Model Curriculum for Three/Four Year Degree Course

(With Multiple Entry /Exit Option)

Based on NEP-2020

BOTANY

Odisha State Higher Education Council, Bhubaneswar

Government of Odisha

Contents

Programme Outcome:

- To prepare the students for a career in Botany
- To prepare the students for Higher Education and Research in Botany
- To develop a conceptual understanding of the subject and to develop an inquisitiveness in the subject.
- To enable the student to acquire basic skills necessary to understand the subject and to master the skills to handle equipment's utilized to learn the subject.
- To generally promote wider reading on the subject and allied inter disciplinary subject.

Core I **Semester-I**

Microbiology and Phycology

Course Objectives:

- To introduce the diverse group of microorganisms and their habitat relationship.
- To learn the discovery, nature and multiplication of virus particles.
- To know the characteristics, growth and physiology of bacteria and their role in agriculture, health and industry.
- To learn the general characteristics and ecological distribution of bacteria, algae and cyanobacteria and their immense importance to the mankind.
- To have knowledge about the habitats, distribution and diversity of algae in the soil, freshwater and marine environments.

Course Outcomes

- The students learn about the diverse nature of microbes and their interaction with other organisms.
- The students certainly get the opportunities to learn the basics of the nature and impact of viruses.
- The students shall be able to understand the potential of various microbes and the approaches to use them for human welfare.
- The students would be able to identify the important microbes including bacteria, cyanobacteria, and algae available in local environments and understand their beneficial roles.
- The students shall learn about the immense potential the algal resources and understand the methods of cultivation and use of algae.

Unit-I:

Learning Outcome: The learners are able to identify diverse group of microorganisms, general features of viruses and their economic importance**.**

- The microbial world, microbial nutrition, growth and metabolism.
- Viruses**:** Discovery, nature, physicochemical and biological characteristics; classification (Baltimore), general structure with special reference to viroids and prions; replication (a general account), DNA virus (T-phage), lytic and lysogenic cycle; RNA virus (TMV). Economic importance of viruses. Vaccine production, role in research, medicine and diagnostics. Viral plant diseases- symptoms, effect and control

Unit–II:

Learning Outcome: The students understand the growth, physiology and economic importance of bacteria and cyanobacteria.

- Bacteria**:** - Discovery, general characteristics, types- archaebacteria, eubacteria, mycoplasma and spheroplasts, Cell structure, inclusions, nutrition, reproduction- vegetative, asexual and recombination (conjugation, transformation and

transduction). Economic importance of bacteria with reference to their role in agriculture, medicine and industry.

- Cyanobacteria**:-** Ecology, occurrence, cell structure, heterocyst, reproduction, economic importance; role in biotechnology. Morphology and life-cycle of *Nostoc*. General characteristics of prochlorophyceae, Evolutionary significance of Prochloron.

Unit–III:

Learning Outcome: The students able to grasp the general characteristics, ecological distribution and economic importance of algae and Chlorophyta.

- **Algae:-** General characteristics; Ecology and distribution; range of thallus organization; Cell structure and components; cell wall, pigments, reserve food (of only groups represented in the syllabus), flagella; methods of reproduction. Classification; criteria, system of Fritsch, and evolutionary classification of Lee (only upto groups); Role of algae in the environment, agriculture, biotechnology and industry.
- **Chlorophyta:-** General characteristics, occurrence, range of thallus organization, cell structure and reproduction. Morphology and life-cycles of *Chlamydomonas*, *Volvox*, *Oedogonium* and *Coleochaete*.

Unit-IV:

Learning Outcome: The students will able to understand the general characteristics, ecological distribution and economic importance of algae and cyanobacteria.

- **Charophyta:-** General characteristics; occurrence, morphology, cell structure and life-cycle of *Chara*; evolutionary significance.
- **Xanthophyta:-** General characteristics; Occurrence, morphology and life- cycle of *Vaucheria*.
- **Phaeophyta:-**Characteristics, occurrence, cell structure and reproduction. Morphology and life-cycles of *Ectocarpus* and *Fucus*.
- **Rhodophyta:-**General characteristics, occurrence, cell structure and reproduction. Morphology and life-cycle of *Polysiphonia*.

Practicals:

1. Electron micrographs/Models of viruses –T-Phage and TMV, Line drawings/ Photographs of Lytic and Lysogenic Cycle.
2. Types of Bacteria to be observed from temporary/permanent slides/photographs.
3. Examination of bacteria from bacterial culture by Gram's staining method.
4. Electron micrographs of bacteria, binary fission, endospore, conjugation, root Nodule (live materials and photographs).
5. Bacterial growth measurement by turbidometry
6. Hemocytometry

7. Colony counting using colony counter
8. Phycology: - Study of vegetative and reproductive structures of *Nostoc*, *Chlamydomonas* (electron micrographs), Volvox, *Oedogonium*, *Coleochaete*, *Chara*, *Vaucheria*, *Ectocarpus*, *Fucus* and *Polysiphonia*, *Procholoron*, Diatoms through, temporary preparations and permanent slides

Text Books:

- ✓ *Singh, V., Pandey, P.C., and Jain, D.K. (2017). Microbiology and Phycology, Rastogi Publication, Meerut.*
- ✓ *Pandey BP (2022). Botany for B.Sc. Students (Archigoniates & Plant Architecture), S. Chand publication, New Delhi*
- ✓ *Dubey RC & Maheshwari DK (2021) A text book of Microbiology, S. Chand publication, New Delhi*
- ✓ *Pandey BP (2023). Botany for B.Sc. Students Semester I, NEP 2020; S. Chand publication, New Delhi*

Reference Books:

- ✓ *Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.*
- ✓ *Prescott, L.M., Harley J.P., Klein D. A. (2010). Microbiology, McGraw-Hill, India. 8th edition.*
- ✓ *Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.*
- ✓ *Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.*
- ✓ *Pelczar, M.J., Chan, E.C.S., Krieg, N.R. (2011) Microbiology, 8th edition, Tata McGraw-Hill Co, New Delhi.*
- ✓ *Willey, Sherwood and Christopher. Laboratory exercises in Microbiology. McGraw- Hill, India. 9th edition.*
- ✓ *Vasistha B.R. (2017) Botany for Degree student, Algae, S. Chand Publication, New Delhi.*
- ✓ *Mishra B. K. (2018) Microbiology and Phycology, Kalyani Publishers, New Delhi.*

Core II **Analytical Techniques in Plant Sciences**

Course Objective

- To learn the principles and operations of microscopes of various complexity and their application in biological studies.
- To learn the techniques of centrifugation for separation of biological samples.
- To learn the methods of radioisotopes measurement in and their importance in study of biological materials and processes.
- To understand and the principles and applications of spectrophotometry and to understand the basic structural design of a standard instrument.
- To learn about various chromatographic techniques in separation of plant extracts.
- To acquaint the students with the advanced methods for characterization of biomolecules

Course Outcomes:

- Proper understanding of the microscopy and knowledge to analyze plant samples using electron microscopy and flow Cytometer.
- Separation of biomolecules and cell organelle and appropriate application of the knowledge of centrifugation for the same.
- Basic knowledge on the use of radioisotopes for analysis of biological samples.
- Extraction and qualitative and quantitative analysis of extracts as well as the assay mixtures using spectrophotometer.
- Skilful application of chromatographic techniques for separation of amino acids, pigments and biomolecules.
- Proper method for characterizing protein and nucleic acids and skill on handling electrophoresis equipment for preparation of gels.

Unit-I:

Learning Outcomes: Students will able to acquires knowledge about principles of microscopy and their types.

Imaging and related techniques: Principles of microscopy; Light microscopy; Fluorescence microscopy; Flow cytometry (FACS); Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit-II:

Learning Outcomes: Students will learn about the principles of centrifugation in biomolecule separation and importance of radiography in biological research

Cell fractionation: Centrifugation: Differential and density gradient centrifugation, Sucrose density gradient, $CsCl_2$ gradient, analytical centrifugation, ultracentrifugation. Radioisotopes: Use in biological research, auto-radiography, pulse chase experiment.

Unit-III:

Learning Outcomes: Students will learn about the components and working principle of different types of Spectrophotometer

Spectroscopy: Principles, Components and working mechanism of UV-Visible and Infra-Red spectroscopy, Fluorescence spectroscopy, Chlorophyll *a* fluorescence, Flame photometer, Bomb Calorimeter and Atomic Absorption Spectrophotometer.

Unit-IV:

Learning Outcomes: Students will learn about the separation methods for biomolecules using chromatography and electrophoresis instruments.

- **Chromatography:** Principle of chromatography, paper chromatography, column chromatography, TLC, HPLC, Ion-exchange chromatography, Molecular sieve chromatography, Affinity chromatography.
- **Characterization of proteins and nucleic acids:** Electrophoresis: AGE, PAGE, SDS-PAGE. Mass spectrometry; X-ray diffraction, X-ray crystallography.

Practicals:

1. Study of different microscopic techniques observation through simple and compound microscope
2. Study of PCR using demonstration.
3. To separate pigments by paper chromatography.
4. To separate phytochemicals by thin layer chromatography.
5. Qualitative analysis of total Carbohydrates, Proteins & Lipids.
6. Demonstration of SEM/ Electrophoresis/ Chromatography.
7. Measuring OD using spectroscopy.
8. Beer Lombard’s law and its validation

Text Books:

- ✓ *Patil, C. S. (2017). Advanced Analytical Techniques, ABE Books, New Delhi.*
- ✓ *Pandey BP (2023). Botany for B.Sc. Students Semester I, NEP 2020; S. Chand publication, New Delhi*

Reference Books:

- ✓ *Aneja, K. R. (2014). Laboratory manual of microbiology and biotechnology, Medtech, New Delhi*
- ✓ *Ausubel, F., Brent, R., Kingston, R. E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. (1995). Short Protocols in Molecular Biology. John Wiley & Sons. 3rd edition.*
- ✓ *Plummer, D.T. (1996). An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd. New Delhi. 3rd edition.*
- ✓ *Ruzin, S.E. (1999). Plant Micro technique and Microscopy, Oxford University Press, New York. U.S.A.*

Pandey, B.P. (2023). Botany for B.Sc. Students Semester I: NEP 2020, S. Chand Publishing.

Core III **Semester II**

Cell Biology

Course Objectives:

- To understand the basic components of prokaryotic and eukaryotic cells and the role of various macromolecules in the cells.
- Understand how the formation of cytoskeleton
- To have an understanding on nucleic acids as the genetic material;
- To learn the basic mechanism of replication of nucleic acids
- Understand how cells undergo mitosis & meiosis

Course Outcomes

- Students will understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.
- Students will understand the components of cell wall & cytoskeleton
- Students will understand how these cellular components are used to generate and utilize energy in cells.
- Students will apply their knowledge of cell biology to selected examples of changes or losses in cell function. These can include responses to environmental or physiological changes.
- Students will understand the cellular components underlying mitotic and meiotic cell division.

Unit-I:

Learning Outcomes: Students will understand the orgin, growth and basic components of cell, cell wall & cytoskeleton.

- The Cell: Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory). Unique features of plant cells
- Plasmodesmata: Structure, role in movement of molecules & macromolecules, comparison with gap junctions.
- Plant Cell wall: Chemistry, structure and function.
- Cytoskeleton: The concept, structure and roles of microtubules, microfilaments and intermediary filament.

Unit–II:

Learning Outcomes: Students will recognize composition of Plasma Membrane and origin, structure, function of cell organelles

- Plasma Membrane: Overview of membrane structure and function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis.
- Cell organelles: Endoplasmic Reticulum, Golgi apparatus, Lysosomes & plant Vacuole.

Unit-III:

Learning Outcomes: Students will realize the importance of photosynthesis and cellular respiration

- Cell organelles: Chloroplast, Mitochondria and Peroxisomes: Structural organization & Function.
- Biogenesis & semiautonomous nature of mitochondria and chloroplast.
- Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina & Function

Unit-IV:

Learning Outcomes: Students will understand the cellular units (DNA& RNA) underlying mitotic and meiotic cell division

- Nucleolus: Structure and function of nucleolus, Chromatin organization, its packaging role of nuclear matrix in chromosome organization and function, matrix binding proteins.
- Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA
- Cell division: Eukaryotic cell cycle, different stages of mitosis and meiosis. Cell cycle, Regulation of cell cycle.

