GIRIJANANDA CHOWDHURY UNIVERSITY

Hathkhowapara, Azara, Guwahati 781017, Assam

Course Structure of Bachelor of Science in Botany

SEM	Core (Major)	Core (Minor)	Multidisciplinary (MDC)*	AEC *	SEC *	VAC *	Internship/ Dissertation / Project	Credit	EXIT OPTION
I	4	8	3	2	3	2		22	Certificate**
II	4	8	3	2	3	2		22	
III	4	8	3	2	3	-		20	Diploma**
IV	16	-	-	2		2		20	
V	16	-	-		-		4	20	Degree (with Single Major and/or Minor /Double Major in Discipline(s)
VI	20	-	-	-	-	-		20	
						Total		**124**	**End of 3rd Year**
VII	8	8	-	-	-	-	Research project I/ one paper of 4 credit (4)	20	Degree Honours with Research/ Without Research (With Single Major and Minor(s) /Double Major) in Discipline(s)
VIII	12	-	-	-	-	-	Research Project (8)/ Two papers of 4 credits each (4+4) ***	20	
						Total		**164**	**End of 4th Year**

List of papers offered for BSc. Botany

A credit is unit by which the course work is measured. It determines the number of hours of instructions required per week.
One credit is equivalent to **one hour of teaching** (lecture or tutorial) or **two hours of practical** work/field work per week.

LIST OF CORE PAPERS

CODE	COURSE TITLE	CREDIT DISTRIBUTION (Hr)		
		Lecture	Tutorial	Practicals
	Basic Skills for Laboratory and Field studies in Plant Sciences	3	0	2
	Evolution in the Plant Kingdom and Its Diversity	3	0	2

LIST OF MINOR PAPERS

CODE	COURSE TITLE	CREDIT DISTRIBUTION (Hr)		
		Lecture	Tutorial	Practicals
	Methods in the Study of Plant Science (Sem I)	3	0	2
	Basic Microbiology and Plant Microbe Interactions (Sem I)	3	0	2
	Plant Diversity and Evolution (Sem II)	3	0	2
	Economic Botany (Sem II)	3	0	2
	Introductory Cell Biology & Biochemistry (Sem III)	3	0	2
	Introduction to Plant Physiology (Sem III)	3	0	2
	Informatics and Statistics for Biology (Sem VII)	3	0	2
	Communication in Plants (Sem VII)	3	0	2

LIST OF MAJOR PAPERS (ESSENTIAL FOR HONOURS)

CODE	COURSE TITLE	CREDIT DISTRIBUTION (Hr)		
		Lecture	Tutorial	Practicals
	Cell Biology and Cellular Controls	3	0	2
	Microbiology and Plant Microbe Interactions	3	0	2
	Basic and Advanced Genetics	3	0	2
	Molecular Biology and Molecular Techniques	3	0	2
	Anatomy of Angiosperms	3	0	2
	Reproductive and Developmental Biology of Angiosperms	3	0	2

	Plant Physiology and Metabolism	3	0	2
	Plant Systematics	3	0	2
	Plant Biotechnology	3	0	2
	Ecology	3	0	2
	Introduction to Computational Biology and Bioinformatics	3	0	2
	Research Methodology	3	0	2
	Molecular Basis of Plant Growth and Development	3	0	2
	Plant Resources and Economic Botany	3	0	2
	Introduction to Proteomics and Metabolomics	3	0	2

ELECTIVES

CODE	COURSE TITLE	CREDIT DISTRIBUTION (Hr)		
		Lecture	Tutorial	Practicals
	Plant Stress Biology OR Plant Diversity and Human Welfare	3	0	2
	Biochemical and Molecular Techniques in Plant Sciences OR Green Belt Development and Urban Management for Smart Cities	3	0	2
	Advance Plant Imaging Techniques OR Ethnobotany & Medicinal Botany	3	0	2
	Intelligent Systems in Plants OR Introductory Floriculture and Horticulture	3	0	2

MULTIDISCIPLINARY COURSE (MDC) PAPER OFFERED BY DEPT. OF BOTANY

CODE	COURSE TITLE	CREDIT DISTRIBUTION (Hr)		
		Lecture	Tutorial	Practicals
	Organic Plant Cultivation and Biofertilizers	3	0	0

DSCC PAPERS OFFERED FOR THOSE NOT OPTING FOR RESEARCH

CODE	COURSE TITLE	CREDIT DISTRIBUTION (Hr)		
		Lecture	Tutorial	Practicals
	Protected Agriculture: Hydroponics and Organic Cultivation	3	0	2
	Biomaterials from Plants	3	0	2

FIRST YEAR

Semester I

CODE	COURSE TITLE	Category of Course	L-T-P (Hr)	Total Credits
	Basic Skills for Laboratory and Field studies in Plant Sciences	Core	3-0-2	4
	Minor 1	Minor	3-0-2	4
	Minor 2	Minor	3-0-2	4
	MDC 1	MDC	3-0-0	3
	AEC 1	AEC	2-0-0	2
	SEC 1	SEC	3-0-0	3
	VAC 1	VAC	2-0-0	2
			Total	22

Credits: 22

Semester II

Credits: 22

CODE	COURSE TITLE	Category of Course	L-T-P (Hr)	Total Credits
	Evolution in the Plant Kingdom and Its Diversity	Core	3-0-2	4
	Minor 3	Minor	3-0-2	4
	Minor 4	Minor	3-0-2	4
	MDC 2	MDC	3-0-0	3
	AEC 2	AEC	2-0-0	2
	SEC 2	SEC	3-0-0	3
	VAC 2	VAC	2-0-0	2
			Total	22

Total Credits for First Year: 44

EXIT OPTION WITH CERTIFICATION. However, such students who desire to exit after 1 year of study need to undertake a vocational course (4 credits).

SECOND YEAR

Semester III

CODE	COURSE TITLE	Category of Course	L-T-P (Hr)	Total Credits
	Cell Biology and Cellular Controls	Core	3-0-2	4
	Minor 5	Minor	3-0-2	4
	Minor 6	Minor	3-0-2	4
	MDC 3	MDC	3-0-0	3
	AEC 3	AEC	2-0-0	2
	SEC 3	SEC	3-0-0	3
			Total	20

Credits: 20

Semester IV

CODE	COURSE TITLE	Category of Course	L-T-P (Hr)	Total Credits
	Microbiology and Plant Microbe Interactions	Major	3-0-2	4
	Basic and Advanced Genetics	Major	3-0-2	4
	Molecular Biology & Molecular Techniques	Major	3-0-2	4
	Plant Stress Biology OR Plant Diversity and Human Welfare	Elective	3-0-2	4
	AEC 4	AEC	2-0-0	2
	VAC 3	VAC	2-0-0	2
			Total	20

Credits: 20

Total Credits after Second Year: 84

EXIT OPTION WITH UG DIPLOMA IN BOTANY. However, such students who desire to exit after 2 years of study need to undertake a vocational course (4 credits).

