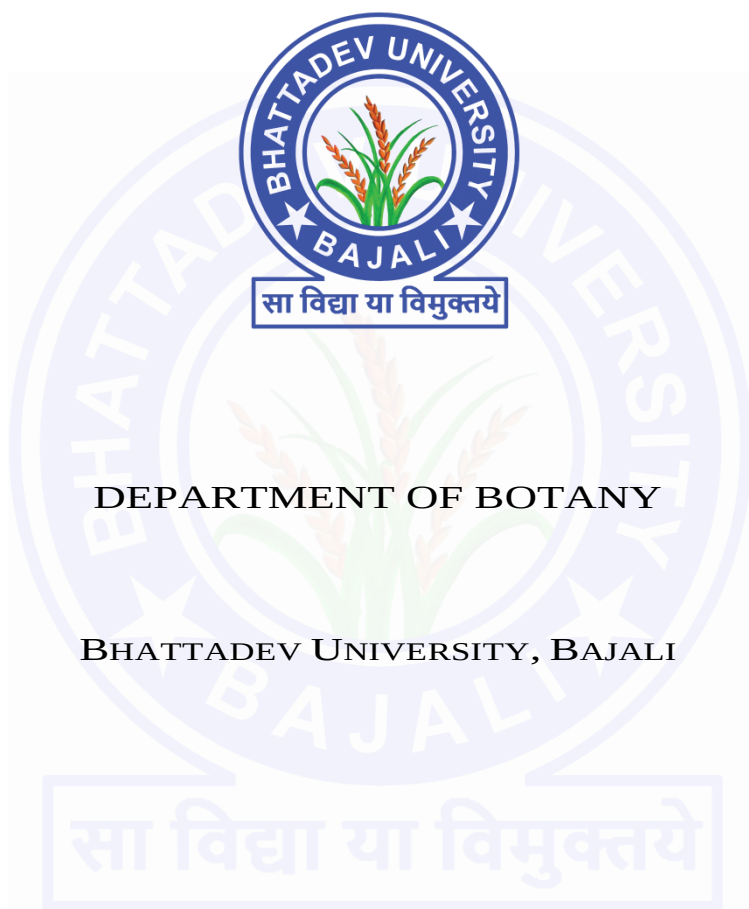

FOUR YEAR UNDERGRADUATE PROGRAM (FYUGP) SYLLABUS

JUNE, 2023



DEPARTMENT OF BOTANY

BHATTDEV UNIVERSITY, BAJALI

Introduction

The University Grants Commission (UGC) has initiated several measures to bring equity, efficiency and excellence in the Higher Education System of country. The important measures taken to enhance academic standards and quality in higher education include innovation and improvements in curriculum, teaching-learning process, examination and evaluation systems, besides governance and other matters. But due to the various diversities present in the system of higher education, there are multiple approaches followed by universities towards examination, evaluation and grading system. However, the academic reforms recommended by the UGC in the recent past have led to overall improvement in the higher education system. On the basis of the recommendation, apart from the flexibility and freedom in designing the examination, there is a need to devise a sensible system for awarding the grades based on the performance of students.

The NEP-2020 based **Four-Year Undergraduate Programme (FYUGP)**, being adopted by Bhattadev University, is an 8-semester (4-year) programme of 160 credits with multiple exit and entry options at the successful completion of courses assigned at the end of each year.

- Students who opt to exit after completion of the first year and have secured 40 credits will be awarded a **certificate** if, in addition, they complete one vocational course of 4 credits during the summer vacation of the first year.
- Students who opt to exit after completion of the second year and have secured 80 credits will be awarded the **diploma** if, in addition, they complete one vocational course of 4 credits during the summer vacation of the second year.
- Students who opt to exit after completion of the third year and have secured 120 credits will be eligible for the **Bachelor degree** in the Major discipline without Honours.
- Students after completion of the fourth year and have secured 160 credits will be eligible for the **Bachelor degree with Honours** in the Major discipline.
- Students are allowed to re-enter the degree programme within three years and complete the degree programme within the stipulated maximum period of seven years.

Outline of Courses :

The broad categories of courses and minimum credits required for the 4-year Honours degrees as per the UGC document are as follows:

1. **Major (Core) course/paper** : 80 credits
2. **Minor course/paper** : 32 credits
3. **Interdisciplinary course/paper (IDC)** : 9 credits
4. **Ability Enhancement Course/paper (AEC)** : 8 credits
5. **Skill Enhancement Course/paper (SEC)** : 9 credits
6. **Value Added Course/paper (VAC)** : 8 credits
7. **Summer Internship** : 2 credits
8. **Research Project/ Dissertation** : 12 credits (for Honours with Research degree)

The following points may be noted:

- In lieu of the Research Project, a student may study 3 courses each of 4 credits (i.e. total 12 credits), leading to an Honours degree (without Research).
- For the 4-year Honours degrees the Major subject/ discipline requires 80 credits and the Minor subject/ discipline requires 32 credits.
- For a Double Major, the minimum credit requirements are 48 (3-year degree) and 60 (4- year Honours degree) respectively in a subject/ discipline other than the original Major.
- In the UGC framework, papers in Major and Minor disciplines are categorized into levels of 100, 200, 300 and 400. Therefore, a course (paper) offered by a Department, say with 4 credits and of level 200, may be taken both as a Major (Core) course by one student and as a Minor course by

another student having a different Major discipline, possibly in different semesters.

Definition of Keywords

In FYUGP the terminologies those are relevant to the B.Sc. curricula have been briefly described below.

Academic Year: Two consecutive (one odd + one even) semesters constitute one academic year.

Semester: Each semester will consist of 15 weeks of regular academic work. The odd semester may be scheduled from July to December and even semester from January to June under normal circumstance.

Programme: An educational programme leading to award of a Certificate, Diploma or Degree (B.Sc., B.A., etc.)

Discipline: This means a particular subject.

Course: Each programme is equipped with number courses of various disciplines/subjects. The course of a particular discipline/subject refers to the content of the papers the students have to study in that discipline/subject required in obtaining a degree. The courses should define learning objectives and learning outcomes. A course may be designed to comprise Lectures/tutorials/laboratory work/field work/outreach activities/project work/seminars/assignments/presentations etc. or a combination of any of these.

Honours: A particular discipline/subject that a student opts as major subject. (e.g. Honours in Botany)

Core Course (CC): A discipline/subject specific compulsory basic course.

Skill Enhancement Course (SEC): A course designed by a department for enhancement of skill of the students in a particular discipline/subject.

Minor Course (M): A course in a discipline/subject corresponding to a subject other than the major subject.

Value Added Course (VAC): Value-based education to include management of biological resources and biodiversity for the development of humanistic, ethical, sustainable development and living, constitutional, and universal human values of truth, righteous conduct, peace, love, nonviolence, scientific temper, citizenship values, and life skills.

Ability Enhancement Compulsory Course (AECC): These are compulsory courses. For science programme there will be two of them. AECC-1 is Communicative English & AECC-2 is Environmental Science.

Vocational Course (VOC): A vocational course is focused on practical work, preparing students for a particular trade or skilled profession. These courses are best for students who have a good idea of their career path and want to gain the knowledge to get there.

Credit: A unit by which the course work is measured. It determines the number of hours of instructions required per week. **Theory/Tutorial classes:** 1 credit = 1 hour / week and **Practical classes:** 1 credit = 2 hours / week

Credit Point: It is the product of grade point and number of credits for a course.

Letter Grade: It is an index of the performance of students in a said course.

Grade Point: It is a numerical weight allotted to each letter grade on a certain point scale. The following table explains the above two points

Letter Grade	Grade Point	Performane	Letter Grade	Grade Point	Performane
O	10	Outstanding	C+	5	Average
A+	9	Excellent	C	4	Pass
A	8	Very Good	F	0	Fail
B+	7	Good	I	0	Absent/Incomplete
B	6	Above Average			

Semester Grade Point Average (SGPA): It is a measure of performance of work done in a semester. It is ratio of total credit points secured by a student in various courses registered in a semester and the total course credits taken during that semester. It shall be expressed up to two decimal places. If C_i = credit point in the i^{th} course/paper and G_i = grade point obtained by a student in the i^{th} course/paper then the grade point average in the i^{th} Semester i.e.

$$\text{SGPA} (S_i) = \Sigma(C_i \times G_i) / \Sigma C_i$$

Example for Computation of SGPA Semester	Course	Credit	Letter Grade	Grade point	Credit Point (Credit x Grade)
I	Course 1	3	A	8	$3 \times 8 = 24$
I	Course 2	4	B+	7	$4 \times 7 = 28$
I	Course 3	3	B	6	$3 \times 6 = 18$
I	Course 4	3	O	10	$3 \times 10 = 30$
I	Course 5	3	C	5	$3 \times 5 = 15$
I	Course 6	4	B	6	$4 \times 6 = 24$
		20			139
SGPA			139/20= 6.95		

Cumulative Grade Point Average (CGPA): It is a measure of overall cumulative performance of a student over all semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters. It is expressed up to two decimal places. If S_i = Semester Grade point average in the i^{th} semester and S = total number of semesters in the program, then the cumulative grade point average i.e. CGPA scored by the student is given by

$$\text{CGPA} = \Sigma (C_i \times S_i) / \Sigma C_i$$

Semester 1	Semester 2	Semester 3	Semester 4	Semester 5	Semester 6
Credit: 21 SGPA:6.9	Credit: 22 SGPA:7.8	Credit:25 SGPA:5.6	Credit: 26 SGPA:6.0	Credit: 26 SGPA: 6.3	Credit 25 SGPA 8.0

$$\text{CGPA} = \mathbf{6.73} (21 \times 6.9 + 22 \times 7.8 + 25 \times 5.6 + 26 \times 6.0 + 26 \times 6.3 + 25 \times 8.0)/145$$

Grade Sheet/Report: Based on the grades earned, a grade certificate shall be issued to all the registered students after every semester. The grade certificate will display the course details (code, title, number of credits, grade secured) along with SGPA of that semester and CGPA earned till that semester.

CC : Core Course/Papers [For Degree with Botany (Major), 3 years UG program]

LISTS OF PAPERS

1. BOT1104C : Microbial and Algal Diversity (Level: 100–199)
2. BOT2104C : Biomolecules and Cell Biology (Level: 200–299)
3. BOT3104C : Mycology and Phytopathology (Level: 200–299)
4. BOT3204C : Archegoniate and Palaeobotany (Level: 200–299)
5. BOT4104C : Morphology and Anatomy of Angiosperms (Level: 200–299)
6. BOT4204C : Genetics and Plant Breeding (Level: 200–299)
7. BOT4304C : Plant Ecology and Taxonomy (Level: 200–299)
8. BOT5104C : Reproductive Biology of Angiosperms (Level: 300–399)
9. BOT5204C : General Microbiology (Level: 300–399)
10. BOT5304C : Molecular Biology (Level: 300–399)
11. BOT5404C : Economic Botany and Biostatistics (Level: 300–399)
12. BOT6104C : Fundamentals of Plant Biotechnology (Level: 300–399)
13. BOT6204C : Bioinformatics (Level: 300–399)
14. BOT6304C : Industrial and Environmental Microbiology (Level: 300–399)
15. BOT6404C : Analytical Techniques in Plant Sciences (Level: 300–399)

SEC : Skill Enhancement Course/Papers

1. BOT1103SE : Biofertilizers
2. BOT2103SE : Mushroom Culture Technology
3. BOT3103SE : Nursery and Gardening

IDC : Interdisciplinary Course/Papers [Offered to the students of **other discipline**]

1. BOT1104ID : Plant Diversity and Human Welfare
2. BOT2104ID : Intellectual Property Rights
3. BOT3104ID : Entrepreneurship in Botany

MC : Minor Course/Papers for FYUGP in the subject Botany

LISTS OF PAPERS

1. BOT1104M : Microbial and Algal Diversity (Level: 100–199)
2. BOT2104M : Biomolecules and Cell Biology (Level: 200–299)
3. BOT3104M : Mycology and Phytopathology (For Single major) (Level: 200–299)
4. BOT3204M : Archegoniate and Paleobotany (Additional course to be chosen for Double Major with BOT3104M) (Level: 200–299)
5. BOT4104M : Morphology and Anatomy of Angiosperms (For Single major) (Level: 200–299)
6. BOT4204M : Genetics and Plant Breeding (Additional course to be chosen for Double Major with BOT4104M) (Level: 200–299)
7. BOT5104M : Reproductive Biology of Angiosperms (For Single major) (Level: 300–399)
8. BOT5204M : General Microbiology (Additional course to be chosen for Double Major) (Level: 300–399)
9. BOT5304M : Molecular Biology (Additional course to be chosen for Double Major with BOT5104M)

10. BOT6104M : Fundamentals of Plant Biotechnology (For Single major) (Level: 300–399)
11. BOT6204M : Bioinformatics (Additional course to be chosen for Double Major) (Level: 300–399)
12. BOT6304M : Industrial and Environmental Microbiology (Additional course to be chosen for Double Major with BOT6104M and BOT6204M) (Level: 300–399)

SEMESTER	TYPE OF THE COURSES						
	Core Course 1	Core Course 2	AE Course	SE Course	ID Course	VA Course	Internship
SEM I	BOT1104C	Any other subject	A commonly designed course of Cr-2	BOT1103SE	BOT1103ID	To be designed CENTRALLY of Credit 4	X
SEM II	BOT2104C	Any other subject	A commonly designed course of Cr-2	BOT2103SE	BOT2103ID	To be designed CENTRALLY of Credit 4	X
Exit option with a Certificate after one year a mandatory VOC of credit 4 has to be chosen or Proceed to Second year							
SEMESTER	Major/Core Course	Minor	AE Course	SE Course	ID Course	VA Course	Internship
SEM III	BOT3104C	Any other subject	A commonly designed course of Cr-2	BOT3103SE	BOT3103ID	N/A	N/A
	BOT3204C						
SEM IV	BOT4104C	Any other subject	A commonly designed course of Cr-2	N/A	N/A	N/A	Has to be engaged in a summer internship of Cr-2
	BOT4204C						
	BOT4304C						
Exit option with a Diploma after two years a mandatory VOC of credit 4 has to be chosen or Proceed to Third year							
SEM V	BOT5104C	Any other subject	N/A	N/A	N/A	N/A	N/A
	BOT5204C						
	BOT5304C						
	BOT5404C						
SEM VI	BOT6104C	Any other subject	N/A	N/A	N/A	N/A	N/A
	BOT6204C						
	BOT6304C						
	BOT6304C						
Exit option with a Bachelor Degree after three years or Proceed to Fourth year							
SEM VII	BOT7104C	Any other subject	N/A	N/A	N/A	N/A	N/A
	BOT7204C						
	BOT7304C						
	BOT7404C						

SEMESTER I

Course Code: BOT1104C

Course Name: Microbial and Algal Diversity

(Credits: Theory-03, Practicals-1)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to understand

1. The concept of kingdom.
2. Three domains of life.
3. Diversity, life forms, life cycles, morphology of microorganisms and algae.
4. Economic and ecological importance of microorganisms and algae.

Course Learning Outcomes:

On successful completion of this course:

1. Students will understand the classification, characteristic features, cell structure and growth and reproduction in viruses, bacteria, fungi and algae and their economic importance.
2. Moreover, students will be able to identify the microbes and algae in laboratory and in field as well.

Section I:

(11 Lectures)

Introduction to Microbes: Hierarchical organization of microbes in living world; Kingdom concept; Three domains of life; Distribution of microorganisms in soil, air, water and food; Economic importance.

Viruses: Discovery, physiochemical and biological characteristics; general structure, with special reference to viroids and prions; Classification (Baltimore 1971), replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV).

Section II:

(12 Lectures)

Bacteria: Discovery, General characteristics; Types-archaebacteria, eubacteria, wall-less forms (mycoplasma and spheroplasts); Cell structure; Nutritional types; Reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction)

Introduction to fungi: General characteristics; Thallus organization; Cell wall composition; Nutrition; Classification (Anisworth, 1973).

Section III:**(10 Lectures)**

Study of major divisions of fungi: General characteristics of Chytridiomycota, Zygomycota, Ascomycota, Basidiomycota: asexual and sexual fruiting bodies; Brief account of *Mucor*, *Aspergillus*, *Penicillium* and *Agaricus* (Mycelial form). Economic importance of fungi.

Section IV:**(12 Lectures)**

Algae: General characteristics; Ecology and distribution; Evolutionary trend in thallus organization; Cell structure; Pigment system; Reserve food; Classification (Lee 2008); Reproduction and Economic importance. Life Cycle of Chlorophyceae (*Volvox*, *Oedogonium*); Charophyceae (*Chara*); Bacillariophyceae (*Diatoms*); Phaeophyceae (*Ectocarpus*); Rhodophyceae (*Polysiphonia*); Cyanophyceae (*Nostoc*) and Xanthophyceae (*Vaucheria*).