Practical:

1. Study of plant cell structure with the help of epidermal peel mount of Onion/Rhoeo
2. Demonstration of the phenomenon of protoplasmic streaming in Hydrilla leaf.
3. Counting the cells per unit volume with the help of hemocytometer. (Yeast/pollen grains).
4. Study the phenomenon of plasmolysis and deplasmolysis.
5. Study of different stages of mitosis and meiosis using acetocarmine and acetoorcine method from Onion root tip and bud respectively.
6. To find out the mitotic index

Text Books:

- ✓ *Rastogi, V. B. (2016). Introductory Cytology, Kedar Nath & Ram Nath, Meerut*
- ✓ *Verma PS & Agarwal VK (2022) Cell Biology (Cytology, Biomoleculus and Molecular Biology) S Chand Publication ,New Delhi.*
- ✓ *Gupta, P. K. (2017). Biomolecules and Cell Biology, Rastogi Publication, Meerut.*
- ✓ *Kumar S. (2023). Cell biology, Pragati prakashan, Meerut*

Reference Books:

- ✓ *Sahoo, K. (2017) Biomolecules and Cell Biology, Kalyani Publishers, New Delhi.*
- ✓ *Tymoczko, J.L., Berg, J.M. and Stryer, L. (2012) Biochemistry: A short course, 2nd ed., W.H. Freeman*
- ✓ *Nelson, D.L. and Cox, M.M. (2008) Lehninger Principles of Biochemistry, 5th Edition, W.H. Freeman and Company.*
- ✓ *Cooper, G.M. and Hausman, R.E. 2009 The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.*
- ✓ *Kumar HD , Molecular Biology 2ed Vikas Publication*
- ✓ *Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009 The World* of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco

Core IV **Mycology and Phytopathology**

Course Objectives

- To learn classification and diversity of fungi and their nutritional requirements.
- To learn the life cycle and ecology of some important genera of fungi and their pathogenicity.
- To understand the beneficial fungal interactions.
- To learn about edible fungi and their role in human nutrition.
- To learn the beneficial application of fungi in agriculture and medicine.
- To know the phyto-pathological processes and the method of their prevention and control.

Course Outcomes

- Have an idea on the vast fungal diversity in nature and method of their identification and culture.
- Know the life cycle of commonly occurring fungal genera and the disease caused by them.
- Have knowledge on the types of fungal associations and their importance.
- Have knowledge and skill on the application of fungi and fungal biomolecules in human welfare.
- Have skill to understand the host - parasite relationship and its role in establishment of viral, fungal and bacterial diseases in plants.
- Understand the causes and conditions for commonly occurring plant diseases and the methods of their control.

Unit-I:

Learning Outcomes: To introduce the students with the classification and diversity of fungi and their nutritional requirements**.**

- Introduction to true fungi: Definition, General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Nutrition; Classification; spore of fungi
- Zygomycota: General characteristics; Ecology; Thallus organization; Life cycle with reference to *Rhizopus*.
- Ascomycota: General characteristics (asexual and sexual fruiting bodies); Ecology; Life cycle, Heterokaryosis and parasexuality; life cycle and classification with reference to *Saccharomyces, Aspergillus*, *Penicillium,* and *Neurospora.*
- Basidiomycota: General characteristics; Ecology and Classification; Life cycle of *Puccinia* and *Agaricus*.

Unit-II:

Learning Outcomes: To introduce the students with the general characteristics, classification of allied fungi and the beneficial symbiotic asociations.

- **Allied Fungi:** General characteristics; Status of Slime molds, Classification; Occurrence; Types of plasmodia; Types of fruiting bodies.
- **Oomycota:** General characteristic; Ecology; Life cycle and classification with reference to *Phytophthora,* and *Albugo.*
- **Symbiotic associations**: Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Nature of associations of algal and fungal partners; Reproduction. Economic importance of Lichens, Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.

Unit-III:

Learning Outcomes: To introduce the students with the role of fungi in food industries, agriculture and medicine.

Applied Mycology: Role of fungi in biotechnology & research, Mushroom cultivation, Application of fungi in food industry (Flavor & texture, Fermentation, Baking,Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides); Medical mycology.

Unit-IV:

Learning Outcomes: To introduce the students with the phytopathological processes and method for prevention and control of plant diseases.

- **Phytopathology:** Terms and concepts; General symptoms; Geographical distribution of diseases; etiology; symptomology; Host- Pathogen relationships; disease cycle and environmental relation; prevention and control of plant diseases, and role of quarantine. **Bacterial diseases** – Citrus canker and angular leaf spot disease of Cotton. Viral diseases – Tobacco Mosaic, Vein Clearing. Fungal diseases – Early blight of potato, Loose and covered smut.

Practical:

1. Introduction to the world of fungi (Unicellular, coenocytic/ septate mycelium, ascocarps & basidiocarps).
2. *Rhizopus*: study of asexual stage from temporary mounts and sexual structures through permanent slides.
3. *Aspergillus, Penicillium and Saccharomyces*: study of asexual stage from temporary mounts. Study of Sexual stage from permanent slides/photographs.
4. *Puccnia* : Study of different stages from temporary mounts and permanent slides.
5. *Agaricus*: Specimens of button stage and full-grown mushroom; sectioning of gills of Agaricus, and fairy rings are to be shown.
6. *Albugo*: Study of symptoms of plants infected with *Albugo*; asexual phase study through section/ temporary mounts and sexual structures through permanent slides.
7. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Viral diseases: Mosaic disease of ladies' finger, papaya, cucurbits, moong, black gram,

Fungal diseases: Blast of rice, Tikka disease of ground nut, powdery mildew of locally available plants and White rust of crucifers.

Text Books:

- ✓ *Mishra, B. K. (2017), Mycology and Phytopathology, Kalynai Publishers, New Delhi.*
- ✓ *Pandey BP (2022).Plant Pathology, S. Chand publication, New Delhi*

Reference Books:

- ✓ *Sharma, P. D. (2017). Mycology and Phytopathology Rastogi Publication, Meerut.*
- ✓ *Agrios, G.N. (1997) Plant Pathology, 4th edition, Academic Press, U.K.*
- ✓ *Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley &Sons (Asia) Singapore. 4th edition.*
- ✓ *Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press, Cambridge. 3rd edition.*
- ✓ *Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Publishers India Ltd.*
- ✓ *Mehrotra, R. S. (2011). Plant Pathology. Tata Mc Graw-Hill Publishing Company Limited, New Delhi*
- ✓ *Vashishta B.R, Sinha A.K & Kumar. A Botany For Degree Students : FUNGI (S chand Publica) New Delhi*
- ✓ *Dubey RC & Maheshwari DK (2021) A text book of Microbiology, S. Chand publication, New Delhi*

Core V **Semester III**

Archegoniatae

Course Objectives

- To know the principles, hypotheses and process of adaptation of plants to land habitat.
- To learn about the origin classification, and characteristics of bryophytes through some representative genera.
- To learn about the origin and distribution of vascular plants and stages of evolution of conducting tissues.
- To study the morphology, and characteristics of pteridophytes through some representative genera.
- To learn the characteristics, classification and importance of the gymnosperms.
- To have a general knowledge on the fossils and fossilization processes.

Course Outcomes:

- Able to understand the mechanism of the evolution of the higher plants and their adaptation to land habit.
- Knowledge on the diversity of archegoniates and their and their pattern of habitat specific distribution.
- Knowledge on the characteristics of bryophytes and skill to differentiate the genera on the basis of their morphology and anatomy.
- Ability to identify the members of pteridophytes and knowledge on their characteristic features.
- Understand the unique features and distribution of gymnosperms.
- Capacity to analyze various types of fossils on the basis of their characters.

Unit-I:

Leaning Outcomes: The students will gain knowledge on the basic characteristics of Archegoniates.

- Introduction: Unifying features of archegoniates; Transition to land habit; Alternation of generations. General characteristics; Origin of land plants and Adaptations to land habit;
- Bryophytes: Origin and Classification; Range of thallus organization. Classification (up to family). Structure, Reproduction and evolutionary trends in *Riccia*, *Marchantia*, *Anthoceros* and *Funaria* (developmental stages not included).
  Ecological and economic importance of bryophytes.

Unit-II:

Leaning Outcomes: The learners shall acquire an understanding on the origin, evolution and structural uniqueness of pteridophytes.

Pteridophytes: General characteristics, classification. Classification (up to family), morphology, anatomy and reproduction of *Psilotum*, *Selaginella*, *Equisetum*, *Pteris* and *Marsilea*. Apogamy, and apospory, heterospory and seed habit, telome theory, stellar evolution and economic importance.

Unit-III:

Leaning Outcomes: The learners shall have the skill to identify and evaluate the importance of gymnosperms in a habitat

Gymnosperms: General characteristics, classification (up to family), morphology, anatomy and reproduction of *Cycas*, *Pinus*, *Ginkgo* and *Gnetum*. (Developmental details not to be included). Ecological and economic importance.

Unit-IV:

Leaning Outcomes: The student will have knowledge to identify and analyze a fossil specimen.

Palaeobotany: Geological time scale, fossils and fossilization process. Morphology, anatomy and affinities of *Rhynia, Calamites, Lepidodendron, Lyginopteris, Cycadeoidea and Williamsonnia*.

Practical:

1. Morphology, anatomy and reproductive structures of *Riccia, Marchantia, Anthoceros, Funaria.*
2. *Psilotum*- Study of specimen, transverse section of synangium (permanent slide).
3. *Selaginella*- Morphology, whole mount of leaf with ligule, transverse section of stem, whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (permanent slide).
4. *Equisetum*- Morphology, transverse section of internode, longitudinal section of strobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide), transverse section of rhizome (permanent slide).
5. Study of temporary preparations and permanent slides of *Marsilea*.
6. *Pteris*- Morphology, transverse section of rachis, vertical section of sporophyll, whole mount of sporangium, whole mount of spores (temporary slides), transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (permanent slide).
7. *Cycas*- Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll and megaspore, T.S root, leaflet, rachis
8. *Pinus*- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones), T.S. Needle, stem, L.S. male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides), L.S. of female cone.

9. *Gnetum*- Morphology (stem, male & female cones), transverse section of stem, vertical section of ovule (permanent slide).

10. Study of some fossil slides / photographs as per theory.

Text Books:

- ✓ *Vasistha, B. R. (2017) Botany for Degree student, Bryophyta, S. Chand Publication, New Delhi.*
- ✓ *Singh, V., Pandey, P.C. and Jain, D.K. (2017). Archegoniate, Rastogi Publication, Meerut.*
- ✓ *Pandey B.P (2020) Botany For Degree Students NEP S Chand Publication New Delhi.*

Reference Books:

- ✓ *Acharya, B. S. (2017), Archegoniate, Kalyani Publishers, New Delhi.*
- ✓ *Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. New Delhi, India.*
- ✓ *Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.*
- ✓ *Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.*
- ✓ *Rashid. A. An Introduction To Archegoniate Plants (Vikas Publication) New Delhi.*

Core VI Anatomy of Angiosperms & Economic Botany

Course Objectives

- To explain the tissues and tissue systems in plants.
- To explain the organization of shoot and root apices.
- To educate the students on the activity of meristems for primary and secondary growth of plants
- To explain about various types of woods in plants and their developmental pattern.
- To give a comprehensive idea about economic botany and its importance in human welfare.
- To provide knowledge on general account, cultivation, propagation and uses of common crops.

Course Outcomes:

- The ability to examine the internal anatomy of plant systems and organs.
- Develop a critical understanding of the evolution of the concept of organization of shoot and root apex.
- Evaluate the adaptive and protective morphological systems of plants.
- Be able to know the origin and evolution of crops and the importance of wild relatives in crop improvement.
- Develop a basic knowledge on germplasm and the basics for their conservation.
- Have an understanding of plants as a source of food, beverages, spices, and materials and its application in human welfare.