THIRD YEAR

Semester V

CODE	COURSE TITLE	Category of Course	L-T-P (Hr)	Total Credits
	Anatomy of Angiosperms	Major	3-0-2	4
	Reproductive and Developmental Biology of Angiosperms	Major	3-0-2	4
	Plant Physiology and Metabolism	Major	3-0-2	4
	Biochemical and Molecular Techniques in Plant Sciences OR Green Belt Development and Urban Management for Smart Cities	Elective	3-0-2	4
	Summer internship project	Internship/ Dissertation	0-0-8	4
			Total	20

Credits: 20

Semester VI

CODE	COURSE TITLE	Category of Course	L-T-P (Hr)	Total Credits
	Plant Systematics	Major	3-0-2	4
	Plant Biotechnology	Major	3-0-2	4
	Ecology	Major	3-0-2	4
	Introduction to Computational Biology and Bioinformatics	Major	3-0-2	4
	Advance Plant Imaging Techniques OR Ethnobotany & Medicinal Botany	Elective	3-0-2	4
			Total	20

Credits: 20

Total Credits after Third Year: 124

EXIT OPTION WITH BSc. in Botany.

FOURTH YEAR

Semester VII

CODE	COURSE TITLE	Category of Course	L-T-P (Hr)	Total Credits
	Research Methodology	Major	4-0-0	4
	Intelligent Systems in Plants OR Agricultural Botany & Weed Science	Elective	4-0-0	4
	Minor 7	Minor	3-0-2	4
	Minor 8	Minor	3-0-2	4
	Research Project Part-1	Major	4-0-0	4
	OR			
	Elective paper not chosen earlier	Major	4-0-0	4
			Total	20

Credits: 20

Semester VIII

CODE	COURSE TITLE	Category of Course	L-T-P (Hr)	Total Credits
	Molecular Basis of Plant Growth and Development	Major	3-0-2	4
	Plant Resources and Economic Botany	Major	3-0-2	4
	Introduction to Proteomics and Metabolomics	Major	3-0-2	4
	Research project II (with research)	Major	0-0-16	8
	OR			
	Protected Agriculture: Hydroponics and Organic Cultivation	Major	3-0-2	4
	Biomaterials from Plants	Major	3-0-2	4
			Total	20

Credits: 20

Total Credits after Fourth Year: 164

EXIT: BSc (Honours) in Botany with Research/ Without Research.

DETAILED COURSE STRUCTURE

FIRST YEAR

SEMESTER I

Core 1: Basic Skills for Laboratory and Field studies in Plant Sciences

Course Objectives

• To be able to understand and apply the fundamental skills for performing laboratory and field experiments

Course Outcomes

Students will acquire the following knowledge:

- Good laboratory practices, handling and management of laboratory waste, understanding hazards and risks to ensure a safe laboratory environment.
- Basics of measurements, units and common mathematical calculations, sampling and data collection.
- Operation and maintenance of instruments.
- Presentation, analysis of data and interpretation of results.

Detailed Course Description (Total 45 hours)

Unit 1: Lab safety and good lab practices, Hours: 06

General laboratory safety, good laboratory practices, storage of chemicals, biosafety measures (first-aid), safety symbols, lab safety equipment (fire extinguisher, fume hood, safety glasses), classes of laboratory chemicals, maintenance, and handling of chemicals (Labels, Quality - LR/ AR/ Molecular biology grade/ HPLC grade; Expiry date; Precautions for use), disinfectants, biocontainment and disposal of hazardous chemicals, radioactive and biological waste, Laboratory waste management.

Unit 2: Laboratory equipment: Use and maintenance, Hours: 04

Weighing balance (Top loading and Analytical), pH meter (calibration and use), magnetic stirrer, pipettes and micropipettes, autoclave, laminar airflow, BOD incubator, incubator shaker, micrometer, haemocytometer, spectrophotometer, agarose gel electrophoresis unit, SDS PAGE unit, centrifuge, distillation unit, conductivity meter, Lux meter.

Unit 3: Microscopy: Sample and slide preparation, Hours: 05

Microscopes (Dissecting, Compound and Electron microscopes). Fixation and Preservation (for light and electron microscopy); staining, mounting; basic introduction to other types of microscopes (Confocal, Fluorescence).

Unit 4: Measurements and calculations, Hours: 04

Units of measurements and conversion from one unit to another, measurement of volumes of liquids, Weighing, calculations: scientific notations, powers, logarithm and fractions.

Unit 5: Solutions and Buffers, Hours: 05

Molarity, Molality, Normality, percent solution, stock solution, standard solution, dilution, dilution series, pH, acids and bases, buffers - phosphate, Tris- acetate, Tris- Cl and Citrate buffer, preparation of various antibiotic solutions.

Unit 6: Basic culturing techniques, Hours: 06

Basic culture media (LB, YEB, MS)- liquid and solid, Culture techniques: plating (streak, spread & pour), replica plating, serial dilution.

Unit 7: Data collection, statistical analysis and interpretation, Hours: 06

Fundamentals of data collection, data types - primary and secondary, methods of data collection, sample, sampling methods - merits and demerits, technical and biological replicates, classification - tabulation and presentation of data, Descriptive statistics - Mean, Mode, Median, Variance, Standard Deviation, Standard error, Coefficient of Variation, difference between sample mean and population mean.

Unit 8: Basic computer skills for biology, Hours: 05

MS-Word, PowerPoint, Excel, introduction to biological databases.

Unit 9: Field Skills, Hours: 04

Identification, collection, cataloguing and preservation of plant specimens, Herbarium and Museum.

Practical component: 30 Hours

1. Preparation of solutions- molar, molal, normal, percentage, stock, standard and serial dilution.
2. Determining pH of solutions (pH paper, Universal indicator, pH meter) and preparation of buffers (Phosphate, Tris-Cl, Electrophoresis buffers - TBE/TAE).
3. Working of instruments -light microscope, autoclave, laminar air flow, spectrophotometer, centrifuge, gel electrophoresis unit (Agarose & Poly acrylamide).
4. Temporary peel mount slide preparation and staining (safranin and acetocarmine).
5. Calculate cell size using micrometer.
6. Calculate number of cells (pollen/spores) using haemocytometer.

7. Preparation of LB medium, growth and maintenance of bacterial cultures (liquid - serial dilution method; and semi-solid cultures - streak, spread and pour plates).
8. Isolation of genomic and plasmid DNA from *E. coli* and genomic DNA from plant leaf material, agarose gel electrophoresis.
9. Calculation of mean, mode, median, standard deviation using data set (collected from experiments 5,6).
10. Using software to draw tables, graphs and calculating descriptive statistics (Microsoft Excel).
11. Laboratory safety equipment (Fire extinguisher, Fume hood, safety glasses).
12. Mounting of a properly dried and processed plant specimen with herbarium label.

Essential/recommended Readings:

• Evert, R. F., Eichhorn, S. E., Perry, J.B. (2012). *Laboratory Topics in Botany*. W.H. Freeman and Company.
• Mesh, M.S., Kebede-Westhead, E. (2012). *Essential Laboratory Skills for Biosciences*. John Wiley & Sons, Ltd.
•Mu, P., Plummer, D. T. (2001). *Introduction to Practical Biochemistry*. Tata McGraw-Hill Education.
•Mann, S. P. (2016). *Introductory Statistics, 9th edition*. Hoboken, NJ, John Wiley and Sons Inc.
•Danniel, W.W. (1987). *Biostatistics*. New York, NY: John Wiley Sons.
•Jones, A.M., Reed, R., Weyers, J. (2016). *Practical Skills in Biology, 6th Edition.* Pearson
•Bisen, P.S. (2014). *Laboratory Protocols in Applied Life Sciences, 1st edition*. CRC Press.

Suggested readings:

•Zar, Z. H. (2010). *Biostatistical Analysis, 5th edition*. Pearson Prentice Hall, New Jersey, USA.

Minor 1: Methods in the Study of Plant Science

Course Objectives

• To acquaint the students with the fundamental skills required for studying plant science.