Practical**(Lectures: 30)**

1. EMs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle.
2. Gram staining of bacteria (For both Gram positive and Gram negative).
3. Types of Bacteria from temporary/permanent slides/photographs and by Gram staining technique; electron micrographs of bacterial reproduction, Binary Fission and Conjugation
4. Study of asexual stage from temporary mounts. Study of sexual stage from permanent slides/ cultured specimens/photographs of the following genera; *Mucor*, *Aspergillus*, *Penicillium*, *Puccinia* and *Agaricus*.
5. Study of diversity in thallus forms of algae: Cyanophyceae, Chlorophyceae, Xanthophyceae, Phaeophyceae and Rhodophyceae through temporary mounts, specimens or permanent slides.

Note: List of practical may be updated depending on the availability of resources.

Suggested Readings

Viruses and Bacteria:

1. Campbell, N.A. & Reece, J.B., 2008, Biology, 8th edition, Pearson Benjamin Cummings, San Francisco.
2. Pelczar, M.J., 2001, Microbiology, 5th Edition, Tata McGraw-Hill Co., New Delhi.
3. Tortora, G.J., Funke, B.R. & Case, C.L., 2010, Microbiology: An Introduction, 10th edition, Pearson Benjamin Cummings, U.S.A.
4. Wiley, J.M., Sherwood, L.M. & Woolverton, C.J., 2013, Prescott's Microbiology, 9th Edition, McGraw Hill International.

Algae:

1. Lee, R.E., 2008, Phycology, 4th edition, Cambridge University Press, Cambridge.
2. Kumar, H.D., 1999, Introductory Phycology, East-West Press, Delhi.
3. Sharma, O.P., 2011, Diversity of Microbes & Cryptogams (Algae). Tata McGraw-Hill, New Delhi.
4. Vashishta, B.R., Sinha, A.K. and Singh, V.P (2010). Botany for degree students- Algae. S. Chand and Co. Ltd., New Delhi.

Fungi:

1. Agrios, G.N., 2011, Plant Pathology, 6th edition, Academic Press, U.K.
2. Alexopoulos, C.J., Mims, C.W. & Blackwell, M., 1996, Introductory Mycology, 4th edition, John Wiley & Sons (Asia) Singapore.
3. Sethi, I.K. & Walia, S.K., 2011, Text book of Fungi and Their Allies, Macmillan Pub. India Ltd.
4. Sharma, P.D., 2011, Plant Pathology, Rastogi Publication, Meerut, India.
5. Webster, J. & Weber, R., 2007, Introduction to Fungi, 3rd Edition, Cambridge Univ Press, Cambridge.

SEMESTER II

Course Code: BOT2104C

Course Name: Biomolecules and Cell Biology

(Credits: Theory-03, Practicals-1)

THEORY

(Lectures: 45)

Course Objectives:

After completion of the course, the learner shall be able to understand:

1. The organization of cell, its features and regulation at different levels.
2. Structure and function of biomolecules (i.e. proteins, carbohydrates, lipids and nucleic acids).
3. Organization and function of cell organelles.
4. The process of cell cycle and cell division.

Course Learning Outcomes:

On successful completion of this course, students:

1. Will be able to demonstrate foundational knowledge in understanding of cell metabolism, chemical composition, physiochemical and functional organization of organelle.
2. Will be able to know contemporary approaches in modern cell and molecular biology.
3. Will be able to demonstrate isolation and estimation of biomolecules.

Section I:

(10 Lectures)

Biomolecules

Types and significance of chemical bonds; Structure and properties of water; pH and buffers.

Carbohydrates: Nomenclature and classification; Monosaccharide and its derivatives; Disaccharide; Polysaccharides; Reducing and non-reducing sugar.

Lipids: Properties and function of lipids; Essential fatty acids; Triacylglycerol and Wax; Phospholipids.

Amino acids and Proteins: Structure and optical properties of amino acids; Peptide and polypeptide; Protein structure- primary, secondary, tertiary and quaternary; Protein denaturation and biological role of proteins.

Section II:

(11 Lectures)

Nucleic acids: Nitrogenous bases; Structure and function of Nucleotides; Types of nucleic acids; Basic structure of dsDNA (with A, B and Z forms) and RNA.

Bioenergetics

Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as an energy currency molecule.

Enzymes:

Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; Features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced - fit theory), Michaelis–Menten equation, enzyme inhibition and factors affecting enzyme activity.

Vitamins:

General characteristics of vitamins and hormones. Nomenclature and classification of vitamins and its significance.

Section III:**(10 Lectures)*****The Cell***

Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory).

Cell wall and plasma membrane

Chemistry, structure and function of Plant cell wall. Overview of membrane function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis.

Cell Organelles

Nucleus: Structure- nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; Nucleolus- Nucleolar-organizing regions.

Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament.

Chloroplast, mitochondria and peroxisomes: Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast.

Ribosomes: Structure and types.

Section IV:**(14 Lectures)**

Endomembrane system: Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing; Smooth ER and lipid synthesis, export of proteins and lipids; Golgi Apparatus – organization, protein glycosylation, protein sorting and export from Golgi Apparatus; Lysosomes.

Nucleus: Structure, nuclear envelope and nuclear matrix; Nucleolus- nucleolar organizing region.

Cell Cycle and Cell Division

Phases of eukaryotic cell cycle; Cell cycle checkpoints; Cell division-mitosis and meiosis; Cell Signaling mechanism, signal transduction and signal protein; role of protein kinases.

Practical
(Lectures: 30)

1. Qualitative test for carbohydrates, reducing sugars, non-reducing sugars, lipid and proteins.
2. Cell structure with the help of epidermal peel mount of Onion/ Rhoeo.
3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla/Vallisneria* leaf.
4. Counting the cells per unit volume with the help of haemocytometer (Yeast/pollen grains).
5. Cytochemical staining: DNA- Feulgen and cell wall in the epidermal peel of onion using Periodic Schiff's (PAS) staining technique.
6. Study different stages of mitosis and meiosis.
7. Meiosis through temporary squash preparation.

Note: List of practical may be updated depending on the availability of resources.

Suggested Readings

Biomolecules:

1. Campbell, M.K. (2012) Biochemistry, 7th ed., Published by Cengage Learning
2. Campbell, P.N. and Smith, A.D. (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
3. Tymoczko, J.L., Berg, J.M. and Stryer, L. (2012) Biochemistry: A short course, 2nd ed., W.H. Freeman
4. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2011) Biochemistry, W.H. Freeman and Company
5. Nelson, D.L. and Cox. M.M. (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company
6. Voet, G and Voet, J.G. (2010). Biochemistry. 4th Edition, Wiley, Hoboken

Cell Biology:

1. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
2. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
3. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. 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

SEMESTER III

Core Course Code: BOT3104C

Course Name: Mycology and Phytopathology

(Credits: Theory-03, Practical-1)

THEORY

Lectures: 45

Course Objectives:

- To introduce students with various fungal groups and lichens, their ecology.
- Classification, characteristics, reproduction and economic importance.
- To introduce students with the phytopathology, its concepts and principles.
- To acquaint with various plant diseases, causal organisms and their control.

Course Learning Outcomes:

- Understand the world of fungi, lichens and pathogens of plants.
- Understand characteristics the ecological and economic significance of the fungi and lichens.
- Understand the application of mycology in various fields of economic and ecological.
- Understand the economic and pathological importance of fungi, bacteria and viruses.
- Identify common plant diseases and their control measures.

Section I

(16 Lectures)

Introduction to true fungi: Definition, General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Heterokaryosis and parasexuality; Nutrition; Classification.

Zygomycota: General characteristics; Ecology; Thallus organization; Life cycle with reference to *Rhizopus*.

Ascomycota: General characteristics; Ecology; Life cycle, life cycle and classification with reference to *Saccharomyces*, *Penicillium*, *Alternaria* and *Neurospora*.

Basidiomycota: General characteristics; Ecology; Life cycle and Classification with reference to black stem rust on wheat *Puccinia* (Physiological Specialization), *Ustilago* (loose and covered smut, symptoms only), *Agaricus*; Fairy Rings and Mushroom Cultivation.

Section II

(06 Lectures)

Symbiotic associations: Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Economic importance of lichens. ; Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.

Section III

(08 Lectures)

Applied Mycology: Role of fungi in biotechnology, Application of fungi in food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes); Secondary metabolites; Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides,).

Section IV

(15 Lectures)

Phytopathology: Terms and concepts; General symptoms; Geographical distribution of diseases; Host-Pathogen relationships; disease cycle and environmental relation; Methods of control of plant diseases, and role of quarantine. Bacterial diseases – Citrus canker and angular leaf spot disease of Cotton. Viral diseases – Tobacco Mosaic viruses.

Practical
(Lectures: 30)

1. Introduction to the world of fungi (Unicellular, coenocytic/septate mycelium, asocarps & basidiocarps).
2. Rhizopus: study of asexual stage from temporary mounts and sexual structures through permanent slides.
3. Aspergillus and Penicillium: study of asexual stage from temporary mounts. Study of Sexual stage from permanent slides/photographs.
4. Alternaria: Specimens/photographs and temporary mounts.
5. Puccinia: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; sections/ mounts of spores on wheat and permanent slides of both the hosts.
6. Agaricus: Specimens of button stage and full grown mushroom; sectioning of gills of Agaricus, fairy rings and bioluminescent mushrooms to be shown.
7. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates. Study of thallus and reproductive structures (soredia and apothecium) through permanent slides. Mycorrhizae: ectomycorrhiza and endo mycorrhiza (Photographs)
8. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Angular leaf spot of cotton, Viral diseases: TMV, Vein clearing, Fungal diseases: Early blight of potato, Black stem rust of wheat and White rust of crucifers.

Suggested Readings

1. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi and Their Allies. (2nd Edition), Medtech Publishers, Delhi (Chapters 1, 3 for Unit I, Chapter 8 for Unit 2, Chapter 9 for Unit 3, Chapters 10, 12-15, 17 for Unit 4, Chapter 18, 19, 22-23 for Unit 5, Chapter 5 for Unit 6, Chapter 7 for Unit 7, Chapters 24, 25 for Unit 8, Chapter 26 for Unit 9, Chapter 27 for Unit 10).
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, 4th edition. Singapore, Singapore: John Wiley & Sons. (Chapter 1 for Unit 1, Chapter 2 for Unit 2, Chapter 5 for Unit 3, Chapters 7, 10, 11-13 for Unit 4, Chapters 16, 17, 20, 21 for Unit 5, Chapter 29 for Unit 6, Chapter 23 for Unit 7).
3. Agrios, G.N. (2005). Plant Pathology, 5th edition. Cambridge, U.K.: Academic Press. (Chapter 1, 8, 9, 11, 12, 14 for Unit 10).
4. Burchett, Stephen and Burchett, Sarah. (2018). Plant Pathology. New York: Garland Science (Chapter 1, 6-8, 10 for Unit 10).

SEMESTER III

Course Code: BOT3204C

Course Name: Archegoniate and Paleobotany

Credits: 06 (Theory-04, Practicals-2)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to:

- Understand morphology, anatomy and reproduction of Bryophytes, Pteridophytes and Gymnosperms.
- Conceptualize plant evolution and their transition to land habitat.
- Learn the context for the origin, extinction and adaptation of plants.

Course Learning Outcomes:

On successful completion of this course the students will:

- Develop critical understanding on morphology, anatomy and reproduction of Archegoniate.
- Develop Understanding of plant evolution and their transition to land habitat.
- Get the knowledge of context for the origin, extinction and adaptation of plants.

Section I:

(14 Lectures)

Introduction to Archegoniates & Bryophytes: Unifying features of archegoniates; Transition to land habit; Alternation of generations. General characteristics; Adaptations to land habit; Classification; Range of thallus organization. *Type Studies*-Classification, morphology, anatomy and reproduction of *Riccia*, *Marchantia*, *Anthoceros*, *Sphagnum* and *Polytrichum*; Reproduction and evolutionary trends in *Riccia*, *Marchantia*, *Anthoceros*, *Sphagnum* and *Polytrichum*. Ecological and economic importance of bryophytes.

Section II:

(10 Lectures)

Pteridophytes: General characteristics; Classification; Early land plants (*Cooksonia* and *Rhynia*). *Type Studies*- Classification, morphology, anatomy and reproduction of *Psilotum*, *Lycopodium*, *Selaginella*, *Equisetum*, *Pteris* and *Marsilea*. *Apogamy* and *apospory*, heterospory and seed habit, telome theory, stelar evolution; Ecological and economic importance.

Section III:

(10 Lectures)

Gymnosperms: General characteristics, classification (up to family), morphology, anatomy and reproduction of *Cycas*, *Pinus*, *Ginkgo* and *Gnetum*; Ecological and economic importance.

Section IV:

(11 Lectures)

Paleobotany: Geological time scale; Brief account of process of fossilization & types of fossils and study

techniques; General account of *Cycadofilicales*, *Bennettitales*, *Pentoxylales* and *Cordaitales*.

Practical
(Lectures: 30)

1. *Riccia* – Morphology of vegetative and reproductive parts.
2. *Marchantia* - Morphology of thallus and reproductive parts; vertical and transverse section of thallus; vertical section of Gemma cup, *Antheridiophore* and *Archegoniophore*.
3. *Sphagnum* - Morphology of plant; whole mount of leaf.
4. *Polytrichum* - Morphology of vegetative and reproductive parts; Transverse Section of rhizome, whole mount of leaf; Longitudinal Section through antheridial and archegonial heads; L.S. of capsule.
5. *Lycopodium* - Morphology of plant, whole mount of leaf; transverse section of stem; Longitudinal Section of strobilus; morphology of sporophyll.
6. *Selaginella* - Morphology of plant, whole mount of leaf with ligule, transverse section of stem and rhizophore; longitudinal section of strobilus; morphology of sporophyll.
7. *Equisetum* - Morphology of plant, transverse section of internode, longitudinal and transverse section of strobilus, whole mount of sporangiophore and spore.
8. *Pteris* - Morphology of plant, transverse section of rachis, vertical section of leaflets through sorus; whole mount of prothallus with sex (permanent slide).
9. *Marsilea* - Morphology of plant, transverse section of rhizome and petiole; vertical transverse and vertical longitudinal section of sporocarp.
10. *Cycas* - Morphology of plant; morphology and transverse section of coralloid roots; transverse section of leaflets; Longitudinal Section of male and female cone; morphology of microsporophyll and megasporophyll; Longitudinal section of ovule (permanent slide).
11. *Pinus* - Morphology of plant; transverse section of Needle; longitudinal section of male cone and female cone; whole mount of Microspores.
12. *Ginkgo* - Morphology of plants and reproductive structures (only photographs).
13. *Gnetum* - Morphology of plant; Morphology of male and female strobilus; vertical section of ovule (permanent slide).
14. *Geological time scale* : concept of geologic time scales including *eons*, *eras*, *epochs*, and *periods*.
15. *Types of Plant fossil* : *Compressions*; *Impressions*; *Casts and Molds*; *Permineralization or Petrification*; *Compactions*; *Molecular Fossils*.
16. *Important fossil in India*: *Glossopteris*; *Pentoxylon*; *Williamsonia sewardiana*; *Birbalsahnia divyadarshanii*; Mandla Plant Fossils National Park.

Note: List of practical may be updated depending on the availability of resources.

Suggested Readings

1. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.
2. Bhatnagar, A.M. 2004. Gymnosperms. New Age International (P) Ltd. Publishers, New Delhi, India.
3. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.
4. Vanderpoorten, A. & Goffinet, B. (2009) Introduction to Bryophytes. Cambridge University Press.
5. Vashistha, B. R., Sinha, A.K. and Kumar, A. (Latest edition). Botany for Degree Students: Bryophyta. S. Chand Publishing 7361, Ram Nagar, Qutab Road, New Delhi-110055.
6. Dutta A.C. 2016. Botany for Degree Students. Oxford University Press.
7. Bhattacharya et. al. 2007. A textbook of Palynology, Central, New Delhi.
8. Sepkoski, D.2011, Rereading the Fossil Record, University of Chicago Press.
9. Jain P.C. & M.S. Anantharaman, 2014, Palaeontology Palaeobiology, Paperback–by Vishal Publishing Co.; 9th (Revised and Enlarged)
10. Stanley Raup, 2006, Principles of Paleontology Paperback– by CBS Publishers & Distributors; 2nd edition

SEMESTER IV

Course Code: BOT4104C

Course Name: Morphology and Anatomy of Angiosperms

Credits: 06 (Theory-04, Practicals-2)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to

1. Develop a comprehensive understanding of the morphology and anatomy of angiosperms.
2. Identify and describe the structural features of various plant organs and tissues.
3. Explore the functional significance of morphological adaptations in angiosperms.
4. Understand the evolutionary relationships among angiosperm taxa based on comparative morphology.
5. Develop practical skills in plant specimen preparation, microscopy, and morphological identification.

Course Learning Outcomes:

On successful completion of this course the students will:

1. Develop a comprehensive understanding of the morphology and anatomy of angiosperms, including the structure and function of various plant organs and tissues.
2. Develop a curiosity and enthusiasm for continued learning and exploration in the field of plant morphology and anatomy.
3. Interpret the relationship between angiosperm morphology and anatomy and their ecological roles, including adaptations to environmental conditions.