Unit-I:

Learning Outcomes: Students will learn about the plant tissues and their anatomical structures. They will also learn about adaptive modifications in plants to adjust at different environments**.**

- Introduction and scope of Plant Anatomy: Applications in systematics, forensics and pharmacognosy.
- Tissues: Classification of tissues; Simple and complex tissues (no phylogeny); cyto-differentiation of tracheary elements and sieve elements; Pits and plasmodesmata; Cell wall ingrowths and transfer cells, adcrustation and incrustation, Ergastic substances.
- Adaptive and Protective Systems: Epidermal tissue system, cuticle, epicuticular waxes, trichomes (uni-and multicellular, glandular and non-glandular: two examples of each), stomata (classification); Anatomical adaptations of xerophytes and hydrophytes.

Unit-II:

Learning Outcomes: Students will learn about the leaf anatomical components. They will also learn about the organization of root and shoot system in plant.

- **Leaf:** Anatomy of dicot and monocot leaf, Kranz anatomy.
- **Stem:** Organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpustheory, continuing meristematic residue, cyto-histological zonation); Types of vascular bundles; Anatomy of dicot and monocot stem. Vascular Cambium: Structure, function and seasonal activity of cambium; secondary growth in stem (normal and anomalous). Root Stem transition.
- **Root:** Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent center; Root cap; Anatomy of dicot and monocot root; Endodermis, exodermis and origin of lateral root. Secondary growth in roots

Unit-III:

Learning Outcomes: Students will learn about the plant domestication and cultivation of important crop pla**nts.**

- **Origin of Cultivated Plants**: Concept of Centers of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversity.
- **Cereals:** Cultivation and brief account of Wheat, Rice and millets.
- **Legumes:** General account, importance to man and ecosystem.
- **Sugars & Starches**: Morphology, cultivation and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, cultivation, propagation & uses.

Unit –IV:

Learning Outcomes: Students will learn about the important timber, spice, oils and fats and drug yielding plants.

- **Timber plants**: General account with special reference to teak and pine. Fibers: Classification based on the origin of fibers, Cotton and Jute (morphology, extraction and uses).
- **Spices:** Listing of important spices, their family and part used, economic importance with special reference to fennel, saffron, clove and black pepper Beverages: Tea, Coffee (morphology, processing & uses).
- **Oils & Fats**: General description, classification, extraction, their uses and health implications groundnut, coconut, linseed and *Brassica* (Botanical name, family & uses)
- **Drug-yielding plants**: Therapeutic and habit-forming drugs with special reference to Cinchona, Digitalis, Papaver and Cannabis

Practical:

1. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
2. Root: monocot, dicot, secondary growth.
3. Stem: monocot, dicot - primary and secondary growth (normal and anomalous); periderm; lenticels.
4. Leaf: isobilateral, dorsiventral, C4 leaves (Kranz anatomy).
5. Ecological anatomy.
6. Cereals: Rice (habit sketch, study of paddy and grain, starch grains).
7. Legumes: Soya bean/moong bean/black gram, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
8. Spice and Beverages: clove, black pepper, Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
9. Fiber-yielding plants: Cotton (specimen, whole mount of seed to show lint and fuzz; whole mount of fiber and test for cellulose), Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fiber).

Text Books:

- ✓ *Singh, V., Pandey, P.C. and Jain, D.K. (2017). Anatomy of Angiosperms, Rastogi Publication, Meerut.*
- ✓ *Pandey, B. P. (2017) Plant Anatomy, S. Chand Publication, New Delhi.*
- ✓ *Pandey, B. P. (2017) Economic Botany , S. Chand Publication, New Delhi.*

Reference Books:

- ✓ *Eames, A.J. and Mc Daniels, L.H., (1953). An introduction to plant anatomy, Tata Mc Grow Hills, New Delhi*
- ✓ *Esau, K. (1977). Anatomy of Seed Plants. John Wiley & Sons, Inc., Delhi.*
- ✓ *Tayal, M. S. (2012) Plant Anatomy Rajpal and Sons, New Delhi*
- ✓ *Mishra, B. K. (2017). Anatomy of Angiosperms, Kalyani Publishers, New Delhi.*
- ✓ *Pandey, B. P. (2017) Plant Anatomy, S. Chand Publication, New Delhi.*
- ✓ *Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.*
- ✓ *Samba Murty, A.V.S.S. and Subrahmanyam, N.S. (2011). Text Book of Modern Economic Botany, CBS Publishers and Distributors, New Delhi.*
- ✓ *Hill, Albert F. Economic Botany, Tata Mc Grow Hill Publishing Company, Ltd. New Delhi.*
- ✓ *Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.*
- ✓ *Singh, V., Pandey, P.C. and Jain, D.K. (2017). Economic Botany, Rastogi Publication, Meerut.*

- ✓ *Baruah, B. (2017). Economic Botany, Kalyani Publishers, New Delhi.*

Core VII **Genetics**

Course Objective

- To know general organization, possible function, and frequency of genes and non-gene DNA sequences in a typical eukaryotic genome.
- Practical methodology for applying Mendelian laws (heavily reliant on problem solving).
- Extensions of Mendelian genetics, including different forms of allelic relationships.
- To know different types of mutations, affect genes and the corresponding mRNAs and proteins.
- Inheritance of linked genes, including recombination mapping, and the physical basis of these rules (chromosomal behaviour during meiosis)

Course Outcomes:

- Learn the basic principles of inheritance at the molecular, cellular and organismal levels.
- Understand the mechanism of inheritance and its relationship with the expression of morphological traits.
- Understand the relationships between molecule/cell level phenomena ("modern" genetics) and organism-level patterns of heredity ("classical" genetics)
- Know about the variations by polyploidy, chromosomal aberration and gene mutations.
- Test and deepen their mastery of genetics by applying this knowledge in a variety of problem-solving situations

Unit-I:

Learning Outcomes: To acquire the basic principles of inheritance at the molecular, cellular and organismal levels

- Mendelian genetics and its extension Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Interaction of genes, Pleiotropy, Recessive and Dominant traits, Polygenic inheritance.
- Extrachromosomal Inheritance: Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast; cytoplasmic male sterility; Maternal effects-shell coiling in snail; Infective heredity- Kappa particles in Paramecium.

Unit-II:
Learning Outcomes: Relationships between modern genetics and classical genetics

Linkage, crossing over and chromosome mapping: Linkage and crossing over- Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numerical based on gene mapping; Sex Linkage.

Unit-III:
Learning Outcomes: To develop mutants using different mutagens

- Variation in chromosome number and structure: Deletion, Duplication, Inversion, Translocation, Position effect, Euploidy and Aneuploidy
- Gene mutations: Types of mutations; Molecular basis of Mutations; Mutagens - physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: CIB method. Role of Transposons in mutation. DNA repair mechanisms.

Unit-IV:
Learning Outcomes: : Applying this knowledge in a variety of problem-solving situations of genetics

- The structure of gene: Classical vs. molecular concepts of gene; Cis-Trans complementation test for functional allelism; Structure of Phage T4, rII Locus.
- Population and Evolutionary Genetics: Gene pool, Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation

Practical:

1. Analysis of allelic and genotypic frequencies.
2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square analysis.
3. Chromosome mapping using test cross data.
4. Pedigree analysis for dominant and recessive autosomal and sex-linked traits.
5. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
6. Blood Typing: ABO groups & Rh factor.
7. Chromosome anomaly: Translocation Ring, Laggards and Inversion Bridge, break etc. (through photographs).

Text Books:

- ✓ *Singh B. D. (2017). Fundamental of Genetics, Kalyani Publishers, New Delhi.*
- ✓ *Gupta P. K. (2017). Genetics, Rastogi Publication, Meerut.*

- ✓ *Verma P. S (2022) Genetics Revised Ed. Schand Publication. New Delhi*

Reference Books:

- ✓ *Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & Sons, India. 8th edition.*
- ✓ *Sinnot, E.W., Dunn, L.C. and Dobzhansky, T. (1985) Principles of Genetics, Tata Mc Grow Hill, New Delhi*
- ✓ *Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. Benjamin Cummings, U.S.A. 10th edition.*
- ✓ *Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W.H. Freeman and Co., U.S.A. 10th edition.*
- ✓ *Strickberger, M.W. Genetics, Pearson Publishers, 3rd Edition*
- ✓ *Rastogi V. B. (2017). Genetics, Kedar Nath & Ram Nath, Meerut*

Core VIII **Semester IV**

Basic Molecular Biology

Course Objectives

- To understand the Historical perspective of DNA and DNA as the carrier of genetic information.
- To learn the Organization and structure of DNA and RNA in pro-and eukaryotes.
- To understand the structure and function organellar and nuclear genomes.
- To understand the General principles of replication and the relationship with genetic code.
- To study about Processing and modification of RNA in prokaryotes and eukaryotes for translation.

Course Outcomes:

On completion of the course the students shall

- Be able to describe Organization and structure and replication of DNA and RNA.
- Have theoretical and practical knowledge the prokaryotic and eukaryotic nucleic acids.
- Have a clear understanding on the structure and function of organellar genome.
- Understand the processes of bidirectional, semi-conservative and semi discontinuous mode of replication and the importance of the genetic code.
- Have ability to understand the mechanism of translation in prokaryotes and eukaryotes.

Unit- I:

Learning Outcomes: Students will gain knowledge about historical perspective and experimental proof of nucleic acids as genetic material.

Nucleic acids: Carriers of genetic information: Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod; McCarty), Types of genetic material, denaturation and renaturation, cot curves. Organization of DNA and structure of RNA- Prokaryotes, Viruses, Eukaryotes, Fraenkel-Conrat's experiment. Organelle DNA - mitochondria and chloroplast DNA. The Nucleosome – Chromatin structure - Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

Unit-II:

Learning Outcomes: This is to gain knowledge about general principles and mechanism of replication of DNA and RNA processing

The replication of DNA: Chemistry of DNA synthesis (Kornberg's discovery); General principles–bidirectional, semi-conservative and semi-discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear ds-DNA, replication of the 5′ end of linear chromosome; Enzymes involved in DNA replication. Central dogma and genetic code: Key experiments

establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features).

Unit-III:

Learning Outcomes: This is to learn the Mechanism of Transcription and transcriptional regulation in Prokaryotes and Eukaryotes

- Mechanism of Transcription: Transcription in prokaryotes and eukaryotes;
- Regulation of transcription in prokaryotes and eukaryotes: Principles of transcriptional
- Regulation; Prokaryotes: Operon concept- Regulation of lactose metabolism and tryptophan synthesis in E. coli. Eukaryotes: transcription factors, heat shock proteins, steroids and peptide hormones; Gene silencing
- Processing and modification of RNA: Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I & group II intron splicing, alternative splicing eukaryotic mRNA processing (5′ cap, 3′ polyA tail); Ribozymes, exon shuffling; RNA editing and mRNA transport.

Unit-IV:

Learning Outcomes: Students will gain knowledge on Mechanism of Translation and Translation regulation in Prokaryotes and Eukaryotes**.**

Translation (Prokaryotes and eukaryotes): Ribosome structure and assembly; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; post-translational modifications of proteins.

Practical:

1. Preparation of LB medium and raising E. coli.
2. Isolation of genomic DNA from suitable plant material.
3. RNA estimation by orcinol method.
4. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
5. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
6. Study of Barr body from buccal smear preparation.

