microscopic observation.
2. To gain practical knowledge of reproductive biology of angiosperm by studying different types of ovules, endosperms and embryos.
3. To know the methods to study the morphology and taxonomic description of plant species of different families of monocots and dicots.
4. To study the different methods used to study relationship between two ecological variable and to estimate the biomass, frequency, density of a species of a grassland community.
5. To study different techniques to check various parameters of different types of water samples.
6. To gain knowledge about the economic importance of plants and plant parts.
7. To learn the basic techniques of plant tissue culture.
8. To gain practical knowledge about different plant pathogen by microscopic observation of anatomical structure of the infected plant parts.

Outcome:

After the completion of the course the students are expected to

1. Know the process of preparation of temporary and permanent slides for microscopic study of anatomical structure of angiosperm.
2. Have practical knowledge about the different types of ovules, endosperms and embryos.
3. Have knowledge and ability for accurate plant identification and nomenclature.
4. Have knowledge to estimate the biomass, frequency, density of a species of a grassland community.
5. Learn the techniques for checking the quality of water samples.
6. Have knowledge on the economic importance of the local plant diversity and their sustainable use.
7. Have sufficient knowledge about the techniques of plant tissue culture.
8. Have knowledge to identify the infected plant from their morphology and anatomy of the infected plant parts.

1. Study of living shoots apices by dissection using Hydrilla plants
2. Study of cytological zonation in the shoot apical meristem (SAM) by preparing L. S of *Coleus* shoot apex and making permanent slides with double stained procedures
3. Study of wood anatomy through temporary and permanent slides
4. Study of different types of ovules, endosperm, and embryos in permanent slide preparation
5. Study of *in vitro* pollen morphology, germination and pollen tube growth
6. Collection, description and identification of locally available wild angiospermic taxa pertaining to nomenclaturally important category
7. Description of various species of a genus and preparation of a key at generic level
8. Finding out the relationship between two ecological variable using correlation and regression analysis.

9. Determination of minimum size and number of quadrants required for reliable estimates of biomass in grassland
10. Determination of frequency, density of a species of a grassland community
11. To estimate dissolved oxygen, chloride, CO_2, acidity and alkalinity content in eutrophic and oligotrophic water samples by Winkler's method
12. Preparation of a short list of ten most important sources of firewood and timber of the locality. Give their local names, scientific names and families to which they belong. Mention their characters.
13. Preparation of tissue culture media.
14. Techniques of surface sterilization and plant regeneration via organ culture.
15. Production of synthetic seeds.
16. Study of common pathogens of plant (fungi, bacteria, mycoplasma) with anatomy of infected parts.
17. Collection, identification and preservation of common plant diseased materials of the locality.
18. Temporary and permanent preparation for microscopic observation of external features, internal structures and reproductive structures of important genera belonging to fungi.
19. Study of biodiversity and important flora of Odisha and India through field trips.

SEMESTER IV
ELECTIVE (A): ENVIRONMENTAL BIOTECHNOLOGY

PAPER 2.4.1: ENVIRONMENTAL TOXICOLOGY AND WASTE TREATMENT
100 Marks (Time: 3 hours) (80 marks end semester and 20 marks mid semester examination)

Objectives:

1. To know the concept of toxicity, toxicity assessment and mechanism of toxicant action.
2. To understand the process of bioaccumulation, and its kinetics in different environment.
3. To understand the pathways and mechanisms of degradation of toxicants.
4. To know about the pesticides and their fate in different environments.
5. To understand the fundamentals of the enzymatic basis of toxicant transformation.

Outcomes:

On completion of the course the students shall

1. Have proper understanding of the toxicity and the aquatic toxicity assessment strategies using various test batteries.
2. Learn about different causes of bioaccumulation of metals, organic toxicants and pesticides and strategies of its prevention.
3. Understand the pathways for biodegradation of organic pollutants and the importance of co-metabolic degradation.
4. Know about pesticide transformation in soil and water and the associated regulating factors.
5. Learn about roles of different enzymes in toxicants biodegradation and skill to manipulate the condition for accelerated toxicant removal.

UNIT -I

Aquatic toxicity assessment: concept of toxicity; mechanism of toxicant action; dose, effect and response; analysis of response curves; statistical doses of toxicants;

Selection of test batteries, media, apparatus and facilities, liquid media and sediment toxicity assessment, microtox acute toxicity test; toxicity test by luminescent and fluorescent bacteria, algae, zooplankton and macrophytes, microplate toxicity test,

UNIT -II

Bioaccumulation: Concept and measurement, food chain and lipophilicity approach, quantitative structure activity relationship, kinetics of uptake and retention, factors affecting bioaccumulation.

Bioaccumulation of metals: metal accumulation by flora and fauna; biosorption, phytofiltration, phytochelation and phytoextraction; role of metalphores,

UNIT -III

Biodegradation of organic pollutants: Microbial processes for degradation; measurement of biodegradability; aerobic and anaerobic degradation of carbohydrates, proteins and lipids, aliphatic hydrocarbons, aromatic hydrocarbons

Catechol, resorcinol and phloroglucinol pathways, degradation of halogenated organics, co-metabolic degradation, degradative capacity of fungi

Fate of pesticides in the environment; fundamental reaction of pesticide metabolism; microbial transformation of pesticides-oxidations, decarboxylation, dealkylation, halogen reaction, aromatic ring cleavage, hydrolysis and nitrate reduction

UNIT -IV

Enzymes in pesticide degradation - CytP450 monooxygenase, esterases, LIPs and Glutathione-S-transferase.

Microbial uptake and removal of metal, Extracellular and intracellular complexation, metal exclusion.

Molecular basis of metal tolerance; phytochelatin and siderophore mediated metal sequestration, Bioleaching and recovery of copper, gold and uranium

PAPER 2.4.2: WASTE MANAGEMENT AND MODELING

100 Marks (Time: 3 hours) (80 marks end semester and 20 marks mid semester examination)

Objectives:

1. To learn about the solid wastes and the processes for treatment, disposal and reuse.
2. To understand the process of wastewater treatment and recycling.
3. To know the energy environment and the potential of non-conventional energy.
4. To learn the methods for modeling of ecosystems and function prediction.

Outcomes:

On completion of the course the students shall

1. Develop a proper understanding of the potential of solid wastes and the processes used to reuse.
2. Clearly understand the importance of protection of surface waters and maximize the water reuse and recycling.
3. Know diversity of energy sources and skill to plan the harvesting and use of alternate energy.
4. Understand the mathematical models for ecosystem analysis and skill to develop the predictive models.