Section I:

(9 Lectures)

Introduction to Angiosperm Morphology and Anatomy: Overview of angiosperm morphology and life cycle; Morphology of inflorescence, stamens and carpel, fruit; Telome theory, phyllode theory; Role of morphology in plant classification. Scope of anatomy; Application of anatomy in systematics, forensics and pharmacognosy

Section II:

(16 Lectures)

Structure and Development of Plant Body: Internal organization of plant body: The three tissue systems, types of cells and tissues. Development of plant body: Polarity, Cytodifferentiation and organogenesis during embryogenic development. Classification of tissues; Simple and complex tissues (no phylogeny); cytodifferentiation of tracheary elements and sieve elements; Pits and plasmodesmata; Wall ingrowths and transfer cells, adcrustation and incrustation, Ergastic substances. Hydathodes, cavities, lithocysts and laticifers.

Section III:**(14 Lectures)**

Apical meristems: Evolution of concept of organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cytohistological zonation); Types of vascular bundles; Structure of dicot and monocot stem. Origin, development, arrangement and diversity in size and shape of leaves; Structure of dicot and monocot leaf, Kranz anatomy. Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin of lateral root.

Section IV:**(21 Lectures)**

Vascular Cambium and Wood: Structure, function and seasonal activity of cambium; Secondary growth in root and stem. Axially and radially oriented elements; Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology. Development and composition of periderm, rhytidome and lenticels.

Adaptive and Protective Systems: Epidermal tissue system, cuticle, epicuticular waxes, trichomes (uni- and multicellular, glandular and nonglandular, two examples of each), stomata (classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes.

Practical**(Lectures: 30)**

1. Study of special types of inflorescence – *Cyathium*, *Hypanthodium*, *Verticillaster*, *Hypanthium*: Dissection of flowers to observe floral organs; Identification of sepals, petals, stamens, and pistils; Observation of floral adaptations for pollination.
2. Study of special types of fruits- Superior fruits (*Dillenia*); Aggregate fruits (Custard apple, *Michelia*, Periwinkles, *Polyalthia*); Multiple fruits (Pine apple, Jack fruits): Identification of different fruit types (e.g., simple, aggregate, multiple).
3. Study of anatomical details through permanent slides/temporary stain mounts /macerations /museum specimens with the help of suitable examples.
4. Apical meristem of root, shoot and vascular cambium.
5. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
6. Root: monocot, dicot, secondary growth.
7. Stem: monocot, dicot - primary and secondary growth; periderm; lenticels.
8. Leaf: isobilateral, dorsiventral, C4 leaves (Kranz anatomy).
9. Adaptive Anatomy: xerophytes, hydrophytes.
10. Secretory tissues: cavities, lithocysts and laticifers.

Suggested Readings

1. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
 2. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
 3. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.
 4. Evert, R.F. (2006) Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc.
- Additional resources provided by the instructor based on specific topics covered in the practical sessions

Note: The syllabus and schedule may be subject to adjustments based on the availability of laboratory facilities and fieldwork opportunities.

SEMESTER IV

Core Course Code: BOT4204C

Course Name: Genetics and Plant Breeding

(Credits: Theory-03, Practicals-1)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to:

1. Understand basic genetics principles and their application in plant breeding.
2. Apply molecular tools and techniques for crop improvement.
3. Evaluate genetic resources and utilize them effectively in breeding programs.
4. Address global agricultural challenges through sustainable breeding practices.

Course Learning Outcomes:

On successful completion of this course the students will:

1. Demonstrate understanding of fundamental genetics principles and their relevance to plant breeding.
2. Apply molecular techniques in crop improvement strategies.
3. Evaluate and utilize genetic resources for developing improved crop varieties.
4. Analyze and address agricultural challenges through sustainable breeding practices.

Section I:

(10 Lectures)

Mendelian and Non-Mendelian genetics: History; Principles of inheritance; Mendel's laws of inheritance; Incomplete dominance and co-dominance; Multiple allelism; Quantitative and polymeric gene interaction; Complementary, supplementary and duplicate gene interactions (plant based examples are to be dealt); Penetrance and expressivity; Chromosomal theory of inheritance; Multiple allelism; Epistasis; Pleiotropy. Non-Mendelian inheritance- Concept of maternal inheritance (Corren's experiment on *Mirabilis jalapa*); Mitochondrial DNA.

Section II:

(10 Lectures)

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; Numericals based on gene mapping

Variation in chromosome number and structure: Deletion, Duplication, Inversion, Translocation, Euploidy and Aneuploidy

Section III:

(9 Lectures)

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.

Fine structure of gene: Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism; Structure of Phage T4, rII Locus.

Section IV:

(12 Lectures)

Population and Evolutionary Genetics: Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation.

Plant Breeding: Plant Breeding and its scope; Genetic basis for plant breeding; Plant Introduction and Acclimatization; Definition, procedure; applications and uses; advantages and limitations of : (a) Mass selection, (b) Pure line selection and (c) Clonal selection; Hybridization – schemes, and technique; Heterosis (hybrid vigour); A brief account on Molecular breeding – DNA markers in plant breeding. RAPD, RFLP.

Practical

(Lectures: 30)

1. Meiosis through temporary squash preparation.
2. Karyotype study in onion and garlic.
3. Study of chromosomal aberration in *Tradescantia/ Rhoeo*
4. Mendel's laws through seed ratios.
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. Permanent slides showing Translocation Ring, Photographs showing Laggards and Inversion Bridge.
7. Demonstration of emasculation, bagging, artificial pollination techniques for hybridization.

Suggested Readings

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & sons, India. 8th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings, U.S.A. 9th edition.
4. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

SEMESTER IV

Core Course Code: BOT4304C

Course Name: Plant Ecology and Taxonomy

(Credits: Theory-03, Practical-1)

THEORY

Lectures: 45

Course Objectives

On completion of this course, the students will be able to:

- To make students understand ecology and basic ecological concepts, inter-relation between the living world and environment.
- To make them aware about identification, nomenclature and classification.

Course Learning Outcome

On successful completion of this course the students will be able to:

- After successful completion of the course the student shall have adequate knowledge about the basic principles of environment and taxonomy.

Section I

(12 Lectures)

Introduction Plant Ecology; Inter-relation between the living world and environment.

Ecological factors: Soil-Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance.

Plant communities: Characters; Ecotone and edge effect; Succession; Processes and types (autogenic, allogenic, autotrophic, heterotrophic, primary and secondary)

Section II

(09 Lectures)

Ecosystem: Structure; energy flow trophic organization; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous

Phytogeography: Principle biogeographical zones; Endemism (definition and types)

Section III

(12 Lectures)

Introduction to plant taxonomy: Identification, Classification, Nomenclature.

Identification: Functions of Herbarium, important herbaria and botanical gardens of the world and India.

Documentation: Flora, Keys: single access and multi-access

Taxonomic evidences: Palynology, cytology, phytochemistry and molecular data.

Taxonomic hierarchy: Ranks, categories and taxonomic groups

Section IV

(12 Lectures)

Botanical nomenclature: Principles and rules (ICN); ranks and names; binominal system, typification,

author citation, valid publication, rejection of names, principle of priority and its limitations.

Classification: Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (up to series).

Practical **(Lectures: 30)**

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer, hygrometer, rain gauge and lux meter.
2. Determination of pH, and analysis of two soil samples for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field test.
3. Study of morphological adaptations of hydrophytes and xerophytes (four each).
4. Study of biotic interactions of the following: Stem parasite (Cuscuta), Root parasite (Orobanchae), Epiphytes, Predation (Insectivorous plants)
5. Determination of minimal quadrat size for the study of herbaceous vegetation within the campus by species area curve method.
6. Quantitative analysis of herbaceous vegetation within the campus for frequency and Comparison.
7. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification): Some selected families.
8. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted on the herbarium sheet with appropriate label.)

Suggested Readings

1. Kotpal, R.L. , Bali, N.P. (1978). Concepts of Ecology. Jullundur, Punjab, Vishal Publications, (Chapter 1 for Unit 1; Chapter 3,4,5,6, for Unit 2; Chapter 12,13 for Unit 3. Chapter 7,8 for Unit 4)).
2. Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.(Chapter 1 for Unit 1, Chapter 2,3,4 for Unit 2; Chapter 9,10 for Unit 3; Chapter 12,13 for Unit 4; Chapter 15 for Unit 5.
3. Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A (Chapter 1, 16 for Unit 6. Chapter 15,17,18 for Unit 7; Chapters 9-12,14, 18-21 for Unit 8; Chapter 1,2 for Unit 9; Chapter 16 for Unit 10; Chapter 7,8 for Unit 11).
4. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi (Chapter 1 for Unit 6; Chapter 5 for Unit 7; Chapter 7 for Unit 8; Chapter 3 for Unit 9; Chapter 2 or Unit 10; Chapter 10 for Unit 11).

SEMESTER V

Core Course Code: BOT5104C

Course Name: Reproductive Biology of Angiosperms

(Credits: Theory-03, Practical-1)

THEORY

Lectures: 45

Course Objective

On completion of this course, the students will be able to

1. To have knowledge of the flowering and fruiting, reproduction processes, role of pollinators, anther, ovule and seed development.

Course Learning Outcomes

On successful completion of this course the students will be able to:

1. Induction of flowering, molecular and genetic aspects of flower development.
2. Anther structure, pollen development, dispersal and pollination.
3. Ovule, embryo sac development and fertilization.
4. Endosperm development and its importance.
5. Alternative pathways of reproduction and their importance.
6. Student would be able to apply this knowledge for conservation of plants, pollinators and fruit development.

Section I

(06 Lectures)

Introduction: History (contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison) and scope.

Reproductive development: Induction of flowering; flower as a modified determinate shoot. Flower development: genetic and molecular aspects.

Section II

(15 Lectures)

Anther and pollen biology: Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance. Microgametogenesis; Pollen wall structure, MGU (male germ Section) structure, NPC system; Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia.

Ovule: Structure; Types; Special structures—endothelium, obturator, aril, caruncle and hypostase; Female gametophyte— megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of Polygonum type); Organization and ultrastructure of mature embryo sac.

Section III

(12 Lectures)

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 (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination.

Section IV

(12 Lectures)

Embryo, Endosperm and Seed: Structure and types; General pattern of development of dicot and monocot embryo and endosperm; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in Paeonia. Seed structure, importance and dispersal mechanisms.

Polyembryony and apomixes: Introduction; Classification; Causes and applications.

Practical

(Lectures: 30)

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehiscent anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.
2. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, pseudomonads, polyads, pollinia (slides/photographs, fresh material), ultrastructure of pollen wall (micrograph); Pollen viability: Tetrazolium test, germination: Calculation of percentage germination in different media using hanging drop method.
3. Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs).
4. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.
5. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.
6. Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages.

Suggested Readings

1. Bhojwani, S.S., Bhatnagar, S.P. Dantu P. K. (2015). The Embryology of Angiosperms, 6th edition. New Delhi, Delhi: Vikas Publishing House. (Chapter 1 for Unit 1, Chapters 3 to 15 for unit 2-10, Chapter 17 for Unit 11).
2. Johri, B.M. (1984). Embryology of Angiosperms. Netherlands: Springer-Verlag. (Chapters 3, 4 for Unit 4, Chapter 6 for Unit 5, Chapter 7, 8 for Unit 7-8; Chapter 12 for Unit 9)
3. Raghavan, V. (2000). Developmental Biology of Flowering plants. Netherlands: Springer (Chapter 13 for Unit 8).

4. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. New Delhi, Delhi: Oxford and IBH Publishing Co. Pvt. Ltd. (Chapters 1, 2, 3, 4 for Unit 2-3; Chapter 7 for unit 5, Chapter 9 for Unit 6)

SEMESTER V

Core Course Code: BOT5204C

Course Name: General Microbiology

(Credits: Theory-03, Practical-1)

THEORY

Lectures: 45

Course Objective

On completion of this course, the students will be able to

1. To understand microorganisms and their roles in health sciences, environmental sciences, biotechnology, food, and agriculture.

Course Learning Outcomes

On successful completion of this course the students will be able to:

1. Thorough knowledge and understanding of concepts of microbiology.
2. Learning and practicing professional skills in handling microbes.
3. Thorough knowledge and application of good laboratory and good manufacturing practices in microbial quality control.

Section I

(08 Lectures)

Historical development of microbiology: Theory of spontaneous generation, Biogenesis and Abiogenesis. Contributions of Anton Von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister and Edward Jenner, Alexander Fleming, Martinus Beijerinck, Sergei Winogradsky, Elie Metchnikoff. Origin of life, primitive cells and evolution of microorganisms. Microscopy- working principle, construction and operation of simple and compound microscopes.

Section II

(14 Lectures)

Staining: Nature of stains, principles, mechanism, methods and types of staining- Simple, Differential-Gram staining, Acid fast staining, staining of capsule, cell wall, endospore, inclusion bodies.

Sterilization: Principles, types and techniques, Physical and chemical methods.

Culture media: Types, Cultivation of aerobic and anaerobic bacteria. Pure culture techniques and Cultural characteristics.

Preservation of microorganisms: Methods of preservation of microorganisms; slant culture, stab culture, soil culture, mineral oil overlaying, glycerol preservation.

Section III

(12 Lectures)

Microbial Diversity and Ecology: Bacterial diversity and classification; Microbial interactions (symbiosis, competition, Pathogenesis); Microbes in ecosystems (soil, water, extreme environments). Microbial roles in

biogeochemical cycles (e.g., carbon, nitrogen, sulfur cycles) and nutrient cycling; Microbial bioremediation of pollutants (e.g., oil spills, heavy metals, pesticides) in soil, water, and air; Microbial contributions to wastewater treatment and sustainable environmental management.

Section IV

(11 Lectures)

Applied Microbiology: Industrial microbiology (fermentation, enzyme production); Bioremediation and environmental applications; Microbes in agriculture and food production. Plant-microbe interactions and their role in plant growth promotion and disease control. Biological control of plant diseases and pests using beneficial microbes. Microbial biofertilizers and biostimulants for sustainable agriculture.

Practical

(Lectures: 30)

1. Microbiological laboratory standards and safety protocols .
2. Standard aseptic conditions of Microbiological laboratory.
3. Operation and working principles of Light/ Compound microscope.
4. A. Working principles and operations of basic equipments of microbiological laboratory (Autoclave, Oven, Incubator, pH meter, Spectrophotometer, Colorimeter, Vortex, Magnetic stirrer).
5. Applications of basic microbiological tools (Pipettes, Micropipette, Bunsen burner, Inoculation loop, Spreader).
6. Demonstration and observations of microorganisms from natural sources under light microscope (Algae, Yeast and Protozoa).
7. Demonstration of bacterial motility by hanging drop method.
8. Differential staining - Gram staining.
9. Preparation of Physiological saline and Serial dilution.
10. Method of obtaining pure cultures of Microorganisms.

Suggested Readings

1. General Microbiology 1st Edition, 2020 , Linda Bruslind, Oregon State University.
2. Prescott, Harley, Klein's Microbiology, J.M. Willey, L.M. Sherwood, C.J. Woolverton, 7th International, edition 2008, McGraw Hill.
3. Foundations in Microbiology, K. P. Talaro, 7th International edition 2009, McGraw Hill.
4. A Textbook of Microbiology, R. C. Dubey and D. K. Maheshwari, 1st edition, 1999, S. Chand & Company Ltd.
5. Brock Biology of Microorganisms, M.T.Madigan, J.M.Martinko, P. V. Dunlap, D. P. Clark- 12th edition, Pearson International edition 2009, Pearson Benjamin Cummings.
6. Microbiology – An Introduction, G. J.Tortora, B. R.Funke, C. L. Case, 10th ed. 2008,Pearson Education.

7. General Microbiology, Stanier, Ingraham et al, 4th and 5th edition 1987, Macmillan education limited.
8. Microbiology- Concepts and Applications, Pelczar Jr, Chan, Krieg, International ed, McGraw Hill.
9. Alexopoulos, C.J., Mims, C.W., and Blackwell, M. 2002. Introductory Mycology. John Wiley and Sons (Asia) Pvt. Ltd. Singapore. 869 pp.
10. Atlas, R.M. 1984. Basic and practical microbiology. Mac Millan Publishers, USA. 987pp.
11. Black, J.G. 2008. Microbiology principles and explorations. 7edn. John Wiley and Sons Inc., New Jersey 846 pp.
12. Pommerville, J.C. Alcamo's Fundamentals of Microbiology. Jones and Bartlett Pub..Sudbury, 835 pp.
13. Schlegel, H.G. 1995. General Microbiology. Cambridge University Press, Cambridge, 655 pp.
14. Tortora, G.J., Funke, B.R. and Case, C.L. 2007. Microbiology 9 th ed. Pearson Education Pte. Ltd., San Francisco. 958pp.

SEMESTER V

Core Course Code: BOT5304C

Course Name: Molecular Biology

(Credits: Theory-03, Practicals-1)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to

1. Understand core concepts of molecular biology, including DNA structure and function.
2. Explore molecular techniques used in research and biotechnology.
3. Analyze gene expression and regulation mechanisms.
4. Apply molecular biology principles to solve biological problems.

Course Learning Outcomes:

On successful completion of this course the students will be able to:

1. Understand fundamental principles of molecular biology.
2. Analyze DNA replication, transcription, and translation processes.
3. Apply molecular techniques in laboratory settings.
4. Interpret genetic mechanisms underlying cellular functions.
5. Evaluate contemporary research in molecular biology.
6. Demonstrate proficiency in molecular experimental design and analysis.

