3 Yr. Degree Course
(One Major & Two Minor)
based on NEP-2020
BOTANY

(Effective from Session 2025-26)

(Batch: 2025-2028)

SAMBALPUR UNIVERSITY

JYOTI-VIHAR, BURLA, SAMBALPUR, ODISHA-768019

COURSE AT A GLANCE (NEP-UG)

SUBJECT: *BOTANY* *ACADEMIC SESSION:* **2025-28**

CORE-I COURSE

Course Number	Semester	Course Title	Type of Paper P-Practical NP-Non-practical	Credit Hour	Maximum Weightage of Marks
Paper-I	I	Microbiology and Phycology	P	4	100
Paper-II		Analytical Technique in Plant Science	P	4	100
Paper-III	II	Cell Biology	P	4	100
Paper-IV		Mycology and Phytopathology	P	4	100
Paper-V	III	Archegoniate	P	4	100
Paper-VI		Anatomy of Angiosperms & Economic Botany	P	4	100
Paper-VII		Genetics	P	4	100
Paper-VIII	IV	Basic Molecular Biological	P	4	100
Paper-IX		Plant Ecology & Phytogeography	P	4	100
Paper-X		Plant Systemic	P	4	100
Paper-XI	V	Reproductive Biology of Angiosperm	P	4	100
Paper-XII		Basic Plant Physiology	P	4	100
Paper-XIII		Basic Plant Biotechnology	P	4	100
Paper-XIV	VI	Basic Plant Metabolism	P	4	100
Paper-XV				4	100
Paper-XVI	VII			4	100
Paper-XVII				4	100
Paper-XVIII				4	100
Paper-XIX				4	100
Paper-XX	VIII			4	100
Paper-XXI				4	100
Paper-XXII				4	100
Paper-XXIII				4	100

CORE-II/CORE-III COURSE

Course Number	Semester Core-II/ Core-III	Course Title	Type of Paper P-Practical NP-Non-practical	Credit Hour	Maximum Weightage of Marks
Paper-I	I/II	Microbiology and Phycology	P	4	100
Paper-II	III/IV	Cell biology	P	4	100
Paper-III	V/VI	Basic Plant Physiology	P	4	100
Paper-IV	VII		P	4	100
Paper-V	VIII		P	4	100

OTHER COURSES

MULTIDISCIPLINARY COURSES (MDC)UNDER NEP-2020

Three courses to be chosen from **baskets of Multidisciplinary courses** for Semester-I/II/III with 3 credits each. Students are advised to choose one course/ Semester from the basket provided. Students are advised to opt for courses outside their discipline. No repetition of courses allowed.

(Ref: University Letter No-3177/Acd. – I, Dated: 15. 07. 2025 & Letter No. 3993/Acd-I dated: 02.09.2025)

SEMESTER: I

Course No.	**Semester**	**Dept. to Teach**	**Course Title**	**Type of Paper** **P-Practical** **NP-Non-practical**	**Credit Hour**	**Maximum Weightage of Marks**
Paper-I	Semester-I	Chemistry	Environmental Chemistry	NP	3	100
		Botany	Gardening and Vermicomposting	NP	3	100
		Economics	Economics in Everyday Life	NP	3	100
		History	History of Education in Modern India	NP	3	100
		Odia	Tulanatmak Sahitya	NP	3	100
		Pol. Sc.	Political Process in India	NP	3	100
		English	Ethical Literature	NP	3	100
		Commerce	Financial Literacy	NP	3	100
		Education	Educational Psychology	NP	3	100

SEMESTER: II

Course No.	Semester	Dept. to Teach	Course Title	Type of Paper P- Practical NP-Non-practical	Credit Hour	Maximum Weightage of Marks
Paper-II	Semester-II	Statistics	Survival Analysis and Biostatistics	NP	3	100
		Zoology	Apiculture	NP	3	100
		Education	Gender and Education	NP	3	100
		Geography/Geology	Climatology	NP	3	100
		Philosophy	Vedic Culture	NP	3	100
		Hindi	Vigyapan Avadharana Aur Prayojanmulak Aayam	NP	3	100
		Home Science	Food Science and Processing	NP	3	100
		Commerce	Fundamentals of Entrepreneurship and E- Commerce	NP	3	100
		Economics	Demography	NP	3	100