UNIT -I

Solid waste processing technology: Sources and types of solid wastes, components of solid waste management, sanitary land filling-biological processes, leachate control and treatment, site management, aerobic composting-non-reactor and reactor composting, vermin composting: methods, production and harvest, anaerobic digestion of wastes-biochemical basis, dry and wet fermentation, treatment of hazardous wastes, biomedical waste management.

UNIT -II

Wastewater treatment and disposal: eutrophication-causes, effects and control

wastewater treatment processes, biological treatment of wastewater oxidation, nitrification, denitrification, role of biofilm, biological removal of phosphorus, secondary treatment systems-conventional and high rate biofilters, rotating biological contactors, activated sludge, nutrient removal through biomass production.

UNIT -III

Energy management: Biomass, bioenergy and biofuels, biofuel-opportunities and challenges, feedstocks and production, cellulosic biofuel feedstocks, biomass production-single and multiple species approach, dedicated energy crops, biohydrogen production.

UNIT-IV

Modelling of environmental systems: Mathematical tools in development of an ecosystem model, modelling elements, components of mathematical models, system variables and forcing functions; sensitivity analysis; model calibration and validation, predictive and precise models. Nutrient and biomass models of lake ecosystems

PAPER 2.4.3: PROJECT WORK

100 marks (Thesis 80 marks + Presentation 20 marks).

Objectives:

1. To learn the methods in the field of environmental biotechnology and their application in mitigation of environmental problems.
2. To prepare a project relevant to address the environmental issues.
3. To identify the knowledge gap in any field of the environment.
4. To plan an experiment and the hypothesis for the same.
5. To learn the process of analysis and interpretation of data.

Outcomes:

On completion of the course the students shall

1. Have ability and skill to identify the current environmental issues and analyze the published research in the field.
2. Know the methods and the selection of appropriate ones for solving a definite environmental issue.
3. Understand basic techniques and use them to achieve the objectives of research.
4. Have ability to formulate a research hypothesis and design experiment.
5. Have knowledge on data interpretation.

ELECTIVE (B): INDUSTRIAL MICROBIOLOGY

PAPER 2.4.1: MICROBIAL TECHNIQUE, MICROBIAL PHYSIOLOGY AND GROWTH
100 Marks (Time: 3 hours) (80 marks end semester and 20 marks mid semester examination)

Objectives:

1. To learn the strategies for isolation, preservation and maintenance of important industrial microbes.
2. To know the techniques of strain selection, strain improvement and strain stability maintenance.
3. To learn the methodologies for large scale production of industrially important enzymes of microbial origin.
4. To know about the modes of microbial nutrition so as to establish healthy microbial culture.
5. To understand the microbial growth kinetics in different culturing systems.

Outcomes:

On completion of the course the students shall

1. Learn the theory and skill for isolation, preservation and maintenance of important industrial microorganisms
2. Have the knowledge for taxonomic identification, ribotyping and lipid profiling that would enhance their skill to select proper microbe for industrial use.
3. Understand the pure culturing methods, mechanisms of enzyme production, enzyme purification and immobilization.
4. Have knowledge on application of microbes for processes such as nitrate reduction, denitrification and sulphate reduction
5. Have a proper understand of the microbial growth kinetics and nutrient utilization efficiency in different culture systems for optimization of the industrial fermentation.

UNIT –I

General concept and scope of industrial microbiology; Isolation, preservation and maintenance of important industrial microorganisms. Strain improvement: Strain improvement strategies, strain selection and strain stability; Microbial taxonomy: microbial phylogeny derived from ribosomal RNA sequences, classical taxonomy, chemotaxonomy (DNA DNA hybridization, ribotyping, and lipid profiling).

UNIT-II

Microbial techniques: Different types of culture media, pure culture methods (isolation and maintenance), enrichment culture, and isolation of DNA.

Microbial enzymes: Sources of enzymes, selection of microorganisms, mechanism of enzyme biosynthesis, large scale production and enzyme recovery, enzyme assay, enzyme production by microbes (α-amylase, Cellulases, Proteases and Lipases), enzyme immobilization.

UNIT-III

Microbial Physiology: Bacterial photosynthesis (photosynthetic pigments and their location in the cell, anoxygenic photosynthesis, oxygenic photosynthesis, CO2 fixation), microbial nutrition (photoautotrophs, photoorganotrophs, chemolithotrophs and chemo-organotrophs), nitrate reduction and denitrification process, sulphate reduction.

UNIT -IV

Microbial growth: Cell growth and population growth, bacterial cell division, Growth kinetics: Concept and mathematics of exponential growth, growth cycle, measurement of microbial growth (direct and indirect measurement methods), Batch, Fed-batch and continuous culture system, monitoring microbial growth in culture, factors affecting microbial growth.

PAPER 2.4.2: **BIOPROCESS ENGINEERING & TECHNOLOGY**

100 Marks (Time: 3 hours) (80 marks end semester and 20 marks mid semester examination)

Objectives:

1. To introduce the bioprocessing techniques like fermentation largely used in the industries.
2. To study about the antibiotics and vaccine usage and their production procedure.
3. To know about the harmful microorganisms responsible for food borne diseases and measures for their control.
4. To know the importance of environmental bioremediation and the microbial processes involved.
5. To learn the mode of transport and action of the antibiotics and the antibiotic resistance in microbes.

Outcomes:

On completion of the course the students shall

1. Understand the processing techniques used in the industries for production of antibiotics, alcohols, amino acids and various milk products.
2. Have knowledge on the importance of antibiotics and vaccines and their production and mode of action.
3. Have ability to identify pathogenic microorganisms and their mode of growth and propagation.
4. The have a better understanding of the bioremediation and resource generation from wastes.
5. Understand the delivery mechanism of antibiotic and also its mechanism of action.

UNIT -I

Industrial products: Production of primary and secondary metabolites, production of alcohols (ethanol and butanol), lactic acid, acetic acids and citric acids; Microbial production of amino acids (Glutamic acid and tryptophan); Food and beverages fermentations: milk products (Yoghurt and cheese), brewing, wine and vinegar fermentation; Production of antibiotics (Penicillin), Vaccines, recombinant therapeutic peptides and proteins.