Course Outcomes

- To understand and apply good laboratory practices and management of laboratory waste.
- Understand and evaluate hazards and risks to ensure a safe laboratory environment.
- To learn about the basics of measurements, units and common mathematical calculations, sampling and data collection.
- To be able to operate and maintain common laboratory instruments.
- To be able to present and analyze data and interpret results.

Detailed Course Description (Total 45 hours)

Unit 1: Lab safety and good lab practices, Hours: 06

General laboratory safety, good laboratory practices, storage of chemicals, biosafety measures (first-aid), safety symbols, lab safety equipment (fire extinguisher, fume hood, safety glasses), classes of laboratory chemicals, maintenance, and handling of chemicals (Labels, Quality - LR/ AR/ Molecular biology grade/ HPLC grade; Expiry date; Precautions for use), disinfectants, biocontainment and disposal of hazardous chemicals, radioactive and biological waste, Laboratory waste management.

Unit 2: Laboratory equipment: Use and maintenance, Hours: 04

Weighing balance (Top loading and Analytical), pH meter (calibration and use), magnetic stirrer, pipettes and micropipettes, autoclave, laminar airflow, BOD incubator, incubator shaker, micrometer, haemocytometer, spectrophotometer, agarose gel electrophoresis unit, SDS PAGE unit, centrifuge, distillation unit, conductivity meter, Lux meter.

Unit 3: Microscopy: Sample and slide preparation, Hours: 05

Microscopes (Dissecting, Compound and Electron microscopes). Fixation and Preservation (for light and electron microscopy); staining, mounting; basic introduction to other types of microscopes (Confocal, Fluorescence).

Unit 4: Measurements and calculations, Hours: 04

Units of measurements and conversion from one unit to another, measurement of volumes of liquids, Weighing, calculations: scientific notations, powers, logarithm and fractions.

Unit 5: Solutions and Buffers, Hours: 05

Molarity, Molality, Normality, percent solution, stock solution, standard solution, dilution, dilution series, pH, acids and bases, buffers - phosphate, tris- acetate, tris- Cl and citrate buffer, preparation of various antibiotic solutions.

Unit 6: Basic culturing techniques, Hours: 06

Basic culture media (LB, YEB, MS)- liquid and solid, Culture techniques: plating (streak, spread & pour), replica plating, serial dilution.

Unit 7: Data collection, statistical analysis and interpretation, Hours: 06

Fundamentals of data collection, data types - primary and secondary, methods of data collection, sample, sampling methods - merits and demerits, technical and biological replicates, classification - tabulation and presentation of data, Descriptive statistics - Mean, Mode, Median, Variance, Standard Deviation, Standard error, Coefficient of Variation, difference between sample mean and population mean.

Unit 8: Basic computer skills for biology, Hours: 05
MS-Word, PowerPoint, Excel, introduction to biological databases.

Unit 9: Field Skills, Hours: 04
Identification, collection, cataloguing and preservation of plant specimens, Herbarium and Museum.

Practical component: 30 Hours

1. Preparation of solutions- molar, molal, normal, percentage, stock, standard and serial dilution.
2. Determining pH of solutions (pH paper, Universal indicator, pH meter) and preparation of buffers (Phosphate, Tris-Cl, Electrophoresis buffers - TBE/TAE).
3. Working of instruments -light microscope, autoclave, laminar air flow, spectrophotometer, centrifuge, gel electrophoresis unit (Agarose & Poly acrylamide).
4. Temporary peel mount slide preparation and staining (safranin and acetocarmine).
5. Calculate cell size using a micrometer.
6. Calculate number of cells (pollen/spores) using haemocytometer.
7. Preparation of LB medium, growth and maintenance of bacterial cultures (liquid - serial dilution method; and semi-solid cultures - streak, spread and pour plates).
8. Isolation of genomic and plasmid DNA from *E. coli* and genomic DNA from plant leaf material, Agarose gel electrophoresis.
9. Calculation of mean, mode, median, standard deviation using data set (collected from experiments 5,6).
10. Using software to draw tables, graphs and calculating descriptive statistics (Microsoft Excel).
11. Laboratory safety equipment (Fire extinguisher, Fume hood, safety glasses).
12. Mounting of a properly dried and processed plant specimen with herbarium label.

Essential/recommended Readings:

• Evert, R. F., Eichhorn, S. E., Perry, J.B. (2012). *Laboratory Topics in Botany*. W.H. Freeman and Company.
• Mesh, M.S., Kebede-Westhead, E. (2012). *Essential Laboratory Skills for Biosciences*. John Wiley & Sons, Ltd.
•Mu, P., Plummer, D. T. (2001). *Introduction to Practical Biochemistry*. Tata McGraw-Hill Education.
•Mann, S. P. (2016). *Introductory Statistics, 9th edition*. Hoboken, NJ, John Wiley and Sons Inc.
•Danniel, W.W. (1987). *Biostatistics*. New York, NY: John Wiley Sons.
•Jones, A.M., Reed, R., Weyers, J. (2016). *Practical Skills in Biology, 6th Edition.* Pearson
•Bisen, P.S. (2014). *Laboratory Protocols in Applied Life Sciences, 1st edition*. CRC Press.

Suggested readings:

•Zar, Z. H. (2010). *Biostatistical Analysis, 5th edition.* Pearson Prentice Hall, New Jersey, USA.

Minor 2: Basic Microbiology and Plant Microbe Interactions

Course Objectives

• An introduction to microbial world and their interactions with plants.

Course Outcomes

• To understand microbes and their roles and applications.
• To understand the modes of reproduction of Viruses, Archaebacteria, Eubacteria.
• To study about plant-microbe interaction

Detailed Course Description (Total 45 hours)

Unit 1: Introduction, Hours: 07

Types of microbes, growth and nutrition of microbes.

Unit 2: Viruses, Hours: 10

Discovery, physicochemical and biological characteristics; Classification (Baltimore); General structure with special reference to viroids and prions; DNA and RNA viruses: general account and mechanism of replication, lytic and lysogenic cycle, general account of viral diseases of plants (mosaic and vein clearing disease).

Unit 3: Bacteria, Hours: 10

Discovery, General characteristics; Types - Archaebacteria, Eubacteria, Wall less forms (Mycoplasma, Phytoplasma and Spheroplasts); Cell structure; Nutritional types; Reproduction - vegetative, asexual and recombination (conjugation, transformation and transduction); General account of bacterial diseases of plants (Citrus canker, Angular leaf spots of cotton).

Unit 4: Applied Microbiology, Hours: 08

Economic importance of viruses: vaccine production, role in research, medicine and diagnostics and agriculture. Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and medicine).

Unit 5: Plant-Microbe Interactions, Hours: 10

General account of Plant-microbe interactions; Plant growth promoting rhizobacteria (PGPR); Mechanism of nitrogen fixation by Cyanobacteria and Rhizobia; Types of mycorrhizal association with plants; Ectomycorrhiza and Endomycorrhiza and their effects on plant growth.

Practical Component: 30 Hours

1. Study of Viruses: Electron micrographs / Model - T-Bacteriophage and TMV; specimens/digital resources/ Line drawings of Lytic and Lysogenic Cycle.
2. Study of Bacteria: Electron micrographs of bacteria; Types of Bacteria from temporary/permanent slides. Endospore, Binary fission, Conjugation, Root nodule through specimens/digital resources.
3. Study of Plant Growth Promoting Rhizobacteria (PGPR) through specimens/digital resources (at least three).
4. Gram staining to differentiate between Gram-positive and Gram-negative bacteria.
5. Study of Rhizobium from root nodules of a leguminous plant.
6. Isolation of *Anabaena* from *Azolla* leaves.
7. Histochemical staining to observe Arbuscular Mycorrhizal Fungi (AMF) colonization in roots.
8. Study of Bacterial diseases (Citrus canker, Angular leaf spots of cotton) and viral diseases of plants (mosaic and vein clearing disease) through specimens/digital resources.