SEMESTER: III

Course No.	Semester	Dept. to Teach	Course Title	Type of Paper P-Practical NP-Non-practical	Credit Hour	Maximum Weightage of Marks
Paper-III	Semester-III	Mathematics/Computer Science	Programming in C++	NP	3	100
		Physics	Introduction to Spectroscopy	NP	3	100
		History	Indian Knowledge System	NP	3	100
		Pol. Sc.	Human Rights	NP	3	100
		Sociology	Environmental Issues and Challenges	NP	3	100
		Commerce	Entrepreneurship Development and Start-up	NP	3	100
		Psychology	Health psychology	NP	3	100
		Sanskrit	Philosophy of Bhagavad Gita	NP	3	100
		Botany	Herbarium Preparation	NP	3	100

ABILITY ENHANCEMENT COURSE(AEC) UNDER NEP-2020

Sl. No.	Semester	Course	Credit hour (CH)	Full Mark
Paper-I	I	Odia/Hindi/Sanskrit/Urdu	4	100
Paper-II	II	English	4	100

SKILL ENHANCEMENT COURSES (SEC) UNDER NEP-2020

Three courses to be chosen from the **baskets of SEC** for Semester-II/V/VI respectively with 3 credits each. Student can opt any one of SEC courses in a particular semester from the basket without repetition.

(Ref: University Letter No-3177/Acd. – I, Dated: 15. 07. 2025) NB: All courses are non-practical (NP) papers.

Sl. No.	Semester	Course title	Credit hour (CH)	Marks
Paper-I	II	Personality Development Or Election studies and public opinion Or Quantitative and Logical Thinking Or Analytical Thinking and Logical Reasoning Or Renewable Energy & Energy Harvesting Or Vermicomposting	3	100
Paper-II	V	Yoga in Everyday Life Or Basics of Museum and Achieves Or Working with Communities Or Fundamentals of data science and data management	3	100

		Or Quantitative and Logical Thinking Or Programming With Mathematica		
Paper-III	VI	Life Skill Education Or Quantitative and Logical Thinking Or Income Tax E-return Filing Or Organic Farming Or Biofertilizer Or Type Setting in Latex	3	100

VALUE AIDED COURSES (VAC) UNDER NEP – 2020

(*Ref: University Letter No-3177/Acd. – I, Dated: 15. 07. 2025)*

Sl No	Semester	Paper	Course title	Credit	Marks
Paper-I	I	PAPER I	Environmental Studies and Disaster Management	3	100
Paper-I	III	PAPER II	Ethics & Values	3	100
Paper-I	V	PAPER III	Understanding Odisha	3	100
Paper-I	VI	PAPER IV	Creative Writing	3	100

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.

COURSE STRUCTURE

THREE –YEAR DEGREE COURSE WITH A SINGLE MAJOR AND TWO MINOR

SEMESTER	CORE-I	CORE-II	CORE-III	MULTI DISCIPLINARY	AEC	SEC	VAC	COMMUNITY ENGAGEMENT AND SERVICE/FIELD WORK/INTERNSHIP	TOTAL MINIMUM CREDIT
I	2x4=8	1x4=4		1x3=3	1x4=4 Odia/Hindi/Sanskrit		1x3=3 Env. Studies And Disaster Management		22
II	2x4=8		1x4=4	1x3=3	1x4=4 English	1x3=3			22
*VOCATIONAL COURSE I (4 CREDIT)									44
III	3x4=12	1x4=4		1x3=3			1x3=3		22
IV	3x4=12		1x4=4					1x4=4	20
* VOCATIONAL COURSE II (4 CREDIT)									42
V	3x4=12	1x4=4				1x3=3	1x3=3		22
VI	2x4=8		1x4=4			1x3=3	1x3=3		18
									40
TOTAL	15x4=60	3x4=12	3x4=12	3x3=9	2x4=8	3x3=9	4x3=12	1x4=4	126

- In case s student opts for NCC and clears 'C' certificate, additional 16 credits shall be awarded and total credit shall be 126+16=142 credit.
- One credit is equivalent to one hour of lecture or tutorials or two hours of practical work/field work per week in a semester. One Credit will be generally equivalent to 15 hours of instructions.
- Each semester shall comprise of 15 weeks of academic activities with a minimum of 90 working days.