UNIT-II

Application of microbial enzymes in food industry. Food borne infections and intoxications: bacterial with examples of infective and toxic types–Clostridium, Salmonella, Shigella, Staphylococcus, Campylobacter. Mycotoxins in food with reference to Aspergillus species. Quality assurance: Microbiological quality standards of food. Food Preservation Methods: Radiations- UV, Gamma and microwave, Temperature, Chemical and naturally occurring antimicrobials.

UNIT –III

Bioremediation- process and organisms involved; Constraints and priorities of bioremediation. Bioaugmentation: Ex-situ and in-situ processes; Intrinsic and engineered bioremediation; Factors affecting the Bioremediation process; Biotransformation of heavy metals and xenobiotics, Petroleum biodegradation; waste water treatment, Bioconversion of lignocellulosic waste.

UNIT –IV

Antibiotics and synthetic antimicrobial agents. Mechanism of action of antibiotics (inhibitors of cell wall synthesis, nucleic acid and protein synthesis). Bacterial resistance to antibiotics. Mode of action of non – antibiotic antimicrobial agents. How the antimicrobial agents reach the targets (cellular permeability barrier, cellular transport system and drug diffusion).

PAPER 2.4.3: PROJECT WORK
100 marks (Thesis 80 marks + Presentation 20 marks).

Objectives:

1. To learn the laboratory methods in the field of microbiology and their application.
2. To prepare a project relevant to apply microbes in the environment and industry.
3. To understand the application potential of microbes through experiments.
4. To plan an experiment and select proper organism.
5. To learn the methods for analysis and interpretation of data.

Outcomes:

On completion of the course the students shall

1. Have ability and skill to understand the industrial potential of microbes.
2. Know the methods and the selection of appropriate organism for industry and for solving an environmental problem.
3. Have a basic knowledge on the techniques and use them in the experiments.
4. Have ability to formulate a research hypothesis and design experiment.
5. Have knowledge on data interpretation.

ELECTIVE (C): PLANT BIOTECHNOLOGY

PAPER 2.4.1: TISSUE CULTURE, PRODUCTION AND UTILIZATION OF TRANSGENIC PLANTS

100 Marks (Time: 3 hours) (80 marks end semester and 20 marks mid semester examination)

Objectives:

1. To study about the basic process and requirements of Plant Tissue culture.
2. To learn about the culture of different types of tissues and cells and their application
3. To learn about Agrobacterium mediated, direct and indirect gene transfer in plants
4. To learn the techniques for developing transgenic plants and their application in crop improvement
5. To study about Metabolic engineering for metabolites and industrial products

Outcomes:

On completion of the course the students shall

1. Have knowledge about methods of plant tissue culture, organogenesis and somatic embryogenesis and their application in crop improvement.
2. Be able to understand the process of protoplast isolation, fusion and culture, selection of hybrid cells and regeneration of hybrid plants
3. Learn the method of gene transfer for developing transgenic plants
4. Gain knowledge on transgenics for herbicide resistance, resistance to biotic stress abiotic stress and other quality improvement
5. Gain knowledge on metabolic engineering for augmentation of secondary metabolite biosynthesis and their industrial potential.

UNIT -I

Plant tissue culture: Major pathways of plant tissue culture and their application: meristem culture, organogenesis and somatic embryogenesis, *Ex vitro* rooting, plant acclimatization

Applications: embryo culture and embryo rescue, anther and microspore culture for production of haploids and development of homozygous lines, production of somaclonal variants, cell suspension culture for secondary metabolite production, cryopreservation and slow growth for germplasm conservation.

UNIT -II

Vector-mediated Gene Transfer to plants: features of Ti and Ri plasmids, molecular mechanism of T - DNA transfer, role of virulence genes, binary and co-integrate vectors, protocol for *Agrobacterium*-mediated genetic transformation. Hairy root cultures as source of pharmaceuticals.

Vectorless / direct gene transfer to plants: Physical methods (particle bombardment, electroporation, microinjection, liposome mediated, silicon carbide fibers), chemical methods (PEG - mediated, calcium phosphate co-precipitation), precision of transgene integration by site-specific recombination.

UNIT -III

Selection & analysis of transgenic lines and progenies: Promoters and terminators, selectable markers and reporter genes, detection of transgene and products, enzyme activity assay (GUS, NPT), transgene stability, Production of marker free transgenic plants.

Transgenic manipulations for crop improvement: Herbicide resistance (phosphinothricin, glyphosate), resistance to biotic stress (insects & fungal pathogens), quality improvement (vitaminA in cereals, longer post-harvest life of flowers and fruits). Molecular farming: Carbohydrates (case study-starch), proteins (Hirudin production in *Brassica napus*).

UNIT -IV

Chloroplast Engineering: Chloroplast genome, chloroplast transformation: rationale, methods used for generation of homoplasmic transplastomic plants, vectors for chloroplast transformation, transplastomics without antibiotic resistant gene, applications of chloroplast transformation. Biosafety regulations and commercialization.

Antisense RNA technology: Regulatory RNA (micro RNA), Antisense RNA, construction of antisense vectors, analysis of antisense clones, applications of antisense technology. Gene silencing: causes (DNA methylation, homology-dependent suppression by antisense gene), CRISPAR-Cas9, strategies for avoiding gene silencing and it's application.

PAPER 2.4.2: TECHNIQUES IN PLANT BIOTECHNOLOGY & IPR

100 Marks (Time: 3 hours) (80 marks end semester and 20 marks mid semester examination)

Objectives:

1. To study about the scope of recombinant DNA technology and learn the basic processes.
2. To learn the principle and mechanism of action of plasmid, DNA isolation and purification and amplification
3. To study the modern methods in plant biotechnology.
4. To understand the Protein engineering
5. To learn modern methods of molecular analysis
6. To understand the Processing of recombinant proteins.
7. To understand the Intellectual property rights (IPR) and Plant genetic resources

Outcomes:

On completion of the courses the students shall

1. Have knowledge in the Recombinant DNA technology and Genetic Engineering.
2. Understand the mechanism of action of different vectors used in genetic engineering.
3. Have knowledge the principle and application of PCR, and other equipment in genetic engineering.
4. Gain knowledge about basics and application of genetic engineering.
5. Be able to use SDS-PAGE, 2-D Gel electrophoresis, mass spectrometry (MALDI-TOF), NMR, and X-ray crystallography
6. Understanding the scope and application of Protein engineering.
7. Learn about the plant genetic resources and their proper protection and management.