Section I:

(12 Lectures)

Nucleic Acids: *Carriers of Genetic Information*- DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod & McCarty experiments). Types of genetic material; DNA Structure (Watson and Crick), Denaturation and Renaturation; Organization of DNA in Prokaryotes, Viruses & Eukaryotes; Structure of RNA; Mitochondria & Chloroplast DNA; Chromatin structure; Euchromatin & Heterochromatin

Section II:

(12 Lectures)

Central Dogma and Genetic Code: The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features)

Replication of DNA: Types of DNA replication; Replication of DNA in prokaryotes and eukaryotes; RNA priming

Section III:

(6 Lectures)

Transcription : Mechanism of Transcription in Prokaryotes and Eukaryotes; Regulation of gene expression

in prokaryotes- lac operon and tryptophan synthesis in *E.coli*.

Section IV:

(15 Lectures)

RNA Processing and Translation: *RNA processing* - Concept of introns and exons, removal of introns, splicing pathways, pre-mRNA processing, spliceosome machinery, alternative splicing, RNA editing and mRNA transport. *Translation*- Various steps involved in translation/protein synthesis (aminoacylation of tRNA, translation, fidelity of translation); Inhibitors of protein synthesis; Post-translational modifications of proteins.

Practical

(Lectures: 30)

1. DNA isolation from any plant material
2. DNA estimation of diphenylamine reagent/UV Spectrophotometry (Demonstration).
3. Study of DNA replication mechanism through photographs semi-discontinuous replication.
4. Study of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
5. Study of the following through photographs: Assembly of Spliceosome machinery; Alternative splicing

Suggested Readings

1. Alberts, B., Bray, D., Hopkin, K., Johnson, A. D., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2013). *Essential Cell Biology* (4th edn.). Garland Science.
2. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell* (6th edn.). Garland Science.
3. Clark, D. P., & Pazdernik, N. J. (2015). *Molecular Biology* (2nd edn.). Academic Cell.
4. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). *Concepts of Genetics*. Benjamin Cummings. U.S.A. 9th edition.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). *Introduction to Genetic Analysis*. W. H. Freeman and Co., U.S.A. 10th edition.
6. Lewin, B. (2008). *Genes IX*. Jones & Bartlett Learning.
7. Russell, P. J. (2010). *Genetics- A Molecular Approach*. Benjamin Cummings, U.S.A. 3 rd edition.
8. Snustad, D.P. and Simmons, M.J. (2010). *Principles of Genetics*. John Wiley and Sons Inc.,U.S.A. 5th edition.
9. Tropp, B. E. (2012). *Principles of Molecular Biology*. Jones & Bartlett Learning.

10. Watson, J.D., Hopkins, N.H., Roberts, J.W. et al. (1987). *Molecular Biology of the Gene* (4th edn.). Menlo Park, CA: Benjamin-Cummings.

SEMESTER V

Core Course Code: BOT5404C

Course Name: Economic Botany and Biostatistics

(Credits: Theory-03, Practical-1)

THEORY

Lectures: 45

Course Objectives

On completion of this course, the students will be able to

1. To make the students familiar with economic importance of diverse plants that offer resources to human life.
2. It emphasize the plants used as- food, fodder and poultry; plants having medicinal value and also plant source of huge economic value etc.
3. To have knowledge of analysis of scientific data.

Course Learning Outcomes

On successful completion of this course the students will be able to:

1. The students will learn the dietary requirements of proteins, fats, amino-acids, vitamins etc that can be met by plants.
2. They will learn to perform the micro-chemical tests to demonstrate various components.
3. Use of fibre plants, beverages, fruits and vegetables that are integral to day to day life of plants.
4. To explore the regional diversity in food crops and other plants and their ethno-botanical importance as well.
5. Understanding of interpreting the scientific data that is generated during scientific experiments.
6. Biostatistics uses the application of statistical methods to conduct research in the areas of biology, public health, and medicine.

Section I

(07 lectures)

Origin of Cultivated Plants: Concept of centres of origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity; Importance of germplasm diversity.

Section II

(16 lectures)

Cereals: Wheat and Rice (origin, evolution, morphology, post-harvest processing & uses).

Legumes: General account with special reference to Gram and soybean.

Spices: Listing of important spices, their family and part used, economic importance with special reference

to clove and black pepper.

Beverages: Tea and coffee (morphology, processing, uses).

Oils and Fats: General description with special reference to mustard seed.

Drug-yielding plants: Therapeutic and habit-forming drugs with special reference to *Cinchona*, *Digitalis*, *Papaver* and *Cannabis*.

Fiber Yielding Plants: Classification based on the origin of fibers; Cotton and Jute (morphology, extraction and uses).

Section III

(08 lectures)

Biostatistics: Definition, statistical methods - basic principles. Variables -measurements, functions, limitations and uses of statistics.

Section IV

(14 lectures)

Measures of central tendency: Mean, median, mode, merits & demerits of harmonic and geometric mean; Measures of dispersion - range, standard deviation, mean deviation, standard error; Co- efficient of variations.

Statistical inference: Hypothesis - simple hypothesis - student't' test - chi square test, Ftest.

Practical

(Lectures: 30)

1. Cereals: Wheat (habit sketch, L.S/T.S. grain, starch grains, micro-chemical tests), Rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests).
2. Legumes: Soybean, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
3. Spices: Black pepper and Clove (habit and sections L.S./T.S.).
4. Beverages: Tea (plant specimen, tea leaves).
5. Oils and fats: Mustard-plant specimen, seeds
6. Drug-yielding plants: Specimens of *Cinchona*, *Digitalis*, *Papaver* and *Cannabis* (male & female plant).
7. 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 cellulose and lignin on transverse section of stem and fiber).
8. Calculation of mean, mode, median, standard deviation, standard error and coefficient of variance.
9. Statistical inference - hypothesis – student 't' test - chi square test.

Suggested Readings

1. Kochhar, S.L. (2012). Economic Botany in Tropics. New Delhi, India: MacMillan & Co.

2. (Chapter 1 for Unit 1; Chapter 3 for Unit 2; Chapter 5 for Unit 3; Chapter 7 for Unit 4; Chapter 4 for Unit 5; Chapter 9 for Unit 6; Chapter 11 for Unit 7; Chapter for Unit 8; Chapter 17 for Unit9; Chapter 14 for Unit 10; Chapter 16 for Unit 11; Chapter 10 for Unit 12; Chapter 2 for Unit 13)
3. Wickens, G.E. (2001). *Economic Botany: Principles & Practices*. The Netherlands: Kluwer Academic Publishers. (Chapter 1,2,3,4,5 for Unit 1; Chapter 14 for Unit 13)
4. Mann, S. P. (2016). *Introductory Statistics*, 9th edition. Hoboken, NJ, Jone Wiley and Sons Inc. Chapter 1 for Unit 1; Chapter 3 for Unit 2; Chapter 3,7 for Unit 2; Chapter 9,10 for Unit 5; Chapter 3 for Unit 3; Chapter 2 for Unit 2; Chapter 6,7 for Unit 6).
5. Danniel, W.W. (1987). *Biostatistic*. New York,NY: John Wiley Sons. (Chapter 1 for unit 1; Chapter 2-3 for Unit 6; Chapter 5 for Unit 2; Chapter 2 for Unit 3; Chapter 9 for Unit 6; Chapter 9 for Unit 4; Chapter 7, 12 for Unit 5).
6. Khan, I.A., Khanum, A. (2004). *Fundamentals of Biostatistics*, 5th edition. Hyderabad: Ukaaz publications.(Chapter 1 for unit 1; Chapter 2-5 for Unit 2; Chapter 6-8 for Unit 3; Chapter 6,9 for Unit 6; Chapter 11-12 for Unit 4; Chapter 13 and 15 for Unit 5).
7. Zar, J.H. (2014). *Biostatistical Analysis*, 5th edition. London, London: Pearson Publication. Chapter 3 for Unit 3; Chapter 5 for Unit 6; Chapter 17,18,19, 20 for Unit 4; Chapter 22 for Unit 5).

SEMESTER VI

Course Code: BOT6104C

Course Name: Fundamentals of Plant Biotechnology

Credits: 06 (Theory-04, Practicals-2)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to

1. Gain a solid understanding of fundamental techniques used in plant biotechnology research and applications such as tissue culture, genetic engineering, and molecular biology tools.
2. Learn about the genetic diversity within plant species and how it can be utilized for crop improvement and genetic engineering purposes.
3. Acquire skills in plant tissue culture techniques for the propagation, manipulation, and regeneration of plants, including callus culture, somatic embryogenesis, and organogenesis.
4. Explore how biotechnology can be applied to improve crop traits such as yield, stress tolerance, nutritional content, and resistance to pests and diseases.

Course Learning Outcomes:

On successful completion of this course the students will be able to:

1. Demonstrate a comprehensive understanding of fundamental principles in plant biology and biotechnology, including plant anatomy, physiology, genetics, and molecular biology.
2. Explain the principles and applications of key biotechnological techniques used in plant research and crop improvement, such as tissue culture, genetic engineering, and molecular markers.

Section I:

(16 Lectures)

Plant Tissue Culture: Definitions, scope & history of plant tissue culture. Importance of plant tissue culture & biotechnology. In vitro culture techniques: Sterilization methods, Culture media – composition, types of medium and role of hormones in *in-vitro* culture. Inoculation, Incubation and Acclimatization. Callus, single cell and suspension culture and its significance. Isolation and cultivation of economically important microbes (*scenedesmus*, *Aspergillus*) culture and purification of single cell protein (*scenedesmus*, *spirulina*), mushroom cultivation. Algal biomass production and maintenance. Organ culture: Anther, Embryo & Meristem culture. Organogenesis, somatic embryogenesis and artificial seeds. Somatic Hybridization: Isolation, fusion and protoplast culture. Somoclonal Variation & cryopreservation.

Section II:**(16 Lectures)**

Plant Molecular Biology: Organisation and function of Plant nuclear genome (*Arabidopsis thaliana*), Genetic transformation of plants by *Agrobacterium*: Genetic organization of Ti plasmids Functions encoded by integrated T- DNA. Molecular mechanism involved in transformation of plants by *Agrobacterium tumefaciens*. Production of primary and secondary metabolites by microbes. (Ethanol by yeast, citric acid by *Aspergillus niger*, penicillin) Bio fertilizers. Plant genome organization - chloroplast genome - nucleus encoded genes - *Agrobacterium rhizogenus* mechanism of T - DNA synthesis, edible vaccines, Transgenic plants, BT - cotton, BT - tomato, bioethics.

Section III:**(16 Lectures)**

Recombinant DNA technology: 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). Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR-mediated gene cloning; Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; PCR.

Section IV:**(12 Lectures)**

Crop Improvement and Transgenic plant: Crop improvement in terms of yield and quality. Molecular markers (RFLP, RAPD and DNA finger printing) in crop improvement program. Transgenic plants resistant to insect. Biosafety and bioethics.

Practical**(Lectures: 30)**

1. Introduction to Laboratory Techniques: Introduction to laboratory safety procedures and equipment; Demonstration of aseptic technique for working with plant tissue culture.
2. Sterilization Techniques: Practice in sterilizing tools, media, and plant materials for tissue culture experiments; Preparation of MS medium and growth hormones for tissue culture experiments
3. Demonstration of in vitro sterilization and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc.
4. Callus Induction and Somatic Embryogenesis: Initiation of callus cultures from plant explants; Observation and documentation of callus growth and morphology; Observation and documentation of somatic embryo development. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs.
5. Organogenesis: Shoot or root organogenesis from callus or somatic embryos; Observation and documentation of shoot or root formation.
6. Genetic Engineering Techniques: Introduction to plasmid DNA extraction and purification techniques; Transformation of plant tissues with a plasmid DNA construct using *Agrobacterium*-mediated or

- biolistic methods; Study of methods of gene transfer through photographs: Agrobacterium-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
7. Molecular Analysis: Isolation of genomic DNA from transformed plant tissues; Polymerase chain reaction (PCR) amplification of target DNA sequences; Agarose gel electrophoresis and visualization of PCR products.
 8. Plant Transformation: Selection and regeneration of transformed plant tissues on selective media; Observation and documentation of transgenic plant growth and phenotype; Analysis of molecular data from PCR and gel electrophoresis experiments.
 9. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs; Isolation of plasmid DNA.

Suggested Readings

1. Scorza, R and Kumar, S. D. P. 2015. Principles of Plant Biotechnology: An Introduction to Genetic Engineering in Plants. Wiley-Blackwell.
2. Ignacimuthu, S., 2003. Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
3. Bhojwani, S.S. and Bhatnagar, S.P. 2011. The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd., New Delhi. 5th edition.
4. Mascarenhas A.F., 1991. Hand book of Plant Tissue Culture. Indian Council of Agricultural Research. New Delhi.
5. Gupta, P. K. 1994. Elements of Biotechnology. Rastogi Publications. Meerut.
6. Chawla, H. S. 2012. Introduction to Plant Biotechnology. Science Publishers.
7. Taiz, H. and Zeiger, E. 2010. Plant Biotechnology: Principles and Applications. Sinauer Associates.
8. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K. 5th edition.

Note: The syllabus and schedule may be subject to adjustments based on the availability of laboratory facilities and fieldwork opportunities.

SEMESTER VI

Core Course Code: BOT6204C

Course Name: Bioinformatics

(Credits: Theory-03, Practicals-1)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to

1. Introduce basic concepts and principles of bioinformatics.
2. Explore algorithms and computational methods in molecular biology.
3. Familiarize students with biological databases and their applications.
4. Develop practical skills in bioinformatics tools and software.
5. Analyze biological data using computational techniques.
6. Encourage critical thinking and problem-solving in bioinformatics research.

Course Learning Outcomes:

On successful completion of this course the students will be able to:

1. Utilize bioinformatics tools for sequence analysis.
2. Apply algorithms for molecular data analysis.
3. Interpret genomic and proteomic data.
4. Construct biological databases and queries.
5. Employ computational methods for biological research.
6. Demonstrate proficiency in bioinformatics programming languages.

Section I:

(7 Lectures)

Introduction to Bioinformatics: Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics.

Databases in Bioinformatics: Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System.

Section II:

(20 Lectures)

Biological Sequence Databases: National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database. EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools. DNA Data Bank of Japan (DDBJ): Introduction, Resources at DDBJ, Data

Submission at DDBJ. Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR. Swiss-Prot: Introduction and Salient Features.

Section III:

(8 Lectures)

Sequence Alignments: Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).

Section IV:

(10 Lectures)

Molecular Phylogeny: Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.

Applications of Bioinformatics: Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement

Practical

(Lectures: 30)

1. Nucleic acid and protein databases.
2. Sequence retrieval from databases.
3. Sequence alignment.
4. Sequence homology and Gene annotation.
5. Construction of phylogenetic tree.

Suggested Readings

1. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
3. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.

SEMESTER VI

Core Course Code: BOT6304C

Course Name: Industrial and Environmental Microbiology

(Credits: Theory-03, Practical-1)

THEORY

Lectures: 45

Course Objectives

On completion of this course, the students will be able to

1. To introduce students with the industrial microbiology: concepts, principles, scope and application.
2. To introduce students with the environmental microbiology: concepts, principles, scope and application.

Course Learning Outcomes

On successful completion of this course the students will be able to:

1. Understand how microbiology is applied in manufacturing of industrial products.
2. Know about design of bioreactors, factors affecting growth and production.
3. Understand the rationale in medium formulation & design for microbial fermentation, sterilization of medium and air.
4. Comprehend the different types of fermentation processes.
5. Comprehend the techniques and the underlying principles in upstream and down- stream processing.
6. Learn the occurrence, abundance and distribution of microorganism in the environment and their role in the environment and also learn different methods for their detection.
7. Understand various biogeochemical cycles – Carbon and Nitrogen, and microbes involved.
8. Understand the basic principles of environment microbiology and application of the same in solving environmental problems – waste water treatment and bioremediation.
9. Comprehend the various methods to determine the quality of water.

Section I

(10 lectures)

Scope of microbes in industry and environment, Bioreactors/Fermenters and fermentation processes. Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors-laboratory, pilot scale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

Section II

(12 lectures)

Microbial production of industrial products-Microorganisms involved, media, fermentation conditions,

downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; Hands on microbial fermentations for the production and estimation (qualitative and quantitative) of Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol) and antibiotic (Penicillin)

Section III

(10 lectures)

Microbial enzymes of industrial interest and enzyme immobilization. Microorganisms for industrial applications and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis. Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase). Microbes and quality of environment- Distribution of microbes in air; Isolation of microorganisms from soil, air and water.

Section IV

(13 lectures)

Microbial flora of water-Water pollution, role of microbes in sewage and domestic waste water treatment systems. Determination of BOD, COD, TDS and TOC of water samples; Microorganisms as indicators of water quality, check coliform and fecal coliform in water samples. Microbes in agriculture and remediation of contaminated soils. Biological fixation; Mycorrhizae; Bioremediation of contaminated soils. Isolation of root nodulating bacteria, arbuscular mycorrhizal colonization in plant roots.

