List of Revised Courses M.Sc. Botany

Minutes of Meetings (MoM) of Board of Studies (BoS)

Academic Year : 2021-22	
School	**: *School of Studies of Botany***
Department	**: *Botany***
Date and Time	**: *January 19, 2022 – 11:00 AM***
Venue	**: *HOD CHAMBER***

The scheduled meeting of member of Board of Studies (BoS) of Department of Botany School of Studies of Life Sciences, Guru Ghasidas Vishwavidyalaya, Bilaspur was held to modify the CBCS based M. Sc. (I and IV semesters) scheme and syllabi.

The following members participated in the meeting:

1. Dr. D. K. Patel (HOD, Associate Prof., Dept. of Botany.-cum Chairman, BOS)
2. Prof N K Sharma (External Expert Member BoS, Dept. ofBotany, IGNTU, Amarkantak)
3. Dr. A. K. Dixit (Member BoS, Dept. of Botany)
4. Dr. V. N. Tripathi (Member BoS, Dept. of Botany)

Following points were discussed during the meeting

- The total syllabus was revised with ~60% changes in contents in UG programme.

विभागाध्यक्ष
Head
वनस्पति शास्त्र विभाग
Department of Botany
गुरु घासीदास विश्वविद्यालय (केन्द्रीय वि.वि.), बिलासपुर (छ.ग.)
Guru Ghasidas Vishwavidyalaya (A Central University), Bilaspur (C.G.)

Signature & Seal of HoD

Department of Botany
School of Studies of Life Science
Guru Ghasidas Vishwavidyalaya, Bilaspur (C.G.), 495009

Minutes of Board of Studies (BOS) (Botany) Meeting

A meeting of BOS was held on 19 January 2022 in the office of the HOD, Department of Botany at 11 am in Hybrid mode to discuss the agenda.

At the outset, Chairman welcomed all the members and put the agenda for discussion. After thorough discussion, following resolutions were made.

Agenda 1- Approval of the modification of the three year UG syllabus for Botany (Hon's) as per LOCF system
Resolution: With the few minor corrections as pointed out by the external member Prof. NK Sharma, Department of Botany, IGNTU, Amarkantak through online discussion and the members of the BOS, the modification of the syllabus was approved for further approval by the academic council/school board of Life Science of the University.

Agenda 2- Approval of the modification of the Two year PG syllabus for Botany as per CBCS system
Resolution: With the few minor corrections as pointed out by the external member Prof. NK Sharma, Department of Botany, IGNTU, Amarkantak through online discussion and the members of the BOS, the modification of the syllabus was approved for further approval by the academic council/ school board of Life Science of the University.

Agenda 3- Approval of the 3 months Certificate course in Botany as proposed by Dr. S. K. Shahi.
Resolution: With the few corrections as pointed out by the external member Prof. NK Sharma, Department of Botany, IGNTU, Amarkantak through online discussion and the members of the BOS, the modification of the syllabus of the certificate course viz., 1. Mushroom Cultivation Technology and agri-business, 2. Protected Horticulture and Entrepreneurship development were approved for further approval by the academic council/school board of Life Science of the University.

Dr. Vibhay Tripathi
Assistant Professor
(Member)
Botany Department
Guru Ghasidas Vishwavidyalaya, Bilaspur

Dr. AK Dixit
Associate Professor
(Member)
Botany Department
Guru Ghasidas Vishwavidyalaya, Bilaspur

Prof. NK Sharma,
(External Member)
Department of Botany
IGNTU, Amarkantak (MP)
Approved by email
(copy attached)

04.02.22
(Chairman)
HOD, Department of Botany
Guru Ghasidas Vishwavidyalaya, Bilaspur

Scheme and Syllabus

M.Sc. (BOTANY)

SEMESTER I

Semester	Course Opted	Course Code	Name of the course	Credit	Hour / weak	End semester marks	Internal Marks	Total marks
Semester I	Core-1	BOPATT1	Advances in Virus, bacteria and Algae	3	3	70	30	100
	Core-1 Lab	BOPALT1	Lab based on core 1	2	4	70	30	100
	Core-2	BOPATT2	Applied Mycology and Advance Phytopathology	3	3	70	30	100
	Core-2 Lab	BOPALT2	Lab based on core 2	2	4	70	30	100
	Core-3	BOPATT3	Advances in Bryophytes, Pteridophytes and Gymnosperm	3	3	70	30	100
	Core-3 Lab	BOPALT3	Lab based on core 3	2	4	70	30	100
	Core-4	BOPATT4	Cell and Molecular Biology	3	3	70	30	100
	Core-4 Lab	BOPALT4	Lab based on core 4	2	4	70	30	100
			TOTAL	20				800

SEMSTER II

Semester II	Core-5	BOPBTT5	Taxonomy of Angiosperm	3	3	70	30	100
	Core-5 Lab	BOPBLT5	Lab based on core 5	2	4	70	30	100
	Core- 6	BOPBTT6	Plant Biochemistry	3	3	70	30	100
	Core- 6 Lab	BOPBLT6	Lab based on core 6	2	4	70	30	100
	Core- 7	BOPBTT7	Ecology and Environment	3	3	70	30	100
	Core- 7 Lab	BOPBLT7	Lab based on core 7	2	4	70	30	100
	Discipline specific Elective	BOPBTD	DSE from the Basket 1	3	3	70	30	100
	Discipline specific Elective Lab	BOPBLD	Lab based on DSE1	2	4	70	30	100
	Educational Tour (one week duration) (BOPBLF1)			2				
			Total	22				800

SEMESTER III								
Semester III	Core- 8	BOPCTT8	Plant Anatomy and Reproductive Biology	3	3	70	30	100
	Core- 8 Lab	BOPCLT8	Lab based on core 5	2	4	70	30	100
	Core- 9	BOPCTT9	Genetics and Cytogenetics	3	3	70	30	100
	Core- 9 Lab	BOPCLT9	Lab based on core 8	2	4	70	30	100
	Core- 10	BOPCTT10	Plant physiology	3	3	70	30	100
	Core- 10 Lab	BOPCLT10	Lab based on core 9	2	4	70	30	100
	Discipline specific Elective	BOPCTD	DSE from the Basket 2	3	3	70	30	100
	Discipline specific Elective Lab	BOPCLD	Lab based on DSE 2	2	4	70	30	100
	Research Methodology (RM11)	BOPCTT11	University common course	4	4	70	30	100
	Seminar (BOPCST5)			2				50
			Total	26				950
SEMESTER IV								
	Discipline specific Elective	BOPDTD	DSE from the Basket 3	3	3	70	30	100
	Discipline specific Elective Lab	BOPDLD	Lab based on DSE 3	2	4	70	30	100
	Open Elective (OE 1)	BOPDTO	From the OE basket	3	3	70	30	100
	Open Elective Lab (OE 1)	BOPDLO	Lab based on the selected OE course	2	4	70	30	100
	Dissertation/ Project work	BOPDDT1	Dissertation/ Project work followed by seminar	6		140	60	200
			TOTAL	16				600

Discipline specifics Elective offered by Botany

(Discipline specifics Elective Basket)

Basket 1 (Semester II)	Basket 2 (Semester III)	Basket 3 (Semester IV)
Algae, Environment and Human Welfare	Agricultural Microbiology	Environmental Pollution
Biofertilizer and Biopesticides Technology	Biodiversity and Conservation	Ethno-Pharmacognosy and Nutraceuticals
Bioinformatics and Evolutionary Biology	Ethnobotany and Traditional knowledge	Food Microbiology
Environmental Microbiology	Herbal Cosmetics	Global Change Biology
Herbal Product Development and Formulation	Microbial Technology	Microbial Genetics
Microbial Physiology	Plant Propagation and Nursery Development	Plant Functional Genomics
Plant Stress Biology	Plant Tissue Culture and Application	Plant Systematics
		Plant Diversity, Uses and Conservation

Course- baskets are dynamic in nature. Courses present in one basket can be shifted to another basket as per the requirement and availability of resources.

OPEN ELECTIVE

1. Bio-Business and Entrepreneurship
2. Ecosystem Services and Biodiversity

CORE COURSES

SEMESTER-I

Core Course 1: Advances in Virus, Bacteria and Algae

Course code: BOPATT1

(Credits: Theory-3, Practical-2)

Learning Outcomes –

The study will support to learn about the Characters, Life pattern and Importance of virus, bacteria and algae.

The students can know about comparison among virus, bacteria and algae and their importance.

The study will be helpful for knowing virus, bacteria and algae following the points associated with their life.

To understand and gain the theory & practical knowledge on virus, bacteria, and algae it will be beneficial.

Unit I: Virus:

General account and classification of viruses, General characteristics of virus with reference to the following points Life cycles, Host range, Host – pathogen interaction, Symptomatology, Control mechanisms. Cyanophages and Mycoviruses; Viroids and Prions. TMV, Bacteriophage, lytic T4 phage) and lysogenic (Lambda phage) cycle.

Unit II. Bacteria:

Morphology and structure of Bacterial cells: Morphology of bacterial cells based on size, shape and arrangement, Bacterial genomes, Halobacteria, Thermoplama, Locomotion, Actinomycetes, Ultra structure of bacteria,Chemosynthetic bacteria, Spheroplasts, Genetic recombination,Mycoplasma: Characteristic features, Morphology, Reproduction. Conjugation- F- factor, Transduction– Generalised and specialized, Symptomatology, Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and medicine).

Unit III. Diversity and distribution of the Algae:

Characteristic features of Algae, Diversified habitats of Algae, Thallus organization, Position of the Algae in plant kingdom, Pigmentation, Reproduction, Sexual evolution in

Algae, Perennation, Life Cycle pattern. Detailed study of important genera, Economic importance of Algae.

Unit IV: Classification and Molecular Taxonomy –

Recent developments in algal classification, special reference to emerging trends in molecular phylogeny and inter relationship of principal groups of algae. Algal culture, Cryopreservation, Aquaculture (micro and macro algae cultivation), Bioremediation, Recent developments, and future of Algal biotechnology. Algal biofuels – Algal biodiesel, bio-ethanol and biological hydrogen production. Algae in global warming – carbon capturing by algae.

Unit V: Algae in Industrial Research:

Algal products, processes and applications, seaweeds polysaccharides such as Agar, Carrageenan and Alginates. Bioactive compounds from algae: Bio-fertilizers; Algae in bioengineering, photo-bioreactors and raceway ponds. Cyanobacteria: General aspects, Structure, Reproduction and importance. Phytoplankton and Diatomes, Eutrophication and water blooms.

Lab (BOPALT1)

1. Gram staining of Bacteria
2. Microscopic preparations and study of available algal materials
3. Prepared slide/Permanent slide study of Bacteria
4. Prepared slide/Permanent slide study of Virus
5. Prepared slide/Permanent slide study of representative members of Algae
6. Collection of available Algae in GGV campus
7. Study of diversity of freshwater algae.

Suggested Reading

1. Bold and Wynne. (1985). Introduction to the Algae. Prentice-Hall Publication. Mumbai.
2. Chapman, V.J. and Chapman D.J. (1973). The Algae. Macmillon and Company, New York.
3. Dubey R. C. and Maheshwari D. (2000). Microbiology, S. Chand and Company, New Delhi

4. Gangulee and Kar (2006). College Botany. New Central Book Agency.
5. Hoek, Christian *et al.*(1995). Alage: An Introduction to Phycology. Cambridge University Press. New Delhi.
6. Lee, R. E. (2009). Phycology. Cambridge University Press. New Delhi
7. Mandahar C. C. (1978). Introduction to Plant virus, S. Chand and Company, New Delhi
8. Round F.E. (1984). The Ecology of algae. Cambridge University Press. New Delhi.
9. Sharma, O.P. (2006). Textbook of Algae. Tata McGraw Hill, New Delhi.
10. Singh, Pandey and Jain. A Textbook of Botany, Rastogi Publication.

SEMESTER-I

Core Course 2: Applied Mycology and Advance Phytopathology

Course code: BOPATT2

(Credits: Theory-3, Practical-2)

Learning Outcome:

Learners will be able to define and explain the unique features of fungi; illustrate a modern classification with characters up to phylum; define and explain homothallism and heterothallism; define and explain phylum Ascomycota; define and explain phylum Basidiomycota.

Learners will be able to explain Fungal metabolism, applied mycology, Mycotoxins: A general account with reference to aflatoxins & phytoalexins. Mycorrhizae.

Regarding Plant Pathology students will be able to define and explain plant diseases; illustrate host-pathogen interactions; Genetics of pathogenecity and molecular aspect of plant pathogens.

Unit I: Unique features of fungi

Origin of fungi and their interrelationships; phylogeny, affinities and position of fungi in modern systematic. Modern concept regarding placement of fungi in separate kingdom. Any modern classification with characters upto phylum. Homothallism, heterothallism, physiological and molecular basis of mating systems. Fungal metabolism - chitin synthesis, lysine biosynthesis, pathway and precursors of secondary metabolism (polyketide pathway, isoprenoid pathway, shikimic acid pathway).

UNIT II: Ascomycota and Basidiomycota

Ascomycota: Diversity of thallus structures and evolutionary trends in asexual and sexual reproductions, asci and their bearing on taxonomy; Development and types of ascocarps; Mechanism of ascospore discharge.

Basidiomycota: Somatic structures, reproduction; Mating system and classification; Origin and structures of basidiospores, basidia, and basidiocarps; Mechanism of basidiospore discharge.

UNIT III: Applied Mycology

Culture repositories and methods of preservation of fungal cultures; Mycological databases; GenBank repositories, open source computational and other internet resources for Mycologists and Plant Pathologists; searching and retrieving from databases.

Use of fungi in antibiotics, organic acids and food production, role of fungi in biotechnology including vaccine production, agriculture and forestry. Fungal toxins: Host non selective toxins- cercosporin (Mode of action); Host specific toxinsstructure, mode of action and concept of Vb gene.

Mycotoxins: A general account with reference to aflatoxins & phytoalexins. Mycorrhizae: interaction; Specific recognition in mycorrhizal association; Application as biofertilizer and bioprotector in forestry and agriculture. Biological control: current status, constrains and future prospect;

Mycopesticide and mycoherbiside. Brief account of seed pathology; post harvest diseases and their control. Mycoremediation, metal resistance, biosensor.

UNIT IV: Plant Diseases

Details studies of fungal diseases: Damping off, powdery mildew, downy mildew, smut, bunt, rust, wilt, root rot, leaf spots, leaf blight and gall of economically important crops. Post harvest disease and their control.

Bacterial diseases: bacterial leaf blight of rice, bacterial wilt of potato, bacterial canker of tomato, crown gall of rose.

Nematode disease: General features; Mechanism of nematode injury to plants; Factors affecting survival and parasitism of nematodes; Molecular approach in the management of virulence genes in potato cyst nematodes.

Virus disease: Symptoms, carrier, transmission, interaction of virus and host; role of nucleic acid in virus infection; establishment and development of virus infection; control strategies.

UNIT V: Genetics of pathogenecity:

Plant disease diagnosis utilizing molecular tools. Development of disease resistant variety by mutation, breeding and recombinant DNA technology; RNAi in plant pathology.

Defense mechanism of host - pre and post infectional structural as well as biochemical defense with reference to role of PR-proteins: systemic acquired resistance. Application of avirulence genes in control of plant pathogens.

Lab (BOPALT2)

1. Study of morphological characters and reproductive structures of common fungal taxa.
2. Isolation of yeasts from some fruits.
3. Submission of fungal specimens.
4. Study of diseased specimens.
5. Isolation and simple culture of pathogens.
6. Determination of carbohydrate, protein and phenol contents of healthy and diseased tissues.
7. Study of factors (pH and temperature) affecting activity of macerating enzymes (pectinase)
8. Study of sensitivity of phytopathogenic bacteria to different antibiotics
9. Isolation of fungi from soil, water, air by culture plate technique.
10. Preparation of monosporous-, polysporous- and tissue- culture.
11. Isolation of fungal/plant DNA and its quantification by spectrophotometric method; separation of DNA by agarose gel electrophoresis; amplification of genomic fragment by polymerase chain reaction.
12. Induction and bioassay of phytoalexin in host plants.
13. Extraction and SDS-PAGE analysis of defense protein in artificially inoculated plants/ induced by abiotic elicitor(s).
14. Assay of metal resistance in fungi.
15. Biological control of plant pathogenic fungi by dual culture technique.
16. Symptomology and histopathology of some common diseases with diagnostic characteristics in available diseased plant specimens.
17. Study of fungal Disease.
18. Study of Bacterial Disease.
19. Study of viral Disease.