Essential/recommended Readings:

- Pelczar, M.J. (2001). *Microbiology, 5th edition*. New Delhi, Delhi: Tata Mc-Graw- Hill Co.
- Tortora, G.J., Funke, B.R., Case, C.L. (2016). *Microbiology: An Introduction.* Indian edition, Pearson India Education Services Pvt. Limited, Noida, India
- Prescott, L.M., Harley J.P., Klein D. A. (2005). *Microbiology, 6th edition.* McGraw Hill, New Delhi.
- Gupta, R., Chugh, G. (2022). *Plants, Microbes and Diseases 1st Edition.* I.K. International Pvt. Ltd., Delhi.
- Subba Rao, N.S. (2000). *Soil Microbiology.* Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi

Suggested readings:

- Talaro, K.P., Talaro, A. (2006*). Foundations in Microbiology*. Mc-Graw Hill, New Delhi

SEMESTER II

Core 2: Evolution in the Plant Kingdom and Its Diversity

Course Objectives

- Learn about the diversity of plants and microbes present on the planet.
- How these organisms are possibly related to each other considering evolution.

Course Outcomes

The students will understand about:

- The diversity of plants and microbes and their general characteristics.
- The evolutionary relationships between various groups of plants.
- Basic principles and concepts of evolution contributing to plant diversity.

Detailed Course Description (Total 45 hours)

Unit 1: Origin of life, Hours: 05

Principles and concepts of evolution, Tree of Life, and classification (up to six kingdoms).

Unit 2: Bacteria, Hours: 04

General introduction, cell structure, asexual reproduction, and modes of gene transfer (conjugation, transformation and transduction), brief introduction to Archaebacteria.

Unit 3: Viruses, Hours: 04

Introduction, replication, RNA virus (structure of TMV), DNA virus (structure of T-phage), Lytic and Lysogenic life cycle (Lambda phage).

Unit 4: Algae, Hours: 06

General characteristic features, cell structure, range of thallus, methods of reproduction and evolutionary classification (only up to groups). Brief account of *Spirogyra*, *Sargassum*.

Unit 5: Fungi, Hours: 06

Introduction, reproduction and broad classification. Myxomycetes and their similarities with fungi, plants and animals. Brief account of *Rhizopus, Agaricus*. Introduction to lichens.

Unit 6: Bryophytes, Hours: 04

General characteristic features and reproduction, adaptation to land habit, broad classification, evolutionary trends in Bryophytes. Brief account of *Marchantia*, *Funaria*.

Unit 7: Pteridophytes, Hours: 04

General characteristic features and reproduction, broad classification, evolutionary trends in Pteridophytes, affinities with Bryophytes. Brief account of *Adiantum*, *Selaginella*.

Unit 8: Gymnosperms, Hours: 06

General characteristic features and reproduction, broad classification, evolutionary trends in Gymnosperm, affinities with Pteridophytes. Brief account of *Gnetum*, *Ephedra*.

Unit 9: Angiosperms, Hours: 06
Introduction to general characteristics and reproduction. Concept of natural, artificial and phylogenetic system of classification. Affinities with Gymnosperms.

Practical component: 30 Hours

1. To study structure of TMV and Bacteriophage (electron micrographs/models)
2. To study morphology of *Volvox*, *Oedogonium*, *Chara*, *Fucus* and *Polysiphonia* (Temporary preparation/specimens/slides).
3. To study *Rhizopus*, *Penicillium*, *Alternaria* (Temporary preparations), symptoms of rust of wheat, white rust of crucifer (specimen).
4. To study *Marchantia* (morphology, WM of rhizoids and scales), *Anthoceros* (morphology), *Sphagnum* (morphology, WM of leaf), *Funari*a (morphology WM of rhizoid and leaf).
5. To study *Selaginella* (morphology, WM of strobilus and spores), *Equisetum* (morphology, WM of spores), *Pteris* (morphology, tease mount of sporangia and spores).
6. To study *Cycas* (morphology, leaf, leaflet anatomy, coralloid root, bulbils, megasporophyll and microsporophyll); *Pinus* (morphology of dwarf shoot, needle anatomy, male and female cones, WM pollen grains).
7. To study variation in leaf venations in dicots and monocots (at least two specimens each).
8. To study the types of inflorescences in angiosperms (through specimens).
9. To study the types of fruits in angiosperms (through specimens).

Essential/recommended readings

- Campbell, N.A., Reece, J.B. (2008). *Biology, 8th edition.* Pearson Benjamin Cummings, San Francisco.
- Evert, RF., Eichhorn, S.E. (2012). *Raven Biology of Plants, 8th edition.* New York, NY: W.H. Freeman and Company.
- Bhatnagar, S.P., Moitra, A. (1996). *Gymnosperms*. New Delhi, Delhi: New Age International (P) Ltd Publishers.
- Kumar, H.D. (1999). *Introductory Phycology, 2nd edition*. Delhi: Affiliated East-West Press Pvt. Ltd.
- Pelczar, M.J. (2001). *Microbiology, 5th edition*. New Delhi, Delhi: Tata McGraw-Hill Co.
- Puri, P. (1985). *Bryophytes*. New Delhi, Delhi, Atma Ram and Sons.
- Sethi, I.K. and Walia, S.K. (2018). Textbook of Fungi and Their Allies. (2nd Edition), Medtech Publishers, Delhi.
- Tortora, G.J., Funke, B.R., Case, C.L. (2007*). Microbiology*. San Francisco, U.S.A: Pearson Benjamin Cummings.

- Vashishta, P.C., Sinha, A.K., Kumar, A. (2010). *Pteridophyta*. New Delhi, Delhi: S. Chand & Co Ltd.
- Singh, G. (2019). *Plant Systematics-An Integrated Approach. 4th edition*. CRC Press, Taylor and Francis Group.
- Blackmore, S., Crane, P. (2019). *How Plants Work–Form, Diversity, Survival*. Princeton University Press; Illustrated edition.
- Ingrouille, M., Eddie, B. (2006). *Plants: Evolution and Diversity*. Cambridge University Press.

Suggestive readings

- Parihar, N.S. (1991). *An Introduction to Embryophyta. Vol. II. Pteridophytes*. Prayagraj: U.P.: Central Book Depot.
- Singh, V., Pandey, P.C., Jain, D.K. (2001*). A Textbook of Botany*. Meerut, UP: Rastogi and Co.
- Webster, J., Weber, R. (2007). *Introduction to Fungi*. Cambridge, Cambridge University Press.

Minor 3- Plant Diversity and Evolution

Course Objectives

- Learn about the diversity of plants and microbes present on the planet.
- How these organisms are possibly related to each other considering evolution.

Course Outcomes

- The diversity of plants and microbes and their general characteristics
- The evolutionary relationships between various groups of plants
- Basic principles and concepts of evolution contributing to plant diversity

Detailed Course Description (Total 45 hours)

Unit 1: Origin of life, Hours: 05

Principles and concepts of evolution, Tree of Life, and classification (up to six kingdoms).