UNIT -I

Techniques in Molecular Biology: Recombinant DNA technology*;* Genomic DNA & plasmid DNA isolation and purification, Vectors - plasmids, phages, cosmids, shuttle vectors, artificial chromosomes, plant viruses and other advanced vectors, construction of recombinant DNA and plant expression cassettes, Transformation selection and analysis of recombinant clones, Chromosome walking, genomic DNA and cDNA libraries. Maps using YACs, BACs and *in situ* hybridization. Gene tagging: Transposable genetic elements in bacteria, IS elements, composite transposon, Class I & II transposable elements in eukaryotes, T-DNA tagging. Concept and features of DNA microarray.

UNIT–II

Processing of the recombinant proteins: Purification and refolding; characterization, stabilization. Analysis of proteins: SDS-PAGE, 2-D Gel electrophoresis, mass spectrometry (MALDI-TOF), NMR, X-ray crystallography, Mutagenesis: tools for protein engineering; site saturated and site-directed mutagenesis. Proteomics: Resolution & characterization of recombinant proteins, post-translational modifications, protein chips, protein- protein interactions.

UNIT -III

Protein and nucleic acid databases (PDB, Swiss Port, BRENDA, NCBI and PlantGDb).

Sequence annotation and biological data mining, concept of phylogenetics
Protein-protein interaction databases (Types, methods and applications)
Structure and Function analysis of Proteins/Enzymes (Rubisco, Carbonic Anhydrase)
Protein visualization tools and its application

UNIT –IV

DNA-based markers: Molecular markers based on DNA restriction-hybridization (RFLP), PCR (RAPD, SSR, ISSR, SNP) and combination approach (AFLP), characterization of genetic diversity and phylogenetic relationship, marker assisted selection for plant breeding.

Intellectual Property Rights (IPRs) and Patents: IPRs, classification, rationale for protection of IPRs, patents-concept and patenting of biological material, Farmer's and breeders right's, plant varietal protection and farmer's right act.

PAPER 2.4.3: PROJECT WORK

100 marks (Thesis 80 marks + Presentation 20 marks).

Objectives:

1. To learn the methods in the field of plant biotechnology and their application in plant improvement.
2. To formulate a research problem relevant to the present need.
3. To identify the knowledge gap.
4. To plan an experiment and and protocol for laboratory work.
5. To learn the process of analysis and interpretation of data.

Outcomes:

On completion of the course the students shall

1. Have ability and skill to collect information in the field and analyze the published research.
2. Have a clear understanding of the methods and the selection of appropriate method for experiment.
3. Understand basic biotechnology techniques and use them to achieve the objectives of research.
4. Have ability to formulate research hypothesis and design experiment.
5. Have knowledge on data interpretation.

ELECTIVE (D): PLANT BIOCHEMISTRY

PAPER 2.4.1 AMINO ACIDS, NUCLEIC ACIDS, DATABASES AND ENZYME KINETICS
100 Marks (Time: 3 hours) (80 marks end semester and 20 marks mid semester examination)

Objectives:

1. To educates students about forms of amino acids and their structural complexity.
2. To learn the biophysical and cellular folding mechanisms
3. To understand the functional properties of proteins and enzymes.
4. To learn the background of bioinformatics and their application in the field of biology.

Outcomes:

On completion of the course the students shall

1. Be able to understand the biochemical structural and functional complexity of amino acids, proteins and enzymes.
2. Understand the importance of the structural integrity of proteins and enzymes.
3. Know the mechanism of enzyme regulation by various chemical and biomelecules and their application.
4. Be able to understand the design and function of various databases and bioinformatic resources and their application in solving biological problems.

UNIT -I

Amino acid synthesis: Synthesis of amino acid of α-ketoglutarate family, 3-phosphoglycerate precursor family, oxalo-acetate and pyruvate family, PEP erythrose-4-phosphate precursor family, Ribose-5-phosphate precursor family.

Feedback control of amino acid biosynthesis: sequential, concerted and cumulative feedback control

Amino acid catabolism (transamination, oxidative deamination and urea cycle).

UNIT-II

Protein folding: chaperon, chaperonin – Strucutre and function

Unfolded protein response.

Protein degradation pathways: lysosomal and proteosomal pathway (ubiquitin/sumo pathway). Autophagy.

Protein folding (biophysical and cellular mechanism)

GroEL-ES complex in plants

UNIT-III

Concept of catalysis

Enzyme Kinetics: Theories, Concept, methods of investigation

Uni and Bi-substrate kinetics, Sequential and Random ordered kinetics.

Enzyme Inhibitors, Approaches to the Rational Design of Enzyme Inhibitors: transition-state analogues, mechanism-based inhibitors, affinity labels.

Application of enzymology

UNIT-IV

Protein and nucleic acid databases (PDB, Swiss Port, BRENDA, NCBI and PlantGDb).
Sequence annotation and biological data mining, concept of phylogenetics
Protein-protein interaction databases (Types, methods and applications)
Structure and Function analysis of Proteins/Enzymes (Rubisco, Carbonic Anhydrase)
Protein visualization tools and its application

PAPER 2.4.2 METABOLISM AND PLANT GROWTH REGULATORS

100 Marks (Time: 3 hours) (80 marks end semester and 20 marks mid semester examination)

Objectives:

1. To learn the mechanism of synthesis and degradation of nucleotides.
2. To study the regulatory systems in nucleotide biosynthesis.
3. To understand the metabolism and synthesis of different carbohydrates in plants.
4. To know about the plant secondary metabolites and their therapeutic importance.
5. To learn about the plant growth regulators and their role in plant growth and development.

Outcomes:

On completion of the course the students shall

1. Understand the biosynthetic pathways of nucleotides and the regulation of their synthesis.
2. Know about the importance of regulation of nucleotide biosynthesis in plant development.
3. Understand the carbohydrate dynamics in plants and the enzymatic basis of its regulation.
4. Learn about various secondary metabolites and their role in plant defense.
5. Have knowledge on plant growth regulators and their application.

UNIT-I

Nucleotide biosynthesis: De-novo synthesis of purine and pyrimidine, Salvage pathway, Synthesis of deoxy-nucleotides. Synthesis of nucleotide triphosphates.

Degradation of nucleotides: catabolism of purines and pyrimidines.

Regulation of nucleotide biosynthesis and chemotherapeutic targeting.