Text Books:

- ✓ *Gupta P. K. (2017). Molecular Biology, Rastogi Publication, Meerut.*
- ✓ *Verma P. S & Agarwal V. K (2022) Molecular Biology Revised Ed. S. chand Publication. New Delhi*

Reference Books:

- ✓ *Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007).*
- ✓ *Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.*
- ✓ *Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc., U.S.A. 5th edition.*
- ✓ *Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin. Cummings. U.S.A. 9th edition.*
- ✓ *Sheeler, P. and Bianchi, D.E. (2009) Molecular Biology of the Cell, Willey Publisher, New Delhi*
- ✓ *Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W.H. Freeman and Co., U.S.A. 10th edition.*
- ✓ *Alberts, B. et al. 2014. Molecular Biology of the cell Garland Science. 6 th Edition*
- ✓ *Power, C. B. (2017) Cell Biology, Himalaya Publishing House, New Delhi*
- ✓ *Sahu, A.C. (2017). Essentials of Molecular Biology, Kalynai Publishers, New Delhi.*
- ✓ *Kumar H. D Molecular Biology 2nd Ed.Vikas Publication New Delhi.*

Core IX **Plant Ecology & Phytogeography**

Course objectives

- To learn the interaction of biotic components with non-living components of an ecosystem.
- To introduce to various natural ecosystems and how the interaction among different biotic and abiotic factors influencing the stability and diversity of an ecosystem.
- To study the physical, biological and chemical characteristics of factors influencing population.
- To know the experimental approach to determine the physical, chemical and organic matters of soil.
- To introduce the students to the characteristics and dynamism of population ecology.

Course Outcomes:

- Have ability to understand the ecological functioning of ecosystems and would certainly help students to maintain the local ecosystems.
- Have information on species' geographical range and how the size and life history influenced by the various components of ecosystems.
- An understanding of the factors that influence patterns of abundance and distribution in populations.
- Have knowledge on the process of soil formation and approaches to study the nature of soils.
- Have skill to evaluate the dynamics of change of population characteristics.

Unit-I:

Learning Outcomes: The students learn the concept of ecology and inter-relationships between the living world and its environment.

- Introduction and Concept of ecology, Autoecology, Synecology, System ecology: Levels of organization. Inter-relationships between the living world and the environment, the components of environment, concept of hydrosphere and lithosphere and dynamism, homeostasis.
- Light, temperature, wind and fire.Variations; adaptations of plants to their variation.

Unit-II:

Learning Outcomes: The students get idea on the formation, composition and profile of soil and state of water in environment.

Soil: Formation; Composition; Physical; Chemical and Biological components; Soil profile; Role of climate in soil development.

Water: Importance: States of water in the environment; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle

Unit-III:

Learning Outcomes: The students grasp about the dynamics of population ecology and plant communities.

- Biotic interactions and Population ecology: Characteristics and Dynamics.
- Plant communities: Concept of ecological amplitude; Habitat and niche; Characters: analytical and synthetic; Ecotone and edge effect; Dynamics: succession – processes, types; climax concepts.

Unit-IV:

Learning Outcome : The students know about the ecosystem process and phytogeography of India.

- Ecosystems: Structure; Processes; Trophic organization; Food chains and Food webs; Ecological pyramids.
- Functional aspects of ecosystem: Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus.
- Phytogeography: Principles; Continental drift; Theory of tolerance; Endemism; Phytogeographical division of India; Vegetation of Odisha.

Practical:

1. Determination of pH of various soil and water samples (pH meter, universal indicator/Lovibond comparator and pH paper)
2. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.
3. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
4. Study of morphological adaptations of hydrophytes, xerophytes, halophiles (two each).
5. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
6. Quantitative analysis of herbaceous vegetation for frequency, density and abundance in the college campus.
7. Field visit to familiarize students with ecology of different sites.

Text Books:

- ✓ *Sharma, P.D. (2017). Fundamentals of Ecology. Rastogi Publications, Meerut, India.*
- ✓ *Shukla R.S. and Chandel P.S. (2016). A Text Book of Plant Ecology. S Chand Publication, New Delhi.*

Reference Books:

- ✓ *Odum, E.P. (2005). Fundamentals of ecology. Cengage Learning India Pvt. Ltd., New Delhi. 5thedition.*
- ✓ *Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.*
- ✓ *Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach. Oxford University Press. U.S.A.*
- ✓ *Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.*
- ✓ *Santra, S. C. (2015) Environmental Science. New Central Book Agency (P) Ltd. Kolkata.*
- ✓ *Das M. C. and Das S. P. (2009). Fundamental of Ecology. Tata MGrow Hill, New Delhi.*
- ✓ *Shukla R.S. and Chandel P.S. (2016). A Text Book of Plant Ecology. S Chand Publication, New Delhi.*
- ✓ *Kumar H D by Modern Concept of Ecology Revised Ed. Vikas Publication.*

Core X **Plant Systematics**

Course Objectives

- A comprehensive presentation of the rules, regulations and codes of governing principles of the International Code of Nomenclature of Algae, Fungi and Plants (ICN)
- To provide knowledge on basic concepts of plant nomenclature and the tools used for naming the taxa.
- To impart knowledge on the traditional and advanced systems of classification of lower and higher plants.
- To acquaint the students with the modern approaches for developing systematic relationships in the plant kingdom.
- To enlighten the students about the phylogeny and the methods for building phylogeny among taxa of various angiosperms.
- To educate the students on the specific taxonomic characteristics of some angiosperm families and the method to make morphological studies of plant materials.

Course Outcomes:

- Knowledge on various levels of taxonomic hierarchy and the relationships among various hierarchical levels with respect to their similarities and variations of characters.
- The skill to use various taxonomic literature, Flora and herbaria, keys of both physical and digital types for plant identification and floristic studies.
- Critical thinking on the ancient, traditional and modern classification systems and evaluation of their applicability in taxonomic placement of taxa.
- Knowledge on the evolution of the concepts in classifying plants and weighing the potential of various tools.
- Ability to build the phylogeny among various taxa of different levels of hierarchy and identifying the apomorphy and plesiomorphy.
- Critical observations of the morphology of plant materials for taxonomic description and identification to the family, genus and species level.

Unit I:

Learning Outcome: The students shall gain knowledge on the importance of specimens, herbaria and flora for study of plant taxonomy**.**

Plant identification, Classification, Nomenclature; Biosystematics. Identification: Field inventory; Functions of Herbarium; Important herbaria and botanical gardens of the world

and India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys: Single access and Multi-access

Unit-II:

Learning Outcome: The learners shall have basic understanding on the application of rules of ICN for plant identification and nomenclature.

- Taxonomic hierarchy: Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary).
- Botanical nomenclature: Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids.

Unit-III:

Learning Outcome: The students shall be able to classify a plant as per the correct taxonomic hierarchy.

- Systematics- an interdisciplinary science: Evidence from palynology, cytology, phytochemistry and molecular data.
- Systems of classification: Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Bentham and Hooker (up to series) and Hutchinson (up to series); Brief reference of Angiosperm Phylogeny Group (APG III) classification.

Unit-IV:

Learning Outcome: The student shall have the skill to apply modern taxonomic tools in plant taxonomy.

- Phylogeny of Angiosperms: Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin& evolution of angiosperms; co- evolution of angiosperms and animals; methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).
- Families of Angiosperms: Descriptive studies of *Magnoliaceae, Rosaceae, Rubiacae, Poaceae, Orchidaceae, Musaceae, Acanthaceae, Apocynaceae, Asclepiadaceae, Lamiaceae.*

Practical:

1. Study of vegetative and floral characters of available materials of the families included in theory syllabus (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification).

2. Field visit, plant collection and herbarium preparation and submission. Mounting of properly dried and pressed specimen of at least fifteen wild plants with herbarium label (to be submitted in the record book)

Text Books:

- ✓ *harma O. P. (2009) Plant Taxonomy, Tata Mc Grow Hill, New Delhi*
- ✓ *Sharma A. K, Sharma R, Taxonomy of Angiosperms and Utilisation of plants, Pragati Prakasan, Meerut*

Reference Books:

- ✓ *Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi.3rdedition.*
- ✓ *Jeffrey, C. (1982). An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge.*
- ✓ *Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2002). Plant Systematics-A Phylogenetic Approach. Sinauer Associates Inc., U.S.A. 2nd edition.*
- ✓ *Saxena, H. O. and Brahman, M. The Flora of Orissa, CSIR Publication.*
- ✓ *Bose T. K. (2009). Trees of the World, Regional Plant Resource Centre, Bhubaneswar, Odisha, India*
- ✓ *Radford, A.E. (1986). Fundamentals of Plant Systematics. Harper and Row, New York.*
- ✓ *Hanes, H. H. (2009). Botany of Bihar and Orissa,*
- ✓ *Mohanty, C. R. (2017). Text Book of Plant Systematics, Kalynai Publisher, New Delhi.*
- ✓ *Subrahmainayam, M. S. (2011) Modern Plant Taxonomy, Vikash Publishing House, New Delhi*

Core XI **Semester V**

Reproductive Biology of Angiosperms

Course Objectives

- To give a comprehensive idea about economic botany and its importance in human welfare.
- To know the origin, introduction, domestication and evolution of new crops / varieties of crop plants.
- To create awareness about importance of germplasm diversity.
- To provide knowledge on general account, cultivation, propagation and uses of common crops and processing of the materials.
- To know the extraction and uses of different oils as well as essential oils.

Course Outcomes:

- Have an understanding on the fundamental concepts of Economic Botany.
- Develop a basic knowledge on the evolution of crops/varieties.
- be aware about the importance of germplasm diversity and learn the methods for their conservation.
- Increase appreciation of diversity of plants and plant products used in everyday life of human and the methods for their enhanced production.
- Have an understanding of plants as a source of food, beverages, spices, and materials.

Unit-I:

Learning Outcome: Learn about structure and function of anther and pollen as well as their abnormalities

- Introduction: History and scope.
- Anther: Anther wall: Structure and functions, micro-sporogenesis, callose deposition and its significance.
- Pollen biology: Micro-gametogenesis; Pollen wall structure, MGU (male germ unit) structure, NPC system; Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia.

Unit-II:

Learning Outcome: Learn about the structure and function of ovule and embryo sac.

Ovule: Structure; Types; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– mega-sporogenesis and mega-gametogenesis; Types and ultrastructure of different mature embryo sacs (Details of *Polygonum* type), Developmental pattern of mono-, bi- and tetrasporic embryo sacs.

Unit-III:

Learning Outcome: Develop knowledge about process of pollination, fertilization and self-incompatibility.

- **Pollination and fertilization**: Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization.
- **Self-incompatibility**: Basic concepts; Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination; Intraovarian and *in vitro* pollination; Modification of stigma surface.

Unit-IV:

Learning Outcome: Students will be aware of the details of endosperm, embryo, seed, polyembryony and apomixes**.**

- **Endosperm:** development, structure and functions
- **Embryo:** Types of embryogeny; General pattern of development of dicot and monocot embryo; Suspensor: structure and functions; Embryo- endosperm relationship; Nutrition of embryo; Embryo development in *Paeonia*.
- **Seed:** Structure, importance and dispersal mechanisms
  Polyembryony and apomixes: Introduction; Classification; Causes and applications

Practical:

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.

2. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, psuedomonads, polyads, pollinia (slides/photographs, fresh material), ultrastructure of pollen wall (micrograph); Pollen viability: Tetrazolium test, Germination: Calculation of percentage germination in different media using hanging drop method.

3. Ovule: Types-anatropous, orthotropous, amphitropous/ campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs). Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.

4. Embryogenesis: Study of development of dicot embryo through permanent slides/photographs; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.

5. Tracing the path of pollen tube.

6. Study of haustorial endosperm

Text Books:

- ✓ *Singh, V., Pandey, P.C, and Jain, D.K. (2017). Reproductive Biology of Angiosperms, Rastogi Publications, Meerut*
- ✓ *Bhojwani SS /S P Bhatnagar and Dantu PK (2015) - The Embryology of Angiosperms 6th ed Vikas Publication*.

Reference Books:

- ✓ Maheswari, P. (2009). Embryology of Angiosperms.
- ✓ *Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.*
- ✓ *Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.*
- ✓ *Johri, B.M. l (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.*
- ✓ *Mishra, B. K. (2017). Reproductive Biology of Angiosperms, Kalyani Publishers, New Delhi.*
- ✓ *Pandey, B. P., (2017). Taxonomy of Angiosperm. S. Chand Publication New Delhi*

Core XII **Basic Plant Physiology**

Course Objectives

- About the mechanism and physiological activities in plants.
- On nutrient uptake and translocation to different plant parts.
- On the nature and physiological roles of various plant hormones on plant growth and development.
- On the physiological requirements for plant morphogenesis and flowering
- On the role of light responsive pigments in plant morphogenesis.