Unit 2: Bacteria, Hours: 04

General introduction, cell structure, asexual reproduction, and modes of gene transfer (conjugation, transformation and transduction), brief introduction to Archaebacteria.

Unit 3: Viruses, Hours: 04

Introduction, replication, RNA virus (structure of TMV), DNA virus (structure of T-phage), Lytic and Lysogenic life cycle (Lambda phage).

Unit 4: Algae, Hours: 06

General characteristic features, cell structure, range of thallus, methods of reproduction and evolutionary classification (only up to groups). Brief account of *Spirogyra*, *Sargassum*.

Unit 5: Fungi, Hours: 06

Introduction, reproduction and broad classification. Myxomycetes and their similarities with fungi, plants and animals. Brief account of *Rhizopus, Agaricus*. Introduction to lichens.

Unit 6: Bryophytes, Hours: 04

General characteristic features and reproduction, adaptation to land habit, broad classification, evolutionary trends in Bryophytes. Brief account of *Marchantia*, *Funaria*.

Unit 7: Pteridophytes, Hours: 04

General characteristic features and reproduction, broad classification, evolutionary trends in Pteridophytes, affinities with Bryophytes. Brief account of *Adiantum*, *Selaginella*.

Unit 8: Gymnosperms, Hours: 04

General characteristic features and reproduction, broad classification, evolutionary trends in Gymnosperm, affinities with Pteridophytes. Brief account of *Gnetum*, *Ephedra*.

Unit 9: Angiosperms, Hours: 06

Introduction to general characteristics and reproduction. Concept of natural, artificial and phylogenetic system of classification. Affinities with Gymnosperms.

Practical component: 30 Hours

1. To study structure of TMV and Bacteriophage (electron micrographs/models)
2. To study morphology of *Volvox*, *Oedogonium*, *Chara*, *Fucus* and *Polysiphonia* (Temporary preparation/specimens/slides).
3. To study *Rhizopus*, *Penicillium*, *Alternaria* (Temporary preparations), symptoms of rust of wheat, white rust of crucifer (specimen).
4. To study *Marchantia* (morphology, WM of rhizoids and scales), *Anthoceros* (morphology), *Sphagnum* (morphology, WM of leaf), *Funari*a (morphology WM of rhizoid and leaf).
5. To study *Selaginella* (morphology, WM of strobilus and spores), *Equisetum* (morphology, WM of spores), *Pteris* (morphology, tease mount of sporangia and spores).
6. To study *Cycas* (morphology, leaf, leaflet anatomy, coralloid root, bulbils, megasporophyll and microsporophyll); *Pinus* (morphology of dwarf shoot, needle anatomy, male and female cones, WM pollen grains).
7. To study variation in leaf venations in dicots and monocots (at least two specimens each).

8. To study the types of inflorescences in angiosperms (through specimens).
9. To study the types of fruits in angiosperms (through specimens).

Essential/recommended readings

•Campbell, N.A., Reece, J.B. (2008). *Biology, 8th edition*. Pearson Benjamin Cummings, San Francisco.

•Evert, RF., Eichhorn, S.E. (2012). *Raven Biology of Plants, 8th edition.* New York, NY: W.H. Freeman and Company.

•Bhatnagar, S.P., Moitra, A. (1996). *Gymnosperms*. New Delhi, Delhi: New Age International (P) Ltd Publishers.

•Kumar, H.D. (1999). *Introductory Phycology, 2nd edition*. Delhi: Affiliated East-West Press Pvt. Ltd.

•Pelczar, M.J. (2001). *Microbiology, 5th edition*. New Delhi, Delhi: Tata McGraw-Hill Co.

•Puri,P. (1985). *Bryophytes*. New Delhi, Delhi, Atma Ram and Sons.

•Sethi, I.K. and Walia, S.K. (2018). *Textbook of Fungi and Their Allies. (2nd Edition*). Medtech Publishers, Delhi.

•Tortora, G.J., Funke, B.R., Case, C.L. (2007). *Microbiology*. San Francisco, U.S.A: Pearson Benjamin Cummings.

•Vashishta, P.C., Sinha, A.K., Kumar, A. (2010). *Pteridophyta*. New Delhi, Delhi: S. Chand & Co Ltd.

•Singh, G. (2019). *Plant Systematics-An Integrated Approach. 4th edition*. CRC Press, Taylor and Francis Group.

•Blackmore, S., Crane, P. (2019). *How Plants Work–Form, Diversity, Survival*. Princeton University Press; Illustrated edition

•Ingrouille, M., Eddie, B. (2006). *Plants: Evolution and Diversity*. Cambridge University Press.

Suggestive readings

•Parihar, N.S. (1991). *An Introduction to Embryophyta*. Vol. II. Pteridophytes. Prayagraj: U.P.: Central Book Depot.

•Singh, V., Pandey, P.C., Jain, D.K. (2001). *A Textbook of Botany*. Meerut, UP: Rastogi and Co.

•Webster, J., Weber, R. (2007). *Introduction to Fungi*. Cambridge, Cambridge University Press.

Minor 4: Economic Botany

Course Objectives

• To familiarize students with the economic importance of diverse plant species and train them in identifying plants of economic importance through field visit/s, live plant specimens, herbarium specimens and digital resources.

• To make students understand the importance of various plant parts and derived products used as food, fibers, medicines, oils and other economically important products.
• To acquaint students with the processing of various economically important plant resources and train them to identify and analyze nutrients using simple microchemical tests.

Course Outcomes

● This course will provide students with information about the economic importance and products derived from plants and their roles in our daily lives.
● Students will learn to perform micro-chemical tests to study presence of various components.
● Students will explore the regional diversity in food crops and other plants and their ethnobotanical importance.

Detailed Course Description (Total 45 hours)

Unit 1: Introduction and Origin of Cultivated Plants, Hours: 04

Importance of plant resources; Vavilov's concept for the origin of cultivated plants; Centres of origin (primary and secondary); centres of diversity, Harlan's concept of gene pools. Plant genetic resources and their conservation.

Unit 2: Cereals, Hours: 06

Wheat (origin, evolution of wheats (tetra- & hexaploid), morphology, production, and economic importance of hexaploid wheat); Rice (origin-monophyletic and polyphyletic, production, economic importance); Other cereals: maize, barley, oats, millets (jowar, bajra, ragi) and pseudocereals. morphology, comparison between *indica* and *japonica* rice, parboiling.

Unit 3: Legumes, Hours: 04

General account (nutritive value of pulses, protein malnutrition, lathyrism, favism, ecological importance); chickpea and pigeon pea (production, morphology and economic importance). other legumes: lentil, cluster bean, Lathyrus, beans, pea, cowpea, fodder legumes and green manure crops.

Unit 4: Sugars and Starches, Hours: 03

sugarcane (morphology, ratooning, nobilization, products and by- products); potato (morphology, tuber anatomy, seed tubers vs true potato seeds and economic uses).

Unit 5: Spices, Condiments & Flavourings, Hours: 04

General account (spices, condiments, culinary herbs and essences, with examples), importance of spices, clove (morphology, anatomy of part used and economic importance) and black pepper (morphology, anatomy of part used and economic importance). Other examples: ginger, turmeric, cinnamon, saffron, cardamom, chillies & pepper, fennel, coriander, cumin, vanilla, nutmeg.

Unit 6: Beverages, Hours: 03

Types of beverages (alcoholic and non-alcoholic) with examples, tea and coffee (morphology, chemistry, processing and economic importance).