Plant Transcriptional factors (functional domains and regulation) and their importance in plant development

UNIT-II

Carbohydrate metabolism in plants: Introduction and general overview

Sucrose metabolism pathway: synthesis, regulation and breakdown in plants. Sucrose-starch conversion

Starch structure and metabolism

Cellulose synthesis, Cellulose Synthase Complex in plants-structure and function

Carbon concentration mechanism in plants

UNIT-III

Secondary metabolite synthesis pathways in plants: importance and function

Alkaloids, Folates, Tannin and Lignin biosynthesis pathway. Defensive resins synthesis in conifers.

Biosynthetic pathways of important medicinal compounds (Taxol, artemisinin)

Metabolite analysis: Extraction, Separation and Purification methods

UNIT-IV

Plant grown regulators: Synthesis and physiology of auxin, gibberellins, cytokinins, Ethelene and ABA.
Concept of hormonal receptors, Auxin transporters
Biochemistry of seed germination
Application of growth regulators in agriculture and horticulture

PAPER 2.4.3: PROJECT WORK

100 marks (Thesis 80 marks + Presentation 20 marks).

Objectives:

1. To learn the method of collection of information in the field of biochemistry.
2. To design a research problem and formulate research hypothesis.
3. To define the gap in the knowledge in the selected research problem.
4. To plan an experiment and collect the data.
5. To learn the process of analysis and interpretation of data.

Outcomes:

On completion of the course the students shall

1. Have ability and skill to understand the published findings and identifying the gap.
2. Have a clear understanding of the importance of laboratory experience for a knowledge on scientific problems.
3. Be able to plan a research proposal and identify the objectives of research.
4. Have ability to formulate research hypothesis and gather experimental information in the support.
5. Have knowledge on data interpretation and ability to draw and experimental conclusion.

VALUE ADDED COURSES (OPTIONAL)

PAPER- VA-01: CHLOROPHYLL FLUORESCENCE ANALYSIS

Course duration- 30 hours, 50 Marks (Course-wise evaluation) (Exam Time: 3 hours)

Objectives:

1. To learn the scope and application of natural and artificial fluorescence and their biological importance.
2. To understand the basis of emission and excitation spectra.
3. To understand chlorophyll a fluorescence kinetics with short, medium and long exposure to light.
4. To have knowledge on JIP fluorescence and ability to analyse the fluorescence spectra.
5. To learn the principles and measurement of the electron transport.

Outcomes:

On completion of the course the students shall

1. Understand the characteristics of natural pigments and synthetic dyes with regard to their absorption and fluorescence properties.
2. Have knowledge on the light absorption and emission.
3. Develop skills to measure fluorescence using spectrofluorometer and ability to interpret the emission spectra.
4. Have knowledge on the energy transfer in the photosystems and JIP-fluorescence rise.
5. Skill to use PEA and MPEA and to analyse the fluorescence spectra and skill to quantify the bioenergetic parameters and interpret the data.

UNIT - I

Fluorescence spectrophotometry: Definition, scope and measuring principles. Spectrofluorimeter-design and function. Chlorophyll and phycobiliprotein fluorescence. Fluorescence ratios as biological tools; room temperature and low temperature fluorescence kinetics; Fluorescence dyes; Absorption and emission spectra; bioapplications.

UNIT - II

Chlorophyll *a* fluorescence: Definition, excitation and emission spectra. Concept of excitation energy transfer; FRET; Energy transfer in LHC; Electronic vibration states; Jablonsky principles; Kautsky effect; Fast and delayed fluorescence, OJIP fluorescence rise-Principles and applications; Native and differential fluorescence spectra.

UNIT- III

Plant efficiency analysis, Principle and application of PEA and MPEA: PSI - absorption changes, water-PS-NADP+ electron transport, Bioenergetic parameters - Performance indicating and stress indicating parameters: End reaction performances; Efficiency analysis, Dissipation function, Performance analysis of OEC; PS I , PS II and whole chain electron transport measurement.

PAPER- VA-02: HYDROPONICS FOR SOILLESS ORGANIC CULTIVATION OF PLANTS

Course duration- 30 hours, 50 Marks (Course-wise evaluation) (Exam Time: 3 hours)

Objectives:

1. To study about Introduction Soilless Organic Cultivation, types, importance of Cultivation of plants under Hydroponic condition.
2. To learn about the Physical parameters affecting growth of Hydroponically Cultivated plants.
3. To study about various Nutrition medium for Hydroponic Cultivated plants.
4. To know about Precaution and troubleshoot of Cultivation of plants under Hydroponic condition.
5. To understand about disease and pest management and management of waste Nutrient Solution
6. To learn about the future prospective of Hydroponic Cultivation of Commercial plants.

Outcomes:

On completion of the course the students shall

1. Have knowledge about the types, methods and importance of Hydroponic Cultivation of plants. Have clear understanding how the physical parameters affect the growth of Hydroponically Cultivated plants.
2. Have ability to understand the Processing and modification of RNA.
3. Gain knowledge about different Nutrition medium for Hydroponic Cultivated plants.
4. Be able to describe the precaution and how to troubleshoot of Cultivation of plants under Hydroponic condition.
5. Be able to describe the Disease and pest management of hydroponic plants
6. Have knowledge about future prospective of Hydroponic Cultivation of Commercial plants.

UNIT - I

Introduction of Soilless Organic Cultivation, Types of Soilless Cultivation, Importance of aquaculture or Hydroponic Cultivation of plants, Current status of Hydroponic Cultivation in Indian Scenario, Bic principle of Hydroponic Culture, Different types of Hydroponic Cultivation Techniques: Raft Systems, Top Feed/Drip System, NFT (Nutrient Film Technique), Vertical growing.

Unit - II

Physical parameters affecting growth: Temperature, Light, Humidity. Nutrition medium for Hydroponic Cultivation of plants. Growing Substrates, Chemical Management of Nutrient Availability in the Hydroponic Solution, Nutrient Chemical Forms and Uptake Processes, Nutrient- nutrient Interactions, Use of Nanoparticles, Plant Growth-Promoting Rhizobacteria in Hydroponic Solutions, Realtime Monitoring of Hydroponic Solutions via Sensors: TDS. pH, DO etc.

Unit - III

Precaution and Troubleshoot of Hydroponic Cultivation: Contaminant control, Algal growth control, Microorganism control, Oxygen control, Flow of nutrient control. Deficiency management of macro and micro nutrient. Disease and pest management. Management of waste Nutrient Solution. Future prospective of Hydroponic Cultivation of commercial plants.