Course Outcomes

- The governing principles behind various physiological processes in plants.
- About various uptake and transport mechanisms (water and solutes) in plants and the factors governing these processes.
- The role of various plant hormones, signaling compounds, and stress responses.
- The skills to manipulate the plant hormones in plants for desired morphological and physiological responses.
- The climatic and physiological requirements for molecular signaling of plants for growth, differentiation, maturity.

Unit -I:

Learning Outcome: The learners shall have the knowledge on importance of water for basic physiological processes of plants.

- Structure and properties of water; pH and buffers; cellular buffering systems; Cell water Potential and its components, plasmolysis and imbibition, soil water potential.
- Water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, trans-membrane pathways.
- Ascent of sap–cohesion-tension theory. root pressure; water movement to leaves.
- Transpiration: Processes; mechanism of stomatal movement; factors affecting transpiration; guttation.
- Translocation in the phloem: experimental evidence in support of phloem as the site of sugar translocation. pressure–flow model; phloem loading and unloading; source–sink relationship.

Unit-II:

Learning Outcome: The students shall know about the nutrient uptakes and hormonal regulation of plant growth and metabolism**.**

- Mineral nutrition: essential and beneficial elements, macro and micronutrients, mineral deficiency symptoms, chelating agents.
- Nutrient Uptake: Transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, Symport and antiport.
- Plant growth regulators: Auxin: Biosynthesis, transport, distribution and function
- Gibberellins: Biosynthesis, transport, distribution and function
- Cytokinin: Biosynthesis, transport, distribution and function
- Abscisic acid: Biosynthesis, transport, distribution and function
- Ethylene: Biosynthesis, transport, distribution and function

Unit-III:

Learning Outcome: The students shall know about photosynthesis and storage of metabolites by plants.

- Photosynthesis: general concept; photosynthetic apparatus; photosynthetic pigments and photosystems; Red drop and Emerson's enhancement effect.
- Primary photochemical reactions: photon, exciton and electron transfer.
- Non-cyclic electron flow: role of tyrosine and phaeophytin, quinine cycle, oxygen evolving complex and water splitting. Cyclic electron flow: process and function; role of ferredoxin-quinone reductase
- C3, C4 and CAM pathways of carbon fixation.
- Photorespiration
- Synthesis and Catabolism of Sucrose and Starch.

Unit-IV:

Learning Outcome: The learners shall have the skill to understand the photomorphogenesis.

- Physiology of flowering: Photoperiodism, flowering stimulus, floral meristems, external and internal factors of flower evocation; florigen concept; ABC model of floral organ identity; chemical signals for floral evocation.
- Seed dormancy: causes, effects, breaking of seed dormancy.
- Senescence: Types and causes, biochemical basis
- Phytochrome: Discovery, chemical nature, role of phytochrome in photo-morphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action.

Practical:

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Study of the effect of wind velocity and light on the rate of transpiration in excised twig/leaf.
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
5. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces).
6. To study the phenomenon of seed germination (effect of light).
7. To study the induction of amylase activity in germinating barley grains
8. To demonstrate suction due to transpiration.
9. Measurement of relation between transpiration and transpiring surface
10. Measurement of cuticular resistance to transpiration.
11. Measurement of primary photochemical reactions by fluorescence.
12. Jain V K Fundamental of Plant physiology,20th ed. S chand publication ,New Delhi

Text Books:

- ✓ *Pandey and Sinha (2011). Plant Physiology, Vikash Publishing House, New Delhi*

Reference Books:

- ✓ *Sinha, R. K. (2015). Modern Plant Physiology, Narosa Publishing House, New Delhi.*
- ✓ *Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.*
- ✓ *Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.*
- ✓ *Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.*
- ✓ *Salisbury, F. B. and Ross, C. W. Plant Physiology Wadsworth Publishing Company, California*
- ✓ *Sahoo, A. C. (2018). Outlines of Plant Physiology Kalyani Publishers, New Delhi.*
- ✓ *Srivastava, N. K. (2017). Plant Physiology, Rastogi Publications, Meerut.*

Core XIII **Basic Plant Biotechnology**

Course Objectives:

- To have a basic idea on principles and methods of Plant Tissue culture and in vitro tissue differentiation.
- To study about Somatic embryogenesis; Embryo culture and embryo rescue
- To have theoretical and practical knowledge on Protoplast isolation, fusion, culture and Selection of hybrid cells for regeneration of hybrid plants.
- To study about Recombinant DNA technology and its application.
- To study various techniques of gene transfer and its application in plant improvement.

Course Outcomes

- Have knowledge the about methods of Plant Tissue culture and its application.
- Be able to describe the Somatic embryogenesis; Embryo culture and embryo rescue
- Have skill to isolate plant Protoplast and differentiate the normal and hybrid protoplasts
- Have knowledge the Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries
- Gain knowledge on methods for developing transgenic plants and application of transgenics for human welfare.

Unit -I:

Learning Outcome: Understanding of the various process of tissue culture mediated plant regeneration protocols.

Plant Tissue Culture: Historical perspective; Aseptic tissue culture techniques; Composition of media; Nutrient and hormone requirements (role of vitamins and hormones). Totipotency; Micropropagation (using nodal explant); Organogenesis (Callus mediated and direct adventitious); Somatic Embryogenesis; Protoplast isolation, culture and fusion, plant acclimatization

Unit-II:

Learning Outcome: Gain knowledge about the fundamental aspects of recombinant DNA technology.

Recombinant DNA technology-I: Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC and briefly PAC, MAC, HAC). Gene Cloning (Recombinant DNA, Bacterial transformation and selection of Recombinant clones, PCR mediated gene cloning).

Unit-III:

Learning Outcome: Gain knowledge about the recombinant DNA technology, gene transfer technology and production of transgenic plants**.**

Recombinant DNA technology-II: Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; Probes-oligonucleotide, heterologous, Methods of gene transfer- *Agrobacterium*-mediated, Direct gene transfer by Polyethylene Glycol (PEG) Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics– selectable marker and reporter genes (Kanamycin, Luciferase, GUS, GFP).

Unit-IV:

Learning Outcome: Have knowledge on chloroplast transformation and biosafety concerns of GM crops.

Chloroplast Engineering: Chloroplast genome, chloroplast transformation: rationale, methods used for generation of transplastomic plants, vectors for chloroplast transformation, transplastomics without antibiotic resistant gene, applications of chloroplast transformation. Biosafety concerns of genetically modified (GM) crops.

Practical:

1. Tissue Culture: laboratory setup (drawing component wise)
2. Demonstration of instruments for Plant tissue culture like Autoclave, Laminar air flow cabinet, and Hot air oven.
3. Demonstration of sterilization techniques for glassware
4. Preparation of tissue culture (MS) medium.
5. Demonstration of surface sterilization techniques.
6. Demonstration of aseptic inoculation of nodal or leaf explants of any available plant species.
7. Isolation of plasmid DNA.
8. Gel electrophoresis and visualization (demonstration/photography)

Text Books:

- ✓ *Chawla, H. S. (2010). Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.*
- ✓ *Ramawat K G & Goyal S Comprehensive Biotechonology 4th ed S chand Publication New Delhi*.

Reference Books:

- ✓ *Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.*
- ✓ *Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.*
- ✓ *Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.*
- ✓ *Singh, B. D. (2018). Plant Biotechnology Kalynai Publishers, New Delhi.*
- ✓ *Gupta, P. K. (2017). Plant Biotechnology, Rastogi Publication, Meerut.*
- ✓ *Dubey, R. C. (2017). Advanced Biotechnology, S, Chand Publication, New Delhi*

Core XIV **Semester VI**

Basic Plant Metabolis

Course Objectives:

- To learn the anabolic and catabolic cellular processes and their regulations.
- To understand the mechanism of signal transduction in plants and the major signaling pathways.
- To learn the photochemical and biochemical mechanisms for photosynthetic carbon fixation.
- To learn the mechanism of carbon oxidation and ATP synthesis.
- To understand the pathways of synthesis and oxidation and of lipids and fatty acids.
- To understand the role of enzymes and enzyme action.

Course Outcomes:

- The students shall be able to explain the importance of biochemical pathways and regulatory pathways.
- The students can explain the role of enzymes in metabolic activities.
- The students shall have ability to differentiate various carbon metabolic pathways.
- The students shall have proper level of knowledge on carbon oxidation and energysyn thesis.
- The students can explain the processes of lipid metabolism and its importance in theg erminating seeds.
- The students shall be able to understand and explain the amino acid metabolic pathways.

Unit–I:

Learning Outcomes: Students will learn about the cellular metabolism and understand metabolic pathways and regulation of glycolysis, TCA cycle, ATP synthesis

- Concept of metabolism: Introduction, anabolic and catabolic pathways
- Glycolysis and its regulation, Fate of pyruvate, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate; regulation of PDH, NADH shuttle.
- TCA cycle, amphibolic role, anaplerotic reactions, regulation of the TCA cycle,
- Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photo-phosphorylation), ATP synthase enzyme
- Boyers conformational model, Racker's experiment, Jaggendorf's experiment
- Role of uncouplers in ATP synthesis and their application.

Unit-II:

Learning Outcomes: Students will learn about fatty acid synthesis, breakdown and their regulation in plants**.**

- Fatty acid biosynthesis: Synthesis, and breakdown of triglycerides and their importance.
- Fatty acid Breakdown: β-oxidation, α oxidation, glyoxylate cycle
- Regulation of fatty acid metabolism. Gluconeogenesis and its role in mobilization of lipids during seed germination

Unit-III:

Learning Outcomes: The learner will understand the aminoacid biosynthesis, degradation along with their regulation in plants.

- Amino acid biosynthesis and degradation in plants and its importance (proteasomal pathway) Synthesis of amino acid of alpha-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

Unit- IV:

Learning Outcomes: Students will learn about the enzymes and their classification, kinetics, inhibition and regulation.

- Enzymes: General properties, nomenclature and classification,
- Energetics of enzyme reactions, free energy change, forward and reverse reactions.
- Michaelis-Menten kinetics of enzyme reactions and its significance, Reciprocal plot, Brigg's-Halden modification, determination of V_{max} and K_m
- Enzyme inhibition: competitive, non-competitive inhibition, determination of K_i,
- Role of regulatory enzymes: allosteric, covalent modulation

Practical:

1. Detection of organic acids: citric, tartaric, oxalic and malic from laboratory samples.
2. Detection and quantification of protein from plant samples samples following Bradford method using spectrophotometer/colorimeter.
3. Detection/Estimation of the nature of carbohydrate – glucose, fructose, sucrose and starch from laboratory samples.
4. Detection of Ca, Mg, Fe, S from plant ash sample
5. Estimation of amino-nitrogen by formol titration method (glycine)
6. Estimation of titratable acidity from lemon.

Text Books:

- ✓ *Gupta, S, K. (2017). Plant Metabolism, Rastogi Publication, Meerut.*
- ✓ *Pandey B P (2019) Botany For Degree Student S Chand Publication. New Delhi*

Reference Books:

- ✓ *Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Develo pment.Sinauer Associates Inc. UA. 6th edition.*
- ✓ *Heldt, Hans-Walter. Plant Bio-Chemistry (3rd ed.), 2005. Elsevier Academic Press.*

Core XV **Natural Resource Management**

Course Objectives:

- To introduce the types of natural resources and the concept of sustainable development.
- To understand the status of biological diversity and their management.
- To know the contemporary tools such as EIA and GIS for assessment and conservation of natural resources.
- To know about the non-conventional energy resources and their application.
- To learn the concept of resource accounting for better natural resource management

Course Outcomes:

- Be able to understand importance of each component of natural resources and try to use the available resources judiciously.
- Know about different biological conventions and treaties emphasizing the conservation of biological diversities.
- Clearly understand the importance of sustainable use of natural resources and procedures for their assessment.
- Have skill to use renewable energy sources for the betterment of the human civilization and actively participate in popularization of the methods of energy and resource conservation.
- Know the national and international efforts for management and accounting of natural resources.

Unit-I:

Learning Outcome: The learners shall gain knowledge about the importance of natural resources.