Vocational Course:

- Students may choose vocational courses after 2nd semester and 4th semester for Certificate Course or Diploma Course respectively with 4 credit each opt for exit.

EVALUATION

Distribution of Marks in Semester End and Continuous Evaluation:

(Irrespective of credit in a course /Paper)

Course Type	Maximum Marks	Semester-End theory Mark	Continues Evaluation Marks /Sessional	Mid Semester theory Mark	Semester-End and Practical mark	Mid Semester Practical Mark
Without Practical	100	60	20	20	----	--
With Practical	100	50	10	10	20	10

Distribution of Sessional Marks

Course Type	Maximum Mark	Mid Semester	Attendance	Surprise Test/Quiz	Assignment/ Presentation
Without Practical	40	20	Above95%- 5Marks	10	05
With Practical	30	(Theory10+ Practical10)=20	85%-94%- 4Marks 75%-84%- 3Marks	05	Nil

Examination Question Pattern of Term End Examination

The term end theory examination shall be for 100 marks of three hour's duration, the weightage shall be 50 with practical and 60 without practical.

Question Pattern		With Practical	Without Practical
Part-I–Objective	Answer in MCQ/One word/Sentence. (All are Compulsory)	1x10=10	1x10=10
Part-II-Very Short Type	Answer maximum 50 words (All are Compulsory)	2x9=18	2x9=18

Part-III-Short Type	Answer maximum 250 words Answer any 8 out of 10 questions	5x8=40	5x8=40
Part-IV-Long Type	Answer maximum 800 words Answer any 4 out of 5 questions	8x4=32	8x4=32
Total		**100**	**100**
For Practical Paper		One Major Experiment-10 Record- 05 Viva voce-05	

BOTANY (MAJOR) SEMESTER-I

PAPER-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 up to 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 ‘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

Textbooks:

- ✓ *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 SemesterI,NEP2020;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. 8thedition.*
- ✓ *Kumar,H.D.(1999).Introductory Phycology . Affiliated East-West Press, Delhi.*
- ✓ *Campbell,N.A.,ReeceJ.B.,UrryL.A.,CainM.L.,WassermanS.A.MinorskyP.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.*

PAPER-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.
- Skillful 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 acquire 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, CsCl2 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, SDSPAGE. 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

TextBooks:

- ✓ *Patil,C.S.(2017).Advanced Analytical Techniques, ABE Books, New Delhi.*
- ✓ *Pandey BP(2023).Botany for B.Sc.Students SemesterI,NEP2020;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:NEP2020,S.Chand Publishing.

SEMESTER-II

PAPER-III 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 discolor*
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.

TextBooks:

- ✓ *Rastogi,V. B. (2016).Introductory Cytology, Kedar Nath & RamNath, Meerut*
- ✓ *Verma PS & Agarwal VK(2022)Cell Biology(Cytology,Biomolecules 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, 2nded., 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, MolecularBiology2edVikas 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

Course Objectives

- To learn classification and diversity of fungi and their nutritional requirements.
- To learn the lifecycle 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; Lifecycle of *Puccinia* and *Agaricus*.

Unit-II:

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

- **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.

TextBooks:

- ✓ *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).Textbook of Fungi and Their Allies, Macmillan Publishers India Ltd.*
- ✓ *Mehrotra, R.S. (2011). Plant Pathology. Tata McGraw-Hill Publishing Company Limited, New Delhi*
- ✓ *Vashishta B.R,Sinha ,A.K & Kumar .A Botany For Degree Students :FUNGI(S Chand Publication) New Delhi*
- ✓ *Dubey RC & Maheshwari DK (2021) A textbook of Microbiology, S.Chand publication, New Delhi*

SEMESTER-III

PAPER-V *ARCHEGONIATE*

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 students 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.