PAPER-VA 03: HAIRY ROOT CULTURE AS A SOURCE OF SECONDARY METABOLITES

Course duration- 30 hours, 50 Marks (Course-wise evaluation) (Exam Time: 3 hours)

Objectives:

1. To study the adventitious root induction and proliferation
2. To know the different method for hairy root initiation and applications
3. To compare the different types of secondary metabolites using different techniques.

Outcomes:

1. This course will provide a platform to prevent the overexploitation of plants having root importance in the natural habitat.
2. Secondary metabolites can be useful for Pharma companies/ Drug industries.
3. Students will aware about the instruments used for secondary metabolite estimation.

Unit-I

Plant Derived Chemicals: Primary metabolites and secondary metabolites, origin, types, structure and function; Morphological and chemical differentiation; secondary metabolites as a source of defence to biotic and abiotic stresses. Industrial applications

Unit-II

Methods for Secondary Metabolite Production: Plant cell, tissue & organ culture; Shoot culture, Root culture Callus culture, Cell suspension culture, Somaclonal variations etc. Hairy root culture using *Agrobacterium rhizogenes* (Protocol for Ri plasmid incorporation, integration and expression). Biochemical (opine analysis) and molecular characterization (PCR with *rol* gene primers).

Methods to enhance the production of secondary metabolites: Metabolic engineering, Precursor feeding, Biotransformation and Mass multiplication using bioreactor.

Unit-III

Different Methods for Extraction of Secondary Metabolites: Multi-elemental analysis by EDXRF and EPIXE techniques, qualitative phytochemical and antimicrobial analysis, quantification by TLC, HPLC, HPTLC and identification by NMR. Institutes involved in this work (IMMT, IOP & NISER Bhubaneswar, CIMAP / CDRI, Lucknow etc.)

ADD ON COURSES (OPTIONAL)

PAPER- AO-01: COMPUTATIONAL BIOINFORMATICS

Course duration- 30 hours, 50 Marks (Course-wise evaluation) (Exam Time: 3 hours)

Objectives:

1. To educates students regarding the interdisciplinary application of biological sciences and information sciences.
2. To study on the algorithms and computational systems in biological sciences and solve biological problems.
3. To have an idea on programming language to biology background students will be helpful in picking career in the exciting world of bioinformatics

Outcome:

On completion of the course the students shall

1. An understanding of the integration of biological and information science for deciphering complex biomelecules.
2. Be able to use computer software for comparison and data interpretation.
3. have additional understanding on the algorithms and programming concepts to students to gain knowledge in the interdisciplinary field of bioinformatics.

UNIT-I

Definition of Identity Substitution Matrix, Amino Acid substitution matrix - concepts of PAM and BLOSUM Matrix. Pairwise Alignment, Concept of Global vs Local Alignment - The Dot plot, The Needleman-Wunsch and The Smith-Waterman Alignment. BLAST - Types and Use, Multiple Sequence Alignment and its application.

UNIT-II

Definition of Phylogeny and Phylogenetics, Concept of molecular clocks, Types of Trees and Tree construction. Terms and Terminology in phylogenetics, Cladograms and Dendrograms, Classes and Types of Tree generation methods, Use of MEGA Packages in Phylogenetics.

UNIT-III

Definition of Programming and Algorithms. Different types of machine languages, Python language and its application in computation bioinformatics, Fundamentals of Python - Variable names, Data Types, Operators and Strings. Fundamentals of visualization tools in structural biology. Use of Pymol tool.

PAPER-AO 02: PLANT TISSUE CULTURE

Course duration- 30 hours, 50 Marks (Course-wise evaluation) (Exam Time: 3 hours)

Objectives:

1. To know the about the plant tissue culture techniques and its practical applications.
2. To understand the requirement for setting up a tissue culture laboratory.
3. To know the commercial aspects of plant tissue culture.

Outcomes:

On completion of the course the students shall

1. Ability to understand the basic of plant tissue culture methods and application for crop improvement.
2. Gain knowledge to develop a startup facilities using tissue culture techniques.
3. Be able to understand the economics of the process and know its potential.

UNIT-I

Introduction to plant tissue culture: Laboratory organization and requirement, Sterilization (Heat, wet, chemical and filter), Culture media and its composition, Role of macro- and micronutrients, vitamins, amino acids, carbon sources and gelling agents in tissue culture, Plant growth regulators and their uses in plant tissue culture, Preparation of culture media.

UNIT-II

Micropropagation: Micropropagation vs Macropropagation, Stages of micropropagation, selection of plants and explants, proliferation of shoot, rooting of shoots, acclimatization; Maintenance: Culture and Environmental factors; Tissue culture of elite/ ornamental/ medicinal plants. National Certification System for Tissue Culture Raised Plants (NCS-TCP). Commercial aspects of plant tissue culture.

UNIT-III

Practical/ Demonstration: Plant tissue culture laboratory equipment, Sterilization of plasticwares, glassware and other accessories, Preparation of stock solution and culture media, Readiness of Laminar airflow cabinet for aseptic culture work, Plant propagation techniques: Collection and sterilization of explants, Inoculation of explants and sub-culture techniques, *in vitro* and *ex vitro* rooting, Plant acclimatization.

PAPER-AO 03: BASICS OF MICROBIOLOGY

Course duration- 30 hours, 50 Marks (Course-wise evaluation) (Exam Time: 3 hours)

Objectives

1. To introduce the students to the early inventions and discoveries, which helped in establishment of Microbiology as a separate discipline.
2. To introduce the students to the classification of amazing diversity, growth and application of microorganisms.
3. To introduce the students to the general features of Archaea and Eubacteria.
4. To introduce the students to the algal, fungal and bacteria toxin and their pathogenicity.

Outcomes

On completion of the course the students shall

1. The content would provide the necessary information on microbial world and their importance to the mankind.
2. Students would learn the morphology and habitats of different types of microbes and their interaction for co-existence.
3. The students shall know the characteristics of Archaea and Eubacteria and their importance to the ecosystems.
4. The students shall have an ides on the diversity of microbial toxins and their impact on human health.

UNIT-I Introduction to Microbiology

Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming; Role of microorganisms in fermentation; Germ theory of disease; Development of various microbiological techniques and golden era of microbiology; Contributions of Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A.Waksman; Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner.