- **Natural resources:** Definition and types.
- **Sustainable utilization**: Concept, approaches (economic, ecological and socio-cultural).
- **Land:** Utilization (agricultural, horticultural, silvicultural); Soil degradation and management.
- **Water:** Fresh water (rivers, lakes, groundwater, water harvesting technology, rainwater storage and utilization.

Unit-II:

Learning Outcome: The students shall be able to know the processes for maintaining sustainability.

- Biological Resources: Biodiversity-definition and types; Significance; Threats; Management strategies; Bioprospecting; IPR; CBD; National Biodiversity Action Plan).
- Forests: Definition, Cover and its significance (with special reference to India); Major andminor forest products; Depletion; Management.

Unit-III:

Learning Outcome: The students shall have skills to use modern tools for effective resource assessment and utilization.

- Energy: Renewable and non-renewable sources of energy-solar, wind, tidal, geothermal and bioenergy resources.
- Contemporary practices in resource management: EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint

Unit-IV:

Learning Outcome: The learners shall gain accounting skills for management and conservation of natural resources.

Resource Accounting; Waste management. National and international efforts in resource management and conservation

Practicals

1. Estimation of solid waste generated by a domestic system (biodegradable and non-biodegradable) and its impact on land degradation.
2. Collections of data on forest cover of specific area.
3. Measurement of dominance of woody species by DBH (diameter at breast height) method.
4. Calculation and analysis of ecological footprint.
5. Ecological modeling.
6. Estimation of soil moisture content and soil texture.
7. Estimation of soil porosity
8. Estimation of soil water-holding capacity.
9. Estimation of soil organic matter and soil carbon

Text Books:

- ✓ *Pandey, B. W. 2005. Natural Resource Management. Mittal Publication, New Delhi*
- ✓ *Singh J S & Singh S P (2017) Ecology, Environmental science, Conservation. (Revised Ed) S Chand Publication New Delhi*

Reference Books:

- ✓ *Vasudevan, N. (2006). Essentials of Environmental Science. Narosa Publishing House, New Delhi.*
- ✓ *Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.*
- ✓ *Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Prentice Hall of India Private Limited, New Delhi.*

Core XVI **Semester VII**

Applied Molecular Biology

Course Objectives:

- To understand the methods of recombinant DNA Technology.
- To learn the isolation, purification and estimation of Plasmid DNA.
- To understand methods of expression of a recombinant Protein in E. coli.
- To learn about the methods to study DNA replication recombination and repair.
- To learn the methods for confirmation of gene cloning and gene expression.
- To understand the application DNA molecular markers: RFLP, RAPD and AFLP techniques

Course Outcomes:

- Be able to describe methods of recombinant DNA Technology.
- Have theoretical and practical knowledge of the isolation, purification and estimation of Plasmid DNA.
- Have a clear understanding on the methods of expression of a recombinant Protein in E.coli.
- Understand the processes of the DNA replication recombination and repair.
- Have ability to understand the mechanism the methods for confirmation of gene cloning and gene expression.
- Be able to describe the application DNA molecular markers: RFLP, RAPD and AFLP techniques

Unit- I:

Learning Outcome: Students will gain knowledge on recombinant DNA Technology, and Expression and purification of a recombinant Protein in *E.coli*

- Plasmid DNA preparation, Agarose gel electrophoresis of DNA and identification of various structural forms of plasmid, Estimation of the purity of the isolated Plasmid DNA spectrophotometrically, Digestion of DNA by restriction enzyme; Purification of DNA from gel. Preparation of competent cells by $CaCl_2$ mediated method. Ligation and transformation of ligated DNA to *E.coli* of competent cells, measurement of Transformation efficiency.
- Expression of a recombinant Protein in *E.coli* and one step purification of the protein by Affinity column Chromatography. Estimation of the purity of the isolated protein by SDS-PAGE.

Unit- II:

Learning Outcome: Students will understand the methods for genetic transformation and detection transformed clones.

Methods for genetic transfers: transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating. Methods to study DNA replication recombination and repair (Radioactive and nonradioactive Tracers, Autoradiography, Southern Blots, DNA Fingerprinting and DNA Typing, *In Situ* Hybridization, DNA Sequencing and Physical Mapping of chromosomes).

Unit- III:

Learning Outcome: Students will gain knowledge on Genomic DNA isolation, purification, and characterization of Genomic DNA and applications of DNA molecular markers.

- Genomic DNA isolation, purification, and characterization from seedlings by Edwards method and visualization by agarose gel electrophoresis, checking the quality of extracted DNA by spectrophotometry.
- Applications of DNA molecular markers: Methods of PCR analysis, different types of PCR technique, RAPD, SSR markers. Restriction digestion of genomic DNA ; RFLP, and AFLP techniques/markers.

Unit- IV:

Learning Outcome: Students will understand the Gene expression at RNA and protein level using various molecular tools and techniques.

Gene expression at RNA and protein level, large scale expression, such as microarray based techniques: Reverse transcription PCR, qRT-PCR, Mapping and Quantifying Transcripts (Northern Blots, Primer Extension, Run-Off Transcription, Cassette Transcription), Measuring Transcription Rates *in vivo* (Nuclear Run-On, Reporter Gene Transcription, Measuring Protein Accumulation *in vivo*), Assaying DNA–Protein Interactions (Filter Binding, Gel Mobility Shift, DNase Footprinting, Chromatin Immunoprecipitation), Assaying Protein–Protein Interactions.

Practicals

1. Plasmid DNA preparation and visualization on Agarose gel electrophoresis
2. Isolation of total plant protein, Protein profiling using SDS-PAGE.
3. Genomic DNA isolation, purification, and visualization by agarose gel electrophoresis,
4. Checking the quality of extracted DNA by spectrophotometry
5. Demonstration of Methods for genetic transformation through Kit
6. DNA Fingerprinting data scoring of RAPD photographs and phylogeny construction applying bioinformatic tools.
7. Southern Blots, Western blots, Chromosome banding by photographs.
8. PCR analysis and its application using RAPD primers.

9. RT-PCR demonstration/ Exposure visit to Molecular laboratory in different institute.

Text Books:

- ✓ *Dubey R C & Maheshwari D K (2004) A Text Book of Microbiology Revised Ed. Schand Publication. New Delhi.*

Recommended Books:

- ✓ *Krebs, J. E., Goldstein, E. S. and Kilpatrick, S. T. (2018) Lewin's GENES XII. Jones and Bartlett Learning.*
- ✓ *Watson, J. D. et al. (2017) Molecular Biology of Gene. 7th edition. Pearson.*
- ✓ *Weaver, R. (2011) Molecular Biology. 5th edition. McGraw-Hill Education.*
- ✓ *Smith, R. H. (2013) Plant Tissue Culture: Techniques and Experiments. 3rd Edition. Academic Press.*
- ✓ *Green, M. R. and Sambrook, J. (2012) Molecular Cloning: A Laboratory Manual. 4th edition. CSHL Press.*
- ✓ *Introduction To Plant Biotechnology, 3rd Edition (2020) by H. S. Chawla. ISBN: 1439894140, 9781439894149. CRC Press.*

Core XVII **Applied Biochemistry**

Course Objectives:

- To learn the use of anabolic and catabolic cellular processes in commercial sectors.
- To understand the mechanism of production of plant based products from biomolecules.
- To learn the need of industries use of biological materials
- To learn the method to discover bioactive components from plant sources
- To understand the pathways of enzyme kinetics.

Course Outcomes:

- The students shall be able to explain the importance of carbohydrates from plant sources and their different uses.
- The students shall be able to explain the importance of lipids from plant sources and their different uses.
- The students shall be able to explain the importance of nucleic acid from plant sources and their different uses.
- The students shall be able to explain the importance of proteins/enzymes from plant sources and understand the underlaying mechanisms.
- The students can explain the processes of lipid metabolism and its importance in the germinating seeds.
- The students shall be able to understand and explain the importance of enzyme kinetics and industrial use.

Unit–I:

Learning Outcome: Students will learn about the industrial use of plant sugars and lipids.

- Role of plant sugars and polysaccharides for biorefining, biofuels, animal feed, food and other industrial uses.
- Methods and understanding of source-sink dynamics for crop yield and productivity; Industrial application of cellulose, starch, fructans, amylose
- Role of plant lipids and fatty acids in biofuels, essential oil, and other industrial uses.
- Industrial application of palm oil, ground nut oil and lemon grass oil.

Unit-II:

Learning Outcome: Students will learn about the nucleic acid synthesis and degradation methods and understand how they can play important role in chemotherapy and developmental process

- 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 process.

Unit-III:

Learning Outcome: Students will learn about importance of plant proteins and their role from infection to storage**.**

- Plant protein synthesis: Organellar compartmentalization, post translational modifications and degradation,
- Mechanism of plant-viral translation
- Proteomics and plant food sources: food security, crop improvement and GMOs
- Plant Storage Proteins: vicilins, legumins, prolamins, 2S Albumins, Ricin
- Seed protein: synthesis, mobilization and degradation

Unit-IV:

Learning Outcome: Students will learn about applied role of enzyme kinetics, mode of action and inhibitors in detail

- Enzyme Kinetics: Bi-substrate kinetics, Sequential and Random ordered kinetics.
- Mechanism of enzyme action: general acid-base catalysis, covalent catalysis, metal catalysis Mechanism of action of RNAse, Lysozyme and Chymotrypsin; Isozymes
- Enzyme Inhibitors: Rational Design of Enzyme Inhibitors, transition-state analogues, mechanism-based inhibitors, affinity labels.
- Application of enzymes in food, agriculture, medicine, disease diagnosis, bioremediation.

Practical:

1. Estimation of enzyme activity in plant samples and effect of substrate, enzyme concentration and pH on enzyme activity and determination of Km value. (Catalase, Peroxidase, Acid phosphatase)
2. Estimation of urease activity in plant samples.
3. Colorimetric estimation of protein by Folin phenol reagent.
4. Preparation of standard curves for quantification of protein, carbohydrate and reducing sugar.
5. Quantification of soluble and total protein and total carbohydrate contents of plant samples.
6. Isolation of Chloroplast and study of protein profile of RUBISCO by SDS-PAGE.

Text Books:

- ✓ *Gupta, S, K. (2017). Plant Metabolism, Rastogi Publication, Meerut.*
- ✓ *Sahoo, A. C. (2018). Outlines of Plant Metabolism, Kalyani Publishers, New Delhi.*
- ✓ *Jain J L, Jain S & Jain Nitin (2020) Fundamental of Biochemistry S Chand Publication. New Delhi*

- ✓ *B P Pandey B P (2019) Plant Metabolism S Chand Publication*

Reference Books:

- ✓ *Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.*
- ✓ *Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development.Sinauer Associates Inc. UA. 6th edition.*
- ✓ *Harborne, J.B. (1973). Phytochemical Methods. John Wiley & Sons. New York.*
- ✓ *Jain, V.K. Fundamental of Plant Physiology (7th ed.) 2004. S. Chand and Company.*
- ✓ *Salisbury, F.B. & Ross, C.W. Plant Physiology (4th ed.), 19992, Wadsoworth Publishing Company.*
- ✓ *Panday, S.N. & Sinha, B.K. Plant Physiology (4th ed.), 2006, Vikas Publishing House Pvt. Ltd.*
- ✓ *Wilkins, M.B. Advances Plant Physiology. 1984, ELBS Longman.*
- ✓ *Heldt, Hans-Walter. Plant Bio-Chemistry (3rd ed.), 2005. Elsevier Academic Press.*
- ✓ *Buchanan, Gruissen and Jones. Plant Physiology & Biochemistry: Biochemistry and Molecular Biology of plants, 2000, I.K. International.*

Core XVIII **Biostatistics**

Course Objectives

- On the importance of collection and analysis of data for inference
- On Procedures for collection, processing and analysis of data
- To identify correct test for analysis and comparison of data
- For understanding the principles of data trend and pattern
- For making the fitting prediction of data

Course Outcomes:

- The methods for primary and secondary data collection.
- Process the data and simulate the data to field conditions.
- How to select correct statistical method for analysis of a set of data
- The skill to build conclusion by outcome of the data analysis
- The skill to analysis complex data sets by multivariate analysis.