Practical

(Lectures: 30)

1. Principles and functioning of instruments in microbiology laboratory (autoclave, laminar air flow, incubators, types of fermenters).
2. Preparation of different culture media (Nutrient medium/ Luria Bertani medium/Potato dextrose medium/Czapek Dox medium).
3. Alcohol production by yeast using sugar/ jiggery.
4. Serial dilution method for isolation of microorganisms from water and soil and study of aeromicroflora.
5. Determination of BOD, COD, TDS and TOC of water samples.
6. Determination of coliforms in water samples using eosin methylene blue (EMB) medium.
 - ❖ *A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations and a report to be submitted.*

Suggested Readings

1. Pelzar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). Microbiology: An application based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.

2. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. Pearson Benjamin Cummings, San Francisco, U.S.A. 9th edition.
3. Stanbury, P.F., Whitaker, A., Hall, S.J. (2016) Principles of Fermentation Technology. Amsterdam, NDL:Elsevier Publication (Chapter 4, 5, 7, 10 , 11 for Unit 1 to 6)
4. Patel, A.H. (2008) Industrial Microbiology, Bangalore, India: McMillan India Limited (Chapter 2, 3, 5, 7, 11, 12, 14, 20 for Unit 1 to 6)
5. Mohapatra. P.K. (2008). Textbook of Environmental Microbiology New Delhi, Delhi, I.K. International Publishing House Pvt.Ltd. (Chapter 1,5,6, 11,12,14 for Unit 5, 6, & 7).
6. Bertrand, Jean-Claude, Caumette, P. , Lebaron, P, Matheron, R., Normand, P., SimeNgando, T. (2015) Environmental Microbiology: Fundamentals and Applications. Amsterdam, Netherlands, Springer (Chapter 14,16,17 for Unit 5 & 7).
7. Joe, S., Sukesh (2010). Industrial Microbiology. New Delhi, Delhi: S.Chand & Company Pvt. Ltd., (Cahpter 1,2,3,,5,13 for Unit 1 to 4)

SEMESTER VI

Core Course Code: BOT6404C

Course Name: Analytical Techniques in Plant Sciences

(Credits: Theory-03, Practicals-1)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to

1. Introduce key analytical methods used in plant sciences.
2. Explore principles and applications of spectroscopic techniques.
3. Develop skills in chromatographic separation methods.
4. Understand microscopy techniques for plant analysis.
5. Apply statistical methods for data interpretation.
6. Foster hands-on experience in laboratory settings.

Course Learning Outcomes:

On successful completion of this course the students will be able to:

1. Identify and apply appropriate analytical techniques for plant sample analysis.
2. Interpret and evaluate analytical data to understand plant physiological processes.
3. Demonstrate proficiency in utilizing modern instrumentation for plant analysis.
4. Apply critical thinking to solve complex problems in plant science research.
5. Communicate scientific findings effectively through written reports and presentations.

Section I:

(10 Lectures)

Imaging and related techniques: Principles and application of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Section II:

(12 Lectures)

Cell fractionation: Introduction, Basic Principles of Sedimentation, components and different types of Centrifuges: Differential and density gradient centrifugation, sucrose density gradient, CsCl gradient,

analytical centrifugation, ultracentrifugation, marker enzymes.

Radioisotopes: Basic concept of radioisotopes, GM and scintillation counter, auto-radiography, pulse chase experiment; Applications in biological science.

Section III:

(9 Lectures)

Spectrophotometry: Properties of Electromagnetic radiations; Beer Lambert's Law, Extinction Coefficient, Principle and Applications of UV-visible light spectroscopy; Atomic absorption and Flame emission spectroscopic techniques; Mass spectrometry; X-ray diffraction; X-ray crystallography; Principle and biological applications of IR and NMR.

Section IV:

(14 Lectures)

Chromatography: Basic principle and biological applications; Paper chromatography; Column chromatography, TLC, GLC, HPTLC, Ion-exchange chromatography; Size exclusion chromatography; Affinity chromatography.

Electrophoresis: Characterization of proteins and nucleic acids; Electrophoresis, Electrophoresis: Agarose Gel Electrophoresis (AGE), Polyacrylamide Gel Electrophoresis (PAGE), Sodium Dodecyl Sulfate-Polyacrylamide Gel Electrophoresis (SDS-PAGE)

Practical

(Lectures: 30)

1. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs.
2. Demonstration of ELISA.
3. To separate nitrogenous bases by paper chromatography.
4. To separate sugars by thin layer chromatography.
5. Isolation of chloroplasts by differential centrifugation.
6. To separate chloroplast pigments by column chromatography.
7. To estimate protein concentration through Lowry's methods.
8. To separate proteins using PAGE.
9. To separate DNA (marker) using AGE.
10. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).
11. Preparation of permanent slides (double staining).

Suggested Readings

1. 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.

2. Banwell C. N. & McCash E. M. (1994). Fundamentals of molecular spectroscopy (4th ed.). McGraw-Hill.
3. Metzenberg, S. (2007). Working with DNA. United Kingdom: Taylor & Francis Group.
4. Plummer, D.T. (1996). An Introduction to Practical Biochemistry (3rd edn.). Tata McGraw-Hill Publishing Co. Ltd. New Delhi.
5. Ruzin, S.E. (1999). Plant Microtechnique and Microscopy, Oxford University Press, New York. U.S.A. 39
6. Wilson, K., & Walker, J. (Eds.). (2010). Principles and Techniques of Biochemistry and Molecular Biology (7th ed.). Cambridge University Press.

SEMESTER I
Course Code: BOT1103SE
Course Name: Biofertilizers
(Credits: Theory-02, Practicals-1)

THEORY
(Lectures: 30)

Course Objectives:

1. To facilitate the students to understand basics of biofertilizers.
2. To explain the role of microorganisms as biofertilizers.
3. To impart training to develop skill both handling, cultivation and propagation of quality microbial inoculants.
4. To make students ready for industry as entrepreneurs.
5. To improve the professional competencies and upgrade the knowledge and develop technical skills of biofertilizer production.

Course Learning Outcomes:

On the successful completion of the course, students will be able to:

1. Describe productions steps and specific requirements for biofertilizers.
2. Produce composting from various resources and study recycling.
3. Make skilled manpower for biofertilizer industry.
4. Perform field experiment to check efficacy of biofertilizers.

Section I: **(10 Lectures)**

General account about the microbes used as biofertilizer – *Rhizobium* – isolation, identification, mass multiplication, carrier-based inoculants, Actinorrhizal symbiosis. *Azospirillum*: isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms. *Azotobacter*: classification, characteristics – crop response to *Azotobacter* inoculum, maintenance and mass multiplication.

Section II: **(6 Lectures)**

Unit 3: *Cyanobacteria* (blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation.

Section III: **(7 Lectures)**

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.

Section IV: **(7 Lectures)**

Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting –

field Application.

Practical
(Lectures: 30)

1. Isolation of *Anabaena* from *Azolla* leaf.
2. Study of *Rhizobium* from root nodules of leguminous plants by Gram staining method.
3. Test for pH, NO₂, SO₄, Cl and organic matter of different composts.
4. Observation of mycorrhizae from roots.
5. Isolation of arbuscular mycorrhizal spores from rhizospheric soil.
6. Photographs of biocompost methods.
7. Projects on any topic mentioned in the syllabus, with *Rhizobium* technology, AMF technology, Organic farming, vermicomposting, biocompost, *Azolla* culture

Note: List of practical may be updated depending on the availability of resources.

Suggested Readings

1. Dubey, R.C. (2005). A Text book of Biotechnology S.Chand & Co, New Delhi.
2. Kumaresan, V. (2005). Biotechnology, Saras Publications, New Delhi.
3. John Jothi Prakash, E. (2004). Outlines of Plant Biotechnology. Emkay Publication, New Delhi.
4. Sathe, T.V. (2004) Vermiculture and Organic Farming. Daya publishers.
5. Subha Rao, N.S. (2000) Soil Microbiology, Oxford & IBH Publishers, New Delhi.
6. Vayas,S.C, Vayas, S. and Modi, H.A. (1998). Bio-fertilizers and organic Farming Akta Prakashan, Nadiad

SEMESTER II

Course Code: BOT2104SE

Course Name: Mushroom Culture Technology

(Credits: Theory-03, Practicals-1)

THEORY

(Lectures: 45)

Course Objectives:

After completion of the course, the learner shall be able to understand about Mushroom cultivation, production and processing techniques.

Course Learning Outcomes:

On successful completion of this course, students will be able to

1. Know about Mushroom cultivation, production and processing techniques.
2. Learn the techniques of identification of edible and non-edible mushrooms.

Section I:

(10 Lectures)

Introduction, Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms. Types of edible mushrooms available in India – *Volvariella volvacea*, *Pleurotus citrinopileatus*, *Agaricus bisporus*.

Section II:

(10 Lectures)

Cultivation Technology: Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag.

Section III:

(15 Lectures)

Pure culture: Medium, sterilization, preparation of spawn, multiplication. Mushroom bed preparation - paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation - Low cost technology, composting technology in mushroom production.

Section IV:

(10 Lectures)

Storage: Short-term storage (Refrigeration - upto 24 hours) Long term Storage (canning, pickles, papads), drying, storage in brine.

Practical

(Lectures: 30)

1. Identification of edible mushroom.
2. Demonstration of spawn preparation.
3. Demonstration of culture

4. Packaging technique of mushroom.

Note: List of practical may be updated depending on the availability of resources.

Suggested Readings

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R., 1999, Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
2. Swaminathan, M., 1990, Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore - 560018.
3. Tewari, Pankaj Kapoor, S.C., 1988, Mushroom cultivation, Mittal Publications, Delhi.
4. Nita, B., 1984-1988, Hand book of Mushrooms, II Edition, Vol. I & Vol. II

SEMESTER III

Course Code: BOT3103SE

Course Name: Nursery and Gardening

Credits: 04 (Theory-02, Practicals-2)

THEORY

(Lectures: 30)

Course Objectives:

On completion of this course, the students will be able to

1. Apply theoretical knowledge gained in the classroom to real-world nursery and gardening scenarios.
2. Demonstrate their ability to identify plants, diagnose problems, and implement appropriate solutions for optimal plant health and growth.
3. Demonstrate proficiency in essential nursery and gardening tasks.

Course Learning Outcomes:

On successful completion this course will:

1. Equip students with fundamental knowledge of horticulture, plant anatomy, and soil science to understand the principles underlying nursery and gardening practices.
2. Develop students' practical skills in plant propagation, care, and maintenance, enabling them to effectively manage nurseries and gardens.

Section I:

(6 Lectures)

Nursery: Definition, objectives and scope and building up of infrastructure for nursery, planning and seasonal activities - Planting - direct seeding and transplants.

Section II:

(6 Lectures)

Seed: Structure and types - Seed dormancy; causes and methods of breaking dormancy -Seed storage: Seed banks, factors affecting seed viability, genetic erosion - Seed production technology- seed testing and certification.

Section III:

(8 Lectures)

Vegetative propagation: Air-layering, cutting, selection of cutting, collecting season, treatment of cutting, rooting medium and planting of cuttings - Hardening of plants – green house -mist chamber, shed root, shade house and glass house. Sowing/raising of seeds and seedlings - Transplanting of seedlings.

Section IV:

(10 Lectures)

Gardening: Definition, objectives and scope - different types of gardening - landscape and home gardening - parks and its components - plant materials and design - computer applications in landscaping - Gardening operations: soil laying, manuring, watering, management of pests and diseases and harvesting. Study of cultivation of different vegetables: cabbage, brinjal, lady's finger, onion, garlic, tomatoes, and carrots, Storage and marketing procedures.

Practical
(Lectures: 30)

1. Study of different types of Nurseries & their layout.
2. Study of different types of tools & accessories for Nursery
3. Seed viability test.
4. Study of germination of dormant & non-dormant seeds (Pea, tomato, maize, bean).
5. Study of different methods of vegetative propagation: *propagation by specialized organs; budding; propagation by cutting; layering; grafting.*
6. Study of different types of Gardening
7. Propagation of Vegetable crops, fruit crops and ornamentals
8. Estimation of Garden soil properties- bulk density and porosity; moisture content & water holding capacity; pH.
9. Visit to tissue culture laboratories and nurseries

Note: List of practical may be updated depending on the availability of resources.

Suggested Readings

1. Bose T.K. & Mukherjee, D., 1972, Gardening in India, Oxford & IBH Publishing Co., New Delhi.
2. Kumar N. & Chadha, K.L., 2008, Principles of Horticulture, 1st edition, New Age International Pvt Ltd Publishers.
3. Kumar N. & Dhawan, A.K., 2007, Vegetable Science, 1st edition, S. Chand & Company Ltd; New Delhi.
4. Peter, K.V., 2005, Textbook of Nursery Management, 1st edition, New India Publishing Agency.
5. Capon, B., 2010, Botany for Gardeners, 3rd edition, Timber Press.
6. Singh, V.P., 2008, Floriculture: Principles and Species, Oxford & IBH Publishing Co., New Delhi.
7. Sadamate, V.V., 2007, Handbook of Horticulture, 1st edition, Agrobios (India).
8. Woodrow, G.M., 2004, Gardening in India, Reprint edition, Isha Books.
9. Datta, S.C., 2008, Nursery Technology, 1st edition, Agrobios (India).

Coleman, E., 2018, The New Organic Grower: A Master's Manual of Tools and Techniques for the Home and Market Gardener, 30th edition, Chelsea Green Publishing.

SEMESTER I

Course Code: BOT1104ID

Course Name: Plant Diversity and Human Welfare

(Credits: Theory-03)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to

1. Conceptualize Plant diversity and its different aspects.
2. Learn about different measures for biodiversity conservation.
3. Learn the role of plants in human welfare.

Course Learning Outcomes:

On successful completion of this course the students will be able to:

1. Identify exotic plant species.
2. Identify forest trees based on the characteristics of bark, flowers and fruits.
3. Understand the preservation methods of fresh and dry fruits.

Section I:

(10 Lectures)

Plant diversity and its scope:

Genetic diversity, Species diversity, Plant diversity at the ecosystem level, Agro biodiversity and cultivated plant taxa, wild taxa; Values and uses of biodiversity: Ethical and aesthetic values; Methodologies for valuation, Uses of plants.

Section II:

(12 Lectures)

Loss of biodiversity: Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agro biodiversity, projected scenario for biodiversity loss.

Management of plant biodiversity: Organizations associated with biodiversity management- Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management and communication.

Section III:

(13 Lectures)

Conservation of biodiversity:

Conservation of genetic diversity, species diversity and ecosystem diversity, In situ and *ex situ* conservation; Social approaches to conservation, Biodiversity awareness programmes; Sustainable development.

Section IV:

(10 Lectures)

Role of plants in relation to Human Welfare: Importance of forestry, their utilization and commercial aspects

a) Avenue trees, b) ornamental plants of India. c) Alcoholic beverages through ages.

Fruits and nuts: Important fruit crops their commercial importance. Wood, fiber and their uses.

Suggested Readings

1. Krishnamurthy, K.V. (2004). An Advanced Text Book of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.
 2. Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.
 3. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Prentice Hall of India Private Limited, New Delhi.
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SEMESTER II

Course Code: BOT2104ID

Course Name: Intellectual Property Rights

(Credits: Theory-03)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to

1. Learn about Intellectual Property Rights (IPR)
2. Conceptualize different aspects of Intellectual Property Rights (IPR)
3. Learn the role of IPR in scientific community

Course Learning Outcomes:

On successful completion of this course the students will:

1. Learn about Intellectual Property Rights (IPR)
2. Know different kinds of IPR and its provisions
3. Get the knowledge of plagiarism in their innovations which can be questioned legally

Section I:

(10 Lectures)

Introduction to intellectual property right (IPR). Concept and kinds. Economic importance. IPR in India and world: Genesis and scope. Patents Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents. Infringement.

Section II:

(11 Lectures)

Copyrights Introduction, Works protected under copyright law, Rights, Transfer of Copyright, Infringement. Trademarks Objectives, Types, Rights, Protection of goodwill, Infringement, Passing off, Defences, Domain name. Geographical Indications Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position.

Section III:

(14 Lectures)

Protection of Traditional Knowledge: Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, need for a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level, Traditional Knowledge Digital Library. Industrial Designs: Objectives, Rights, Assignments, Infringements, Defences of Design Infringement Protection of Plant Varieties: Plant Varieties Protection-Objectives, Justification, International Position, Plant varieties protection in India. Rights of farmers, Breeders and Researchers. National gene bank, Benefit sharing. Protection of Plant Varieties and Farmers' Rights Act, 2001.

Section IV:**(10 Lectures)**

Information Technology Related Intellectual Property Rights: Computer Software and Intellectual Property, Database and Data Protection, Protection of Semi-conductor chips, Domain Name Protection, Biotechnology and Intellectual Property Rights. Patenting Biotech Inventions: Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues

Suggested Readings

1. Ahuja, V.K., 2017, Intellectual Property Rights: Text and Cases, LexisNexis.
2. Narayanan, P., 2021, Intellectual Property Rights: Law and Practice in India, Taxmann Publications.
3. Ali, F. & Unni, V.K., 2020, Intellectual Property Law in India, Oxford University Press.
4. Anand & Anand, 2019, Intellectual Property Rights: Indian and International Perspectives, LexisNexis.
5. Narayanan, P., 2018, Law Relating to Intellectual Property Rights, Eastern Book Company.