UNIT-II Microbes and Our surroundings

Environmental microbiology: Definitions of environment and examples of important microbes in soil, water and sediments covering the planet and their role in biogeochemical cycling. Microbial flora of water: Water pollution, role of microbes in sewage and domestic waste water treatment systems. Microorganisms as indicators of water quality. Microbes in agriculture and remediation of contaminated soils: Biological fixation; Mycorrhizae; Bioremediation of contaminated soils

UNIT-III Microbial Interactions

Microbe interactions: Mutualism, synergism, commensalism, competition, amensalism, parasitism, predation Microbe-Plant interaction: Symbiotic and non-symbiotic interactions Microbe-animal interaction: Example of common human diseases and their causative agents.

Suggested Reading Books:

1. Brock Biology of Microorganism, M T Madigan, JM Martinko and J parker, Prentice Hall.
2. Microbiology, M J Jr Pelzar, ECS Chan and N R kreig, Tata Mc Graw Hill.

SUGGESTED READING

FIRST SEMESTER

1. Basic Experimental microbiology. Ronald M Atlas, Alfred E. Brown, Kenneth W. Dobra. Lionas Miller- Prentice Hall
2. Fundamentals of Bacteriology. Sake A.J., Mc Graw Hill
3. Brock Biology of Microorganisms-Magdigan M.T. Martinako, J.M. Parker, J.- Prentice Hall.
4. Microbiology. Pelczar M. J, Chan E.C.S., Kreig N.R, -McGraw Hill.
5. Modem Microbiology, Bridge F.A - WMC Brown Publisher. Oxford, England
6. General Microbiology, Stainer RY., Ingharam J.I., Wheelis M.I., Printer P.R, Mc Millan Education Ltd.
7. Experimental Microbiology Laboratory Guide, Robert c., Cros, Kalyani Publishers Ludhiana
8. Discussion in Cytogenetics. Dumham CR. Burgass publishing Co. Minnosota
9. Human Genetic Concept and Application. Lewis. WCB McGraw Hill
10. Cytogenetics of Aneuploids. Khush SS. Academic press New York London.
11. Genetics Principles and Analysis. Hartl DL and Jones EW. Jone and Barteet Publishers Massachusetts USA.
12. Principles of Genetics. Sunsted DP and Sunpens MJ. John Willey and Sons Inc. USA
13. Fundamentals of Genetics, Singh BD. Kalyani Publishers, New Delhi
14. Cytogenetics. Gupta PK Kalyani Publishers, New Delhi
15. Genes and molecular Biology Concepts and Experiments. Karp G. John Wiley and Sons, USA
16. Genetics. Russe PJ. The Benarnin Curuning Publishing Company Inc, USA
17. Essential of Biochemistry, Satyanarayan U and Chandrapani v., Books and Allied (P) Ltd.
18. Molecular Cell Biology, Lodish H., Berk A, Zipurskt S.L., Matsudaire P., Baltimore D and Darnell 1. W.H., Freeman and Co. New York, USA
19. Genetics. Strickberger MW. Prentice-Hall of India Private Limited, New Delhi.
20. General Biochemistry: J.H. Well, New Age International Pvt. Ltd.
21. Genes IX, Lewin B, Oxford University Press, London
22. Photosynthesis Energy transduction, Hipkins M.F. and Baker N.R, IRL Press, Washington D.C.
23. Lehninger's Principles of Biochemistry, Nelson D. and Cox M, Macmillan Worth Publishers
24. Biochemistry, Stryer-W.H. Freeman & Co

SECOND SEMESTER

1. Algae, Vashistha B.R, S. Chand and Company, New Delhi.
2. Fungi, Vashistha B.R, S. Chand and Company, New Delhi.
3. Bryophyta, Vashistha B.R, Sinha AK. and Kumar A, S. Chand and Company, New Delhi.
4. Pteridophyta. Vashistha B.R, S. Chand and Company, New Delhi.
5. Gymnosperm. Vashistha P.C., S. Chand and Company, New Delhi.
6. Molecular Biology of the Cell. Albert B, Bary D, Lewis J, Raff M, Roberts K and Watson JD Garland Science (Taylor & Francis group).
7. Molecular Cell Biology. Damell J, Lodish H and Baltimore D. Scientific American Books, Inc.
8. Gene IX. Lewin B. Oxford university press, New York, U.S.A

9. Cell and Molecular Biology. Rastogi Sc. New Age international Publisher, New Delhi
10. Molecular Biology of the Cell. Alberts, B Bary D. Lewis, Raff M, Roberts, K and Watson, J.D. Garland. Wolfe S.L.
11. The Diversity of crop plants, Hawkws 1.G., Havard University Press, London.
12. Rosaceae in India, Dikshit B.K and Panigrahi G., Bishen Singh and Mahendrapal Singh Publishers, Dehradun.
13. Taxonomy of Angiosperms, Sambamurthy AVSS, IK International Publishers, New Delhi.
14. Economic Botany, Hill A.F., Tata McGraw Hill Ltd., New Delhi.
15. Economic Botany, Pandey H.P., Silver Line Publications
16. Molecular and Cellular Biology. Words Worth Publishing Co. California, USA
17. Gel electrophoresis of proteins, Dunn M.J., Bios Scientific Publishers, UK.
18. Plant Biotechnology, the genetic manipulation of plants. Adrian Slater, Nigel Scott and Mark Fowler. Oxford University Press.
19. Plant Cell, Tissue and Organ Culture, Fundamental Methods. Gamborg O.L. and Phillips G. C. (Editors). Narosa Publishing House.
20. Plant Tissue Culture: Theory and Practice, Bhojwani S.S. and Razdan M.K, Elsevier.
21. Introduction to Plant Biotechnology, Chawla. H.S., Oxford & IBH Publishing Co. Pvt. Ltd.
22. From Genes to Genomes, Concepts and Applications of DNA technology. Dale J.W and Yon Schantz M. John Wiley and Sons Ltd.
23. Introduction to instrumentation in life sciences, by Anjana Sharma, Prakash Singh Bisen, Publisher**:** Taylor & Francis Inc