Unit 7: Fibres and Fibre-yielding plants, Hours: 04

Classification of fibres based upon their origin (surface fibres, bast fibres, and leaf fibres, with examples); jute (morphology, extraction and economic importance), cotton (*Gossypium* species, morphology, processing and economic importance) comparison between jute and cotton fibers. Other examples: flax, hemp and coconut.

Unit 8: Oil-Yielding Plants, Hours: 04

Fatty oils and essential oils, comparison between fatty oils and essential oils; fatty oils (classification with examples, keeping quality), groundnut (morphology and economic importance); essential oils (general characteristics, methods of extraction and economic importance, with examples). Other examples: rapeseed & mustard (canola), coconut, olive, castor, cottonseed, sesame, soybean, linseed.

Unit 9: Medicinal and Drug-Yielding Plants, Hours: 03

Brief account of therapeutic drugs with examples; morphology, chemical constituents, economic importance of Cinchona, Rauwolfia, Digitalis.

Unit 10: Fumigatory & Masticatory, Hour: 04

Tobacco (morphology, species - *Nicotiana tabacum & N. rustica*), processing, products, economic importance and health hazards), *Cannabis, Papaver* (morphology, chemical constituents, economic importance).

Unit 11: Rubber, Hour: 02

Para rubber - *Hevea brasiliensis* (morphology, tapping of latex, processing, products and economic importance).

Unit 12: Fruits & Nuts, Hour: 02

Tropical & Temperate; citrus, mango, banana, apple, pineapple, papaya; nuts: cashew, walnut, almond & pistachio.

Unit 13: Vegetables, Hour: 02

Common examples of root crops, leafy vegetables, fruit seed vegetables.

Practical Component: 30 Hours

1. Cereals: Wheat (Habit Sketch, L.S/T.S. grain, W.M. starch grains, Micro-chemical tests), Rice (Habit Sketch, study of paddy and grain, W.M. starch grains, Micro- chemical tests). Millets - Pearl Millet, Finger Millet and Pseudocereals - Amaranth Grain, Quinoa (specimens/digital resources and grains).

2. Legumes: Chickpea, pigeon pea (Habit, fruit, seed structure, Micro-chemical tests).

3. Sugars and Starches: Sugarcane (Habit Sketch, Products and By-products, Cane Juice-Micro - chemical tests); Potato (Habit Sketch, Tuber morphology, T.S. tuber to show localization of starch grains, W.M. starch grains, Micro-chemical tests).

4. Spices: Clove, Black pepper (Habit and sections L.S./T.S.), Saffron, fennel (specimen/digital resources).

5. Beverages: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).

6. Fibres: Jute (specimens/digital resources of *Corchorus capsularis* and *C. olitorious*, T.S. stem, test for cellulose and lignin on section of stem and fibre). Cotton (specimen, W.M. seed to show lint and fuzz; W.M. fibre and test for cellulose).

7. Oil-Yielding Plants: Fatty Oils: Groundnut (Habit-specimen, Fruit, seeds, Microchemical Tests) Coconut-Habit (photograph), Fruit, T.S. nut, Mustard - (Habit- specimen, Fruit, seeds); Essential Oils: Habit Sketch of Rose, Jasmine, Vetiver, Sandalwood and Eucalyptus (specimens/photographs).

8. Drug-Yielding plants: Habit - Fever Bark Tree, Poppy, Foxglove and Cannabis (Specimens/ Photographs).

9. Tobacco: Nicotiana tabacum and N. rustica (specimens/photographs), Tobacco Products

10. Rubber: Para Rubber-Habit, Tapping of latex (Specimen/photograph), Rubber Products

11. Petro-crops: *Saccharum officinarum*, *Jatropha* sp.

Essential/recommended Readings:

1. Kochhar, S.L. (2012). *Economic Botany in Tropics*. New Delhi, India: MacMillan & Co.
2. Kochhar, S.L. (2016). *Economic Botany – A Comprehensive Study, 5th Edition*. New Delhi, India: Cambridge University Press.
3. Wickens, G.E. (2001). *Economic Botany: Principles & Practices*. The Netherlands: Kluwer Academic Publishers.

4. Chrispeels, M.J., Sadava, D.E. (1994). *Plants. Genes and Agriculture*. Jones & Bartlett-Publishers.

SECOND YEAR

SEMESTER III

Major 1: Cell Biology and Cellular Controls

Course Objectives

The students will acquire knowledge on the following topics:

- Cell as a structural and functional unit of all organisms.
- The various types of biomolecules present in a cell and their structure and function.
- Structures of different organelles and their functions in the metabolic processes of a cell.

Course Outcomes

Students will gain the basic knowledge on:

- The properties of macromolecules, their interaction between each other and their cellular and biological functions.
- The composition of organelles, organization and functions.
- Basic principles and concepts of evolution that contribute to plant diversity.

Detailed Course Description (Total 45 hours)

Unit 1: Biomolecules, Hours: 10

Types of chemical bonds and their biological significance. Structure and biological roles of carbohydrates, lipids, proteins and nucleic acids. ATP: structure and function as an energy currency molecule. Introduction to 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.

Unit 2: The Cell, Hours: 06

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

Unit 3: Cell Wall and Plasma Membrane, Hours: 03

Chemistry, structure, and function of plant cell wall. Singer and Nicolson's fluid mosaic model of cell membrane.

Unit 4: Cell Organelles: Structure and function of the following Organelles, Hours: 20

Nucleus: Structure and function (nuclear envelope, nuclear pore complex, nuclear lamina); types of chromatins; nucleolus.

Chloroplast and Mitochondria: Structural organization; Function; Semi- autonomous nature of mitochondria and chloroplast.

Endomembrane system: Endoplasmic Reticulum – Structure and function of RER and SER, protein folding, processing in ER, export of proteins and lipids; Golgi apparatus organization, protein glycosylation, protein sorting and export from Golgi Apparatus. Introduction to post- translational modifications.
Peroxisome and Lysosomes: Structure and function.
Cytoskeleton: Role and structure of microtubules, microfilaments, intermediary filament and motor proteins.

Unit 5: Cell division, Hours: 04
Eukaryotic cell cycle, mitosis and meiosis; regulation of cell cycle.

Unit 6: Tools of the Cell Biologist, Hours: 02
Microscopy (fluorescence, electron, atomic force), tissue culture techniques, protein expression and purification, flow cytometry, subcellular fractionation, chromatography (HPLC, UPLC) and gel electrophoresis.

Practical component: 30 Hours

1. Study of the cell and its organelles with the help of electron micrographs and other digital resources.
2. Study of plant cell structure with the help of epidermal peel mount of *Allium*.
3. Microchemical tests for carbohydrates (reducing, non-reducing sugars and starch), lipids and proteins
4. Separation of chloroplast pigments by paper chromatography/ Thin Layer Chromatography.
5. Separation of amino acids by paper chromatography.
6. Study the effect of organic solvent and temperature on membrane permeability.
7. Demonstration of the phenomenon of protoplasmic streaming in Hydrilla leaf.
8. Demonstration of the phenomenon of plasmolysis and deplasmolysis.
9. Study different stages of mitosis and meiosis.

Essential/recommended Readings:

1. Hardin, J. and Lodolce, J.P. (2022). *Becker's World of the cell, 10th edition*. Pearson.
2. Berg, J.M., Tymoczko, J.L., Stryer, L. (2011). *Biochemistry*. New York, NY: W. H. Freeman and Company.
3. Campbell, N.A. (2020). *Biology: A Global Approach, 12th Edition.* Pearson.
4. Campbell, P.N., Smith, A.D. (2011). *Biochemistry Illustrated, 4th edition*. London, UK: Churchill Livingstone.