Suggested Reading

1. Introductory Mycology, C. J. Alexopoulos, C.W. Mims, M Blackwell (1996), John Wiley & Sons.

2. The Fungi: An Advanced Treatise, GC Ainsworth, KF Sparrow, AS Sussman.
3. An Introduction to Fungi, H. C. Dube (1983), Vikas Publ, New Delhi.
4. The Fungi, PD Sharma (2003), Rastogi Publications, Meerut.
5. Fungi: Experimental Methods in Biology, R Maheshwari (2012), CRC Press, Boka Raton, Florida.
6. Introduction to Fungi, J Webster & WS Roland (2007), Cambridge University Press.
7. A Text Book of Modern Plant Pathology, K S Bilgrami, H C Dube.
8. Plant Pathology, RS Mehrotra.
9. Fungi and Plant Disease, VK Gupta, TS Paul.
10. Diseases of Crop Plants in India, Rangaswamy & Mahadevan.
11. Plant Pathology, GNAgrios (2006), fifth Edn, Elsevier Academic Press.
12. Molecular Plant Pathology, Dickinson CM (2003), Bios Scientific Publisher.
13. Plant Pathology: Concepts and Laboratory Exercises, NT Robert, MT Windham, AS Windham (2003), CRC Press.
14. Plant Diseases, RS Singh (2008), Oxford and IBH Publishing Co. Pvt Ltd.
15. Principles of Plant Pathology, RS Singh (2008), Oxford and IBH Publishing Co. Pvt Ltd.

SEMESTER-I

Core Course 3: Advances in Bryophyta, Pteridophyta and Gymnosperm

Course code: BOPATT3

(Credits: Theory-3, Practical-2)

Learning Outcomes–

The study will support to learn about the Characters, Life pattern and Importance of bryophytes, pteridophytes and gymnosperms.

It will be helpful to know about comparison among bryophytes, pteridophytes and gymnosperms.

The study will focus on bryophytes, pteridophytes and gymnosperms following the points associated with their life.

The students can understand and gain knowledge on the theory & practical aspects ofbryophytes, pteridophytes and gymnosperms with the study of Fossils.

Unit I Bryophyta:

Characteristic features, Morphology, Anatomy, Affinities with Thallophytes and Pteridophytes, Alternation of generation, Classification, Reproduction, Sporophyte and Life cycle of some important genera,Ecological and Economical importance of Bryophytes. Fossil bryophytes, Contributions of Indian Bryologists.

Unit II: Pteridophtya:

Characteristic features,Origin of Pteridophytes, First land vascular Plant Morphology, Anatomy, Distribution, Classification, Affinities with Bryophytes Alternation of generation, Classification,Telome Theory, Stelar Evolution, Homospory, Heterospory and Seed habit, Reproduction and Life cycle of some important genera,Apogamy and Apospory, Economic importance of Pteridophytes.

Unit III. Gymnosperm:

Characteristic features, Distribution, Classification, Morphology, Anatomy and Life cycle of some important genera, Economic importance of Gymnosperm.

Unit IV. Fossil Pteridophytes and Gymnosperms:

Definition, Fossils, Process of Fossilization, Palaeobotany and its significance, Fossil fuels, Peat and coal,*Rhynia, Lepidodendron,*Lepidophyllum, Stigmaria, Lepidocarpon, Fossil Gymnosperms: Glassopteris, Lepidopteris, Caytonia, Bennettitales and Pentoxylales.

Unit V. Recent trends:

Current trends/Studies in Bryophyta, Pteridophyta and Gymnosperm.

Lab (BOPALT3)

1. Morphological and Anatomical study of *Riccia, Marchantia, Anthoceros, Pellia, Sphagnum, Funaria, Polytrichum.*
2. Prepared Slides study of Bryophyta representative members.
3. Morphological and Anatomical study of *Lycopodium, Selaginella, Equisetum, Adiantum, Pteridium, Isoetes, Ophioglossum, Marsilea, Azolla,*
4. Prepared Slides study ofPteridophyta representative members.
5. Anatomical study of vegetative and reproductive parts of *Cycas, Pinus, Ephedra, Gnetum, Ginkgo, Taxus and Welwitschia,*
6. To study about fossil Gymnosperms using prepared slides and available specimens.
7. To collect different available Gymnospermic plant materials.
8. Prepared Slides study of Gymnosperm representative members.

Suggested Reading

1. Agashe S.N. (1995). Paleobotany. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
2. Arnold A.C. (2005). An Introduction to Paleobotany. Agrobios (India). Jodhpur.
3. Bhatnagar, S. P. and Moitra, A. 1996. Gymnosperm, New age international Pvt. Ltd. New Delhi.
4. Chopra R.N. and Kumar P.K. (1988). Biology of Bryophytes. John Wiley & Sons, New York, NY.
5. Gangulee and Kar (2006). College Botany. New Central Book Agency.
6. Parihar N.S. (1976). Biology and Morphology of Pteridophytes. Central Book Depot.
7. Parihar N.S. 1991. Bryophyta. Central Book Depot, Allahabad

8. Rashid A. (1999). An Introduction to Pteridophyta. Vikas Publishing House Pvt. Ltd. New Delhi.
9. Rashid A. (2009). An Introduction to Bryophyta. Vikas Publishing house. New Delhi.
10. Sharma O.P. (1990). Textbook of Pteridophyta. MacMillan India Ltd. Dehi.
11. Singh, Pandey and Jain. A Text book of Botany, Rastogi Publication.
12. Sprone, K. K. (1991. The Morphology of Gymnosperm, BI Publicating Pvt. Ltd. Bombay.
13. Steward, W. N. and Ruthwell, G. W. (1993). Paleobotany and Evolution of plants. Cambridge University Press U K.
14. Sundar Rajan S. (1999). Introduction to Pteridophyta. New Age International Publishers, New Delhi.
15. Surange K.R. (1966). Indian Fossil Pteridophytes. CSIR., New Delhi.
16. Vashishta P. C. (2005). Botany for Degree Students Pteridophyta, S Chand and Company, New Delhi.
17. Vashishta, P. C., Sinha AK and Kumar A. (2005). Botany for Degree Students Bryophyta, S. Chand & company, New Delhi.
18. Vashishta, P. C., Sinha AK and Kumar A. (2005). Botany for Degree Students Gymnosperms, S. Chand & company, New Delhi.

SEMESTER-II

Core Course 4: Cell and Molecular Biology

Course code: BOPATT4

(Credits: Theory-3, Practical-2)

Learning Outcome

Learners should have developed knowledge of the major ideas and current experimental approaches in cell biology and molecular biology.

Learners should be able to progress to related courses in Biological Sciences, including Biochemistry, Genetics, Neuroscience, Pathology, Plant Sciences.

Unit I: Introduction to modern tools and techniques of cell biology:

Advances in light and electron-microscopy, techniques supplementing microscopy (cytochemistry, microprobe analysis, x-ray diffraction, etc.), Cell fractionation and visualization/characterization of various cell fractions.

Unit II: Cell components and their functions:

Dynamic structure, functions and biogenesis of cell wall and plasma membrane; new insights in structure and function of cytoplasmic cell organelles and biopolymers; nucleus; its components, chromatin structure in eukaryotes, condensation, and packaging of DNA in prokaryotes, their dynamic state and role in gene regulation; structure and function of plant cytoskeletal genes and gene products; protein sorting and intracellular trafficking.

Unit III: Cell multiplication and turnover:

Cell cycle, Cell growth and division (mitosis, meiosis and cell differentiation) Programmed Cell Death

UnitIV: Gene structure, regulation, and expression in eukaryotes:

Gene and promoter architecture, cistrons, regulatory sequences, enhancers and their mechanism of action, DNA replication; transcription - RNA polymerases, transcription factors, Introns, RNA splicing, alternative splicing, RNA stability - cap structure and function, polyadenylation; translation, posttranslational modifications.

UnitV: Organellar genomes:

Organization and function of mitochondrial and chloroplast genomes, diversity and evolution of organelle genomes, chloroplast protein targeting to different compartments, mitochondrial DNA and male sterility, transfer of genes between nucleus and organelles.

Lab (BOPALT4)

1. Microscopic observation of plant cells
2. Isolation and purification of nuclei and their staining with Feulgen stain or DAPI.
3. In silico analysis (sequence comparison) of mitochondrial and chloroplast genes foridentification of the loci for interspecific discrimination.
4. Isolation of plasmid from the bacteria
5. Isolation of DNA from plant sample and their spectrophotometric quantification
6. Restriction digestion of the plasmid
7. Amplification of plant DNA using Polymerase Chain Reaction
8. Electrophoretic separation and visualization of the DNA/PCR product

Suggested Readings:

1. Alberts B, Johnson A, Lewis J, Raff Martin, Roberts K and Walter P. (2007) MolecularBiology of the Cell. Garland Publ., New York.
2. Bonifacino JS, Dasso M, Harford JB, Liipincott-Schwartz J and Yamada KM. (2004) ShortProtocols in Cell Biology. John Wiley & Sons, New Jersey.
3. Bregman AA (1987) Laboratory Investigations in Cell Biology. John Wiley & Sons, NewYork.
4. Hawes C and Satiat-Jeunemaitre B (2001) Plant Cell Biology: Practical Approach. OxfordUniversity Press, Oxford.
5. Hirt RP and Horner DS (2004) Organelles, Genomes and Eukaryote Phylogeny: Anevolutionary synthesis in the age of genomics. CRC Press.
6. Karp G. (2008) Cell and Molecular Biology: Concepts and Experiments. John Wiley &Sons.
7. Lodisch H, Berk A, Kaiser CA, Krieger M, Scott MP, Bretscher A, Ploegh H and MatsudaireP (2008) Molecular Cell Biology. WH Freeman & Co., New York.
8. Ruzin SE (1999) Plant Microtechnique and Microscopy. Oxford Univ. Press, Oxford.

9. Wischnitzer S. (1989) Introduction to Electron Microscopy. Pergamon Press, New York.

SEMESTER-II

Core Course 5: Taxonomy of Angiosperms

Course code: BOPBTT5

(Credits: Theory-3, Practical-2)

Learning outcomes:

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

Recognize the importance of herbarium and Virtual herbarium and molecular taxonomy and plant systematics and classify plants

Evaluate the Important herbaria and botanical gardens

Acquire field knowledge of Plants, their classification and have exposure to the botanical zones of India.

Interpret the rules of ICN in botanical nomenclature

Assess terms and concepts related to Phylogenetic Systematics and plant taxonomy

Unit I: Classification, Cladistics and Angiosperm Diversity

Indian history of plant classification and taxonomy of plats, Major systems of classification: basis, merits and demerits: Cronquist (1981); Takhtajan's System(1997), basis of APG Classification, APG IV (2016).

Concepts of palaeoherbs and eudicots (tricolpates). Cladistics: A brief account: definition and application. Angiosperms diversity: Salient features, phylogeny and evolutionary trends in Magnollidae, Asteridae, Alismatidae, and Liliidae.

Unit II: International Code of [Botanical] Nomenclature /[ICN/ICBN]

Salient features-Principles, Important Rules, latest changes: overview; Status, typification, and priority of names; effective publication: new provisions, Provisions for the governance of the Code; valid publication: general provisions; Names of new taxa (species); new combinations; names at new rank; replacement names; rejection of names. ProposedBioCode and PhyloCode.

Unit 3: Data Sources and Tools of Taxonomy

Data sources in Taxonomy: Embryology, Palynology, Anatomy, Molecular taxonomy–DNA

barcoding. Tools of Taxonomy: Herbarium, floras, Botanical gardens, Computers, GPS, GIS Application of GIS and GNSS (Remote Sensing) in Botany.

Unit 4: Species, Biosystematics and Numerical Taxonomy

Species concept. Biosystematics: Objectives, steps, categories, relationship with classical taxonomy.

Numerical Taxonomy (Phenetic methods): Definition, Principles, methods, merits and demerits.

Lab (BOPBLT5)

1. Submission of at least 25 herbarium specimens of common plants.
2. Study of at least 20 locally available families of flowering plants.
3. Identification of genus and species of locally available wild plants.
4. Preparation of botanical keys
5. Knowledge of at least 25 plant species from each of the following categories : A) Medicinal Plants.B) Endemic plants. C) Exotic weeds.
6. Field excursion for familiarization with and study of vegetation type(s) and flora(s) of areas outside the state, and in the local areas, (one with in state and one outside state) and training in collection and preservation methodologies.

Suggested Readings:

1. Davis, P. H. and V. H. Heywood 1991.Principles of Angiosperm Taxonomy. Today and
2. Tomorrow Publications, New Delhi
3. Manilal, K. S. and M. S. Muktesh Kumar (ed.) 1998. A Hand book of Taxonomy Training, DST, New Delhi
4. Naik, V. N. 1984. Taxonomy of Angiosperms Tata McGrow-Hill Publication Com. Ltd., New Delhi
5. Quicke, Donald, L. J. 1993. Principles and Techniques of Commemoratory Taxonomy.Blakie Academic and Professional, London
6. Stace, C. A. 1989. Plaul.Taxonomy and Biosystematics Etwaed Arnold, London.
7. Stuessy T. F. 2002. Plant taxonomy .The systematic Evaluation of comparative data.Biseu
8. SighMahendra Pal Sign PehraDuk.

9. Taylor, D. V. and L. J. Hickey 1997. Flowering plant : Origin, evolution and phylogeny CBS

10. Publishers a Distributors New Delhi.

11. Datta, S. C. 1988. Systematic Botany.Wiley Eastern Limited, New Delhi. Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F., Donoghue, M. J. 2008. Plant Systematics– A Phylogenetic Approach.SinauerAssoociates, Inc., Sunderland, Massachusetts USA.

12. Simpson, M. G. 2010. Plant Systematics. Elsevier Academic Press, Amsterdam.

13. Simpson, M. G. 2019. Plant Systematics.3rd Edition, Academic Press, Amsterdam.

14. Singh, Gurucharan 2012.Plant Systematics – Theory and Practice. Oxford &IBH Publishing Co. Pvt. Ltd., NewDelhi.

15. Singh, Gurucharan 2019. Plant Systematics – A Integrated Approch. CRC press.

16. Sivarajan, V. V. 1991. Introduction to the Principles of Plant Taxonomy. Oxford &IBH PublishingCo. Pvt. Ltd., New Delhi.

Stuessy, T. F. 2008. Plant Taxonomy – The Systematic Evaluation of Comparative Data.ColumbiaUniversity press, New York.

17. Sharma O, 2017. Plant Taxonomy, McGraw Hill Education

18. Pandey Arun K., KasanaShruti, 2021, Plant Systematics, CRC Press

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SEMESTER-II

Core Course 6: Plant Biochemistry

Course code: BOPBTT6

(Credits: Theory-3, Practical-2)

Learning Outcomes

Learn the structure, function and biosynthetic pathways of essential biochemical molecules including their key chemical and physical properties.

Understand how light energy is captured and used to provide chemical formsof energy to power the functions of cells and whole plants. The importance ofCO_2 fixation and carbohydrate metabolism will be presented. The nature andcomposition of plant cell walls will be explored.

Understand central metabolism, its plant-specific components, and their functional significance at multiple levels.

Learn principles of enzyme kinetics and apply these through hands onproblem sets. Students will be shown how enzyme properties contribute tometabolic processes.

UnitI: Structure and function Biomolecules

The biochemistry of amino acids and proteins, sugars and carbohydrates,and lipids.

Unit II: Plant specific pathways and biochemical processes

Biochemical processes and metabolic pathways specific to plants, including photosynthesis, photorespiration, cell wall biosynthesis, nitrate and sulfate assimilation, distinctive aspects of central metabolism, and plant secondary metabolism.

Unit III: Plant metabolism

Metabolism in a structure-function context from molecular to subcellular, cellular, organ, and whole-plant levels.