SEMESTER III

Course Code: BOT3104ID

Course Name: Entrepreneurship in Botany

Credits: 04

THEORY

(Lectures: 30)

Course Objectives:

On successful completion this course will:

- Provide students with a solid understanding of business principles and practices relevant to the botanical industry, including market analysis, financial management, and marketing strategies.
- Equip students with the necessary skills and knowledge to identify opportunities, innovate, and effectively manage botanical enterprises, fostering an entrepreneurial mindset and readiness for real-world challenges.

Course Learning Outcomes:

On completion of this course, the students will be able to

- Demonstrate proficiency in applying business principles and strategies relevant to the botanical industry, including market analysis, financial planning, and marketing tactics.
- Develop the skills and mindset necessary to identify market opportunities, innovate solutions, and effectively communicate business ideas and plans, preparing them for entrepreneurial endeavors in the field of botany.

Section I:

(8 Lectures)

Horticulture, floriculture and sugar industry: Fruits- types, nutritional value, economic importance, preservation and storage. *Ber and Amla* - agro-technology. *Flowers* - economic importance (decorative, medicinal, aromatic, food). *Gladiolus and marigold* – agro-technology and market trends. Composition and uses of vegetable oils (food and medicinal). Extraction and refining of vegetable oils (oil expeller, degumming, bleaching and hydrogenation). *Sugarcane and beet sugar*- agro-technology, extraction and economic importance of sugars.

Section II:

(6 Lectures)

Food and fodder: Essential components of human nutrition; concept of human disorders due to nutritional deficiencies, concept of rabi (wheat) and kharif (rice) crops. *Cereals*- rice and wheat, nutritional value, *Legumes*- pea and soybean, nutritional value, agro-technology and varieties. Fodder crops- types (conserved forage, compound feed, crop residues, freshly cut forage) and their storage.

Section III:

(12 Lectures)

Industrial Entrepreneurships: *Medicinal and aromatic plants (MAPs)*- Introduction, history of use of MAPs and quality control in medicinal plants. *Ashwgandha* and *Safed musli*, *Lemon grass* and *Rose*-cultivation, agro-technology and economics. Extraction of essential oils (distillation, expression, effleurage, maceration).

Plant fibres, natural dyes and paper industry: Plant fibres-types; and extraction of fibres. *Natural dyes-* types, and extraction of dye. *Dyeing with natural dyes.* *Paper industry* - sources and processes.

Section IV:

(4 Lectures)

Entrepreneurship Development: Industrial incubation, product development and quality control, FSSAI registration and licencing, availing government schemes, proposal preparation and processing grants.

Suggested Readings

1. Radhakrishnan, T., Anandaraja, N., Ramasubramanian, M., Nirmala, L. and Israel, M.T., 2009, Traditional Agricultural Practices: Applications and Technical Implementations, New India Publishing, India.
2. Awasthi, D. & Sebastian, J., 1996, Evaluation of Entrepreneurship Development Programmes, Sage Publications New Delhi.
3. Charantimath, P. M., 2009, Entrepreneurship Development and Small Business Enterprise, 5th edition, Pearson India, New Delhi.
4. Verma, V., 2009, Textbook of Economic Botany. Ane Books Pvt. Ltd, India.
5. Maiti, R.K. & Singh R.K., 2006, An Introduction to Modern Economic Botany. Agrobios (India).
6. Kent, N.L., 1983, Technology of Cereals. 3rd Edition. Pergamon Press, Oxford.
7. Jadhav, D., 2009, Medicinal Plants of India. Vol. 1-3. Scientific Publishers, India.
8. Jadhav, D., 2009, Medicinal Plants of India. Vol. 1-3. Scientific Publishers, India.
9. Bedi, Y.S., Dutt, H.C. & Kaur, H., 2011, Plants of Indian System of Medicine (Vol. I & II), Lambert Academic Publishing, Germany.
10. Furry S.M. & Viemont, V.M., 1935, Home Dyeing with Natural Dyes. Thresh Publications. California.

SEMESTER I

Course Code: BOT1104M

Course Name: Microbial and Algal Diversity

(Credits: Theory-03, Practicals-1)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to understand

5. The concept of kingdom.
6. Three domains of life.
7. Diversity, life forms, life cycles, morphology of microorganisms and algae.
8. Economic and ecological importance of microorganisms and algae.

Course Learning Outcomes:

On successful completion of this course:

3. Students will understand the classification, characteristic features, cell structure and growth and reproduction in viruses, bacteria, fungi and algae and their economic importance.
4. Moreover, students will be able to identify the microbes and algae in laboratory and in field as well.

Section I:

(11 Lectures)

Introduction to Microbes: Hierarchical organization of microbes in living world; Kingdom concept; Three domains of life; Distribution of microorganisms in soil, air, water and food; Economic importance.

Viruses: Discovery, physiochemical and biological characteristics; general structure, with special reference to viroids and prions; Classification (Baltimore 1971), replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV).

Section II:

(12 Lectures)

Bacteria: Discovery, General characteristics; Types-archaeobacteria, eubacteria, wall-less forms (mycoplasma and spheroplasts); Cell structure; Nutritional types; Reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction)

Introduction to fungi: General characteristics; Thallus organization; Cell wall composition; Nutrition; Classification (Anisworth, 1973).

Section III:

(10 Lectures)

Study of major divisions of fungi: General characteristics of Chytridiomycota, Zygomycota, Ascomycota, Basidiomycota: asexual and sexual fruiting bodies; Brief account of *Mucor*, *Aspergillus*, *Penicillium* and *Agaricus* (Mycelial form). Economic importance of fungi.

Section IV:

(12 Lectures)

Algae: General characteristics; Ecology and distribution; Evolutionary trend in thallus organization; Cell structure; Pigment system; Reserve food; Classification (Lee 2008); Reproduction and Economic importance. Life Cycle of Chlorophyceae (*Volvox*, *Oedogonium*); Charophyceae (*Chara*); Bacillariophyceae (*Diatoms*); Phaeophyceae (*Ectocarpus*); Rhodophyceae (*Polysiphonia*); Cyanophyceae (*Nostoc*) and Xanthophyceae (*Vaucheria*).

Practical

(Lectures: 30)

6. EMs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle.
7. Gram staining of bacteria (For both Gram positive and Gram negative).
8. Types of Bacteria from temporary/permanent slides/photographs and by Gram staining technique; electron micrographs of bacterial reproduction, Binary Fission and Conjugation
9. Study of asexual stage from temporary mounts. Study of sexual stage from permanent slides/ cultured specimens/photographs of the following genera; *Mucor*, *Aspergillus*, *Penicillium*, *Puccinia* and *Agaricus*.
10. Study of diversity in thallus forms of algae: Cyanophyceae, Chlorophyceae, Xanthophyceae, Phaeophyceae and Rhodophyceae through temporary mounts, specimens or permanent slides.

Note: List of practical may be updated depending on the availability of resources.

Suggested Readings

Viruses and Bacteria:

5. Campbell, N.A. & Reece, J.B., 2008, Biology, 8th edition, Pearson Benjamin Cummings, San Francisco.
6. Pelczar, M.J., 2001, Microbiology, 5th Edition, Tata McGraw-Hill Co., New Delhi.
7. Tortora, G.J., Funke, B.R. & Case, C.L., 2010, Microbiology: An Introduction, 10th edition, Pearson Benjamin Cummings, U.S.A.
8. Wiley, J.M., Sherwood, L.M. & Woolverton, C.J., 2013, Prescott's Microbiology, 9th Edition, McGraw Hill International.

Algae:

5. Lee, R.E., 2008, Phycology, 4th edition, Cambridge University Press, Cambridge.
6. Kumar, H.D., 1999, Introductory Phycology, East-West Press, Delhi.
7. Sharma, O.P., 2011, Diversity of Microbes & Cryptogams (Algae). Tata McGraw-Hill, New Delhi.
8. Vashishta, B.R., Sinha, A.K. and Singh, V.P (2010). Botany for degree students- Algae. S. Chand and Co. Ltd., New Delhi.

Fungi:

6. Agrios, G.N., 2011, Plant Pathology, 6th edition, Academic Press, U.K.
7. Alexopoulos, C.J., Mims, C.W. & Blackwell, M., 1996, Introductory Mycology, 4th edition, John Wiley & Sons (Asia) Singapore.
8. Sethi, I.K. & Walia, S.K., 2011, Text book of Fungi and Their Allies, Macmillan Pub. India Ltd.
9. Sharma, P.D., 2011, Plant Pathology, Rastogi Publication, Meerut, India.
10. Webster, J. & Weber, R., 2007, Introduction to Fungi, 3rd Edition, Cambridge Univ Press, Cambridge.

SEMESTER II

Course Code: BOT2104M

Course Name: Biomolecules and Cell Biology

(Credits: Theory-03, Practicals-1)

THEORY

(Lectures: 45)

Course Objectives:

After completion of the course, the learner shall be able to understand:

5. The organization of cell, its features and regulation at different levels.
6. Structure and function of biomolecules (i.e proteins, carbohydrates, lipids and nucleic acids).
7. Organization and function of cell organelles.
8. The process of cell cycle and cell division.

Course Learning Outcomes:

On successful completion of this course, students:

4. Will be able to demonstrate foundational knowledge in understanding of cell metabolism, chemical composition, physiochemical and functional organization of organelle.
5. Will be able to know contemporary approaches in modern cell and molecular biology.
6. Will be able to demonstrate isolation and estimation of biomolecules.

Section I:

(10 Lectures)

Biomolecules

Types and significance of chemical bonds; Structure and properties of water; pH and buffers.

Carbohydrates: Nomenclature and classification; Monosaccharide and its derivatives; Disaccharide; Polysaccharides; Reducing and non-reducing sugar.

Lipids: Properties and function of lipids; Essential fatty acids; Triacylglycerol and Wax; Phospholipids.

Amino acids and Proteins: Structure and optical properties of amino acids; Peptide and polypeptide; Protein structure- primary, secondary, tertiary and quaternary; Protein denaturation and biological role of proteins.

Section II:

(11 Lectures)

Nucleic acids: Nitrogenous bases; Structure and function of Nucleotides; Types of nucleic acids; Basic structure of dsDNA (with A, B and Z forms) and RNA.

Bioenergetics

Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as an energy currency molecule.

Enzymes:

Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; Features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced - fit theory), Michaelis–Menten equation, enzyme inhibition and factors affecting enzyme activity.

Vitamins:

General characteristics of vitamins and hormones. Nomenclature and classification of vitamins and its significance.

Section III:**(10 Lectures)*****The Cell***

Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory).

Cell wall and plasma membrane

Chemistry, structure and function of Plant cell wall. Overview of membrane function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis.

Cell Organelles

Nucleus: Structure- nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; Nucleolus- Nucleolar-organizing regions.

Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament.

Chloroplast, mitochondria and peroxisomes: Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast.

Ribosomes: Structure and types.

Section IV:**(14 Lectures)**

Endomembrane system: Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing; Smooth ER and lipid synthesis, export of proteins and lipids; Golgi Apparatus – organization, protein glycosylation, protein sorting and export from Golgi Apparatus; Lysosomes.

Nucleus: Structure, nuclear envelope and nuclear matrix; Nucleolus- nucleolar organizing region.

Cell Cycle and Cell Division

Phases of eukaryotic cell cycle; Cell cycle checkpoints; Cell division-mitosis and meiosis; Cell Signaling mechanism, signal transduction and signal protein; role of protein kinases.

Practical
(Lectures: 30)

8. Qualitative test for carbohydrates, reducing sugars, non-reducing sugars, lipid and proteins.
9. Cell structure with the help of epidermal peel mount of Onion/ Rhoeo.
10. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla/Vallisneria* leaf.
11. Counting the cells per unit volume with the help of haemocytometer (Yeast/pollen grains).
12. Cytochemical staining: DNA- Feulgen and cell wall in the epidermal peel of onion using Periodic Schiff's (PAS) staining technique.
13. Study different stages of mitosis and meiosis.
14. Meiosis through temporary squash preparation.

Note: List of practical may be updated depending on the availability of resources.

Suggested Readings

Biomolecules:

7. Campbell, M.K. (2012) Biochemistry, 7th ed., Published by Cengage Learning
8. Campbell, P.N. and Smith, A.D. (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
9. Tymoczko, J.L., Berg, J.M. and Stryer, L. (2012) Biochemistry: A short course, 2nd ed., W.H. Freeman
10. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2011) Biochemistry, W.H. Freeman and Company
11. Nelson, D.L. and Cox. M.M. (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company
12. Voet, G and Voet, J.G. (2010). Biochemistry. 4th Edition, Wiley, Hoboken

Cell Biology:

5. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
6. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
7. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
8. 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

SEMESTER III

Core Course Code: BOT3104M

Course Name: Mycology and Phytopathology

(Credits: Theory-03, Practical-1)

THEORY

Lectures: 45

Course Objectives:

- To introduce students with various fungal groups and lichens, their ecology.
- Classification, characteristics, reproduction and economic importance.
- To introduce students with the phytopathology, its concepts and principles.
- To acquaint with various plant diseases, causal organisms and their control.

Course Learning Outcomes:

- Understand the world of fungi, lichens and pathogens of plants.
- Understand characteristics the ecological and economic significance of the fungi and lichens.
- Understand the application of mycology in various fields of economic and ecological.
- Understand the economic and pathological importance of fungi, bacteria and viruses.
- Identify common plant diseases and their control measures.

Section I

(16 Lectures)

Introduction to true fungi: Definition, General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Heterokaryosis and parasexuality; Nutrition; Classification.

Zygomycota: General characteristics; Ecology; Thallus organization; Life cycle with reference to *Rhizopus*.

Ascomycota: General characteristics; Ecology; Life cycle, life cycle and classification with reference to *Saccharomyces*, *Penicillium*, *Alternaria* and *Neurospora*.

Basidiomycota: General characteristics; Ecology; Life cycle and Classification with reference to black stem rust on wheat *Puccinia* (Physiological Specialization), *Ustilago* (loose and covered smut, symptoms only), *Agaricus*; Fairy Rings and Mushroom Cultivation.

Section II

(06 Lectures)

Symbiotic associations: Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Economic importance of lichens. ; Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.

Section III

(08 Lectures)

Applied Mycology: Role of fungi in biotechnology, Application of fungi in food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes); Secondary metabolites; Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides,).

Section IV

(15 Lectures)

Phytopathology: Terms and concepts; General symptoms; Geographical distribution of diseases; Host-Pathogen relationships; disease cycle and environmental relation; Methods of control of plant diseases, and role of quarantine. Bacterial diseases – Citrus canker and angular leaf spot disease of Cotton. Viral diseases – Tobacco Mosaic viruses.

Practical

(Lectures: 30)

9. Introduction to the world of fungi (Unicellular, coenocytic/septate mycelium, asocarps & basidiocarps).
10. Rhizopus: study of asexual stage from temporary mounts and sexual structures through permanent slides.
11. Aspergillus and Penicillium: study of asexual stage from temporary mounts. Study of Sexual stage from permanent slides/photographs.
12. Alternaria: Specimens/photographs and temporary mounts.
13. Puccinia: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; sections/ mounts of spores on wheat and permanent slides of both the hosts.
14. Agaricus: Specimens of button stage and full grown mushroom; sectioning of gills of Agaricus, fairy rings and bioluminescent mushrooms to be shown.
15. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates. Study of thallus and reproductive structures (soredia and apothecium) through permanent slides. Mycorrhizae: ectomycorrhiza and endo mycorrhiza (Photographs)
16. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Angular leaf spot of cotton, Viral diseases: TMV, Vein clearing, Fungal diseases: Early blight of potato, Black stem rust of wheat and White rust of crucifers.

Suggested Readings

5. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi and Their Allies. (2nd Edition), Medtech Publishers, Delhi (Chapters 1, 3 for Unit I, Chapter 8 for Unit 2, Chapter 9 for Unit 3, Chapters 10, 12-15,17 for Unit 4, Chapter 18, 19, 22-23 for Unit 5, Chapter 5 for Unit 6, Chapter 7 for Unit 7, Chapters 24, 25 for Unit 8, Chapter 26 for Unit 9, Chapter 27 for Unit 10).
6. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, 4th edition. Singapore, Singapore: John Wiley & Sons. (Chapter 1 for Unit 1, Chapter 2 for Unit 2, Chapter 5 for Unit 3, Chapters 7, 10, 11-13 for Unit 4, Chapters 16, 17, 20, 21 for Unit 5, Chapter 29 for Unit 6, Chapter 23 for Unit 7).
7. Agrios, G.N. (2005). Plant Pathology, 5th edition. Cambridge, U.K.: Academic Press. (Chapter 1, 8, 9, 11, 12, 14 for Unit 10).

8. Burchett, Stephen and Burchett, Sarah. (2018). Plant Pathology. New York: Garland Science (Chapter 1,6-8, 10 for Unit 10).

SEMESTER III

Course Code: BOT3204M

Course Name: Archegoniate and Paleobotany

Credits: 06 (Theory-04, Practicals-2)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to:

- Understand morphology, anatomy and reproduction of Bryophytes, Pteridophytes and Gymnosperms.
- Conceptualize plant evolution and their transition to land habitat.
- Learn the context for the origin, extinction and adaptation of plants.