THIRD SEMESTER

1. An introduction to Mycology. Mehrotra, RS, New Age Intermediate Press.
2. Introduction to Soil Science, Das D.K, Kalyani Publishers, New Delhi.
3. ICBN. Greuter et. al. Koetz Scientific books, Germany.
4. Statistical Proceedings for Agricultural Research. Gomej A.A and. Gomej KA, Wiley,USA.
5. Introduction to Practical Biostatistics, Misra B.N. & Misra M.K, Naya Prakash, Cuttack
6. Statistical Analysis, Zar J.H., Pearson Edition, Singapore
7. Plant Embryogenesis, Suarez M.F & Bozhkov P.Y., Humana Press, New Jersey.
8. Marine Eutrophication in Perspective, F.de. Jong, Springer, Germany.
9. Environmental Chemistry, Sharma B.K, Goel Publishing House. Meerut.
10. Biodiversity: an Introduction. Gaston KJ. and Spicer 1.1, Blackwell Science Ltd.
11. Biodiversity and Conservation. Gabriel Melchias. Oxford & IBH Publishing Co. Pvt. Ltd.
12. An Advanced Textbook on Biodiversity, Principles and Practice. Krishnamurthy KV., Oxford Publishing Co. Pvt. Ltd.
13. The Embryology of Angiosperms, Bhojwani, S.S. and Bhatnagar, S.P., Vikaas Publishing House, New Delhi.
14. An Introduction to Plant Structure and Development- Beck, Cambridge University Press; 2 edition (May 1, 2010)
15. Plant Science: Growth, Development, and Utilization of Cultivated Plants, Margaret E. McMahon , Anton M. Kofranek, Vincent E. Rubatzky - Prentice Hall

16. Mechanisms in Plant Development, Ottoline Leyser, Stephen Day (Author) - Blackwell Science Ltd.;

FOURTH SEMESTER

1. Biochemistry and Molecular Biology of Plants. Buchanan. B.B. guissem, W. and Jones RL. American Society of Plant Physiologist, Maryland, USA
2. Plant Metabolism Dechis, D.T. Turpin, D.H., Lefebvre, D.D. and Layzell, D.B (EDS), (Second Edition) Longman, Essex, England
3. Life Processes in Plants Galston, A W. Scientific American Library, Springer - Verlag, New York, USA
4. Concepts in Photobiology Photosynthesis and Photomorphogenesis Singhal, G.S. Renge, G., Sopory, S.K Irrgang, KD. and Govingjee. Narosa Publishing House, New Delhi
5. Introduction to Plant Physiology. Hopkins. W.G. John Wiley & sons. Inc., New York, USA
6. Molecular Cell Biology, Lodish, H. Berk, Azipurskt S.L. Matsudaire, P. Baltimore, D and Darnell, J., W.H. Freeman and Co. New York, USA
7. Plant Physiology, Salisbury F.B. and Ross C.W., Words Worth Publishing Co. California, USA
8. Plant Physiology, Taiz,L and Zeiger, E., Sinauer associate. Inc Publishers Massachusetts, USA
9. Introductory Plant Physiology, Noogie, C.R and Fritz, G.J, , Prentice Hall
10. Introduction of Plant Biochemistry, Goodwin T.W. & Mercer, E.I, Pergamon Press, New York
11. Advanced Plant Physiology, Wilkins M.B., ELBS
12. Biochemistry and Molecular Biology of Plant Hormones, HooyKaas P.J.J., Hall M.A and Libbenga KR (EDS), Elsevier, Amsterdam, The Netherlands.
13. Biochemistry and Plant Physiology of Plant Hormones, Moore T.C., Springer-Verlag New York, USA
14. Photoperiodism in Plant, Thomas B. and Vince-Prrune, D., Academic Press, San Diego, USA
15. Biochemistry, Stryer, Freeman W.H. & Co.
16. Aspects of Flora development, Leins P. Tucker S.C and Enress P.K, 1. Crammer, Germany
17. Photosynthesis Energy transduction, Hipkins M.F. and Baker N.R, IRL Press, Washington D.C.
18. Pesticide Microbiology, Hill I.R and Wright SJL, Academic Press, California.
19. Gel electrophoresis of oroteins. Dunn M.J. Bios Scientific Publishers. UK.
20. Text book of environmental Microbiology, Mohapatra P.K., IK International Publishers, New Delhi.
21. Environmental Biotechnology: Concepts and applications, Jordening J.H and Winter J., Wiley-VCH, Germany.
22. Biopesticides: Use and delivery, Hall F.R &. Menn J.J, Humana Press, New Jersey.
23. Harmful Cynobacteria: Huisman J., Matthijs HCP & Visser P.M., Springer, Germany.
24. Microbial Enzymes and biotransformations, J.L. Bawedo, Humana Press, New Jersey.
25. Salinity: Environment-Plant-Molecules, A. Uiuchii & U. Liittge, Kluwer Academic Publisher, Dordrecht
26. Biofuel: Special volume of *in vitro* cellular and development biology-Plants. 2009 (Volume 45), Springer, Germany.

27. Integration of Ecosystem Theories: A pattern, S.E. Jorgensen, Kluwer Academic Publisher, Dordrecht
28. Plant Biotechnology, the genetic manipulation of plants. Adrian Slater, Nigel Scott and Mark Fowler. Oxford University Press.
29. Plant Cell, Tissue and Organ Culture, Fundamental Methods. Gamborg O.L. and Phillips G.e. (Editors). Narosa Publishing House.
30. Introduction to Plant Biotechnology. Chawla H.S. Oxford & mH Publishing Co. Pvt. Ltd.
31. From Genes to Genomes, Concepts and Applications of DNA technology. Dale IW. And Von Schantz M. John Wiley and Sons Ltd.
32. Plant Tissue Culture: Theory and Practice. Bhojwani S.S and Razdan M.K., Elsevier.
33. Introduction to Bioinformatics. Lesk M., Oxford University Press.
34. Biochemistry and Molecular Biology of Plants, Buchanan. B.B., Guissem, W. and Jones RL., American Society of Plant Physiologist, Maryland, USA
35. Molecular Cell Biology, Lodish, H., Berk, A., Zipurskt S.L. Matsudaire, P. Baltimore, D and Darnell J., W.H. Freeman and Co. New York, USA
36. Practical Application of Plant Molecular Biology, Henry R J., Cuapmman and Hall
37. Annual Review of Plant Physiology and Molecular Biology, annual review of Biochemistry, Academic Press
38. Lehninger Principles of Biochemistry, D. Nelson and M. Cox, Macmillan Worth Publishers
39. Biochemistry, Stryer, W.H. Freeman & Co.
40. Principles of Fermentation Technology, Stanbrurry P.F., Whittaker, A & Hall S.J. Pergamon Press