Textbooks:

- ✓ *Vasistha, B. R. (2017) Botany for Degree student, Bryophyta, S. Chand Publication, New Delhi.*
- ✓ *Singh, V., Pandey, P.C.andJain, D.K.(2017).Archegoniate,RastogiPublication, 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.NewDelhi, 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.*

PAPER-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 Corpus theory, 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 plants.

- **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).

Textbooks:

- ✓ *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.*

PAPER-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 co dominance; 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 chisquare analysis.
3. Chromosome mapping using testcross 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).

Textbooks:

- ✓ *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. S Chand Publication, New Delhi*

Reference Books:

- ✓ *Gardner, E.J., Simmons, M.J., Snustad, D.P.(1991).PrinciplesofGenetics,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).Introductionto Genetic Analysis. W.H. Freeman and Co., U.S.A. 10th edition.*
- ✓ *Strickberger,M.W.Genetics,PearsonPublishers,3rd Edition*
- ✓ *Rastogi V.B. (2017).Genetics, Kedar Nath& Ram Nath, Meerut*

SEMESTER-IV

PAPER-**VIII** **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 – Chromatinstructure - 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;

EnzymesinvolvedinDNAreplication.Centraldogmaandgeneticcode:Keyexperiments 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′ poly A 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.

TextBooks:

- ✓ *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).Introductionto Genetic Analysis. W.H. Freeman and Co., U.S.A. 10th edition.*
- ✓ *Alberts, B.etal.2014. Molecular Biology of the cell GarlandScience.6thEdition*
- ✓ *Power, C.B. (2017)Cell Biology ,Himalaya Publishing House, New Delhi* ✓ *Sahu, A.C.(2017).Essentials of Molecular Biology, Kalyni Publishers, New Delhi.* ✓ *KumarH.DMolecularBiology2ndEd.VikasPublicationNew Delhi.*

PAPER-IX PLANT ECOLOGY AND 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 based efficiency 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, halophytes (two each).
5. Determination of minimal quadrate 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).FundamentalsofEcology.RastogiPublications,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).ConceptsofecologyPHILearningPvt.Ltd.,Delhi,India.4thedition.*
- ✓ *Santra,S.C.(2015)EnvironmentalScience.NewCentralBookAgency(P)Ltd.Kolkata.*
- ✓ *DasM.C.andDasS.P.(2009).FundamentalofEcology.TataMGrowHill,NewDelhi.*
- ✓ *Shukla R.S. and Chandel P.S. (2016). A Text Book of Plant Ecology. S Chand Publication, New Delhi.*
- ✓ *Kumar HD by Modern Concept of Ecology Revised Ed. Vikas Publication.*

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 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 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)

TextBooks:

- ✓ *Harma O. P. (2009)Plant Taxonomy, Tata McGraw Hill, New Delhi*
- ✓ *Sharma A. K, Sharma R, Taxonomy of Angiosperms and Utilization 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).TextBookofPlantSystematics,KalynaiPublisher,New Delhi.*
- ✓ *Subrahmainayam,M.S.(2011)ModernPlantTaxonomy,VikashPublishingHouse,NewDelhi*

SEMESTER-V

PAPER-XI REPRODUCTIVE BIOLOGY OF ANGIOSPERMS

Course Objectives

- To give a comprehensive idea about economic botany and its importance inhuman 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 ultra structure 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; Intra ovarian 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

  Polyembryonyandapomixes:Introduction;Classification;Causesandapplications

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),ultra structure 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).DevelopmentalBiologyofFloweringplants,Springer,Netherlands.*
- ✓ *Johri, B.M.l (1984).Embryology of Angiosperms, Springer-Verlag, Netherlands.*
- ✓ *Mishra, B.K.(2017).ReproductiveBiologyofAngiosperms,KalyaniPublishers,New Delhi.*
- ✓ *Pandey, B.P., (2017).Taxonomy of Angiosperm .S. Chand Publication New Delhi*

PAPER- 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.
- Theclimaticandphysiologicalrequirementsformolecularsignalingofplantsfor 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, path way 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 photo systems; 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 evolvingcomplexandwatersplitting.Cyclicelectronflow:processandfunction;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 photo morphogenesis.