Course Learning Outcomes:

On successful completion of this course the students will:

- Develop critical understanding on morphology, anatomy and reproduction of Archegoniate.
- Develop Understanding of plant evolution and their transition to land habitat.
- Get the knowledge of context for the origin, extinction and adaptation of plants.

Section I:

(14 Lectures)

Introduction to Archegoniates & Bryophytes: Unifying features of archegoniates; Transition to land habit; Alternation of generations. General characteristics; Adaptations to land habit; Classification; Range of thallus organization. *Type Studies*-Classification, morphology, anatomy and reproduction of *Riccia*, *Marchantia*, *Anthoceros*, *Sphagnum* and *Polytrichum*; Reproduction and evolutionary trends in *Riccia*, *Marchantia*, *Anthoceros*, *Sphagnum* and *Polytrichum*. Ecological and economic importance of bryophytes.

Section II:

(10 Lectures)

Pteridophytes: General characteristics; Classification; Early land plants (*Cooksonia* and *Rhynia*). *Type Studies*- Classification, morphology, anatomy and reproduction of *Psilotum*, *Lycopodium*, *Selaginella*, *Equisetum*, *Pteris* and *Marsilea*. *Apogamy* and *apospory*, heterospory and seed habit, telome theory, stelar evolution; Ecological and economic importance.

Section III:

(10 Lectures)

Gymnosperms: General characteristics, classification (up to family), morphology, anatomy and reproduction of *Cycas*, *Pinus*, *Ginkgo* and *Gnetum*; Ecological and economic importance.

Section IV:

(11 Lectures)

Palaeobotany: Geological time scale; Brief account of process of fossilization & types of fossils and study techniques; General account of *Cycadofilicales*, *Bennettitales*, *Pentoxylales* and *Cordaitales*.

Practical
(Lectures: 30)

1. *Riccia* – Morphology of vegetative and reproductive parts.
2. *Marchantia* - Morphology of thallus and reproductive parts; vertical and transverse section of thallus; vertical section of Gemma cup, *Antheridiophore* and *Archegoniophore*.
3. *Sphagnum* - Morphology of plant; whole mount of leaf.
4. *Polytrichum* - Morphology of vegetative and reproductive parts; Transverse Section of rhizome, whole mount of leaf; Longitudinal Section through antheridial and archegonial heads; L.S. of capsule.
5. *Lycopodium* - Morphology of plant, whole mount of leaf; transverse section of stem; Longitudinal Section of strobilus; morphology of sporophyll.
6. *Selaginella* - Morphology of plant, whole mount of leaf with ligule, transverse section of stem and rhizophore; longitudinal section of strobilus; morphology of sporophyll.
7. *Equisetum* - Morphology of plant, transverse section of internode, longitudinal and transverse section of strobilus, whole mount of sporangiophore and spore.
8. *Pteris* - Morphology of plant, transverse section of rachis, vertical section of leaflets through sorus; whole mount of prothallus with sex (permanent slide).
9. *Marsilea* - Morphology of plant, transverse section of rhizome and petiole; vertical transverse and vertical longitudinal section of sporocarp.
10. *Cycas* - Morphology of plant; morphology and transverse section of coralloid roots; transverse section of leaflets; Longitudinal Section of male and female cone; morphology of microsporophyll and megasporophyll; Longitudinal section of ovule (permanent slide).
11. *Pinus* - Morphology of plant; transverse section of Needle; longitudinal section of male cone and female cone; whole mount of Microspores.
12. *Ginkgo* - Morphology of plants and reproductive structures (only photographs).
13. *Gnetum* - Morphology of plant; Morphology of male and female strobilus; vertical section of ovule (permanent slide).
14. *Geological time scale* : concept of geologic time scales including *eons*, *eras*, *epochs*, and *periods*.
15. *Types of Plant fossil* : *Compressions*; *Impressions*; *Casts and Molds*; *Permineralization or Petrification*; *Compactions*; *Molecular Fossils*.
16. *Important fossil in India*: *Glossopteris*; *Pentoxylon*; *Williamsonia sewardiana*; *Birbal sahnii* *divyadarshanii*; *Mandla Plant Fossils National Park*.

Note: List of practical may be updated depending on the availability of resources.

Suggested Readings

1. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.
2. Bhatnagar, A.M. 2004. Gymnosperms. New Age International (P)Ltd Publishers, New Delhi, India.
3. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.
4. Vanderpoorten, A. & Goffinet, B. (2009) Introduction to Bryophytes. Cambridge University Press.
5. Vashistha, B. R., Sinha, A.K. and Kumar, A. (Latest edition). Botany for Degree Students: Bryophyta. S. Chand Publishing 7361, Ram Nagar, Qutab Road, New Delhi-110055.
6. Dutta A.C. 2016. Botany for Degree Students. Oxford University Press.
7. Bhattacharya et. al. 2007. A textbook of Palynology, Central, New Delhi.
8. Sepkoski, D.2011, Rereading the Fossil Record, University of Chicago Press.
9. Jain P.C. & M.S. Anantharaman, 2014, Palaeontology Palaeobiology, Paperback–by Vishal Publishing Co.; 9th (Revised and Enlarged)
10. Stanley Raup, 2006, Principles of Paleontology Paperback– by CBS Publishers & Distributors; 2nd edition

SEMESTER IV

Course Code: BOT4104M

Course Name: Morphology and Anatomy of Angiosperms

Credits: 06 (Theory-04, Practicals-2)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to

6. Develop a comprehensive understanding of the morphology and anatomy of angiosperms.
7. Identify and describe the structural features of various plant organs and tissues.
8. Explore the functional significance of morphological adaptations in angiosperms.
9. Understand the evolutionary relationships among angiosperm taxa based on comparative morphology.
10. Develop practical skills in plant specimen preparation, microscopy, and morphological identification.

Course Learning Outcomes:

On successful completion of this course the students will:

4. Develop a comprehensive understanding of the morphology and anatomy of angiosperms, including the structure and function of various plant organs and tissues.
5. Develop a curiosity and enthusiasm for continued learning and exploration in the field of plant morphology and anatomy.
6. Interpret the relationship between angiosperm morphology and anatomy and their ecological roles, including adaptations to environmental conditions.

Section I:

(9 Lectures)

Introduction to Angiosperm Morphology and Anatomy: Overview of angiosperm morphology and life cycle; Morphology of inflorescence, stamens and carpel, fruit; Telome theory, phyllode theory; Role of morphology in plant classification. Scope of anatomy; Application of anatomy in systematics, forensics and pharmacognosy

Section II:

(16 Lectures)

Structure and Development of Plant Body: Internal organization of plant body: The three tissue systems, types of cells and tissues. Development of plant body: Polarity, Cytodifferentiation and organogenesis during embryogenic development. Classification of tissues; Simple and complex tissues (no phylogeny); cytodifferentiation of tracheary elements and sieve elements; Pits and plasmodesmata; Wall ingrowths and transfer cells, adcrustation and incrustation, Ergastic substances. Hydathodes, cavities, lithocysts and laticifers.

Section III:**(14 Lectures)**

Apical meristems: Evolution of concept of organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cytohistological zonation); Types of vascular bundles; Structure of dicot and monocot stem. Origin, development, arrangement and diversity in size and shape of leaves; Structure of dicot and monocot leaf, Kranz anatomy. Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin of lateral root.

Section IV:**(21 Lectures)**

Vascular Cambium and Wood: Structure, function and seasonal activity of cambium; Secondary growth in root and stem. Axially and radially oriented elements; Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology. Development and composition of periderm, rhytidome and lenticels.

Adaptive and Protective Systems: Epidermal tissue system, cuticle, epicuticular waxes, trichomes (uni- and multicellular, glandular and nonglandular, two examples of each), stomata (classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes.

Practical**(Lectures: 30)**

11. Study of special types of inflorescence – *Cyathium*, *Hypanthodium*, *Verticillaster*, *Hypanthium*: Dissection of flowers to observe floral organs; Identification of sepals, petals, stamens, and pistils; Observation of floral adaptations for pollination.
12. Study of special types of fruits- Superior fruits (*Dillenia*); Aggregate fruits (Custard apple, *Michelia*, Periwinkles, *Polyalthia*); Multiple fruits (Pine apple, Jack fruits): Identification of different fruit types (e.g., simple, aggregate, multiple).
13. Study of anatomical details through permanent slides/temporary stain mounts /macerations /museum specimens with the help of suitable examples.
14. Apical meristem of root, shoot and vascular cambium.
15. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
16. Root: monocot, dicot, secondary growth.
17. Stem: monocot, dicot - primary and secondary growth; periderm; lenticels.
18. Leaf: isobilateral, dorsiventral, C4 leaves (Kranz anatomy).
19. Adaptive Anatomy: xerophytes, hydrophytes.
20. Secretory tissues: cavities, lithocysts and laticifers.

Suggested Readings

1. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
 2. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
 3. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.
 4. Evert, R.F. (2006) Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc.
- Additional resources provided by the instructor based on specific topics covered in the practical sessions

Note: The syllabus and schedule may be subject to adjustments based on the availability of laboratory facilities and fieldwork opportunities.

SEMESTER IV

Core Course Code: BOT4204M

Course Name: Genetics and Plant Breeding

(Credits: Theory-03, Practicals-1)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to:

5. Understand basic genetics principles and their application in plant breeding.
6. Apply molecular tools and techniques for crop improvement.
7. Evaluate genetic resources and utilize them effectively in breeding programs.
8. Address global agricultural challenges through sustainable breeding practices.

Course Learning Outcomes:

On successful completion of this course the students will:

5. Demonstrate understanding of fundamental genetics principles and their relevance to plant breeding.
6. Apply molecular techniques in crop improvement strategies.
7. Evaluate and utilize genetic resources for developing improved crop varieties.
8. Analyze and address agricultural challenges through sustainable breeding practices.

Section I:

(10 Lectures)

Mendelian and Non-Mendelian genetics: History; Principles of inheritance; Mendel's laws of inheritance; Incomplete dominance and co-dominance; Multiple allelism; Quantitative and polymeric gene interaction; Complementary, supplementary and duplicate gene interactions (plant based examples are to be dealt); Penetrance and expressivity; Chromosomal theory of inheritance; Multiple allelism; Epistasis; Pleiotropy. Non-Mendelian inheritance- Concept of maternal inheritance (Corren's experiment on *Mirabilis jalapa*); Mitochondrial DNA.

Section II:

(10 Lectures)

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; Numericals based on gene mapping

Variation in chromosome number and structure: Deletion, Duplication, Inversion, Translocation, Euploidy and Aneuploidy

Section III:

(9 Lectures)

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.

Fine structure of gene: Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism; Structure of Phage T4, rII Locus.

Section IV:

(12 Lectures)

Population and Evolutionary Genetics: Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation.

Plant Breeding: Plant Breeding and its scope; Genetic basis for plant breeding; Plant Introduction and Acclimatization; Definition, procedure; applications and uses; advantages and limitations of : (a) Mass selection, (b) Pure line selection and (c) Clonal selection; Hybridization – schemes, and technique; Heterosis (hybrid vigour); A brief account on Molecular breeding – DNA markers in plant breeding. RAPD, RFLP.

Practical

(Lectures: 30)

8. Meiosis through temporary squash preparation.
9. Karyotype study in onion and garlic.
10. Study of chromosomal aberration in *Tradescantia/ Rhoeo*
11. Mendel's laws through seed ratios.
12. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
13. Permanent slides showing Translocation Ring, Photographs showing Laggards and Inversion Bridge.
14. Demonstration of emasculation, bagging, artificial pollination techniques for hybridization.

Suggested Readings

5. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & sons, India. 8th edition.
6. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India. 5th edition.
7. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings, U.S.A. 9th edition.
8. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

SEMESTER V

Core Course Code: BOT5104M

Course Name: Reproductive Biology of Angiosperms

(Credits: Theory-03, Practical-1)

THEORY

Lectures: 45

Course Objective

On completion of this course, the students will be able to

2. To have knowledge of the flowering and fruiting, reproduction processes, role of pollinators, anther, ovule and seed development.

Course Learning Outcomes

On successful completion of this course the students will be able to:

7. Induction of flowering, molecular and genetic aspects of flower development.
8. Anther structure, pollen development, dispersal and pollination.
9. Ovule, embryo sac development and fertilization.
10. Endosperm development and its importance.
11. Alternative pathways of reproduction and their importance.
12. Student would be able to apply this knowledge for conservation of plants, pollinators and fruit development.

Section I

(06 Lectures)

Introduction: History (contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison) and scope.

Reproductive development: Induction of flowering; flower as a modified determinate shoot. Flower development: genetic and molecular aspects.

Section II

(15 Lectures)

Anther and pollen biology: Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance. Microgametogenesis; Pollen wall structure, MGU (male germ Section) structure, NPC system; Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia.

Ovule: Structure; Types; Special structures—endothelium, obturator, aril, caruncle and hypostase; Female gametophyte— megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of Polygonum type); Organization and ultrastructure of mature embryo sac.

Section III

(12 Lectures)

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 (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination.

Section IV

(12 Lectures)

Embryo, Endosperm and Seed: Structure and types; General pattern of development of dicot and monocot embryo and endosperm; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in Paeonia. Seed structure, importance and dispersal mechanisms.

Polyembryony and apomixes: Introduction; Classification; Causes and applications.

Practical

(Lectures: 30)

7. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehiscent anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.
8. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, pseudomonads, polyads, pollinia (slides/photographs, fresh material), ultrastructure of pollen wall (micrograph); Pollen viability: Tetrazolium test, germination: Calculation of percentage germination in different media using hanging drop method.
9. Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs).
10. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.
11. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.
12. Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages.

Suggested Readings

5. Bhojwani, S.S., Bhatnagar, S.P. Dantu P. K. (2015). The Embryology of Angiosperms, 6th edition. New Delhi, Delhi: Vikas Publishing House. (Chapter 1 for Unit 1, Chapters 3 to 15 for unit 2-10, Chapter 17 for Unit 11).
6. Johri, B.M. (1984). Embryology of Angiosperms. Netherlands: Springer-Verlag. (Chapters 3, 4 for Unit 4, Chapter 6 for Unit 5, Chapter 7, 8 for Unit 7-8; Chapter 12 for Unit 9)
7. Raghavan, V. (2000). Developmental Biology of Flowering plants. Netherlands: Springer (Chapter 13 for Unit 8).

8. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. New Delhi, Delhi: Oxford and IBH Publishing Co. Pvt. Ltd. (Chapters 1, 2, 3, 4 for Unit 2-3; Chapter 7 for unit 5, Chapter 9 for Unit 6)

SEMESTER V

Core Course Code: BOT5204M

Course Name: General Microbiology

(Credits: Theory-03, Practical-1)

THEORY

Lectures: 45

Course Objective

On completion of this course, the students will be able to

2. To understand microorganisms and their roles in health sciences, environmental sciences, biotechnology, food, and agriculture.

Course Learning Outcomes

On successful completion of this course the students will be able to:

4. Thorough knowledge and understanding of concepts of microbiology.
5. Learning and practicing professional skills in handling microbes.
6. Thorough knowledge and application of good laboratory and good manufacturing practices in microbial quality control.

Section I

(08 Lectures)

Historical development of microbiology: Theory of spontaneous generation, Biogenesis and Abiogenesis. Contributions of Anton Von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister and Edward Jenner, Alexander Fleming, Martinus Beijerinck, Sergei Winogradsky, Elie Metchnikoff. Origin of life, primitive cells and evolution of microorganisms. Microscopy- working principle, construction and operation of simple and compound microscopes.

Section II

(14 Lectures)

Staining: Nature of stains, principles, mechanism, methods and types of staining- Simple, Differential-Gram staining, Acid fast staining, staining of capsule, cell wall, endospore, inclusion bodies.

Sterilization: Principles, types and techniques, Physical and chemical methods.

Culture media: Types, Cultivation of aerobic and anaerobic bacteria. Pure culture techniques and Cultural characteristics.

Preservation of microorganisms: Methods of preservation of microorganisms; slant culture, stab culture, soil culture, mineral oil overlaying, glycerol preservation.

Section III

(12 Lectures)

Microbial Diversity and Ecology: Bacterial diversity and classification; Microbial interactions (symbiosis, competition, Pathogenesis); Microbes in ecosystems (soil, water, extreme environments). Microbial roles in biogeochemical cycles (e.g., carbon, nitrogen, sulfur cycles) and nutrient cycling; Microbial bioremediation of pollutants (e.g., oil spills, heavy metals, pesticides) in soil, water, and air; Microbial contributions to

wastewater treatment and sustainable environmental management.

Section IV

(11 Lectures)

Applied Microbiology: Industrial microbiology (fermentation, enzyme production); Bioremediation and environmental applications; Microbes in agriculture and food production. Plant-microbe interactions and their role in plant growth promotion and disease control. Biological control of plant diseases and pests using beneficial microbes. Microbial biofertilizers and biostimulants for sustainable agriculture.