Unit -I:

Learning Outcome: The students shall have the skill to collect and statistically process the date of biological samples**.**

- **Statistical methods** - basic principles. Population; Sample from population, sample size and frequency.
- **Sampling**: sampling procedure-completely randomized design, complex block design, lattice design, group balanced block design, strip plot design and split-plot design.
- **Data collection**: primary and secondary data, frequency and frequency class.
- **Measures of central tendency**: Mean, median, mode of small and large samples.
- **Measures of dispersion**: variance, standard deviation, mean deviation, standard error, Co- efficient of variations and confidence interval.

Unit-II:

Learning Outcome: The learners shall have the skill to test the hypothesis using proper statistical procedure statistical procedure.

- Data distribution: probalility of distribution; normal, binomial and poisson distribution; test of hypothesis-Chi square test; Symmetry and kurtosis
- Hypothesis – setting of hypothesis- probability considerations; error of acceptance and rejection, type I and type II errors.
- Two sample comparison: paired student 't' test and unpaired ‘t’ test.
- Multiple comparison: The Turkey’s test

Unit-III:

Learning Outcome: The learners shall be able to analyze the trend among data and determine the rates of change.

- Types and methods of correlation and regression, computational requirements, derivation of simple linear regression equations, slopes and intercepts, fitting prediction, similarities and dissimilarities of correlation and regression.
- Data transformation: logarithmic, exponential and reciprocal transformations; non-linear regressions of data.

Unit -IV:

Learning Outcome: The students shall be able to make the intra-group and inter-group comparison of data.

- Multiple regression equations; comparison of slopes and intercepts; analysis of variance of multiple datasets; analysis of variance, one factor and two factor ANOVA.
- Group comparison test.
- Least significant difference (LSD) test, ranking of means with LSD.
- Duncan's multiple range (DMRT) test; ranking of means with DMRT

Practical:

1. Calculation of central tendency and dispersion of data
2. Chi-square test of field samples to test distribution pattern (binomial and poisson distribution)
3. Dependent 't' comparison of data
4. Independent 't' comparison of data
5. Calculation of 'F' value and finding out the probability value for the F value.
6. Two factor ANOVA and test of hypothesis
7. Test for LSD of data
8. Test for DMRT of data
9. Regression and correlation of linearly distributed data
10. Regression and correlation of transformed distributed data (logarithmic and exponential)

Text Book:

- ✓ *Banerjee K. Pranab (Revised Ed) Introduction to Biostatistics S Chand Publication New Delhi*

Reference book:

- ✓ *Biostatistical Analysis, Jar, J.H., 2006, 4th Ed, Pearson Education Inc.*
- ✓ *Stastical Procedure for Agricultural Research, Gomez, K.A., and Gomez, A. A., 1984, Wiley.*
- ✓ *Statistical Analysis of epidemiological data, Selvin, S., 1991. New York University Press.*
- ✓ *Statistics for Biology, Boston, Bishop, O.N. Houghton, Mifflin.*
- ✓ *The Principles of scientific research, Freedman, P. New York, Pergamon Press.*
- ✓ *Statistics for Biologists, Campbell, R.C., 1998.Cambridge University Press.*
- ✓ *Biostatistic, Danniel, W.W., 1987.New York, John Wiley Sons.*
- ✓ *An introduction to Biostatistics, 3rd edition, Sundarrao, P.S.S and Richards, J. Christian Medical College, Vellor*

Core XIX **Applied Ecology**

Course Objectives:

- On the methods for analyzing a community and a population
- On the solid wastes management, disposal and reuse.
- Regarding the process of wastewater treatment and recycling.
- About energy environment and the potential of non-conventional energy.
- On the methods for modeling of ecosystems and function prediction.

Course Outcomes:

- Have skill to analyse a plant community and determine its importance in the habitat
- Develop a proper understanding of the potential of solid wastes and the processes used to reuse.
- Clearly understand the importance of protection of surface waters and maximize the water reuse and recycling.
- Know importance of bio-energy and skill to plan the harvesting and use of alternate energy.
- Understand the mathematical models for ecosystem analysis and skill to develop the predictive models.

Unit-I:

Learning Outcome: The learners shall understand the structure, function and ecology of a population.

- Phytosociological analysis of vegetation: density, diversity and distribution; keystone species; importance value index; species richness; ecological indices; community homeostasis.
- Population growth patterns; density-dependent and independent population growth,
- Population interactions: types and ecological importance
- Population restoration, bio-security and conservation.
- Meta-population: characteristics, structure, ecological importance.

Unit-II:

Learning Outcome: The students shall gain the knowledge on treatment and use of wastes of various types.

- Solid waste processing technology: Components of solid waste management, leachate control and treatment, Vermicomposting; treatment of hazardous wastes, biomedical waste management.

- Wastewater treatment and disposal: eutrophication-causes, effects and control
- Waste water treatment processes; secondary treatment systems; conventional and high rate biofilters, rotating biological contactors; activated sludge; nutrient removal through biomass production.

Unit-III:

Learning Outcome: The students shall gain the knowledge on alternate and sustainable energy resources and on efficient energy management.

- Energy management: Biomass, bioenergy and biofuels, biofuel-opportunities and challenges, levels of biofuel technology;
- Feedstocks and production- starch, cellulosic and algal biofuel feedstocks.
- Biomass production-single and multiple species approach,
- Dedicated energy crops, alternate habitats for biomass production
- Biodiesel, bioethanol, biogas and biohydrogen production.

Unit-IV:

Learning Outcome: The learners shall understand the toxicity of xenobiotics and have knowledge on their effective degradation**.**

- **Aquatic toxicity assessment**: concept of toxicity; mechanism of toxicants' action.
- Selection of test batteries; First, second and higher tiers of toxicity testing.
- **Bioaccumulation**: Concept and measurement, food chain and lipophilicity approach, quantitative structure activity relationship, kinetics of uptake and retention, factors affecting bioaccumulation.
- Microbial transformation of metals; biosorption, phytofiltration, phytochelation and phytoextraction; role of metalphores.
- Biodegradation of organic pollutants: measurement of biodegradability; aerobic and anaerobic aliphatic hydrocarbons, and aromatic hydrocarbons and pesticides

Practical:

1. Phytosociological analysis of vegetation.
2. Succession study in grassland ecosystem.
3. Determination of COD, BOD of different samples- surface water, ground water, drinking water and waste water.
4. Measurement of nitrate, sulphate and phosphates of waste water.
5. Organic carbon content of domestic solid waste.
6. Aerobic composting and degradation analysis.
7. Vermicomposting and degradation analysis.
8. Algal culture in waste water.

9. Measurement of BOD of water under different6 aeration regime.
10. Nutrient analysis of water, growth with macrophytes.

Text Books:

- ✓ S*harma, P.D. (2017). Fundamentals of Ecology. Rastogi Publications, Meerut, India.*

Reference Book:

- ✓ Odum, E.P. (2005). Fundamentals of ecology. Cengage Learning India Pvt. Ltd., New Delhi. 5th edition.
- ✓ Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.
- ✓ Santra, S. C. (2015) Environmental Science. New Central Book Agency (P) Ltd. Kolkata.
- ✓ Mohapatra P.K. (2006) Environmental Biotechnology, IK Publ., New Delhi, India.
- ✓ Smith, T.M., Smith, R.L. (2012). Elements of Ecology, 8 th Ed., Pearson Edn. USA
- ✓ Begon, M., Townsend, S.R., Harper, J.L. (2006). Ecology: from individuals to ecosystem, 4 thEd., Blackwell Publ.
- ✓ Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.
- ✓ Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach.Oxford University Press. U.S.A.
- ✓ Das M. C. and Das S. P. (2009). Fundamental of Ecology. Tata MGrow Hill, New Delhi.
- ✓ Shukla R.S. and Chandel P.S. (2016). A Text Book of Plant Ecology. S Chand Publication, New Delhi
- ✓ Singh J S & Singh S P (2017) Ecology, Environmental science, Conservation. (Revised Ed) S Chand Publication New Delhi.

Core XX **Semester VIII**

Applied Plant Physiology

Course Objectives:

- About the mechanism and of uptake of nutrients by plants.
- On various secondary metabolites and their role in plant growth, development and defense.
- About the plant reactions to stress and stress adaptations and resistance.
- On the practical application of plant growth promoters and hormones
- On the progresses for augmenting crop production.

Course Outcomes:

- The pathways of nutrient uptake and the physiological principles regulating the uptake.
- The skill to identify the secondary metabolites for plant defense and apply the same for plant defense induction.
- About the biotic and abiotic components to induce disease resistance in plants.
- The skills to manipulate the plant hormones in plants for desired morphological and physiological responses.
- The progress in augmenting plant production

Unit-I:

Learning Outcome: The learners shall able to understand mechanism of mineral assimilation

- Energetics of nutrient assimilation.
- Nitrate assimilation by roots and shoots; role of nitrate reductase. Ammonium assimilation.
- Symbiotic nitrogen fixation: exchange of signals; role of NOD factors; hormonal regulation; nitrogenase activity.
- Sulphur assimilation: enzymatic and non-enzymatic reactions; role of cysteine in sulphur assimilation.
- Assimilation of phosphate and cations (K^+, Mg^{2+}, Ca^{2+}); Oxygen assimilation.

Unit-II:

Learning Outcome: The learners able to comprehend the plant metabolites and their significance.

- **Secondary metabolites**: Terpenes: structure, biosynthesis and function in growth, development and defense of plants; Phenolic compounds: structure and biosynthesis; Flavonoids, lignins and tannins; role in plant growth and pathogen defense.

- **Nitrogen containing compounds**: alkaloids, glycosides, and non-protein amino acids.
- **Antimicrobial compounds**: phytoalexins
- Biotic and abiotic stress factors, Stress signaling; signaling pathways: Calcium modulation, Phospholipid signaling. Pathogen induced Signal Transduction Cascade
- Systemic acquired resistance; Induced systemic resistance; modoration of insect and disease resistance by biological and chemical inductions; Hypersensitive reaction; Pathogenesis–related (PR) proteins; bacterial and fungal inducers of resistance; Role of jasmonates, riboflavin, salicylic acid, and silicon.

Unit-III:

Learning Outcome: The learners will be able to know the use of plant hormones and their significance.

- **Phytochrome:** regulation for plant development; cellular and molecular mechanism of function; phytochrome mediated gene expression and modulation of other photoreceptors.
- **Blue light receptors**: role in plant growth and development.
- **Vernalization**: mechanism and application.
- **Auxins:** signal transduction pathways; auxins application for stress adaptation and plant growth.
- **Gibberellins:** signal transduction pathways; application of GA for modulation of plant growth.
- **Cytokinine:** cellular and molecular functions; role in plant development.
- **Ethylene:** cellular and molecular functions; role in plant defense.
- **Abscisic** acid: cellular and molecular functions; role in plant development and flowering.

Unit-IV:

Learning Outcome: The learners shall grasp about the photosynthesis and building resilient plant species

- Regulation of photosynthesis; regulation of Rubisco-oxygenase activity; designing of photosystems and antenna complex; role of bicarbonate on PS II; action of PS I and PS II herbicides; artificial photosynthesis; Biohydrogen function.
- Photorespiration: role in nitrogen and sulphur assimilation.
- Pleurality of carbon pathways for improved photosynthesis-C_2, C_2+C_4 and C_3+C_4 pathways.
- C_4 rice initiatives: single enzyme expression; gene pyramiding and multienzyme expression; C_3 gene editing; achievements and limitations.