Unit IV: Quantitative aspects of biochemistry

Quantitative aspects of biochemistry including enzyme kinetics, protein ligand binding, analytical techniques, and bioenergetics.

Lab (BOPBLT6)

1. Estimation of reducing sugar.
2. Effect of substrate concentration on enzyme activity and determination of Km.
3. Effect of temperature and pH on enzyme activity.
4. Study of invertase, diastase and urease activity.
5. Extraction of fat by Soxhlet's apparatus.
6. Determination of acid value and saponification value of fat.
7. Paper chromatography of amino acids.

Suggested Reading

1. Biochemistry and Molecular Biology of PlantsBuchannan B, Gruiseem W, Jones R, ASPP, Maryland; (Latest edition)
2. Plant BiochemistryHans-Walter Heldt; 2006 Edition
3. Plant Biochemistry and Molecular BiologyLea PJ, Leegood RC; Second Edition 1999John Wiley & Sons
4. Taiz L and Zeiger E. (2006) Plant Physiology, 6th Edition, Sinauer Associates Inc. Publishers, Massachusetts, USA

SEMESTER-II

Core Course 7: Ecology and Environment

Course code: BOPBTT7

(Credits: Theory-3, Practical-2)

Learning outcomes

Students after completion of course will have following knowledge's

Important components of life and their interactions

Importance of biodiversity for ecosystem and role of biodiversity

Various environmental problems due to pollutants

Unit I - Principles of Ecology:

Physical environment; biotic environment; biotic and abiotic interactions, Concept of habitat and niche; fundamental and realized niche; resource partitioning; character displacement.

Unit II – Population and Community:

Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); Community: structure and attributes; edges and ecotones; Succession: Types; mechanisms; changes involved in succession; concept of climax

Unit III- Ecosystem Organization:

Structure and Functions, Primary Production (methods of measurement, controlling factors), Energy Dynamics (trophic organization, energy flow pathways, ecological efficiencies)

Unit IV- Biological diversity:

Concept and levels; distribution and global patterns; terrestrial biodiversity, hot spots; IUCN categories of threat; inventory; conservation.

Unit V- Environmental pollution:

Kinds, sources, effects on plants and ecosystems, greenhouse gases, consequences of climate change; Ozone layer depletion: causes and consequences.

Lab((BOPBLT7)

1. To determine the frequency, density, abundance of plant species in different terrestrial ecosystems.
2. To estimate IVI of the species in a woodland ecosystem.
3. To study the life form of a woodland ecosystem.
4. To compare protected and unprotected grassland ecosystems using community coefficients (similarity indices).
5. To determine diversity indices (Shannon-Wiener, Concentration of Dominance, Species richness, Equitability and B-diversity) of protected and unprotected ecosystems.
6. Estimation of biomass estimation using harvest method.
7. To determine the water holding capacity of soils collected from different ecosystems.
8. To determine the percent organic carbon and organic matter in the soils of cropland, grassland and forest.
9. Field visits to different ecosystems

Suggested Readings:

1. Kormondy E. J., 2000. Concept of Ecology. 4th Edition. Benzamin Cummings. UK
2. Odum E.P., 1996. Fundamentals of Ecology, Natraj Publishers, Dehradun.
3. Patrick L. 2000. Tropical Ecosystems and Ecological Concepts. Cambridge University Press. UK.
4. Sharma P.D. 2007. Ecology and Environment. Rastogi Publication, Meerut.
5. Singh J.S., S.P. Singh and S.R. Gupta 2006. Ecology, Environment and Resource Conservation, Anamya Publication, New Delhi.
6. Singh J.S., S.P. Singh and S.R. Gupta 2015. Ecology Environmental Science and Conservation.S. Chand Publishing, New Delhi.

SEMESTER-III

Core Course 8: Plant Anatomy and Reproductive Biology

Course code: BOPCTT8

(Credits: Theory-3, Practical-2)

Learning Outcomes:

The students will be learning

Develop an understanding of concepts and fundamentals of plant anatomy

Examine the internal anatomy of plant systems and organs

Develop critical understanding on the evolution of concept of organization of shoot and root apex and tissue system.

Analyze the composition of different parts of plants and their relationships

To undertsand the anatomy of transition zones

What are the proximate causes and consequences of transition in the reproductive attributes of flowering plants?

Why breakdown in self-incompatibility to self-compatibility does not revert in nature?

What are dynamics of plant-pollinator interaction?

Does the breeding system analysis in a plant truly indicate the relative contribution of selfing and outcrossing?

Why the development of embryo and endosperm is essentially interdependent, and are their exceptions to this interdependence?

Why the ratio of flowers to fruit and that of ovule to seed is low in flowering plants?

How to differentiate aposporous and sexual modes of reproduction?

UNIT I. Theories

Cell wall, types, pits, plasmodesmata, functions; Secondary wall organization;Theories of organization of meristem in stem and root, cytological and molecular aspects of SAM;Secondary cambium types – vascular cambium and phellogen; Cambial activity in wound healing and grafting; Nodal anatomy; Cambium in arborescent monocotyledons (Liliflorae).

UNIT II. Tissues, Anomalous secondary growth and Applications:

Overview of simple and complex tissues: structure and functions. Secondary xylem and secondary phloem structure and function; Ontogeny of vessels;Sieve tube differentiation, transition of vasculature in root and stem;Leaf structure and types;Secondary growth in dicot and monocot stem, dicot and monocot roots; Wood types and structures.

Unequal activity of vascular cambium, discontinuous, unidirectional and bidirectional activity of cambium

Utility in systematics, archaeology climatic studies and crime detection.

UNIT III. Development of flower:

Male and female gametophytes: Transition to flowering – vegetative to floral evocation, floral homeotic mutations in *Arabidopsis*, regulation of anther and ovule development; Microsporogenesis and microgametogenesis, megasporogenesis and megagametogenesis; Male sterility- mechanisms and applications, pollen embryogenesis.

UNIT IV. Pollen-pistil interaction and plant-pollinator interactions:

Pollen-pistil interaction: In vivo and in vitro pollen germination, pollen tube growth and guidance, recognition and rejection reaction, double fertilization, role of synergids, self-compatibility mechanisms, incongruity.

Plant-pollinator interactions: Plant-pollinator interaction: floral display, attractants and rewards, pollen load, temporal details and foraging behaviour, pollination energetics; phenology; Mating systems: differential reproductive success; resource allocation; pollen:ovule ratio; sibling rivalry, ovule abortion.

UNIT V. Embryogenesis, seed development, apomixis and contributions:

Embryogenesis, seed development and Apomixis: Polarity during embryogenesis, pattern mutants, embryo development in monocots and dicots, endosperm development, apomixis, polyembryony, somatic embryogenesis.

Contributions: C.R. Metcalfe, L. Chalk, A. Fahn,W. Hofmeister, Edward Strasburger, Sergius Nawaschin, PanchananMaheshwari, S.C.Maheshwari, B.M.Johri, W.A. Jensen, J. Heslop-Harison.

Lab (BOPCLT8)

1. Study of living shoots apices by dissection using aquatic plants such as *Ceratophyllum* and *Hydrilla.*

2. Maceration technique of different woods to examine different kinds of vessel elements, fibres, tracheids and parenchyma.
3. Ecological Anatomy.
4. Study of leaf anatomy – structure, stomata, trichomes, types of stomata.
5. Study of anamolous secondary growth in selected plant species.
6. Study of different types of anthers and microsporogenesisalogwithUntrastructure of male gametophyte.
7. Pollen germination – sitting and hanging drop.
8. Study of different types of ovules and Ultrastructure of female gametophyte.
9. Test for stigma receptivity.
10. To study pollination mechanisms – flower structure, pollen and ovule variations.
11. Study of zygotic embryo- globular, heart shape, torpedo and mature. Polyembryony in mango and *Citrus.*
12. Study of endosperm – nuclear and cellular.

Suggested Reading:

1. Cutler DF (1978). Applied Plant Anatomy, Longman, United Kindom
2. Cutter EG (1978) Plant Anatomy, Part I & II, Edward Arnold, United Kingdom.
3. Bhojwani, S. S. and Bhatnagar, S. P. 1984. Embryology of Angiosperms.Vikas Publ. House, New Dehli.
4. Dickinson WC (2000).Integrative Plant Anatomy, Harcourt Academic Press, USA.
5. Fahn A (1974) Plant Anatomy, Pergmon Press, USA & UK.
6. Johri, B. M. 1984.Comparative embryology of Angiosperms. Ind. Nat. Sc. Acad. New Delhi.
7. Maheshwari, P. 1985. An Introduction to Embryology of Angiosperms. Tata McGraw Hill. New Delhi
8. Mauseth JD (1988). Plant Anatomy, The Benjamin/ Cummings Publisher, USA
9. Raghavan V (2000) Developmental Biology of Flowering Plants, Springer, Netherlands
10. RaghavanV (1997). Molecular Embryology of Flowering Plants. Cambridge. University Press.

11. Shivanna KR (2003) Pollen Biology and Biotechnology, Science Publishers.

12. Shivanna, K. R. and N. S. Rangaswamy. 1992. Pollen Biology- A Laboratory Manual. Springer-Verla

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SEMESTER-III

Core Course 9: Genetics and Cytogenetics

Course code: BOPCTT9

(Credits: Theory-3, Practical-2)

Learning Outcomes

On completion of the course, the student should be able to:

Understand basic concepts in genetics and cytogenetics

Explain the processes involved in transfer of genetic material and other genetic changes

Identify and distinguish genetic regulatory mechanisms at different levels

Solve theoretical and practical problems in genetic analysis particularly concerning genetic mapping and population genetics

Gain insights into current, exciting topics in Genetics and related fields and plan basic experiments in genetics and use common methods in genetics

Describe and summarize experimental work in a correct way in a laboratory notebook

Unit I: Basic Concepts in Genetics and Genetic Analyses

Mendelian principles; Non-Mendelian Inheritance, Epistasis, Extra nuclear inheritance (Chloroplast and Mitochondrial Genomes)

Chromosomal theory of inheritance, sex chromosomes and determination, dosage compensation, gene mapping methods, Linkage and Crossing over; LOD score, Tetrad analysis in Neurospora.

Unit II: Genetic Integrity and Diversity

Chromosome variation in number (Euploidy and Aneuploidy). Changes in chromosome structure (deficiencies, duplications, inversion, and translocations)

Gene mutation - Types of mutation, molecular basis of mutation, physical and chemical mutagens and mechanism of their action

Unit III: Quantitative and Evolutionary Genetics

Quantitative Inheritance: traits controlled by many loci; significance of polygenic inheritance; quantitative inheritance in plants;

Population Genetics: Population models, Genotype and allelic frequencies, the Hardy-Weinberg equilibrium- barriers to gene flow and mechanism of speciation; testing for fit with H-W equilibrium; non-random mating, consequences of homozygosity (inbreeding), factors affecting gene frequencies, heterosis, mutation – effect on allele frequencies, migration and genetic drift optimum phenotype and selection pressure, kinds of selection; Fisher's fundamental theorem of Natural selection.

Evolutionary Genetics: concepts of evolutionary forces that change allelic frequencies; molecular clock concept, Genomic imprinting, synteny

Unit IV: Genome Organization

Chromatin organization and replication: Chemical constituents- DNA and histones, nucleosome and higher order organization, DNA packaging and genetic activity, nucleosome assembly and deassembly

Chromosome banding patterns: Linear differentiation of chromosome segments, types of chromosome banding, uses of chromosome banding in cytogenetics

Organization of eukaryotic genetic material: Nuclear DNA and C-value paradox, DNA content and adaptability, repetitive DNA, split genes, overlapping genes

Chromatin modification and genome expression: chromatin remodeling, Epigenetic control of gene expression in plants.

Unit V: Genomics and Molecular Genetics

Chromosome Mapping and molecular markers (RFLP, RAPD and AFLP), Map position-based cloning of genes, sequencing of genomes (Sanger's method and Next gen sequencing)

Lab (BOPCLT9)

1. Preparation of stains and staining techniques for chromosome analysis.
2. Karyotype analysis in diploids and polyploids.
3. Phases of division in Plant cells: chromosome pairing in diploids and polyploids.
4. Construction of genetic (Linkage) maps.
5. Restriction mapping to locate the position of restriction sites.
6. Theoretical problems based on Genetic Interactions and Population genetics
7. Demonstration of special chromosomes (Polytene and lampbrush chromosomes)

Suggested Readings

1. Genetics. M. W. Strickberger,Macmillan Publishing co., New York.
2. Principles of Genetics. Gardner, E. J., Simmons, M. J. and Snustad, D. P., John Wiley & Sons, New York.
3. An Introduction to genetic analysis. Anthony A. J. F. Griffiths; Susan R. Wessler; Sean B. Carroll; John Deebly, W. H. Freeman & Company, New York.
4. Genetics: analysis of genes and genomes. Daniel L Hartl; Maryellen Ruvolo.
5. Gene. Benzamin Lewin.Jones and Batlett Learning Publisher. USA.

SEMESTER-III

Core Course 10: Plant Physiology

Course code: BOPCTT10

(Credits: Theory-3, Practical-2)

Learning outcomes

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

Understand the soil-plant-atmosphere continuum of water, uptake of solutes and translocation of photoassimilates

Have deeper insightsinto basic metabolic processes (Photosynthesis and Respiration) in plants

Explain the mineral acquisition in plants with especial reference to nitrate assimilation and biosynthetic pathways of important secondary metabolites

Have advanced understanding of sensory photobiology and Physiological responses of plat growth regulators

Explain the responses and acclimation of pants in relation to major abiotic stresses at different levels from physiological point of view

Unit I: Plant-water relationship, solute transport, and photoassimilates translocation

Uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem and phloem; transpiration; Soil-Plant-atmosphere continuum, mechanisms of loading and unloading of photoassimilates.

Unit II: Primary metabolic processes

Photosynthesis:

Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO_2 fixation-C3, C4 and CAM pathways.

Respiration, and Photorespiration:

Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway.

Unit III: Plant nutrition &secondary Metabolites

Mineral nutrition in plants, Nitrogen metabolism (nitrate uptake and assimilation)

Biosynthesis of terpenes, phenols, and nitrogenous compounds and their roles

Unit IV: Plant hormones & Sensory photobiology

Physiological effects and mechanism of action of plant growth hormones

Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks.

Unit V: Stress physiology

Responses of plants to abiotic stress (water, temperature and salt), acclimation of physiological processes under abiotic stresses

Lab (BOPCLT10)

1. Determination of water potential of plant samples by Chardakov's method.
2. To measure the rate of transpiration by using Ganong's Potometer
3. To demonstrate the liberation of oxygen in Photosynthesis
4. To demonstrate transpiration by cobalt chloride method
5. Separation of chloroplast pigments by solvent extraction process
6. To determine the respiratory quotient (R.Q.) of different respiratory substrates
7. Demonstrate that energy is released during respiration
8. Demonstration of anaerobic respiration
9. Demonstration of the effect of abiotic stresses on plant growth
10. Separation and extraction of Plant leaf pigments by various chromatographic approaches

Suggested Readings:

1. Latest edition of Devlin Robert M. Plant Physiology, Prindle Weber and Schmidt Publisher; 4th edition. UK.
2. Latest edition of Fitter Alastair H. 2001. Environmental Physiology of Plants. Academic Press Publisher, 3rd Edition. UK.

3. Latest edition of Hopkins and Hunner. Introduction to Plant Physiology. John Wiley. UK.
4. Latest edition of Salisbury Frank and Cleon Ross. Plant Physiology. Brooks Cole Publishers; 4th edition. USA.
5. Latest edition of Taiz Lincoln and Zeiger Eduardo, Plant Physiology. Sinauer Associates, Inc. Publishers, UK.

DISCIPLINE SPECIFIC ELECTIVE

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 1: Algae, Environment and Human Welfare

Course code: BOPBTD1

(Credits: Theory-3, Practical-2)

Learning Outcomes:

The student will learn about organization of the photosynthesis apparatus from blue green algae to red algae, photosynthetic pigments and light harvesting, light absorption: PSI and PSII, electron transport chain which is important for production of ATP with the help of ATP synthase.