Practical (Lectures: 30)

11. Microbiological laboratory standards and safety protocols .
12. Standard aseptic conditions of Microbiological laboratory.
13. Operation and working principles of Light/ Compound microscope.
14. A. Working principles and operations of basic equipments of microbiological laboratory (Autoclave, Oven, Incubator, pH meter, Spectrophotometer, Colorimeter, Vortex, Magnetic stirrer).
15. Applications of basic microbiological tools (Pipettes, Micropipette, Bunsen burner, Inoculation loop, Spreader).
16. Demonstration and observations of microorganisms from natural sources under light microscope (Algae, Yeast and Protozoa).
17. Demonstration of bacterial motility by hanging drop method.
18. Differential staining - Gram staining.
19. Preparation of Physiological saline and Serial dilution.
20. Method of obtaining pure cultures of Microorganisms.

Suggested Readings

15. General Microbiology 1st Edition, 2020 , Linda Bruslind, Oregon State University.
16. Prescott, Harley, Klein's Microbiology, J.M. Willey, L.M. Sherwood, C.J. Woolverton, 7th International, edition 2008, McGraw Hill.
17. Foundations in Microbiology, K. P. Talaro, 7th International edition 2009, McGraw Hill.
18. A Textbook of Microbiology, R. C. Dubey and D. K. Maheshwari, 1st edition, 1999, S. Chand & Company Ltd.
19. Brock Biology of Microorganisms, M.T.Madigan, J.M.Martinko, P. V. Dunlap, D. P. Clark- 12th edition, Pearson International edition 2009, Pearson Benjamin Cummings.
20. Microbiology – An Introduction, G. J.Tortora, B. R.Funke, C. L. Case, 10th ed. 2008,Pearson Education.
21. General Microbiology, Stanier, Ingraham et al, 4th and 5th edition 1987, Macmillan education limited.
22. Microbiology- Concepts and Applications, Pelczar Jr,Chan, Krieg, International ed, McGraw Hill.

23. Alexopoulos, C.J., Mims, C.W., and Blackwell, M. 2002. Introductory Mycology. John Wiley and Sons (Asia) Pvt. Ltd. Singapore. 869 pp.
24. Atlas, R.M. 1984. Basic and practical microbiology. Mac Millan Publishers, USA. 987pp.
25. Black, J.G. 2008. Microbiology principles and explorations. 7edn. John Wiley and Sons Inc., New Jersey 846 pp.
26. Pommerville, J.C. Alcamo's Fundamentals of Microbiology. Jones and Bartlett Pub..Sudbury, 835 pp.
27. Schlegel, H.G. 1995.General Microbiology. Cambridge University Press, Cambridge, 655 pp.
28. Toratora, G.J., Funke, B.R. and Case, C.L. 2007. Microbiology 9 th ed. Pearson Education Pte. Ltd., San Francisco. 958pp.

SEMESTER V

Core Course Code: BOT5304M

Course Name: Molecular Biology

(Credits: Theory-03, Practicals-1)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to

5. Understand core concepts of molecular biology, including DNA structure and function.
6. Explore molecular techniques used in research and biotechnology.
7. Analyze gene expression and regulation mechanisms.
8. Apply molecular biology principles to solve biological problems.

Course Learning Outcomes:

On successful completion of this course the students will be able to:

7. Understand fundamental principles of molecular biology.
8. Analyze DNA replication, transcription, and translation processes.
9. Apply molecular techniques in laboratory settings.
10. Interpret genetic mechanisms underlying cellular functions.
11. Evaluate contemporary research in molecular biology.
12. Demonstrate proficiency in molecular experimental design and analysis.

Section I:

(12 Lectures)

Nucleic Acids: *Carriers of Genetic Information*- DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod & McCarty experiments). Types of genetic material; DNA Structure (Watson and Crick), Denaturation and Renaturation; Organization of DNA in Prokaryotes, Viruses & Eukaryotes; Structure of RNA; Mitochondria & Chloroplast DNA; Chromatin structure; Euchromatin & Heterochromatin

Section II:

(12 Lectures)

Central Dogma and Genetic Code: The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features)

Replication of DNA: Types of DNA replication; Replication of DNA in prokaryotes and eukaryotes; RNA priming

Section III:

(6 Lectures)

Transcription : Mechanism of Transcription in Prokaryotes and Eukaryotes; Regulation of gene expression in prokaryotes- lac operon and tryptophan synthesis in *E.coli*.

Section IV:

(15 Lectures)

RNA Processing and Translation: *RNA processing* - Concept of introns and exons, removal of introns, splicing pathways, pre-mRNA processing, spliceosome machinery, alternative splicing, RNA editing and mRNA transport. Translation- Various steps involved in translation/protein synthesis (aminoacylation of tRNA, translation, fidelity of translation); Inhibitors of protein synthesis; Post-translational modifications of proteins.

Practical
(Lectures: 30)

6. DNA isolation from any plant material
7. DNA estimation of diphenylamine reagent/UV Spectrophotometry (Demonstration).
8. Study of DNA replication mechanism through photographs semi-discontinuous replication.
9. Study of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
10. Study of the following through photographs: Assembly of Spliceosome machinery; Alternative splicing

Suggested Readings

11. Alberts, B., Bray, D., Hopkin, K., Johnson, A. D., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2013). *Essential Cell Biology* (4th edn.). Garland Science.
12. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell* (6th edn.). Garland Science.
13. Clark, D. P., & Pazdernik, N. J. (2015). *Molecular Biology* (2nd edn.). Academic Cell.
14. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). *Concepts of Genetics*. Benjamin Cummings. U.S.A. 9th edition.
15. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). *Introduction to Genetic Analysis*. W. H. Freeman and Co., U.S.A. 10th edition.
16. Lewin, B. (2008). *Genes IX*. Jones & Bartlett Learning.
17. Russell, P. J. (2010). *Genetics- A Molecular Approach*. Benjamin Cummings, U.S.A. 3 rd edition.
18. Snustad, D.P. and Simmons, M.J. (2010). *Principles of Genetics*. John Wiley and Sons Inc.,U.S.A. 5th edition.
19. Tropp, B. E. (2012). *Principles of Molecular Biology*. Jones & Bartlett Learning.
20. Watson, J.D., Hopkins, N.H., Roberts, J.W. et al. (1987). *Molecular Biology of the Gene* (4th edn.). Menlo Park, CA: Benjamin-Cummings.

SEMESTER VI

Course Code: BOT6104M

Course Name: Fundamentals of Plant Biotechnology

Credits: 06 (Theory-04, Practicals-2)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to

5. Gain a solid understanding of fundamental techniques used in plant biotechnology research and applications such as tissue culture, genetic engineering, and molecular biology tools.
6. Learn about the genetic diversity within plant species and how it can be utilized for crop improvement and genetic engineering purposes.
7. Acquire skills in plant tissue culture techniques for the propagation, manipulation, and regeneration of plants, including callus culture, somatic embryogenesis, and organogenesis.
8. Explore how biotechnology can be applied to improve crop traits such as yield, stress tolerance, nutritional content, and resistance to pests and diseases.

Course Learning Outcomes:

On successful completion of this course the students will be able to:

3. Demonstrate a comprehensive understanding of fundamental principles in plant biology and biotechnology, including plant anatomy, physiology, genetics, and molecular biology.
4. Explain the principles and applications of key biotechnological techniques used in plant research and crop improvement, such as tissue culture, genetic engineering, and molecular markers.

Section I:

(16 Lectures)

Plant Tissue Culture: Definitions, scope & history of plant tissue culture. Importance of plant tissue culture & biotechnology. In vitro culture techniques: Sterilization methods, Culture media – composition, types of medium and role of hormones in *in-vitro* culture. Inoculation, Incubation and Acclimatization. Callus, single cell and suspension culture and its significance. Isolation and cultivation of economically important microbes (*scenedesmus*, *Aspergillus*) culture and purification of single cell protein (*scenedesmus*, *spirulina*), mushroom cultivation. Algal biomass production and maintenance. Organ culture: Anther, Embryo & Meristem culture. Organogenesis, somatic embryogenesis and artificial seeds. Somatic Hybridization: Isolation, fusion and protoplast culture. Somoclonal Variation & cryopreservation.

Section II:

(16 Lectures)

Plant Molecular Biology: Organisation and function of Plant nuclear genome (*Arabidopsis thaliana*), Genetic transformation of plants by *Agrobacterium*: Genetic organization of Ti plasmids Functions encoded

by integrated T- DNA. Molecular mechanism involved in transformation of plants by *Agrobacterium tumefaciens*. Production of primary and secondary metabolites by microbes. (Ethanol by yeast, citric acid by *Aspergillus niger*, penicillin) Bio fertilizers. Plant genome organization - chloroplast genome - nucleus encoded genes - *Agrobacterium rhizogenus* mechanism of T - DNA synthesis, edible vaccines, Transgenic plants, BT - cotton, BT - tomato, bioethics.

Section III:

(16 Lectures)

Recombinant DNA technology: 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). Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR-mediated gene cloning; Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; PCR.

Section IV:

(12 Lectures)

Crop Improvement and Transgenic plant: Crop improvement in terms of yield and quality. Molecular markers (RFLP, RAPD and DNA finger printing) in crop improvement program. Transgenic plants resistant to insect. Biosafety and bioethics.

Practical

(Lectures: 30)

10. Introduction to Laboratory Techniques: Introduction to laboratory safety procedures and equipment; Demonstration of aseptic technique for working with plant tissue culture.
11. Sterilization Techniques: Practice in sterilizing tools, media, and plant materials for tissue culture experiments; Preparation of MS medium and growth hormones for tissue culture experiments
12. Demonstration of in vitro sterilization and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc.
13. Callus Induction and Somatic Embryogenesis: Initiation of callus cultures from plant explants; Observation and documentation of callus growth and morphology; Observation and documentation of somatic embryo development. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs.
14. Organogenesis: Shoot or root organogenesis from callus or somatic embryos; Observation and documentation of shoot or root formation.
15. Genetic Engineering Techniques: Introduction to plasmid DNA extraction and purification techniques; Transformation of plant tissues with a plasmid DNA construct using *Agrobacterium*-mediated or biolistic methods; Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
16. Molecular Analysis: Isolation of genomic DNA from transformed plant tissues; Polymerase chain

reaction (PCR) amplification of target DNA sequences; Agarose gel electrophoresis and visualization of PCR products.

17. Plant Transformation: Selection and regeneration of transformed plant tissues on selective media; Observation and documentation of transgenic plant growth and phenotype; Analysis of molecular data from PCR and gel electrophoresis experiments.
18. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs; Isolation of plasmid DNA.

Suggested Readings

1. Scorza, R and Kumar, S. D. P. 2015. Principles of Plant Biotechnology: An Introduction to Genetic Engineering in Plants. Wiley-Blackwell.
2. Ignacimuthu, S., 2003. Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
3. Bhojwani, S.S. and Bhatnagar, S.P. 2011. The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd., New Delhi. 5th edition.
4. Mascarenhas A.F., 1991. Hand book of Plant Tissue Culture. Indian Council of Agricultural Research. New Delhi.
5. Gupta, P. K. 1994. Elements of Biotechnology. Rastogi Publications. Meerut.
6. Chawla, H. S. 2012. Introduction to Plant Biotechnology. Science Publishers.
7. Taiz, H. and Zeiger, E. 2010. Plant Biotechnology: Principles and Applications. Sinauer Associates.
8. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K. 5th edition.

Note: The syllabus and schedule may be subject to adjustments based on the availability of laboratory facilities and fieldwork opportunities.

SEMESTER VI

Core Course Code: BOT6204M

Course Name: Bioinformatics

(Credits: Theory-03, Practicals-1)

THEORY

(Lectures: 45)

Course Objectives:

On completion of this course, the students will be able to

7. Introduce basic concepts and principles of bioinformatics.
8. Explore algorithms and computational methods in molecular biology.
9. Familiarize students with biological databases and their applications.
10. Develop practical skills in bioinformatics tools and software.
11. Analyze biological data using computational techniques.
12. Encourage critical thinking and problem-solving in bioinformatics research.

Course Learning Outcomes:

On successful completion of this course the students will be able to:

7. Utilize bioinformatics tools for sequence analysis.
8. Apply algorithms for molecular data analysis.
9. Interpret genomic and proteomic data.
10. Construct biological databases and queries.
11. Employ computational methods for biological research.
12. Demonstrate proficiency in bioinformatics programming languages.

Section I:

(7 Lectures)

Introduction to Bioinformatics: Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics.

Databases in Bioinformatics: Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System.

Section II:

(20 Lectures)

Biological Sequence Databases: National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database. EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools. DNA Data Bank of Japan (DDBJ): Introduction, Resources at DDBJ, Data Submission at DDBJ. Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR. Swiss-Prot: Introduction and Salient Features.

Section III:**(8 Lectures)**

Sequence Alignments: Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).

Section IV:**(10 Lectures)**

Molecular Phylogeny: Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.

Applications of Bioinformatics: Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement

Practical**(Lectures: 30)**

1. Nucleic acid and protein databases.
2. Sequence retrieval from databases.
3. Sequence alignment.
4. Sequence homology and Gene annotation.
5. Construction of phylogenetic tree.

Suggested Readings

1. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
3. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.

SEMESTER VI

Core Course Code: BOT6304M

Course Name: Industrial and Environmental Microbiology

(Credits: Theory-03, Practical-1)

THEORY

Lectures: 45

Course Objectives

On completion of this course, the students will be able to

3. To introduce students with the industrial microbiology: concepts, principles, scope and application.
4. To introduce students with the environmental microbiology: concepts, principles, scope and application.

Course Learning Outcomes

On successful completion of this course the students will be able to:

10. Understand how microbiology is applied in manufacturing of industrial products.
11. Know about design of bioreactors, factors affecting growth and production.
12. Understand the rationale in medium formulation & design for microbial fermentation, sterilization of medium and air.
13. Comprehend the different types of fermentation processes.
14. Comprehend the techniques and the underlying principles in upstream and down- stream processing.
15. Learn the occurrence, abundance and distribution of microorganism in the environment and their role in the environment and also learn different methods for their detection.
16. Understand various biogeochemical cycles – Carbon and Nitrogen, and microbes involved.
17. Understand the basic principles of environment microbiology and application of the same in solving environmental problems – waste water treatment and bioremediation.
18. Comprehend the various methods to determine the quality of water.

Section I

(10 lectures)

Scope of microbes in industry and environment, Bioreactors/Fermenters and fermentation processes. Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors-laboratory, pilot scale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

Section II

(12 lectures)

Microbial production of industrial products-Microorganisms involved, media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; Hands on microbial fermentations for the production and

estimation (qualitative and quantitative) of Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol) and antibiotic (Penicillin)

Section III

(10 lectures)

Microbial enzymes of industrial interest and enzyme immobilization. Microorganisms for industrial applications and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis. Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase). Microbes and quality of environment- Distribution of microbes in air; Isolation of microorganisms from soil, air and water.

Section IV

(13 lectures)

Microbial flora of water-Water pollution, role of microbes in sewage and domestic waste water treatment systems. Determination of BOD, COD, TDS and TOC of water samples; Microorganisms as indicators of water quality, check coliform and fecal coliform in water samples. Microbes in agriculture and remediation of contaminated soils. Biological fixation; Mycorrhizae; Bioremediation of contaminated soils. Isolation of root nodulating bacteria, arbuscular mycorrhizal colonization in plant roots.

Practical

(Lectures: 30)

7. Principles and functioning of instruments in microbiology laboratory (autoclave, laminar air flow, incubators, types of fermenters).
8. Preparation of different culture media (Nutrient medium/ Luria Bertani medium/Potato dextrose medium/Czapek Dox medium).
9. Alcohol production by yeast using sugar/ jiggery.
10. Serial dilution method for isolation of microorganisms from water and soil and study of aeromicroflora.
11. Determination of BOD, COD, TDS and TOC of water samples.
12. Determination of coliforms in water samples using eosin methylene blue (EMB) medium.
 - ❖ *A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations and a report to be submitted.*

Suggested Readings

8. Pelzar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). Microbiology: An application based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.
9. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. Pearson Benjamin Cummings, San Francisco, U.S.A. 9th edition.

10. Stanbury, P.F., Whitaker, A., Hall, S.J. (2016) Principles of Fermentation Technology. Amsterdam, NDL:Elsevier Publication (Chapter 4, 5, 7, 10 , 11 for Unit 1 to 6)
11. Patel, A.H. (2008) Industrial Microbiology, Bangalore, India: McMillan India Limited (Chapter 2, 3, 5, 7, 11, 12, 14, 20 for Unit 1 to 6)
12. Mohapatra. P.K. (2008). Textbook of Environmental Microbiology New Delhi, Delhi, I.K. International Publishing House Pvt.Ltd. (Chapter 1,5,6, 11,12,14 for Unit 5, 6, & 7).
13. Bertrand, Jean-Claude, Caumette, P. , Lebaron, P, Matheron, R., Normand, P., SimeNgando, T. (2015) Environmental Microbiology: Fundamentals and Applications. Amsterdam, Netherlands, Springer (Chapter 14,16,17 for Unit 5 & 7).
14. Joe, S., Sukesh (2010). Industrial Microbiology. New Delhi, Delhi: S.Chand & Company Pvt. Ltd., (Cahpter 1,2,3,,5,13 for Unit 1 to 4)