- 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:

- Determination of osmotic potential of plant cell sap by plasmolytic method.
- Determination of water potential of given tissue(potato tuber) by weight method.
- Study of the effect of wind velocity and light on the rate of transpiration in excised twig/leaf.
- Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
- To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces).
- To study the phenomenon of seed germination (effect of light).
- To study the induction of amylase activity in germinating barley grains.
- To demonstrate suction due to transpiration.
- Measurement of relation between transpiration and transpiring surface
- Measurement of cuticular resistance to transpiration.
- Measurement of primary photochemical reactions by fluorescence.

Text Books:

✓ *Pandey and Sinha (2011).Plant Physiology, Vikash Publishing House, New Delhi* ✓ Jain VK Fundamental of Plant physiology,20th ed.Schand publication, 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.*

✓ *BajracharyaD.(1999).ExperimentsinPlantPhysiology-ALaboratoryManual.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.*

PAPER-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, Micro projectile 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)

TextBooks:

- ✓ *Chawla, H. S. (2010). Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.*
- ✓ *Ramawat K G & Goyal S Comprehensive Biotechonology 4th edS 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).PlantBiotechnology&Genetics:Principles,Techniquesand Applications. John Wiley & Sons Inc. U.S.A.*
- ✓ *Singh,B. D.(2018). Plant Biotechnology Kalyani Publishers, New Delhi.*
- ✓ *Gupta,P. K.(2017). Plant Biotechnology , Rastogi Publication, Meerut.* ✓ *Dubey, R.C.(2017).Advanced Biotechnology, S, Chand Publication, New Delhi*

SEMESTER-VI

PAPER-XIV BASIC PLANT METABOLISM

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 energy synthesis .
- 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 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, break down 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 amino acid 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 Vmax and Km
- Enzyme inhibition: competitive, non-competitive inhibition, determination of Ki, 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 (3rded.), 2005. Elsevier Academic Press.*

PAPER-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); Soild degradation and management.
- **Water:** Freshwater (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 and minor 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 foot print

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

Textbooks:

- ✓ *Pandey, B.W. 2005.Natural Resource Management. Mittal Publication, New Delhi*
- ✓ *Singh JS & Singh SP(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.andBoyd,J.A.(2008).AnIntroductiontoSustainableDevelopment. Prentice Hall of India Private Limited, New Delhi.*

PAPER-I **SEMESTER-I/II**

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 up to 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 lifecycle 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:

9. Electron micrographs/Models of viruses–T-Phage and TMV, Line drawings/Photographs of Lytic and Lysogenic Cycle.
10. Types of Bacteria to be observed from temporary/permanent slides/photographs.
11. Examination of bacteria from bacterial culture by Gram ‘staining method.
12. Electron micrographs of bacteria, binary fission, endospore, conjugation, root Nodule (live materials and photographs).
13. Bacterial growth measurement by turbidometry.
14. Hemocytometry
15. Colony counting using colony counter
16. 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

Textbooks:

- ✓ *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 SemesterI,NEP2020;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. 8thedition.*
- ✓ *Kumar,H.D.(1999).Introductory Phycology . Affiliated East-West Press, Delhi.*
- ✓ *Campbell,N.A.,ReeceJ.B.,UrryL.A.,CainM.L.,WassermanS.A.MinorskyP.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.*

PAPER-II SEMESTER-III/IV

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 discolor*

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.

TextBooks:

- ✓ *Rastogi,V. B. (2016).Introductory Cytology, Kedar Nath & RamNath, Meerut*
- ✓ *Verma PS & Agarwal VK(2022)Cell Biology(Cytology,Biomolecules 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, 2nded., 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,MolecularBiology2edVikas 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

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PAPER-III SEMESTER-V/VI

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.
- Theclimaticandphysiologicalrequirementsformolecularsignalingofplantsfor 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, path way 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 photo systems; 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 photo morphogenesis.

- **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.

Text Books:

- ✓ *Pandey and Sinha (2011).Plant Physiology, Vikash Publishing House, New Delhi* ✓ Jain VK FundamentalofPlantphysiology,20th ed.Schand publication, 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.*
- ✓ *BajracharyaD.(1999).ExperimentsinPlantPhysiology-ALaboratoryManual.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.*