5. Brown, T.A. (2020). *Gene Cloning and DNA Analysis: An Introduction*, *8th Edition.* Wiley Blackwell.

Suggested readings:

1. Cooper, G.M., Hausman, R.E. (2019). *The Cell: A Molecular Approach, 7th edition*. Sinauer/OUP.
2. Iwasa, J, Marshall, W. (2020). *Karps's Cell Biology, 9th edition.* New Jersey, U.S.A.: John Wiley & Sons.
3. Majumdar, R., Sisodia, R. (2019). *Laboratory Manual of Cell Biology, with reference to Plant Cells.* New Delhi, Delhi: Prestige Publication.
4. Nelson, D.L., Cox, M.M. (2021). *Lehninger Principles of Biochemistry, 8th edition*. New York, NY: W.H. Freeman and Company.
5. Reven, F.H., Evert, R.F., Eichhorn, S.E. (1992). *Biology of Plants.* New York, NY: W. H. Freeman and Company.
6. Berg L, (2008). *Introductory Botany: Plants, People, and the Environment.* Thomson Brooks/Cole.
7. Cook F.E.M. (1995). *Economic Botany: Data Collection Standard*. Royal Botanic Garden, Kew, Richmond.

Minor 5: Introductory Cell Biology and Biochemistry

Course Objectives

The students will learn about the following:

- Cell as a structural and functional unit of all organisms.
- The various types of biomolecules present in a cell and their structure and function.
- Structures of different organelles and their functions in the metabolic processes of a cell.

Course Outcomes

Students will be able to describe the following:

- The properties of macromolecules, their interaction between each other and their cellular and biological functions.
- The composition of organelles, organization and functions.
- Basic principles and concepts of evolution that contribute to plant diversity.

Detailed Course Description (Total 45 hours)

Unit 1: Biomolecules, Hours: 10

Types of chemical bonds and their biological significance. Structure and biological roles of carbohydrates, lipids, proteins and nucleic acids. ATP: structure and function as an energy currency molecule. Introduction to 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.

Unit 2: The Cell, Hours: 06

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

Unit 3: Cell Wall and Plasma Membrane, Hours: 03

Chemistry, structure, and function of plant cell wall. Singer and Nicolson's fluid mosaic model of cell membrane.

Unit 4: Cell Organelles: Structure and function of the following Organelles, Hours: 20

Nucleus: Structure and function (nuclear envelope, nuclear pore complex, nuclear lamina); types of chromatins; nucleolus.

Chloroplast and Mitochondria: Structural organization; Function; Semi- autonomous nature of mitochondria and chloroplast.

Endomembrane system: Endoplasmic Reticulum – Structure and function of RER and SER, protein folding, processing in ER, export of proteins and lipids; Golgi apparatus organization, protein glycosylation, protein sorting and export from Golgi Apparatus. Introduction to post- translational modifications.

Peroxisome and Lysosomes: Structure and function.

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

Unit 5: Cell division, Hours: 04

Eukaryotic cell cycle, mitosis and meiosis; regulation of cell cycle.

Unit 6: Tools of the Cell Biologist, Hours: 02

Microscopy (fluorescence, electron, atomic force), tissue culture techniques, protein expression and purification, flow cytometry, subcellular fractionation, chromatography (HPLC, UPLC) and gel electrophoresis.

Practical component: 30 Hours

1. Study of the cell and its organelles with the help of electron micrographs and other digital resources.
2. Study of plant cell structure with the help of epidermal peel mount of *Allium*.
3. Microchemical tests for carbohydrates (reducing, non-reducing sugars and starch), lipids and proteins

4. Separation of chloroplast pigments by paper chromatography/ Thin Layer Chromatography.
5. Separation of amino acids by paper chromatography.
6. Study the effect of organic solvent and temperature on membrane permeability.
7. Demonstration of the phenomenon of protoplasmic streaming in Hydrilla leaf.
8. Demonstration of the phenomenon of plasmolysis and deplasmolysis.
9. Study different stages of mitosis and meiosis.

Essential/recommended Readings:

- Hardin, J. and Lodolce, J.P. (2022). *Becker's World of the Cell*, *10th edition*. Pearson.
- Berg, J.M., Tymoczko, J.L., Stryer, L. (2011). *Biochemistry*. New York, NY: W. H. Freeman and Company.
- Campbell, N.A. (2020). *Biology: A Global Approach, 12th Edition.* Pearson.
- Campbell, P.N., Smith, A.D. (2011). *Biochemistry Illustrated, 4th edition*. London, UK: Churchill Livingstone.
- Brown, T.A. (2020). *Gene Cloning and DNA Analysis: An Introduction (2020), 8th Edition.* Wiley Blackwell.

Suggested readings:

- Cooper, G.M., Hausman, R.E. (2019). *The Cell: A Molecular Approach, 7th edition*. Sinauer/OUP.
- Iwasa, J, Marshall, W. (2020). *Karps's Cell Biology, 9th edition.* New Jersey, U.S.A.: John Wiley & Sons.
- Majumdar, R., Sisodia, R. (2019). *Laboratory Manual of Cell Biology, with reference to Plant Cells*. New Delhi, Delhi: Prestige Publication.
- Nelson, D.L., Cox, M.M. (2021). *Lehninger Principles of Biochemistry, 8th edition*. New York, NY: W.H. Freeman and Company.
- Reven, F.H., Evert, R.F., Eichhorn, S.E. (1992). *Biology of Plants*. New York, NY: W. H. Freeman and Company.

Minor 6: Introduction to Plant Physiology

Course Objectives:

- To educate students about the mechanism and physiological processes in plants.
- To learn about the contemporary aspects of plant physiology with emphasis on recent progress.

Course Outcomes:

- Students will be able to describe about the water, sugar, and transport processes in plants.
- They will understand the importance of photosynthesis and the different nutrient assimilation processes in plants.
- Students will learn about secondary metabolites and plant defense.
- The students will be able to explain the roles of light and hormones in plant development.

Detailed Course Description (Total 45 Hours)

Unit 1: Plant-water relationship, Hours: 06

A brief account on water potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap–cohesion-tension theory. Transpiration and factors affecting transpiration.

Unit 2: Photosynthesis, Hours: 08

Light harvesting complexes, PSI, PSII: Red Drop and Emerson's enhancement effect. Photolysis of water, photophosphorylation, mechanisms of electron transport (Hill Reaction), photoprotective mechanisms. C3, C4 and CAM pathways, photorespiration and chlororespiration.

Unit 3: Mineral nutrition, Hours: 05

Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents.

Unit 4: Solute transport and photoassimilate translocation, Hours: 06

Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport. Experimental evidence in support of phloem as the site of sugar translocation. Pressure–Flow Model; phloem loading and unloading; Source–sink relationship.

Unit 5: Secondary metabolites and plant defense, Hours: 05

Structure and function of cutin, suberin and waxes in plant defense, overview of the shikimate/phenylpropanoid pathway and roles of terpenes, phytolaexins, phenolic compounds in plant defense, secondary cell wall formation and importance.

Unit 6: Plant growth regulators, Hours: 05

Discovery, chemical nature (basic structure), bioassay and physiological roles of auxin, gibberellins, cytokinin, abscisic acid, ethylene, brassinosteroids and jasmonic acid.