Practical:

1. Quantitative estimation of peroxidase activity in the seedlings in the absence and presence of salt stress.
2. Superoxide activity in seedlings in the absence and presence of salt stress.
3. Plant response measurement under light and salt stress
4. Zymographic analysis of superoxide dismutase activity.
5. Quantitative estimation of catalase.
6. Quantitative estimation of glutathione reductase.
7. Estimation of superoxide anions.
8. Measurement of photosynthesis with light, salt and herbicide stress.
9. Measurement of the effect of PS II herbicides
10. Measurement of the effect of PS II herbicides

Text book:

- ✓ *Jain V K By Fundamental of Plant physiology,20th ed. S Chand publication, New Delhi*

Reference Book:

- ✓ *Govindjee (ed) Advances in photosynthesis and Respiration, Book series, Springer.*
- ✓ *Voet D. and Voet J.G. (2021). Biochemistry, 6th Edn, Wiley.*
- ✓ *Sinha, R. K. (2015). Modern Plant Physiology, Narosa Publishing House, New Delhi.*
- ✓ *Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.*
- ✓ *Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.*
- ✓ *Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.*
- ✓ *Salisbury, F. B. and Ross, C. W. Plant Physiology Wadsworth Publishing Company, California*
- ✓ *Sahoo, A. C. (2018). Outlines of Plant Physiology Kalyani Publishers, New Delhi.*
- ✓ *Srivastava, N. K. (2017). Plant Physiology, Rastogi Publications, Meerut.*
- ✓ *Pandey and Sinha (2011). Plant Physiology, Vikash Publishing House, New Delhi*

Core XXI **Applied Biotechnology**

Course Objectives:

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

Course Outcomes:

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

UNIT –I:

Learning Outcome: Learn the in vitro propagation, somatic embryogenesis and crop improvement using plant tissue culture

Tissue culture applications: Micropropagation, virus elimination; embryo culture and embryo rescue, anther and microspore culture, production of triploid, hybrid, somaclonal variants, cell suspension culture and hairy root culture for secondary metabolite production, synthetic seed and cryopreservation for germplasm conservation.

UNIT –II:

Learning Outcome: To use plant tissue culture as back bone of plant biotechnology

Applications of Biotechnology: Pest resistant (Bt-cotton); herbicide resistant plants (Round Up Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Protease, Lipase); Genetically Engineered Products-Human Growth Hormone; Humulin.

UNIT –III:
Learning Outcome: Learn the method of gene transfer for developing transgenic plants

Gene Silencing: 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 its application.

UNIT –IV:
Learning Outcome: Knowledge on metabolic engineering for augmentation of secondary metabolite biosynthesis and their industrial potential

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

Practicals

1. Preparation of different stock solution; preparation of tissue culture media.
2. Preparation of synthetic seeds by alginate encapsulation method.
3. Study of Anther culture and microspore culture through photograph.
4. Study of Bt Cotton through photographs.
5. Cytological examination of regenerated plants.
6. *Agrobacterium*- mediated transformation protocol (using photographs/ video).
7. RAPD / any PCR based marker analysis and data scoring.
8. Exposure visit to commercial Tissue culture Laboratory in different institute

Text book:

- ✓ *Introduction to Plant Biotechnology. Chawla H.S. Oxford & mH Publishing Co. Pvt. Ltd.*

Suggested readings:

- ✓ *Plant Biotechnology, the genetic manipulation of plants. Adrian Slater, Nigel Scott and Mark Fowler. Oxford University Press.*
- ✓ *Plant Cell, Tissue and Organ Culture, Fundamental Methods. Gamborg O.L. and Phillips G.e. (Editors). Narosa Publishing House.*
- ✓ *From Genes to Genomes, Concepts and Applications of DNA technology. Dale IW. And Von Schantz M. John Wiley and Sons Ltd.*
- ✓ *Plant Tissue Culture: Theory and Practice. Bhojwani S.S and Razdan M.K., Elsevier*

- ✓ *Dubey R C (Revised Ed.) Advanced Biotechnology S Chand Publication. New Delhi*
- ✓ *Ashish s Verma Laboratory Manual for Biotechnology S Chand Publication. New Delhi*

Core XXII **Applied Microbiology**

Course Objective:

- To explain fermentation processes and its bi-product, their industrial uses and recent advances.
- To explain the basic idea on designing of bioreactors for production of microbial products.
- To make the students understanding the role of disinfectants and sterilization
- To give an introduction to the various aspects of environmental biotechnology

Course Outcomes:

- The students would be able to understand the roles of microbes and production of microbial products
- The students certainly get the opportunities to learn the basics of idea on bioreactors and utility
- The students shall be able to understand the application of various disinfectants and instruments used for sterilization.
- The students would be able to identify the important microbes for bioremediation of pollutants

UNIT I:
Learning Outcome: The students will learn about fermentation process and its application.

Microbial production of industrial products, Brief history and developments in Fermentation Technology & Industrial Microbiology, Primary and secondary screening, strain development, preservation and maintenance of industrial strains, Typical composition & characteristics of industrial fermentation media, Crude and synthetic media; molasses, corn-steep liquor; microbial production of ethanol, penicillin, amylase and lipase

UNIT II:
Learning Outcome: The learners will learn about the biofermentors and their working**.**

Fermentation processes & Instrumentation, Solid-state and liquid-state (stationary and submerged) fermentations; Batch, fed-batchand continuous fermentations, Components of a typical bioreactor, types of bioreactors-Laboratory, pilot- scale, and production fermenters; stirred tank fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

UNIT III:
Learning Outcome: The students will learn about microbes in pharmaceutical industry and sterilisation process**.**

Pharmaceutical Microbiology: Disinfection: Classification, mode of action, factors influencing disinfectants, uses, evaluation and effectiveness. Sterilization: Introduction,

significance, sensitivity of microorganisms, detailed methods for sterilization processes. Sterilization control and sterility assurance. Sterility testing of pharmaceutical products as per pharmaceutical standards. Microbiological assays of antibiotics.

UNIT IV:

Learning Outcome: The learners will understand about bioremediation process of wastelands.

Bioremediation:Bioremediation of inorganic pollutants, Biodegradation of hydrocarbons, pesticides, herbicides and other important compounds. Bioremediation of contaminated soil and waste lands. Genetically engineered microbes in biodegradation, Sewage/ waste water treatment

Practical:

1. Types of Bacteria to be observed from temporary/permanent slides/photographs.
2. Study of instruments used for microbiology research and sterilization techniques
3. Preparation of nutrient media
4. Preparation of pure culture
5. Examination of bacteria from bacterial culture by Gram's staining method.
6. Isolation of amylase and lipase producing bacteria
7. Production of amylase and lipase

Text Books:

- ✓ *R C Dubey & Maheshwari D K (2020) A Text Book Of Microbiology Schand Publication New Delhi.*

References books

- ✓ *Pelzer. Chan, B.C.s and Krej, N.R. 1993. Microbiology. MC Graw Hill-Inc. New Delhi.*
- ✓ *Prescott,L.M, Harley, J.P and Klein, D.A 1998. Microbiology W M C Brown Publishers. New Delhi.*
- ✓ *Rangaswami, G and Bagyaraj,D.J.(1996). Agricultural Microbiology 2nd edn. Prentice Hall of India New*
- ✓ *Glazer, A.N and Nikaido. H. (1995). Microbial Biotechnology. W.H.Freeman And co. New York.*
- ✓ *Kumar H.D. Environmental Technology & Biosphere Management. Oxford & IBH Publishing Co. Pvt. Ltd R.K. Sinha and R. Sinha, 2008, Environmental Biotechnology. Aavishkar Publisher Distributors.Delhi.*
- ✓ *Evans G.G., Furlong J. (2011). Environmental Biotechnology: Theory and Application, John Wiley & Sons, 290 pp.*
- ✓ *Brock Biology of Microorganisms, 14th Edition. Clinical Microbiology Made Ridiculously Simple, 6th Edition.*

- ✓ *Microbiology: An Introduction (12th Edition) Jawetz Melnick &Adelbergs Medical Microbiology.*
- ✓ *Raskin, I (1999). Phytoremediation of Toxic Metals: Using Plants to Clean Up the Environment. Wiley-Interscience, New York.*
- ✓ *Willey, Sherwood and Chritopher, Laboratory Excercises in Microbiology. McGrow-Hill, India. 9 th Edition*
- ✓ *Kaushik Purshotam (Revised Ed) Microbiology (Question & Answer) Schand Publication.*

Core XXIII **Bioinformatics**

Course Objectives:

- To know the principles, hypotheses, and process in the field of bioinformatics
- To prepare the expert manpower in the bioinformatics industry, academia, and society
- To learn and promote research in the field of bioinformatics.
- To aware students on using computer for analyzing and solving biological data
- To learn computer aided drug discovery
- To create awareness and research facility in bioinformatics and molecular modeling

Couse Outcomes:

- The students shall have ability to correlate with evolutionary development.
- The students shall be able to compare the diversity of different aspects in analyzing the genetic and proteomic data.
- The students shall have skill to differentiate the primitive and modern traits of species.
- The students shall be able to use computer and different biological softwares and tools for solving biological problems.
- The students can categorize and apply computational approaches in understanding biological data.
- The students can analyze aspects in drug discovery.

Unit-I:

Learning Outcome: Students will learn about bioinformatics and understand the different biological databases**.**

- Bioinformatics: Introduction, History, Scope, and Application of bioinformatics. Concept of omics – genomics, transcriptomics proteomics, and metabolomics
- Biological databases, Types of sequence databases-primary, secondary, and composite.
- Nucleotides sequence repositories: NCBI (GenBank), DDBJ and EMBL-EBI (ENA); Protein sequence repositories: Uniport, Interpro, CATH, SCOP
- Other biological databases: Structural databases (pdb), Pathway database (KEGG, Reactome), Disease database (OMIM), Plant database (PlantGDB) and interaction database (BioGRID)

Unit-II:

Learning Outcome: Students will learn about biological sequence and methods for their alignment.

- Concept of program and algorithm. Basic concepts of sequence similarity, identity,

annotation; Definitions of homologues, orthologues, paralogues, concepts behind scoring matrices.

- Alignment of pairs of sequence, Global & Local Alignment, Basic Local Alignment Search tool (BLAST), PSI-BLAST and other variations. Application of BLAST tools.
- Multiple sequence alignment and its applications.

Unit-III:

Learning Outcome: Students will learn about methods of phylogenetics and phylogenetic tree construction. They will also have understanding on phylogenetic analysis tool.

- Concept of phylogenetics: Definition and description of phylogenetic tree and phylogenetic tree construction.
- Evolution, elements of phylogeny, methods of phylogenetic analysis, Phylogenetic tree of life, comparison of genetic sequence of organisms, 16SrRNA data analysis, general understanding of phylogenetic analysis tools-Phylip, ClustalW, MEGA
- Biodiversity informatics: current challenges and future prospects.

Unit-IV:

Learning Outcome: Students will learn about application of bioinformatics in the field of drug development and discovery.

- Natural products and Drugs; Principles of drug development. Bioinformatics in drug development, Chemoinformatics and Pharmacoinformatics.
- Applications of Drug Discovery and *In-Silico* Drug Designing, Drug discovery in the field of Molecular Biology, pharmaco-genomics and pharmaco-proteomics.
- Structure-based drug designing approaches:- Target Identification and Validation, homology modeling and protein folding, receptor mapping, active site analysis.

Practical:

1. To retrieve nucleotide, protein sequence and protein structure from a biological database.
2. To perform multiple sequence alignment for any number of sequences
3. To predict the secondary structure of protein using suitable proteomics tool
4. To retrieve biological data from various database (SwissProt, PDB, OMIM, KEGG)
5. To find the similar sequence to a given protein sequence using BLAST.
6. To perform homology modelling using Swiss PDB viewer
7. To perform structure visualization using suitable visualization tool.

Text Books:

- ✓ *P. E. Bourne and J. GU; Structural bioinformatics; 2nd edition. John Wiley and Sons. 2009.*
- ✓ *A. Leach; Molecular modelling – principles and applications; Pearson Education Ltd, 2001.*
- ✓ *Pandey B P (2020) NEP Botany For Bsc Students (molecular Biology And Bioinformatics) S chand Publication. New Delhi*

Reference Books:

- ✓ *N. C Jones and A. Pavel; Introduction to Bioinformatics Algorithms; the MIT Press, 2004.*
- ✓ *P. G. Higgs and T. K Attwood; Bioinformatics and Molecular Evolution; Blackwell Publishing, 2005.*
- ✓ *Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata Mc Graw Hill, Delhi.*

Singh Ruchi Bioinformatics: Genomics And Proteomics Vikas Publication New Delhi