The students will learn about uptake mechanism(s) of HMs through various transporters present on plasma membrane. They will also learn about how algal cells have various strategies to counter the HMs induced oxidative stress and their negative consequences on vital metabolic occurrences like photosynthesis and nitrogen metabolism.

The course teaches about various beneficial products from algae and their industrial production. These include various algae utilized for food, as neutraceuticals or as fuel.

Contents:

Unit I: Photosynthesis in various class of algae

Photosynthesis advancement in various class of algae. Organization of the photosynthesis apparatus from blue green algae to red algae, photosynthetic pigments and light harvesting, light absorption: PSI and PSII, electron transport chain, proton transport and ATP synthesis, CO2 assimilation under dark reaction, RUBISCO activity and its interaction with light and oxygen.

Unit II: Nitrogen fixation and assimilation in algae:

GS-GOGAT cycle, GDH cycle, Nitrogenase, Heterocyst differentiation, structural significance, physiological and biochemical adaptation for Nitrogen fixation, NR, NiR, GS, GOGAT, and AspAT enzymes biosynthesis, structure and their functions, nitrogen fixation and photosynthesis-ralationship, nitrate reduction and assimilation in algae, assimilation of organic nitrogen in algae: urea, amino acids and amides.

Unit III: Tolerance and detoxification mechanisms of HMs in algae:

Effective methods of culturing the potent algae for efficient phycoremediation of HMs, various methods implied by algae for efficient accumulation of HMs, uptake of HMs by various cell membrane associated transporters, reactive oxygen species, oxidative stress, carbonylation of proteins during HMs stress, metallothionein, antoxidative enzymes: SOD, CAT, APX, GR, DHAR, MDHAR and non enzymatic antioxidants: GSH, AsA, proline, and polyamines.

Unit IV: Algal application for human welfare:

Algae for food, pigments, antioxidants, proteins and carbohydrate. Unit V: Algal Lipids, biodiesel and biofuel production.Fatty acid biosynthesis, Polyunsaturated fatty acid accumulation, Biodiesel production, Biohydrogen, Bioethanol production. Research hurdles and possible solutions.

Unit VI: Biotechnological advancements in algal research:

Genetic engineering in algae, Mutagenesis for strain improvement, engineering efforts for advancement in culturing techniques, Integrated multitrophic aquaculture. Ai in algal Research.

Lab (BOPCLD1):

As per the course

Suggested Reading

1. Fritsch,F.E.1945. The structure and reporocution of Algae Vols. 1& II. Cambridge University Press, London;
2. Smith, G.E.Ed., 1950. Fresh water algae
3. Chapman, V.J.1962. The Algae
4. Lewin,R.A. 1962. Physiology and Biochemistry of Algae
5. Round, E.E. 1962. Ecology of algae
6. Morris, I 1967. An Introduction to the Algae.
7. Presscot,G.W. 1969. The Algae- a review.
8. Bold, H.C and Wyne.M.J. 1978. Introduction to the algae
9. Kumar, H.D.1988.Introductory Phycology 10. Round, E.E. 1986. The Biology of Algae.

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 2: Biofertilizer and Biopesticides Technology

Course code: BOPBTD2

(Credits: Theory-3, Practical-2)

Learning Outcome:

Syllabus focus on current needs of agriculture sector with respect to fertilizers.

Outcome : Will prepare students to understand the problems of farmers and tackle them with recent Biotechnological advances. Become skilled in Biofertilizer production.

Objectives : To enables students to understand the role of Biofertilizers in the field of agriculture and allied industry. Prerequisites : Technical understanding of microbial culturing, fermentation techniques is prerequisite to student to learn this syllabus.

UNIT I: Introduction to Biofertilizers

Introduction to Biopesticides Advantages of biofertilizers over chemical fertilizersGeneral account of the microbes used as biofertilizers (any one) for various crop plants and their advantages over chemical fertilizers. Symbiotic N2 fixers: Rhizobium - Isolation, characteristics, types, inoculum production and field application, legume/pulses plants.

UNIT II: Biofertilizers and Biopesticides I

Types and application of Biofertilizers and Biopesticides Media composition and screening of superior strains Scale up of Inoculum. Mass scale production of Bio-inoculant Selection of carrier Factors affecting mass production of Bio-inoculant.

Unit III: Biofertilizers and Biopesticides II

Phosphate solubilizing microbes (any one) - Isolation, characterization, mass inoculum production, field Application.

Importance of mycorrizal inoculum, types of mycorrhizae and associated plants, Mass inoculum production of VAM, field applications of Ectomycorrhizae and VAM.

UNIT IV: Production methods

General account of microbes used as bioinsecticides and their advantages over synthetic pesticides, *Bacillus thuringiensis*, production, Field applications. Curing of Inoculum and carrier mixture Norms for Packaging and Labelling of Bio-inoculant Efficacy study of developed inoculants, Importance of *Trichoderma* spp., *Pseudomonas* spp. and *Bacillus* spp. as a biocontrol agent. Mechanism of disease control by these organisms bioagents.

UNIT V: Strategies of marking

Strategies of marking, and Registration with CIB and organic farming institute. Importance of *Trichogramma*, *Cryptolaemus*, *Chrysoperla*, NPV and entomofungal pathogens. Quality parameters as per CIB specifications, Registration of biopesticides and case. Importance of Verticillium/Beauveria/ Metarhzium/Nomuraea/ Paecilomyces/Hirsutella thompsoni as biopesticides and their mass production.

Strategies of marking and Registration with CIB of bioagents and biopesticides

Lab (BOPCLD2)

1. Media used for biofertilizers, Biopesticides and bioagents production.
2. Isolation of *Rhizobium* from root nodules. Isolation of *Azotobacter*, Acetobactor, Beijernickia, Azospirillium. I. By dilution pour plate technique and II. By enrichment culture technique
3. Isolation of BGA, PSB, sulphur oxidizing microorganisms, ion chealator, potash mobilizers , organic matter decomposers I. By dilution pour plate technique and II. By enrichment culture technique
4. Estimating the efficiency of *Rhizobium* through pot culture experiments and through nodulation tests in test tubes and Leonard jar.
5. Production of *Rhizobium* commercial biofertilizers of *Azotobacter* , *Azospirillum Acetobacter*, organic matter decomposers
6. Production of carrier biofertilizers of sulphur oxidizing microorganisms, ion chealator, potash mobilizers
7. Study of VA-mycorrhiza: growth on Guinea grass roots and observations for root colonization. Methods of preparation and application of VA-mycorrhizal inoculum
8. Mass production of *Trichogramma*, *Cryptolaemus*, *Crysoperla* (As per availability)
9. Mass production of HaNPV, SlNPV and EPN (As per availability)
10. Mass production of Verticillium/ Beauveria/ Metarhzium/ Nomuraea/ Paecilomyces/ Hirsutella thompsoni/ Trichoderma (As per availability)

11. Mass multiplication of BGA and Azolla and its application in paddy field (As per availability)
12. Methods of application of biofertilizers, Biopesticides and bioagents
13. Quality control of biofertilizers: ISI standards specified and estimating the viable bacterial count in carrier based biofertilizers, Biopesticides and bioagents
14. Quality control tests for the biofertilizers, Biopesticides and bioagents
15. Preparation of plan of biofertilizers, Biopesticides and bioagents production unit and proposal of loan.
16. CIB Registration for Biopesticides and bioagents
17. Screening of superior strains using some in vitro techniques
18. Inoculum development
19. Check for cross contaminations
20. Large scale production of Bio-inoculant by using Lab fermenter
21. Preparation of carrier
22. Mixing of Inoculum and carrier
23. Effect of packaging on viability of inoculants
24. Study of shelf life of inoculant
25. Efficacy check of developed inoculant by using Pot experiment and its comparison with already available commercial Biofertilizers
26. Visits to Commercial biocontrol units and Krishi Seva Kendra

Suggested readings

1. Kannaiyan, S. (2003). Bioetchnology of Biofertilizers, CHIPS, Texas.
2. Mahendra K. Rai (2005). Hand book of Microbial biofertilizers, The Haworth Press, Inc. New York.
3. Reddy, S.M. et. al. (2002). Bioinoculants for sustainable agriculture and forestry, Scientific Publishers. 4. Subba Rao N.S (1995) Soil microorganisms and plant growth Oxford and IBH publishing co. Pvt. Ltd. NewDelhi.
4. Saleem F and Shakoori AR (2012) Development of Bioinsecticide, Lap Lambert Academic Publishing GmbH KG
5. Aggarwal SK (2005) Advanced Environmental Biotechnology, APH publication.

6. Textbook of Biotechnology : R C Dubey (S. Chand Publication)
7. Biofertilizer Technology: Singh and Purohit (Agrobiose Publication)
8. Alexander M. 1977. Soil Microbiology. John Wiley.
9. Bergerson FJ. 1980. Methods for Evaluating Biological Nitrogen Fixation. John Wiley and Sons.
10. Motsara, I.M.R., Bhattacharyya, P. and Srivastava, B. 1995. Biofertilizer Technology, Marketing and Usage- A Source Book-cum-glossary. FDCO, New Delhi.
11. Subba Rao, N.S. Biofertilizers in Agriculture and Forestry. 1993. Oxford and IBH. Publ. Co., New Delhi. 5. Burges, H.D. and Hussey, N.W. (1971). Microbial Control of Insects and mites. Academic Press, New York.
12. Burges, H.D. Formulation of microbial pesticides – Kluversep, ACB, Dordrecht-ISBN. 0412 625 202.
13. Coppel H.C. and J.W. Martin. (1977). Biological control of insect pest suppression. Springail.
14. De Bach P. 1964. Biological control of Insect Pest and Weeds Chapman and Hall, New York.
15. Gautam, R.D. (2006). Biological suppression of insect pests. Kalyani Publisher, New Delhi.
16. Huffaker, C.B. and Messenger, P.S. (1976). Theory and Practice of Biological control. Academic Press, New York.
17. Ignacimuthu, S.S. and Jayaraj, S. (2003). Biological Control of Insect Pests. Phoenix Publ. New Delhi.
18. Saxena, A.B. (2003). Biological Control of Insect Pests. Anmol Publ. New Delhi.
19. Huffaker, C.B. and Messenger, P.S. (1976). Theory and Practice of Biological control. Academic Press, New York.
20. Pepper HJ and Perlman D. 1979. Microbial Technology. 2nd Ed. Academic Press.
21. A century of Nitrogen Fixation Research Present status and Future propects. 1987. F.J. Bergersen and J.R. Postgate The Royal Soc., London.
22. Biology and Biochemistry of Nitrogen fixation. 1991. M.J. Dilworth,and A.R. Glenn, Elsevier, Amsterdam. .

23. Nitrogen Fixation in plants. 1986. R.O.D. Dixon,and C.T. Wheeler, Blackie USA, Chapman and Hall, New York.
24. A treatise on dinitrogen Fixation Section IV. Agronomy and Ecology 1977. R.W.F Hardy, and A.H. Gibson John Wiley & Sons, New York..
25. Bioresearches technology for sustainable agriculture. 1999. S. Kannaiyan, Assoc. Pub. Co., New Delhi.
26. Biofertilizer Technology, Marketing and usage- A source Book -cum-glossary 1995. Motsara, I. M.R., P. Bhattacharyya and Beena Srivastava, FDCO, New Delhi.
27. Symbiotic nitrogen fixation in plants, 1976. P.S. Nutman, Cambridge Univ. Press, London.
28. Hand book for Rhizobia; Methods in legume Rhizobium Technology, 1994. P. Somasegaran and H.J. Hoben Springer-Verlag, New York.
29. Biofertilizers in Agriculture and Forestry 1993. N.S. Subba Rao Oxford and IBH Publ. Co., New Delhi.

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 3: Bioinformatics and Evolutionary Biology

Course code: BOPBTD3

(Credits: Theory-3, Practical-2)

Learning Outcomes:

Students will acquire understanding of:

Patterns of biological variation and underlying processes responsible for these patterns.

Evolutionary history and methods of study.

Processes of evolution and methods of study.

Tree thinking (in contrast to group thinking), skills in application.

Population thinking (in contrast to typological thinking), skills in application.

Knowing about the recent trends on the origin of Angiosperms

Unit I. Biological Databases and Sequence Alignment

Primary sequence databases (Protein and DNA databases), secondary databases, composite databases; Online international database access

Evolutionary basis of sequence alignment; Optimal alignment methods- Dot Plot, dyanamic programming, similarity searching, algorithms of FASTA, BLAST; Multiple Sequence alignment- CLUSTAL W .

Unit II. Phylogeny: Concept, definitions and terms

Primitive and advanced, homology and analogy, parallelism and convergence, monophyly and polyphyly;Phylogenetic analysis; The nature of phylogeny; How we depict phylogeny?; The importance of homology, polarizing characters of homology; Rooting Trees; The problem of homoplasy; Statistical significance of alignment; Substitution Scores and Gap penalties; Introduction to Parsimony method.

Unit III: Biological diversity

The evolutionary theory by Darwin and Wallace; Tree of Life; The fossil record; Phylogeny and the fossil record. Rates of evolution;Geological time scale, Continental Drift, Land Bridges, shifting of poles, theories of differentiation and natural selection,

centre of origin, theory of tolerance, phytogeographic regions of the world, Botanical provinces of India and their characteristic vegetation with emphasis on Vegetation and Phytogeography of the Western Ghats.

Unit IV. Microevolution and Macroevolution

Genetic drift, coalescence; Founder effects; Neutral theory of molecular evolution; Natural selection; Adaptation in action; Levels of selection;Genetical theory of natural selection; Fitness, modes and models of selection; Evolution of phenotypic traits, conflict and co-operation; Species and speciation; Reproductive success; Co-evolution.

Phylogenetic trees, reading and using trees;Inferring phylogenies; Gene trees, species trees;Patterns of evolutionary change; Adaptive radiation.

Unit V. On the Origin of Angiosperms

A critical study of the current ideas on the origin of Angiosperms with special reference to their ancestral stock, time and place of origin;The concept of primitive angisoeprm flower; Theories on origin and evolution of flower; Co-evolution of flowers vis-à-vis pollinators;Origin and evolution of structure and morphology of stamens, nectarines and nectar;Origin and evolution of carpels: different types- concept of foliar origin of carpels, types of ovary, evolution of placentation types- inferior ovary- foliar and axial concepts.

Lab (BOPDLD3)

1. Computer simulation practical: studying population genetics using Popgene.
2. Reading and interpreting a DNA chromatogram.
3. BLAST search for homology.
4. Multiple sequence alignment of the plant gene for homology prediction.
5. Finding Open Reading Frame using ORF Finder.
6. Construction of phylogenetic trees with Parsimony method using MEGA.

Reading:

1. David Briggs, Stuart Max Walters (1997). Plant Variation and Evolution, Cambridge University Press.
2. Douglas J. Futuyma (1998). Evolutionary Biology (3rd Edition), Sinauer Associates. 23
2. Mark Ridley (2003) Evolution (3rd edition), Blackwell.

3. Roderic D. M. Page, Edward C. Holmes (1998). Molecular Evolution: A Phylogenetic Approach, Blackwell.
4. Scott R, Freeman and Jon C. Herron (2003). Evolutionary Analysis, Prentice Hall.

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 4: Environmental Microbiology

Course code: BOPBTD4

(Credits: Theory-3, Practical-2)

Learning Outcomes:

The main objective is to understand the role of microbes in biogeochemical processes in different ecosystems.

To give information about various pollution sources and preventive measures to control pollution.

To learn in depth of various effluent treatments

Recognise and use the properties of microorganisms, principally bacteria, to remedy problems of contamination and other environmental impacts

Understand the various concepts of ecology

Aware of biogeochemical cycles – Carbon, Nitrogen, Phosphorus cycles etc. and microbes involved

Capable to assess the quality of water

Able to analyze solid waste management by various methods

Apply the various effluent treatment methods

Monitor the health status of ecosystems using AI

Unit I: Microorganisms and their Habitats

Structure and function of ecosystems-Terrestrial Environment: Soil profile and soil microflora Aquatic Environment: Microflora of fresh water and marine habitats Atmosphere: Aeromicroflora and dispersal of microbes Animal Environment: Microbes in/on human body (Microbiomics) & animal (ruminants) body. Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels. Microbial succession in decomposition of plant organic matter

Unit II: Aerobiology

Microbial contamination of air-Sources of contamination-Biological indicators of air pollution. Enumeration of bacteria from air, Air sampling devices. Significance of air Microflora, Air sanitation. Air pollution : Types, source, method of sampling, measurement, impact on ecosystem and control. Control of noise and air pollution by biotechnological methods. Gaseous pollutants and odours: General sources, methods of control; fundamentals of adsorption, mechanism of adsorption.Application of adsorption for control of gaseous and odour emission. Noise pollution: Source, measurement, impact on ecosystem and control.