Unit 7: Physiology of flowering, Hours: 04
Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy.

Unit 8: Photoreceptors, Hours: 06
Discovery, chemical nature, role and mode of action of phytochrome in photomorphogenesis. Brief introduction to blue light/UV receptors: cryptochrome, phototropins, ZTL/FKF1/LKP2, UVR8.

Practical Component: 30 Hours

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Study of the effect of wind velocity and light on the rate of transpiration in excised twig/leaf.
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
5. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces).
6. To study the effect of different concentrations of IAA on pea/gram root elongation (IAA Bioassay).
7. To study the induction of amylase activity in germinating barley grains.
8. To compare chlorophyll content in juvenile and matured leaves.

Demonstration experiments
1. To demonstrate suction due to transpiration.
2. Fruit ripening/Rooting from cuttings (Demonstration).

Essential/recommended Readings:

- Hopkins, W.G. and Huner, A. (2008). *Introduction to Plant Physiology*. John Wiley and Sons. U. S.A. 4th edition.
- Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). *Plant Physiology and Development*. Sinauer Associates Inc. USA. 6th edition.
- Bhattacharya D. (1999). *Experiments in Plant Physiology-A Laboratory Manual*. Narosa Publishing House, New Delhi.

MDC COURSE OFFERED BY DEPT. OF BOTANY TO STUDENTS OF OTHER DEPARTMENTS:

Organic Plant Cultivation and Biofertilizers

Course Objectives:

•To develop an understanding of biological systems used as fertilizers and build skills in handling microbial inoculants.

•To understand the optimum conditions for growth and multiplication of useful microbes such as *Rhizobium*, cyanobacteria, mycorrhizae, *Azotobacter* etc.

•To understand the role of microbes in mineral cycling and nutrition of plants.

•To gain expertise in various methods of decomposition of biodegradable waste, conversion into compost and apply this knowledge and skill in their daily life.

Course Outcomes:

•To visualize and identify different types of microorganisms with a compound microscope.

•To understand the classification of microorganisms according to their shape/ structure for morphological identification.

•Students will learn the development of various organic products such as biopesticides, biofertilizers and biogrowth promoters.

Detailed Course Description (Total 45 Hours)

Unit 1: Introduction to Protected Agriculture, Hours: 02

Protected Agriculture types (hydroponics, aquaponics and organic farming), definition history, terminology, importance and advantages over traditional agriculture, limitations and challenges.

Unit 2: Introduction to biofertilizers, Hours: 07

Introduction to microbial inoculants or biofertilizers, macro and micro nutrition of plants, chemical fertilizers versus biofertilizers; Methods and steps in mass multiplication of biofertilizers: stock culture, broth culture, growth medium, fermentation, blending with the carrier, packaging, and quality check, ISI standard specification for biofertilizers; scope of biofertilizers in India.

Unit 3: Microbial inoculants, Hours: 08

Study of important microbial inoculants: *Rhizobium*, *Azospirillum*, *Azotobacter*, Actinorhizae; Characteristics, isolation, identification, and crop response.

Unit 4: Role of cyanobacteria, Hours: 02

Role of Cyanobacteria (blue-green algae) in rice cultivation; *Azolla* and *Anabaena azollae* association, nitrogen fixation, and factors affecting growth.

Unit 5: Mycorrhizal association, Hours: 08

Types of mycorrhizal association, occurrence and distribution; Role of Arbuscular mycorrhizal fungi (AMF) in phosphorus nutrition, growth and yield of crop plants; AMF – methods in isolation (wet sieving and decanting), identification (morphological and molecular methods). Methods of inoculum production (Pot culture and root culture).

Unit 6: Organic farming, Hours: 06

Introduction to organic farming, recycling of biodegradable municipal (domestic), agricultural and industrial waste; green manuring, bio-composting, vermicomposting and their field application. Use of biofertilizers, biopesticides, bioherbicides, biocontrol agents (plant growth promoting rhizobacteria (PGPR), pheromone trapping, *Trichoderma*, *Pseudomonas*, neem oil, garlic etc.) in management.

Unit 7: Introduction to hydroponic growing systems, Hours: 08

Basic concepts and designs (closed and open systems techniques Nutrient Film Technique (NFT), Deep Water Culture (DWC), Dutch Bucket and other small-scale systems), systems layout. Strengths and weaknesses of various systems, site considerations, componentry, nutrient delivery, pumping. Hydroponics associated pest - mites, thrips, whiteflies, leaf miners; Identification and management of diseases -bacterial, fungal and viral diseases; safety practices (Good Agricultural Practices (GAP) and Integrated Pest Management (IPM).

Unit 8: Herbal technology, Hours:

A. Pharmacognosy – Definition, A general survey of different systems of medicines – Indian systems of medicine – Siddha, Ayurveda and Unani systems – Future pharmacognosy and the need for organic cultivation.
B. A systematic study of crude drugs with reference to their vernacular name, family, preparations and uses. Drugs obtained from roots (Rauwolfia), underground stem (Garlic), Stems & Woods (Ephedra), Bark (Chinnamon), leaves (Aloe), flowers (saffron), fruits (Emblica), and seeds (Cardamom).

Unit 9: Marketing and Policies, Hours: 04

Marketing of the produce and government institutes and policies related to protected farming (hydroponics and organic farming).

Essential/recommended readings

- Kumaresan, V. (2005). *Biotechnology.* New Delhi, Delhi: Saras Publication.
- Sathe, T.V. (2004). *Vermiculture and Organic Farming.* New Delhi, Delhi: Daya Publishers.

- Subha Rao, N.S. (2020). *Soil Microbiology*, 5th edn. New Delhi, Delhi: Oxford &IBH Publishers.
- Reeta Khosla (2017). *Biofertilizers and Biocontrol Agents for Organic Farming*, Kojo Press
- Hasan, M., Sabir, N., Singh, A.K., Singh, M.C., Patel, N., Khanna, M., Rai, T., Pragnya, P. (2018). *Hydroponics Technology for Horticultural Crops*, Tech. Bull. TB-ICN188/2018. Publ. by I.A.R.I., New Delhi-110012 INDIA.
- Misra S., Misra S., Misra R.L. (2017). *Soilless Crop production*. Daya Publishing House, Astral International (P) Ltd., New Delhi.
- Palaniappan S. P., Annadurai K. (2018). *Organic Farming: Theory & Practice*. Scientific Publisher.
- Roseline. (2011). *Pharmacognosy.* MJP Publishers.
- Ekiert, H. M., Ramawat, K. G. & Arora, J. (2021). *Medicinal Plants*. Springer International Publishing.
- Agrawal S.S. & Paridhavi. M. (2007). *Herbal Drug Technology*, Universities Press.
- Ponnuswami. V, et.al (2014). *Medicinal Herbs and Herbal Cure*. Jeya Publishing House, Delhi.
- Muzumdar B.C. (2006), *Principles and Practices of Herbal Garden*, Daya Publishing House, Delhi.

Suggestive readings

- Jones, J. B. (2014). *Complete Guide for Growing Plants Hydroponically*. CRC Press.
- *Azotobacter* - Isolation and characterization - https://youtu.be/1Z1VhgJ2h6U
- *Rhizobium* - Identification and characterization - https://youtu.be/jELlo-pMvc4.
- 3-Days Online Workshop on Arbuscular Mycorrhizal Fungi - Biodiversity, Taxonomy and Propagation 19-2 (2022-01-20 at 02_27 GMT-8) -https://youtu.be/LKzK4IuSRc4.