Unit III: Aquatic Microbiology

Microbiology of water (Aquatic environment-Fresh and Marine)-Water pollution: Impurities in water, water pollution by industrial waste, examination of water, collection of water samples, water analysis – physical, chemical and biological. Assessment of water quality (Chemical and Microbialindicator organisms) Water treatment processes: Primary treatment, screening, skimming with coagulants, flocculation, filtration, aeration and disinfection; Secondary treatment: Aerobic processes – activated sludge, oxidation ditches, trickling filter, towers, rotating discs, rotating drums, oxidation ponds. Anaerobic digestion, anaerobic filters, Up flow anaerobic sludge blanket reactors; Tertiary treatment: Activated carbon treatment, reverse osmosis and electro dialysis. Water borne pathogens.

Unit IV: Solid Waste Management

Sewage sludge treatment and utilization, refuse disposal, excreta disposal in unsewered area; composting and vermiculture.; bioconversion of cellulosic wastes into protein and fuel ;biodegradation of noncellulosic wastes for environmental conservation; bioaugmentation and biostimulation,; biodegradation of xenobiotics; bioremediation of contaminated soils and waste lands; radioactive product waste disposal.

Sources of pollution, impact on ecosystem and treatment of following industrial effluents: starch, paper and pulp, tannery, dairy, textile, distillery, oil refineries and pharmaceutical. Significance of ETP, STP, AHU, Bio inactivation plant. Microbes in mining, ore leaching, oil recovery, biopolymers, biosurfactants

Unit V: AI in Environmental Microbiology

Artificial Intelligence in monitoring the environment, species protection, saving energy and efficient agriculture. • Hsieh, William. (2009). Machine learning in the environmental sciences. Neural networks and kernels.

Expert lectures, online seminars – webinars •

Lab (BOPDLD4)

As per the course

Suggested Readings

1. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
2. Madigan MT, Martinko JM and Parker J. (2014). Brock Biology of Microorganisms. 14th edition. Pearson/ Benjamin Cummings
3. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press
4. Okafor, N (2011). Environmental Microbiology of Aquatic & Waste systems. 1st edition, Springer, New York 5. Singh A, Kuhad, RC & Ward OP (2009). Advances in Applied Bioremediation. Volume 17, Springer-Verlag, Berlin Hedeilberg
5. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA Campbell RE. (1983). Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
6. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
7. Lynch JM & Hobbie JE. (1988). Microorganisms in Action: Concepts & Application in Microbial Ecology. Blackwell Scientific Publication, U.K.
8. Martin A. (1977). An Introduction to Soil Microbiology. 2nd edition. John Wiley & Sons Inc. NewYork & London.
9. Stolp H. (1988). Microbial Ecology: Organisms Habitats Activities. Cambridge University Press,Cambridge, England.
10. Subba Rao NS. (1999). Soil Microbiology. 4th edition. Oxford & IBH Publishing Co. New Delhi.
11. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition.McGraw Hill Higher Education.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14 Environmental Science – All modules 2 https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-89-environmentalmicrobiology-fall-2004/syllabus/ Environmental Microbiology – study

materials of MIT 3 https://swayam.gov.in/nd1_noc20_ce17/preview - Applied Environmental Microbiology

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DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 5: Herbal Product Development and Formulation

Course code: BOPBTD5

(Credits: Theory-3, Practical-2)

Learning Outcomes:

To learn and understand the advances in the field of identification and isolation of drugs of herbal origin, various phytopharmaceuticals, nutraceuticals and their medicinal use and health benefits and to develop products based on herbs.

Upon completion of the course, the student shall be able to know the

Basics of the herbal based industry, its requirements and production of drugs.

Knowledge of various phyto-pharmaceuticals and their source, its utilization and medicinal value.

Various nutraceuticals/herbs and their health benefits.

Drugs of herbal origin.

Herbal pharmacovigilance.

Herbal product development

Unit-I : Introduction

Herbal Based industry: Scope, study of infrastructure, staff requirements, project profiles, equipments, processing, research and development & Regulatory requirements. Role of natural products in herbal medicines. General status and importance of herbal medicines. Safety of herbals/herbal pharmacovigilance.

Unit -II : Herbs as raw materials

Definition of herb, herbal medicines, herbal medicinal product and herbal drugpreparations. Source, selection, identification and authentication of herbal materials. Drying and processing of herbal raw materials. Packing and labelling of finished products.

Unit-III :Standaridization of herbal extracts

Physical, chemical, spectral and toxicological standardization, qualitative and quantitative estimations exemplified by the methods of preparation of at least two standardized extracts.

Stability studies for extracts. Predictable chemical and galenical changes

Unit-IV : Herbal Product Development

Preparation of liquid orals, tablets, capsules, ointments, creams and cosmetics.

Methods involved in monoherbal and polyherbal formulation with their merits and demerits.

Excipients used in herbal formulation, Compatibility studies, Stability studies Bioavability & Pharmacokinetic aspects for herbal drugs.

Quality Control of finished herbal medicinal products.

Unit -V: Screening of natural products for the following biological activities

(a)Antidiabetic (b)Antifertility (c)Antihypertensive (d) Antiarrhythmics (e)Antipyretics (f)Antioxidants (g)Antibacterial (h)Antifungal (i)Antiepileptics (j)Osteoporosis (k) Nephroprotective (l)Immunomodulators and (m)Alzheimers etc.

Lab (BOPDLD5)

As per the course

Suggested readings

1. Pharmacognosy by G.E. Trease, W.C.Evans, ELBS.
2. Pharmacognosy by Verno E. Taylor, Linn.R.Braddy, James E.Robberts, K.M.Varghese Co.Mumbai.
3. Text Book of Pharmacognosy by T.E.Wallis, CBS Publication, Delhi.
4. Clark's Isolation and Identification of drugs by A.C.Mottal.
5. Drug Analysis by Chromatography by P.K.Lalla
6. Phytochemical methods of chemical analysis by Harborne
7. Quantitative Thin layer chromatography and its industrial application by TrieberL.R.
8. HPTLC- Quantitative analysis of Pharmaceutical Formulation by P.D.Sethi
9. Plant drug analysis by H.Wagner
10. Indian Herbal Pharmacopoeia Vol.I and II

11. British Herbal Pharmacopoeia
12. Herbal drug industry by R.D.Chaudhari
13. The compleate German Commision E. Monographs- Bluementol, Busse, Goldberg Greenwald. Hall, klien, Riggins and Rister
14. Quality control methods of Herbal Drugs by Pulok.V.Mukherjee
15. HPLC methods of drug analysis by Mantuke Ghosh
16. Standardisation of botanicals testing and extraction methods of Medicinal Herbs by Dr. Rajpal.Vol. I and II
17. General Pharmacy by J.W. Cooper and Coline Gunn
18. Tutorial Pharmacy by S.J.Carter
19. Cosmeceuticals- Drugs Vs Cosmetics by Peter ElsnerandHovard. D. Maibach
20. Herbal Medicinal Plants by Fraukle and Barbana Steinhoff
21. Research guideline for evaluating for the safety and efficacy of herbal medicines, WHO publications (ISBN)
22. Quality control methods for medicinal plant materials- WHO

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 6: Microbial Physiology

Course code: BOPBTD6

(Credits: Theory-3, Practical-2)

Learning Outcomes

On completion of the course, the student should be able to:

Explain principles/concepts involved in bacterialphysiology

Gain knowledge on basic aspects of bacterial respiration and photosynthesis

Understand bacterial energetics (energy production and utilization)

Understand different fermentation techniques and their utilization in industrial growth

Understand role of physiological adaptations under stress conditions.

Unit I: Bacterial Photosynthesis

Photosynthetic microorganisms, photosynthetic pigments, and generation of reducing power by cyclic and non-cyclic photophosphorylation, electron transport chain in photosynthetic bacteria. Carbon dioxide fixation pathways.

Unit II: Bacterial Energetics and N_2-Fixation

Concept of aerobic respiration, anaerobic respiration and fermentation, Components of respiratory chain, and their inhibitors. Oxidative phosphorylation: ATP synthesis and ATP synthase. Bacterial anaerobic respiration: Introduction. Nitrate, carbonate and sulfate as electron acceptors. Electron transport chains in some anaerobic bacteria. Catalase, super oxide dismutase, mechanism of oxygen toxicity.

Nitrogen Fixation – Physiology of nitrogen cycle. Assimilatory and dissimilatory nitrate reduction, biological nitrogen fixation. Nitrogen fixers and mechanism of nitrogen fixation, Genetics of nitrogen fixation. Denitrification, nitrate/nitrite respiration.

Unit III: Bacterial Metabolism

Glycolysis, PPP, ED pathway, Citric acid cycle: Branched TCA and Reverse TCA, glyoxylate cycle. Utilization of sugars other than glucose and complex polysaccharides

Metabolism of amino acids: Amino acid biosynthesis and utilisation, polyamine biosynthesis and regulation.

Biosynthesis and degradation of lipids, Purine and pyrimidine biosynthesis and regulation

Unit IV: Bacterial Transport Mechanisms

Structure and organization of membrane, Solute Transport (passive diffusion, facilitated diffusion, active diffusion), Proton Motive Force, PTS, role of permeases in transport, ABC transporters, Phosphotransferase system, Drug export systems, amino acid transport, liposomes and proteo-liposomes.

Unit V: Physiological Adaptations and Intercellular Signaling

Sporulation - molecular architecture of spores, induction and stages of sporulation, Influence of different factors on sporulation. Cytological and macromolecular changes during sporulation. Heat resistance and sporulation.

Introduction to two component system, regulatory systems during aerobic- anaerobic shifts (Arc, Fnr, Nar, FhlA regulon), response to phosphate supply: The Pho regulon, Quorum sensing, Heat-Shock responses, pH homeostasis, osmotic homeostasis.

Lab (BOPDLD6)

As per the course

Suggested Readings (Latest available edition):

1. Microbial Physiology and Metabolism. Caldwell D.R., Brown Publishers.
2. Microbial Physiology by Moat A.G. and Foster J. W., Wiley- Liss.
3. Prokaryotic Development by Brun. Y.V. and Shimkets L.J. 2000. ASM Press.
4. Advances in Microbial Physiology. Volumes. Edited by By A.H. Rose. Academic Press, New York.

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 7: Plant Stress Biology

Course code: BOPBTD7

(Credits: Theory-3, Practical-2)

Learning Outcome:

Achieve a good working knowledge of concepts, principles, and recent discoveries in plant stress biology.

Read, discuss, and critically evaluate recent research papers related to plant stress biology.

Unit I: Basic Concept of stress

Introduction. Plant and environment, environmental strain, environmental extremities. Stress and life, acclimation, adaptation.

Concept of plant stress, stressors, eustress, distress, biotic and abiotic stresses, the stress syndrome, stress phases, alarm reaction, hardening, resistance, exhaustion. Phenotypical plasticity, acclimation, adaptation. Stress and evolution.

Stress response, specific and aspecific responses, general and specific markers. Synergism, antagonism. Tolerance, avoidance, cross-tolerance.

Unit II: Components and signalling in stress response

Components and functioning of signal transduction pathway, sensing, receptors, signal transduction in the membrane and in the cell, signal transduction cascades. Kinases, calmodulin. Role of second messengers (Ca2+, inositol-phosphatides, NO, H2O2, etc)

Role of hormones in signal transduction. Abscisic acid, jasmonic acid, electrical signal transduction. Plant "neurobiology", integration of signal transduction processes.

Unit III: Oxidative stress

Oxidative stress. Production of active oxygen forms in plants, their physiological effects. Oxidative damage of macromolecules. Protective mechanisms. Sensing of anoxia and hypoxia caused by flooding. Signal transduction.

Unit IV: response to various abiotic stresses

Various abiotic stress. Role of membranes in sensing, heat shock proteins. Antifreeze proteins and other protecting mechanisms.

Sensing of drought stress, water deficit compensating mechanisms. ABA dependent and -independent responses. Role of proline and glycine-betaine.

Salinity stress, mechanism of salt tolerance. Salt sensing, salt stress signaling. Possible responses.

Photoinhibition, stress caused by excess light. Inhibition on donor or acceptor side of PS2. Repair cycle. Role of active oxygen forms. Protective mechanisms, xanthophyll cycle, functioning of ELIP-s. UV-B stress.

Unit V: Stress caused by xenobiotis

Stress caused by xenobiotics, lethal and nonlethal toxifications. Inhibition of enzymes, generation of active oxygen forms. Protective mechanisms. Possible reasons for resistance to xenobiotics.

Lab (BOPDLD7)

1. Seedling stress assay
2. Seed germination assay
3. Leaf disc assay
4. Measurement of osmotic potential using vapour pressure osmometer
5. Determination of Sodium and Potassium in plant tissue
6. Measurement of water content in soil and plant tissue
7. Imposition of drought by gravimetric approach
8. Photosynthetic pigments analysis in plants
9. Estimation of chlorophyll stability index and carotenoid stability index inleaf tissue
10. Estimation of proline content in plant tissue
11. Estimation of antioxidant enzymes

Suggested Readings

1. Jenks M. A. and Hasegawa P. M. (eds..) Plant Abiotic Stress p.270. Blackwell Publishing, Oxford (2005)
2. Smirnoff N. (ed.) Antioxidants and Reactive Oxygen Species in Plants p. 302. Blackwell Publishing, Oxford (2005)

3. Huang B. (ed.) Plant-Environment Interactions p.388 Taylor & Francis Boca Raton, etc (2006)

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 8: Environmental Biology

Course code: BOPBTD8

(Credits: Theory-3, Practical-2)

Learning outcomes

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

Develop foundation on Environmental Biology and concept of structure and function of different compartments of the Environment.

Gain scientific perspective of the issues confronting our present-day environment.

Enable to analyze the national and global environmental issues relating to atmosphere, water,
soil and land use, environmental impact assessment and current trends in environmental management

Unit I: Introduction to the Environment

Vedic science in environment and current understanding; Introduction to environmental thought, Early issues in Indian environmentalism, Urbanization and environment

Unit II: Air Pollution

Sources of air pollution and types, Introduction to meteorology and transport of air pollution Effects of Air Pollution on human beings, plants, animals and ecosystem, Air Pollution in Indian perspective

Unit III: Water Pollution

Different aspects of water pollution in ground and surface water, waste water treatment & biological remediation

Unit IV: Soil Pollution

Chemical and mineralogical composition, physico-chemical properties of soil, soil pollution with especial reference to emerging persistent organic pollutants.

Unit IV: Environmental impact assessment& Environmental management

An introduction. Environmental policy, Concept of Sustainability, Sustainable Development and its different constituents, Environmental management strategies

Lab (BOPDLD8)

1. To estimate dust holding capacity of different plant species
2. To monitor Total Suspended Particulate matter (TSPM) in ambient air
3. To monitor Respirable Suspended Particulate matter (RSPM) in ambient air
4. Analysis of Soil and Water: Different Physicochemical parameters
5. Study of various ground water sources and its quality.
6. Preparation of Wind rose diagrams

Suggested Readings:

1. Ecology, Environmental Science and Conservation, by JS Singh, SP Singh and SR Gupta, 2014. S Chand Publication.
2. Pepper, Ian. Environmental chemistry. Wiley Publication. UK.
3. Ecology and environment 13th edition, by PD Sharma, Rastogi Publication.
4. Bell and Treshow 2002. Air Pollution and Plant Life. Willey Publication. UK

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 9: Agricultural Microbiology

Course code: BOPCTD9

(Credits: Theory-3, Practical-2)

Learning Outcomes:

To gain knowledge about fundamentals of Agriculture Microbiology.

To understand the concept of microbial interactions with plants and diseases caused by microbes.

To learn about Biopesticides, Bioherbicides and Biofertilizers.

To learn the scope and applications of Artificial intelligence and Machine learning in agricultural microbiology

To learn about role of earth worms-microbes interactions

Gain wide information about agricultural microbiology. K3

Able to formulate, produce and guide the usage of biopesticides, bioherbicides and biofertilizers to the needy farmers K6

Able to understand the scope and applications of AI & ML. K4

Able to start small scale industries on spirullina and mushroom cultivation.

Unit I: Basics of Soil Microbiology

Soil Microbiology-Structure, Types, Physical and Chemical properties-Soil microbes (Types and Enumeration)-Weathering and Humus formation, Soil pollution-Sources. Biogeochemical cyclingNitrogen, Carbon, Phosphorous, Sulphur, Iron cycles and its importance.

Unit II: Microbial Interactions

Microbial interaction-among microbes- Neutralism, Commensalism, Symbiosis, Synergism, Amensalism, Parasitism, Predation and Competetion. With plants-Phyllosphere, Rhizosphere, Mycorhizzae - vesicular arbuscular mycorrhizae -VAM) - ecto, endo, ectendomycorrhizae . Symbiotic and free-living nitrogen fixers (Rhizobium, Azotobacter, Azospirillum, Frankia, BGA and Azolla -Phosphate solubilizers

(Phosphobacterium and Aspergillus) Interrelationships between soil microbes and plants, Rhizosphere concept, R:S ratio, rhizoplane; spermosphere; phyllosphere, Mycorrhizae-types, Rumen flora, Insects microbial interactions

Unit III: Phytopathology

Phytopathology – Classification of plant diseases, signs, and related terminology. Bacterial disease – Citrus canker, Blight of paddy, Fungal Disease- Red rot of sugarcane, Black stem rust of wheat, Tikka leaf spot, Wilt of cotton, Viral Disease – TMV, Vein clearing disease. Principles and methods of plant disease management, integrated plant disease management.

Unit IV: Biocontrol Agents and Symbiotic Microorganisms

Interaction of pesticides with soil microorganisms. Biopesticides- Bacillus thuringiensis, B. Sphaericus, B. Popilliae, Psuedomonassyringae. Microbial control of plant pathogensTrichoderma, Use of Baculovirus, NPV virus, Protozoa & Fungi in biological control. Microbial herbicides-Useful genes from microorganisms for agriculture (Herbicide resistant, Bt, Viral). Agricultural antibiotics.

Earthworms and microorganisms- The effects of earthworms on the number, biomass and activity of microorganisms, Role of Earth worms in organic agriculture. Production, formulation, packing and marketing of single cell proteins (mushrooms, spirullina and yeast); BiofertilizersIntroduction, biofertilizers using nitrogen fixing microbes-phosphate solubilisation- *Rhizobium, Azospirillum, Azolla; Anabaena* symbiosis, Blue green algae and Ecto and Endomychorizae. Cultivation, mass production and inoculation of *Rhizobium, Azobacter, Azospirillum, Azolla* and *Cyanobacteria*, Carrier-based inoculants, methods of application, quality control and agronomic importance. Application methods. Microorganisms for Bioassay and Biological warfare.

Unit V: AI in Agricultural Microbiology

Expert lectures, online seminars – webinars Scope of Artificial intelligence (AI) -Disease detection-health monitoring of crops. Applications of machine learning (ML)-prediction of microbial species-microbial communities to predict diseaseinteraction between microbes; Microbiome –disease association.

Lab (BOPDLD8)

As per the syllabus topics

Suggested Readings

1. Dirk J, Elas V, Trevors JT, Wellington, EMH (1997) Modern Soil Microbiology, Marcel Dekker INC, New York.
2. Agricultural Microbiology by G.Rangaswamy and D.J.Bagyaraj, Prentice Hall India.
3. Bio-fertilizers in Agriculture and Forestry, 1995, by N.S. SubbaRao.
4. Microbes for Sustainable Agriculture by K.V.B.R. Tilak, K.K. Pal, RinkuDey
5. Soil Microbiology and Plant Growth, 1995, by N.S. SubbaRao.
6. Plant Growth and Health Promoting Bacteria by Dinesh K. Maheshwari
7. Plant-microbe interactions and biological control Volume 63 of Books in soils, plants, and the environment by Greg J. Boland, L. David Kuykendall
8. Plants, genes and agriculture by M.J. Chrispeels and D.F. Sadava.2000.The American Scientific Publishers, USA.
9. Practical Application of Plant Molecular Biology by R.J. Henry.1997. Chapmans and Hall. Page 17 of 82 M.Sc. Microbiology 2020-21 onwards - UD - Annexure No. 79A SCAA DATED: 23.09.2020
10. Plant Biotechnology and Transgenic Plants, Edited by Kirsi-MarjaOksman-Caldentey and Wolfgang H. Barz. 2002, Marcel Dekker, Inc. New York.
11. Chauhan, A. (2012)Vermitechnology, Vermiculture, Vermicompost and Earthworms: Vermiculture, Vermicomposting, Vermitechnology and Mirobes,Lambert Academic Publishing, Germany

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

https://nptel.ac.in/courses/126/105/126105014/

https://swayam.gov.in/nd1_noc19_ag04/preview

https://www.youtube.com/watch?v=-UFiFpMxM3M

https://www.youtube.com/watch?v=mU1tlx0JGM8

https://www.youtube.com/watch?v=gsH3kR-6mG4

http://agrimoon.com/agricultural-microbiology-icar-ecourse-pdf-book/

https://www.youtube.com/watch?v=U9sDkDhmf08

https://www.frontiersin.org/articles/10.3389/fpls.2019.01457/full

https://www.youtube.com/watch?v=8YuqlgsC4ns

https://www.frontiersin.org/articles/10.3389/fpls.2016.01419/full

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DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 10: Biodiversity and Conservation

Course code: BOPCTD10

(Credits: Theory-3, Practical-2)

Learning outcomes:

The students will have following important knowledge after completing the course

Basic concepts of diversity and its important components

Distribution pattern of biodiversity on the globe

Importance of biodiversity for human beings

Why biodiversity conservation is needed?

Unit I– Biodiversity:

Concept and definition, Composition and Scales of Biodiversity: Genetic Diversity, Species diversity, Ecosystem Diversity, Agrobiodiversity.

Unit II- Biodiversity Distribution:

Origin of Species; Global biodiversity patterns and biodiversity in geologicaltimes; Current Centers of Biodiversity

Unit III - Values of Biodiversity:

Utilitarian value and their categories, Direct and Indirect values; value, value of biodiversity in monetary terms.

Unit IV - Threats to Biodiversity:

Habitat loss and its fragmentation, Transformation, Degradation and Loss: Invasive Species: introduction and biological impacts of invasive species onterrestrial/ aquatic systems; Pollution and biodiversity.

Unit V- Biodiversity Extinction:

Types of Extinctions, Processes responsible for Species Extinction, Current andFuture Extinction Rates, IUCN Threatened Categories

Lab (BOPDLD9)

1. To determine the species diversity in different terrestrial ecosystems.

1. 2 To determine various diversity indices (Shannon-Wiener, Concentration of Dominance, Species richness, Equitability and B-diversity)

2. Field visits to different degraded ecosystems.

Suggested Readings:

1. Groom, M. J., Meffe, G. R. and C. R. Carroll. 2006. Principles of Conservation Biology.Sinauer Associates, Inc., USA.
2. Krishnamurthy, K. V. 2003. Textbook of Biodiversity. Science Publication.
3. Primack, R. 2006. Essentials of Conservation Biology.Sinauer Associates, Inc., USA.
4. Hambler, C. 2004. Conservation. Cambridge University Press.
5. Van Dyke,F.2008.Conservation Biology Foundations, Concepts, Applications 2nd Edition, Springer.

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 11: Ethnobotany and Traditional knowledge

Course code: BOPCTD11

(Credits: Theory-3, Practical-2)

Learning outcome:

Appreciate the need to conserve floristic and cultural diversity of the region.

Rescue and document Ethnobotanicals for sustainable use of plant resources.

Understand the need for development of new drugs for safe and more rational use of herbal preparations.

Recognition of intellectual property rights (IPR) and its benefit to people and society, who share their knowledge and wisdom.

Develop laboratory skill in testing of herbal drugs and new commercial products.

Unit-I: Ethnobotany

Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science. The relevance of ethnobotany in the present context; Major and minor ethnic groups or Tribals of India, and their life styles. Plants used by the tribals: a) Food plants, b) intoxicants and beverages and c) Resins and oils and miscellaneous uses.

Unit-II: Indigenous, Traditional Knowledge

Brief history and use of medicinal herbs; Introduction to indigenous systems of medicines; Ayurveda, Unani and Siddha system of medicine. Ethnomedicine: Definition, history and its scope; Interdisciplinary approaches in ethnobotany; Collection of ethnic information, Plants used by ethnic groups as food, medicines (Ethnomedicine), beverages, fodder, fiber, resins, oils, fragrances and other uses. Methods of ethnobiological study, Definition of Traditional Knowledge (TK), Traditional Knowledge Resource Classification (TKRC), importance of traditional knowledge, Traditional plant knowledge of Indian tribes - sources and problems with reference to central India, Traditional Knowledge Digital Library (TKDL)

Unit-III: Methods and techniques used inEthnobotany

Field level activities for data collection- Approach, Documentation (Audio, Video recording, Photographs, Interview- Methods, Questionnaire, and Data sheet), Consent forms, Authentication of plant species (Field Book, Herbarium) Field and Lab Procedures, Preparation of DataSheet and Database. People's biodiversity Register (PBR). Impact of Ethnobotany in herbal-medicine industry, land-use development, agriculture, forestry, betterment of rural livelihoods and education. Biodiversity and conservation of some useful medicinalplants.Sharing of wealth concept with few examples from India.

Unit-IV: Role of ethnobotany in modern Medicine

Medico-ethnobotanical sources in India; Role of ethnopharmacology in drug development, Significance of the important plants in ethno-botanical practices along with their habitat and morphology.

Unit-V: Intellectual Property Rights (IPR)

Definition & types of IPR, general account and importance of patents, copyrights (plants, utility and design) trademarks, geographical indicators and trade secret.

Lab (BOPDLD10)

1. Collection, identification and preparation of herbarium of ten ethnobotanically important plants with appropriate references.
2. Preparation of crude extract of ethnobotanically important plants with appropriate references (any method to be used).
3. Project work-documentation, literature survey, and collection of information on ethnobotanically useful plants from traditional healers.
4. Local field study tour for plant wealth survey and report writing.
5. Study of locally available traditional medicinal plants uses by tribal communities.
6. Field visits to identify and collect ethnomedicinal plants used by local tribes/folklore.

Suggested Readings:

1. Acharya, D., Jose Luis Rios, Rai, M. (2011) Ethnomedicinal Plants Revitalizing of Traditional Knowledge of Herbs, CRC Press, USA.
2. Colton C.M. 1997. Ethnobotany: Principles and applications. John Wiley and sons, Chichester

3. Cunningham, A. B. (2001). Applied Ethnobotany. Earthscan publishers Ltd. London & Sterling, VA, USA Cotton, C.M. (1996).
4. Das, A.P. and Pandey, A.K., 2007. Advances in Ethnobotany, Bishen Singh and Mahendra Pal Singh, Dehradun.
5. Dutfield, G. (2000) Intellectual Property Rights Trade and Biodiversity, Earthscan, London, United Kingdom
6. Gary J. Martin, G.J. (2014) Ethnobotany: A Methods manual, U.K.
7. Jadhav, D., (2008) Medicinal Plants of Madhya Pradesh and Chhattisgarh, Publisher: Daya Publishing House, New Delhi.
8. Jain, A.K., (2016) Indian Ethnobotany: Emerging Trends, Scientific Publishers, Jodhpur.
9. Jain, S. K. (1991). Dictionary of Indian Folk Medicine and Ethnobotany, Deep Publications, New Delhi.
10. Jain, S.K., Manual of Ethnobotany, Scientific Publishers, Jodhpur, 1995.
11. Kaufman Peter B.*et al*., 1990, Natural Products from Plants, CRC Press, UK.
12. Pullaiah, T., Krishnamurty, K.V. and Bahaduur, B. (2016) Ethnobotany of India, Vol. 5, The Indo-Gangetic Region and Central India, Apple Academic Press USA.
13. Sengupta, N. (2019) Traditional Knowledge in Modern IndiaPreservation,Promotion, Ethical Access and Benefit Sharing Mechanisms, Springer India.

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 12: Herbal Cosmetics

Course code: BOPCTD12

(Credits: Theory-3, Practical-2)

Learning Outcomes:

After undergoing this course students will be able to:

Explain the economic aspects of various herbal/natural cosmetic preparations

Describe the regulatory provisions and the principles of various herbal/natural cosmetic preparations

Analyse commonly used raw materials and design of herbal cosmetic formulations.

Develop the skill to formulate and evaluate herbal cosmetics

Apply the test methods in the analysis of cosmetics, as per Drug and Cosmetics Act and also toxicity screening methods.

Discuss the market potential of herbal cosmetics and various aspects including its raw materials, preparations and analysis.

This subject deals with the study of preparation and standardization of herbal/natural cosmetics. This subject gives emphasis to various national and international standards prescribed regarding herbal cosmeceuticals.

After completion of the course, student shall be able to

Understand the basic principles of various herbal/natural cosmetic preparations.

Current Good Manufacturing Practices of herbal/natural cosmetics as per the regulatory authorities.

Unit I: Introduction

Herbal/natural cosmetics, Classification & Economic aspects

Regulatory Provisions Relation to Manufacture of Cosmetics, License, GMP, offences & Penalties, Import & Export of Herbal/natural cosmetics, Industries involved in the production of Herbal/natural cosmetics

Unit II: Herbal cosmetics

Commonly used herbal cosmetics, raw materials, preservatives, surfactants, humectants, oils, colors, and some functional herbs

Pre-formulation studies, compatibility studies, possible interactions between chemicals and

Herbs, Design of herbal cosmetic formulation

Unit III: Herbal Cosmetics science

Physiology and chemistry of skin and pigmentation, hairs, scalp, lips and nail, Cleansing cream, Lotions, Face powders, Face packs, Lipsticks, Bath products, soaps and baby product

Preparation and standardisation of the following: Tonic, Bleaches, Dentifrices and Mouth washes& Tooth Pastes, Cosmetics for Nails

Unit IV: Cosmeceuticals of Herbal and Natural Origin

Hair growth formulations, Shampoos, Conditioners, Colorants & hair oils, Fairness formulations, vanishing & foundation creams, anti-sun burn preparations, moisturizing creams, deodorants

Unit V: Analysis of Cosmetics

Analysis of Cosmetics, Toxicity Screening and Test Methods Quality control and toxicity studies as per Drug and Cosmetics Act

Lab (BOPDLD11)

As per the course

Suggested readings

1. Panda H. Herbal Cosmetics (Handbook), Asia Pacific Business Press Inc, New Delhi.
2. Thomson EG.Modern Cosmetics, Universal Publishing Corporation, Mumbai.
3. P.P.Sharma. Cosmetics - Formulation, Manufacturing & Quality Control, Vandana Publications, New Delhi.
4. Supriya K B. Handbook of Aromatic Plants, Pointer Publishers, Jaipur.
5. Skaria P. Aromatic Plants (Horticulture Science Series), New India Publishing Agency,

   New Delhi.
6. KathiKeville and Mindy Green.Aromatheraphy (A Complete Guide to the Healing Art), Sri Satguru Publications, New Delhi.

7. Chattopadhyay PK. Herbal Cosmetics & Ayurvedic Medicines (EOU), National Institute ofIndustrial Research, Delhi.
8. Balsam MS & Edward Sagarin. Cosmetics Science and Technology, Wiley Interscience, New York.

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 13: Microbial Technology

Course code: BOPCTD13

(Credits: Theory-3, Practical-2)

Learning Outcomes:

The students will -

Be able to understand and appreciate role of microbes in their life.

Develop theoretical and technical skills of basic microbiology (sterilize, isolate, culture, preserve microbes).

Understand the physiological, biochemical and molecular mechanisms underlying the use of microbes in human welfare and environment.

Unit I: General Microbiology:

Diversity of the microbial world; Microbial nutrition, growth and metabolism

Unit II: Agricultural Microbiology:

Agriculturally important microorganisms; Biological nitrogen fixation; Mycorrhizae, microbial mineralization, Biocontrol of plant diseases, Plant growth promoting rhizobacteria (PGPR).

Unit III: Microbes and quality of environment:

Distribution and implications of microbes in air – bio-aerosols, microbial flora of water, water pollution, drinking water and domestic waste treatment systems; Microbial pesticides, microbial degradation of pesticides and toxic chemicals, biodegradation of the agricultural residues, bioremediation of contaminated soils. Microbes in nanotechnology, biosensors; Microbes in extreme environments.

Unit IV: Food and industrial microbiology:

Fermentation, fermented foods, fermenter design and growth processes, food spoilage, methods of food preservation; Microbes in recovery of metal (bioleaching) and oil, Cell and enzyme immobilization, microbial enzymes of industrial interest; Novel medicines from microbes.

Lab (BOPDLD12)

As per the course

Suggested Readings:

1. Willey, Joanne M.; Sherwood, Linda M. and Woolverton, Christopher J. 2017. Prescott's Microbiology, 10th Edition, McGraw-Hill, USA
2. Okafor, Nduka and Okeke, Benedict C. 2018. Modern Industrial Microbiology and Biotechnology, 2nd Edition, CRC Press, Boca Raton
3. Subba Rao, N. S. 2018. Soil Microbiology, 5th Edition, Medtech, New Delhi
4. Subba Rao, N. S. 2018. Advances in Agricultural Microbiology, 2nd Edition, Medtech, Department of Botany, University of Delhi 39 New Delhi
5. Aneja, K. R. 2016. Laboratory Manual of Microbiology and Biotechnology, Medtech, New Delhi.

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 14: Plant Propagation and Nursery Development

Course code: BOPCTD14

(Credits: Theory-3, Practical-2)

Learning Outcome

Student can go for establishment of their own nursery where they can multiply the plants of their own interest as per demand.

The study will be helpful for propagation and care of varied valuable plant species such as ornamental, medicinal and other important plants.

To circulate technical knowledge related to plant propagation and for nursery development it will be beneficial.

Unit I:.Plant nursery

What is and why need, Types, Significance, Basic Requirements to set up a Plant Nursery, Steps involved in its set up. Components for Nursery Development. Glass house and green house.

Unit II:.Plant Propagules

Vegetative plant parts and Seeds, Modifications of plant parts – as a source of new plantlets, Biotic and abiotic agents and their role in plant development.

UnitIII:.Plant Propagation

Methods for Plant Propagation using by Vegetative/modified plant parts and by seeds, Budding, Layering, Cutting and Grafting and their significance of plant propagation.

Unit IV: Plant Tissue culture

Basics of tissue culture, Requirements, Precautions, Totipotency, Callus and Cell differentiation, Morphogenesis. Application of plant tissue culture in plant propagation and conservation. Hybrids and Cybrids, Artificial Seeds.

Unit V: Seeds as a source of new plantlets

Basic structure of flower,Steps involved in Seed development, Embryo sac and endosperm, Seed structure, diversity, types, dispersal and germination.

Lab (BOPDLD13)

1. To Study Monocot and Dicot Seeds
2. To study structure of seeds
3. Experiment on Plant propagation using Stem/leaf cutting
4. Experiment on Budding in plants
5. Experiment on Layering in plants
6. Experiment on Grafting in plants
7. To study on variation in Seeds
8. To study on Seed dispersal
9. To study aerial plant parts modification
10. To study underground plant parts modification.

Suggested Reading

1. PullaiahE., RaoT., SubbaM.V. and Sreedevi E., 2017, Plant Tissue culture, Scientific publisher.
2. Razdan M.K. Introduction to Plant Tissue culture, Oxford & IBH Publishing Co Pvt.Ltd
3. Sharma P. C. Plant Tissue Culture, Arjun Publishing House
4. Bhojwani S. S. and Bhatnagar S. P. The Embryology of Angiosperm, Vikas Publishing House Pvt. Ltd.
5. Purohit and Vyas, Medicinal plants cultivation techniques

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 15: Plant Tissue Culture and Application

Course code: BOPCTD15

(Credits: Theory-3, Practical-2)

Learning Outcome:

To understand the basic and latest techniques for in vitro culture of plants.

Providing advanced knowledge about use of plant biotechnology in breeding and micropropagation techniques.

To introduce the students to the theory and practice of plant tissue culture and their role from modifying plants in plant biotechnology to the propagation of endangered plants.

Capable of understanding the totipotency of plants.

Able to identify the cell differentiation and optimization using classical techniques and ANN.

Able to understand cell and tissue culture contributes to global sustainability

Abe to develop the graduate capabilities of knowledge ability, comprehension andapplications of plants in cell, tissue culture and genetic engineering.

It will also develop the practical skills and confidence of students to successfully

Capacity to establish commercial plant tissue culture lab.

Unit I: Basics of Plant Tissue Culture

Laboratory organization and Techniques in Plant Tissue Culture. Organ culture, root, shoot tip or meristem, ovary, flower and ovule culture and their importance.

Unit II: Principles of Cell Culture

Callus culture-principle, protocol and significance, Cell suspension culture – Principle, protocol and its importance. Totipotency, cytodifferentiation and organogenesis – Principle, factors influencing Organogenesis and applications.

Unit III: Culture Techniques

Somatic embryogenesis and synthetic seeds – Principle, protocol and importance. Single cell culture, embryo culture – Principle, protocol and applications. Anther and Pollen culture – Principle, protocol, and its significance. Protoplast, isolation, fusion and culture somatic hybridization, chemofusion, electrofusion, important properties of protoplast, somatic hybrids, cybrids – Principle, protocol and importance

Unit IV: Applications of Plant Tissue Culture

Somaclonal variation – Causes and significance, plant tissue culture in forestry, micro propagation, clonal propagation production of useful biochemicals – Gene conservation bank plant tissue culture in biotechnology-commercial aspects of plant tissue culture

Unit V: Applications in Plant Genetic Engineering

Application of transgenic plants for Biotic Stress tolerance: Herbicide resistance: phosphoinothricin and glyphosate; Insect resistance: Btgenes and alpha amylase inhibitor. Disease resistance: chitinase and 1,3-beta glucanase; Virus resistance: coat protein mediated, nucleocapsid gene; Nematode resistanc;. Abiotic stress: Drought, cold and salt; Post-harvest losses: long shelf life of fruits and flowers, male sterile lines, RNAi and Reverse genetics; Nutritional enhancement- Golden rice; Edible vaccine

ANN IN PLANT TISSUE CULTURE 7 hours Expert lectures, online seminars webinars . Introduction to Artificial Neural Network (ANN), optimization of culture conditions in plant tissue culture using ANN. E-Learning

https://www.nature.com/articles/s41598-020-60278-x
https://www.frontiersin.org/articles/10.3389/fpls.2016.00274/full
https://nptel.ac.in/courses/102/103/102103016/

Lab (BOPDLD14)

As per the course

Suggested reading

1. Kalyanakumar De. 1997. An Introduction to Plant Tissue Culture, New Central Book Agency, Calcutta.
2. Plant Biotechnology by H. S. Chawla, Oxford and IBH, 2009
3. Plant Biotechnology by B D Singh. Kalyani publisher, 2003
4. Dixon, R.A. and Gonzales, R. A. (Eds.) 1994. Plant Cell Culture - A Practical Approach. Oxford University Press, New York.

5. Gamborg, O.L and Phillips, G.C. 1998. Plant Cell, Tissue Organ Culture. 1998. Narosa Publishing House, NewDelhi
6. Gamborg, O.L and Phillips, G.C. 1998. Plant Cell, Tissue Organ Culture. 1998. Narosa Publishing House, NewDelhi.
7. Edwin F. George and Paul Sherington, D. 1984. Plant Propagation by Tissue Culture, Exegetics Ltd., Edington, Westbury, England.
8. Indra K. Vasil, 1980. Cell Culture and Somatic Cell Genetics of Plants. Academic Press Inc., New York.
9. Plant Biotechnolgy-the genetic manipulation of plants, 2nd Edition by A Slater, N.W. Scott M.R. Fowler, Oxford Univ Press (2008) Page 55 of 82 M.Sc. Microbiology 2020-21 onwards - UD - Annexure No. 79A SCAA DATED: 23.09.2020
10. R.L.M. Pierik, 1987. In vitro culture in higher plants. Martinus Nijhoff Publishers, Boston.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

https://actascientific.com/ASAG/pdf/ASAG-02-0156.pdf
https://www.sciencedirect.com/science/article/pii/S2214317319300940

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 16: Environmental Pollution

Course code: BOPDTD16

(Credits: Theory-3, Practical-2)

Learning outcome:

Students will get acquainted with following things after going through the course

They will have knowledge about problem of fluoride and arsenic in drinking water

Will get knowledge associated with aluminium industry pollutants

Students will get knowledge about less discussed but important environmental problems.

Unit I: Soil and Ground Water Contamination

Metal Contamination of soil; Ground Water Pollution-Fluoride and Arsenic Contamination.

Unit II: Aluminium Mining

Aluminium mining and Toxicity and Acid Mine Drainage; Reclamation of Degraded Wastelands (mine sites)

Unit III: Global Climate Change

Global Warming; Ozone Pollution and its Impact on Plants

Unit IV: New Environmental Problems

Ocean Acidification- Causes and Implications; Light Pollution.

Unit V: Extreme Environmental Events

Cloud bursting; Droughts; Tsunamis; Earthquakes; Cyclones

Lab (BOPDLD15)

1. Visit to aluminium mining industry and site
2. Estimation of fluoride in ground water
3. Visit to degraded ecosystem sites and reclamation sites

4. To observe effects of artificial lights on plants
5. Study of extreme environmental events through visuals and videos

Suggested Readings:

1. Larcher, W. 2003. Physiological Plant Ecology. Springer-Verlag Berlin Heidelberg.
2. Adger, W. N. 2005. Adapting to climate change. Wiley Publication. UK.
3. Bell and Treshow 2002. Air Pollution and Plant Life. Willey Publication. UK
4. Pepper, Ian. 2003. Environmental chemistry. Wiley Publication. UK.
5. Gerrish G.A, Morin J.G., Rivers T.J., Patrawala Z. 2009. Darkness as an ecological resource: the role of light in partitioning the nocturnal niche. Oecologia. 160:525–536.
6. Rich C., Longcore T. 2006a. Introduction. In: Rich C, Longcore T, editors. Ecological consequences of artificial night lighting. Washington: Island Press; p. 1–13.
7. Meyers, R.A. 2011. Extreme Environmental Events. Springer, New York, NY
8. Castillo F., Wehner M., Stone D. A. 2021. Extreme Events and Climate Change: A Multidisciplinary Approach. John Wiley & Sons, Inc.

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 17: Ethno-Pharmacognosy and Nutraceuticals

Course code: BOPDTD17

(Credits: Theory-3, Practical-2)

Learning outcomes

Knowledge of ethno traditional medicinal plants of India

Scope, medicinal value and standardization of nutraceuticals and regulatoryaspect of nutraceuticals

Occurrence, isolation, characterization, identification, biosynthesis and activityprofile of biologically active natural products.

Study for quality and safety monitoring of herbal drugs.

Unit I: Ethnobotany

Introduction, scope and relevance and interdisciplinary Science. The ethnobotanical data documentation; Traditional Botanical Knowledge (TBK), TKDL

Unit II: Nutraceuticals- Current trends and future scope

Inorganic mineral supplements, Vitamin supplements, Digestive enzymes, Dietary fibres, Cereals and grains, Health drinks of natural origin, Antioxidants, Polyunsaturated fatty acids, Herbs as functional foods, Formulation and standardization of nutraceuticals, Regulatory aspects, FSSAI guidelines. Sources, name of marker compounds and their chemical nature, medicinal uses and healthbenefits of following, Spirulina, Soya bean, Ginseng, Garlic, Broccoli, Green and Herbal Tea, Flax seeds, Turmeric and "Sattu".

Unit III: Phytopharmaceuticals

Occurrence, isolation and characteristic features (Chemical nature, uses in pharmacy, medicinal and health benefits) of following • Carotenoids – α and β – Carotene, Xanthophyll (Lutein) •Limonoids – d-Limonene, α – Terpineol•Saponins – Shatavarins• Flavonoids – Resveratrol, Rutin, Hesperidin, Naringin, Quercetin • Phenolic acids-

Ellagic acid • Vitamins •Tocotrienols and Tocopherols •Andrographolide, Glycolipids, Gugulipids, Withanolides, Vascine, Taxol • Miscellaneous

Unit IV: Classification of crude drugs

Alphabetical, Taxonomical, Morphological, Clinical, Pharmacological and Chemotaxonomic. Study of crude drugs: Bark drug-*Cinchona*; Leaf drug- *Digitalis*; Flower drug: Clove; Seed drug: *Isaphaghula*; Fruit drug: Poppy; Rhizome and root drug: *Glycyrrhiza*, Unorganized drug: *Butea*; Gums: *Acacia*, Resin: *Ferula*; Fixed oil: *Ricinus*

Unit V: Methods of drug evaluation

Morphological, physical, chemical, biological, phytochemical investigations. Preliminary phytochemical tests for alkaloids, saponins, phenolic compounds, tannins, gums, mucilage, starch, carbohydrates and glycosides

Lab (BOPDLD16)

1. Determination of Stomatal number index, Frequency and Pore Area and Organolaptic studies.
2. Documentation of traditional and local patterns of plant use and Submission of Reports.
3. Phytochemical tests for alkaloids, saponins, phenolic compounds, tannins, gums, mucilage, starch, carbohydrates and glycosides.
4. Demonstration of Phytochemical screening methods: Paper Chromatography, TLC, HPLC, Spectrophotometry etc.
5. Industry visit within and nearby areas,
6. Methods of extraction

Suggested readings

1. Pharmacognosy - G. E. Trease and W.C. Evans. Saunders Edinburgh, New York.
2. Pharmacognosy-Tyler, Brady, Robbers.
3. Modem Methods of Plant Analysis- Peach &M.V. Tracey, Vol. I&II.
4. Text Book of Pharmacognosy by T.E. Wallis.
5. Marine Natural Products-Vol.I to IV.
6. Natural products: A lab guide by Raphael Ikan, Academic Press.
7. Glimpses of Indian Ethano Pharmacology, P. Pushpangadam. Ulf Nyman. V.George Tropical

8. Botanic Garden & Research Institute.
9. Medicinal natural products (a biosynthetic approach), Paul M. Dewick, John Wiley & SonsLtd., England.
10. Chemistry of Marine Natural Products- Paul J. Schewer.
11. Herbal Drug Industry by RD. Choudhary, Eastern Publisher, New Delhi.
12. Cultivation of Medicinal Plants by C.K. Atal &B.M. Kapoor.
13. Cultivation and Utilization of Aromatic Plants, C.K. Atal &B.M. Kapoor.
14. Cultivation of medicinal and aromatic crops, AA Farooqui and B.S. Sreeramu.UniversityPress.
15. Natural Products from Plants, by Peter B. Kaufman, CRC Press, New York.
16. Recent Advances in Phytochemistry- Vol. 1&4: ScikelRuneckles- Appleton Century crofts.
17. Text book of Pharmacognosy, C.K.Kokate, Purohit, Ghokhale, NiraliPrakasshan.

Pharmacognosy and Pharmacobiotechnology, Ashutoshkar, New Age Publications, New Delhi.

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 18: Food Microbiology

Course code: BOPDTD18

(Credits: Theory-3, Practical-2)

Learning Outcomes:

To impart knowledge about the various areas related to food science as a discipline

To encode the importance of the role of microorganisms in food industries both in beneficial and harmful ways

To develop an understanding of food composition, principles of preservation, new product development, food quality and analysis and food safety standard law.

Explain importance of different types of food in balanced diet and diet planning

Differentiate between different nutrient components in food and their role in processing and consumption

Determine food quality by food analysis as per food safety standard law and the their importance in food industry

Apply traditional methods for food preservation in developing a new food product.

Able to identify the characteristics of foodborne, waterborne and spoilage microorganisms

Unit I: Fermentation Products

Dairy products: - Production of starter cultures; Cheese - principles of cheese making. Cheddar Cheese, Swiss Cheese, Surface ripened Cheeses; Mold ripened Cheeses. General principles of manufacture of Yogurt, acidophilus milk, Kefir, Koumiss. Fermented foods: Soy sauce, Miso, Sufu, Natto, Idli, fermented fish products. Fermented vegetables: Sauer kraut, pickles, Olives. Fermented sausages.

Unit II: Distilled beverages & Food additives

Alcohol, wine, brandy and beer. • Production of additives - organic acid (acetic acid, lactic acid and citric acid), amino acids (glutamic acid, lysine, threonine, arginine and histidine), food flavourants and pigments

Unit III: Food Spoilage and Public Health & Food Preservation

Staphylococcal, Salmonellosis, E.coli, Botulism, aflatoxin and amine production; food spoiling enzymes; Deterioration of foods- vegetables, meat, poultry, sea food and fruits, • Principles of food preservation – methods of preservation: Physical (irradiation, drying, heat processing, chilling and freezing, high pressure and modification of atmosphere); Chemical (Sodium benzoate Class I & II); Biological: Probiotics and bacteriocins.

Unit IV: Indicator Organisms

Direct examination – culture techniques – enumeration methods – plate – Viable & Total Count; Alternative methods – Dye reduction tests , electrical methods , ATP determination: Rapid methods, immunological methods – DNA / RNA methodology – Laboratory accreditation,

Unit V: Food Process Technology

Packaging and canning of foods – preparation for packaging, thermal processing of foods: Microwave heating, thermal inactivation of microorganisms, thermal process, and evaluations, freezing and thawing of foods. Food process operations: Evaporation - single and multi-effect evaporation, dehydration, psychomatric charts, drying-tunnel, tray, spray, drum, freeze, distillation; food processing aid through biotechnology, Food sanitation: Good manufacturing practices – Hazard analysis, Critical control points, Personnel hygiene. Food safety regulation in India

Contemporary Issues

Expert lectures, online seminars – webinars

Machine learning in food industry https://spd.group/machine-learning/machine-learning-and-ai-in-food-industry/

Examples of AI application in food industry https://foodindustryexecutive.com/2018/04/6-examples-of-artificial-intelligence-in-thefood-industry/

AI in Food Processing – Use Cases and Applications That Matte https://emerj.com/ai-sector-overviews/ai-in-food-processing/

Application of Machine Learning in Microbiology

https://www.frontiersin.org/articles/10.3389/fmicb.2019.00827/full

Lab (BOPDLD17)

As per the course

Suggested Reading

1. Industrial Microbiology, 1983, 4th Edition, Prescott and Dunn's, Gerald Reed, AVI Publishing Company Inc. Conneticut.
2. Food Microbiology- Frazier, 1987, Tata McGraw-Hill Education
3. Food Biotechnology. 1982. by Knorr, D. Marcel Dekker, New York
4. Biotechnology, 1983, VI-VIII, Rehm, H.J. and Reed,G, Verlag Chemie,Wainheim
5. Genetic Engineering Applications for Industry, 1981, Paul,J.K.,Noyer Corporation, New Jersey
6. Fundamentals of Food Process Engineering, 1980, Toledo,R.T., AVI Publishing Co., USA.
7. Food Engineering Operations, 1979, 2nd Edition, Brennan,J.G., Bulters,J.R., Gowelx,N.D Page 41 of 82 M.Sc. Microbiology 2020-21 onwards - UD - Annexure No. 79A SCAA DATED: 23.09.2020 and Lilly, A.E.V., Applied Science Publishers
8. Food Process Engineering, 1977, 2nd Edition, Heldman, D.R., AVI Publishing

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

Food Science and Processing https://swayam.gov.in/nd2_cec19_ag05/preview 2 Food Microbiology and Food Safety https://swayam.gov.in/nd2_cec20_ag13/preview 3 Food Preservation Technology https://swayam.gov.in/nd2_cec19_ag01/preview 4 Introduction to food Microbiology https://nptel.ac.in/courses/126/103/126103017/

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 19: Global Change Biology

Course code: BOPDTD19

(Credits: Theory-3, Practical-2)

Learning outcomes

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

Gain knowledge on the development of the Earth's atmosphere, its dynamic nature and variability

Develop understanding on the elements of the climate and climate change, human impacts on climate, and impacts realized on different scales

Gain knowledge on emerging trends of plant-atmosphere exchange of trace gases and climate change policies on local, regional, and global scales and its future implications

Unit I: Atmosphere and climate

Basic atmospheric properties, climatic controls. Climatic classifications and variability. Movement in the atmosphere: global scale, regional scale, local scale, Earth Systems: Atmosphere, Hydrosphere, Lithosphere, Biosphere and their linkage.

Unit II: Anthropocene & the Human Impacts on climate

Causes and consequences of Global warming: Greenhouse effect; Global and regional trends in greenhouse gas emissions; Sea level rise; role of oceans and forests as carbon sinks; Ozone depletion and Ozone hole.

Unit III: Impacts of Climate change

Effects on organisms including humans; effects on ecosystems and productivity; species responses in terms of distribution ranges, adaptation; spread of diseases; Extinction risk for temperature-sensitive species; UV effects.

Unit IV: Plant atmosphere exchange of trace gases:

Biogenic volatile organic compounds (BVOCs) and their importance in global climate change. Impact of eco-physiological factors on the exchange of trace gases.

Unit V: Climate change and Policy

Montreal Protocol; Kyoto Protocol; Paris Agreement; Carbon trading; clean development mechanism (CDM) and recent developments in Indian and Global perspectives

Lab (BOPDLD18)

1. Future projections of species' distribution ranges in response to climate change
2. Measurements of CO_2 in different environmental conditions and its relevance
3. Measurements of different Eco-physiological factors relevant to climate change
4. Statistical analyses based on the data of meteorology and its implications
5. Future projections based on air-temperature measurements
6. Visit to meteorological department to learn about real time monitoring and prediction of weather.
7. Viva-Voce based on the above practicals
8. Study of various meteorological parameters and climate.

Suggested Readings:

2. Barry, R. G., 2003. Atmosphere, weather and climate. Routledge Press, UK
3. Ellis, E.C., Kaplan, J.O., Fuller, D.Q., Vavrus, S., Goldewijk, K.K. and Verburg, P.H. 2013.Usedplanet: A global history. Proceedings of the National Academy of Sciences, **110**: 7978-7985.
4. Guenther, A. 2013. Biological and Chemical Diversity of Biogenic Volatile Organic Emissions into the Atmosphere. ISRN Atmospheric Sciences,
5. Kesselmeier J. &Staudt, M. 1999. Biogenic Volatile Organic Compounds (VOC): An Overview on Emission, Physiology and Ecology. Journal of Atmospheric Chemistry.33, 23-88.
6. Lovelock, J. 2000. Gaia: A New Look at Life on Earth, Oxford University Press. Raymo, M.E. 1992. Global climate change: a three-million-year perspective. In Start of aGlacial (pp.207-223), Springer, Berlin, Heidelberg.
7. Steffen, W., Grinevald, J., Crutzen, P. and McNeill, J., 2011. The Anthropocene: conceptual andhistorical perspectives. Philosophical Transactions of the Royal

Society of London A:Mathematical, Physical and Engineering Sciences, **369**: 842-867.

8. AR6 Climate Change 2021:The Physical Science Basis: Sixth assessment role: Available at: https://www.ipcc.ch/report/ar6/wg1/

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 20: Microbial Genetics

Course code: BOPDTD20

(Credits: Theory-3, Practical-2)

Learning Outcomes

On completion of the course, the student should be able to:

Explain principles/concepts involved in prokaryotic genetics

Identify genetic transfer mechanisms and their uses

Use common methods in microbial genetics

Understand mutagenesis, Mutation and mutants and their significance in microbial evolution

Design experiments based on different microbial techniques, like genotype- phenotype correlation

Unit I: Genetic Analysis of Bacteria

Inheritance in bacteria: Structure of Circular DNA molecule, Primary, Secondary, Tertiary and Quaternary structure of DNA, Watson and Crick model of double stranded DNA, DNA replication: DNA replication mechanism, enzymes involved in DNA replication and models of DNA replication.

Importance and uses of mutation analysis: types of mutations, isolation and selection of mutants, Complementation tests, recombination tests and gene replacements. Cloning genes by complementation. Cloning genes by marker rescue.

Systems that safeguard DNA: DNA methylation and DNA repair mechanisms - excision, mismatch, SOS, photoreactivation, and recombination repair.

Unit II: Prokaryotic Transcription and Translation

Mechanism of transcription in prokaryotes, enhancer sequences and control of transcription (Different transcription factors), Ribonucleoprotein, structure of mRNA, rRNA, and tRNA.

Translation process in prokaryotes: Direction of protein synthesis, RNA template, ribosomes and their organization in prokaryotes, polycistronic mRNA in bacteria, initiation of translation in bacteria, SD sequence in bacteria, initiator tRNA, elongation of translation, translocation and termination mechanisms. Post-translational modification. Salient features of genetic code.

Unit III: Regulation of Gene Expression in Prokaryotes

Operon concept, co-ordinated control of structural genes, stringent response, catabolite repression, instability of bacterial RNA, positive regulation in E.coli [Arabinose operon] and negative regulation in E.coli [lac operon], inducers and repressors, regulation by attenuation by trp operon, two-component regulatory system. Feed-back inhibition and regulation of virulence genes in pathogenic bacteria

Unit IV: Genetic Recombination

Role of rec proteins in homologous recombination. Conjugation: Discovery, F+ , F- and Hfr cells, Mechanism of conjugation (genes and proteins involved). Sexduction, conjugational transfer of colicinogenic and resistance transfer factors. Genetic mapping. Plasmid Replication and Incompitability, Control of copy number.

Natural transformation and competence. Molecular basis of natural transformation: DNA uptake competence systems in gram positive and gram negative bacteria. Regulation of competence in B. subtilis. Importance of natural transformation. Artificially induced competence.

Generalized versus specialized transduction, T4 (structure and life cycle) and lambda phage (structure, life cycle, lysogenic repression and phage immunity). applications of phages in microbial genetics.

Transposons – Insertion sequences and composite transposons, phages as transposons, replicative, non-replicative and conservative transposition. Mechanism of transposition, Types of transposons and their properties.

Unit V: Microbial Genetics and Research

Overexpression and tagging of recombinant proteins in *E. coli*, (driven by lac, T7 and Tet-regulatable promoters). Overexpression systems in S. cerevisiae. Baculovirus overexpression system.

Analysis of protein-DNA and protein-protein interactions: Gel retardation assay, DNA footprinting by DNase I, yeast one-hybrid assay, ChIP-chip assays, Yeast two hybrids system. Co-immunoprecipitations, pull-downs and Far-Westerns.

Lab (BOPDLD19)

1. Study of conjugation in E. coli.
2. Transformation in E. coli and characterization of transformed cells.
3. Purification of plasmid DNA, Restriction digestion and separation by Agarose gel electrophoresis.
4. Effect of UV radiations to study the survival pattern of E. coli. Repair mechanisms in E. coli (Dark and photoreactivation)
5. Isolation of antibiotic resistant mutants by chemical mutagenesis.
6. Ampicillin selection method for isolation of auxotrophic mutant.
7. Studies on gene expression in E.coli with reference to lac operon.

Suggested Readings

1. Molecular Genetics of Bacteria. Larry Snyder and Wendy Champness, ASM press, USA.
2. Microbial Genetics. Stanly R. Maloy, John E. Cronan, Jr. & David Freifelder, Jones and Bartlett Learning Publishers, USA.
3. Molecular Biology of the Gene. J.D. Watson et al., The Benjamin / Cummings Publications Co. Inc. California, USA.
4. Gene. Benzamin Lewin. Jones and Batlett Learning Publishers. USA.
5. Fundamental Bacterial Genetics. Nancy Trun and Janine Trempy; Willey-Blackwell Science Publishers, USA.
6. Modern Microbial Genetics. U.N. Streips and R.E. Yasbin, Wiley Publishers, USA.

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 21: Plant Functional Genomics

Course code: BOPDTD21

(Credits: Theory-3, Practical-2)

Learning Outcomes

Describe the overall structure and organisation of the plant genome

Differentiate between genomic, and other large-scale analyses, at different levels, including genomics, transcriptomics, proteomics, metabolomics, metagenomics and systems biology

Describe and explain a broad spectrum of large-scale functional genomics methods, as well as current technical developments within the genomics and functional genomics fields

Suggest and outline solutions to theoretical and experimental problems within the genomics and functional genomics fields

Plan and carry out a small functional genomics project, both theoretically and experimentally

Handle and analyse large-scale experimental datasets, and present results and interpretations in a scientifically stringent manner

Unit I: Finding Genes in Complex Plant Systems

An Improved Method for Plant BAC Library Construction Constructing Gene-Enriched Plant Genomic Libraries Using Methylation Filtration Technology Rescue Protocols for Maize Functional Genomics Precious Cell Contain Precious Information: Strategies and Pitfalls in Expression Analysis from a Few Cells Combined ESTs from Plant-Microbe Interactions: Using GC Counting to Determine the Species of Origin

Unit II: In Silico Prediction of Plant Gene Prediction

Computer Software to Find Genes in Plant Genomics DNA Genomic Collinearity as a Tool for Plant Gene Isolation Using Natural Allelic Diversity to Evaluate Gene Function Quantitative Trait Locus Analysis as a Gene Discovery Tool

Unit III: Forward and Reverse Genetic Strategies

T-DNA Mutagenesis in Arabidopsis Physical and Chemical Mutagenesis High Throughput TILLING for Functional Genomics Gene and Enhancer Traps from Gene Discovery High Throughput TAIL-PCR as a Tool to Identify DNA Flanking Insertions Custom Knock-Outs with Hairpin RNA-Mediated Gene Silencing Virus-Induced Gene Silencing Exploring the Potential of Plant RNAse P as a Functional Genomics Tool Maintaining Collections of Mutants for Plant Functional Genomics

Unit IV: Gain of Function Approaches

Vector Construction for Gene Overexpression as a Tool to Elucidate Gene Function T-DNA Activation Tagging

PART V: Phenotypic Profiling as a Tool to Determine Gene Function

Expression Profiling Using cDNA Microarrays Open Architecture Expression Profiling of Plant Transcriptomes and Gene Discovery Using Gene Calling Technology Proteomics as a Functional Genomics Tool Metabolite Profiling as a Functional Genomics Tool Growth Stage-Based Phenotypic Profiling of Plants

Lab (BOPDLD20)

1. Insilico Identification of promoter sequences
2. Identification of gene sequences
3. Gene structure prediction
4. Protein sequence alignment and phylogenetic study of protein sequences
5. Characterization of promoter sequences
6. Identification of stress inducible genes
7. Genomic DNA isolation
8. Amplification of promoter sequences from the genomic DNA

Suggested Readings:

1. Grasser, K.D. -Eds. (2006) Regulation of Transcription in Plants. Blackwell Publishing Ltd.,UK.
2. Kahl, G. and Meksem, K. -Eds. (2008) The Handbook of Plant Functional Genomics. WileyVCH Verlag GmbH & Co., Germany.
3. Latchman, D.S. (2005) Gene Regulation. Taylor & Francis Group, USA.
4. Lewin, B. (2008) Genes IX. Jones and Bartlett Publishers, Inc., USA.

5. Lodish, H., Berk, A., Zipursky, S.L., Matsudaria, P., Baltimore, D. and Darnell, J. - Eds.(2000) Molecular Cell Biology. W.H. Freeman & Co., USA.

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 22: Plant Systematics

Course code: BOPDTD22

(Credits: Theory-3, Practical-2)

Learning Outcomes:

The students will learn

What do we mean by systematics? What are different components of systematics? Why is systematics important? What are different data sources in systematics?

What are different methods of naming plants? What are different principles of nomenclature? Why name changes?

What is phylogeny and phylogenetic systematics? Which methods are used in molecular systematic studies?

What are different methods of collecting and preserving plants?

UNIT I: Introduction and Classification systems

Systematics-concepts and components,history of developments in taxonomy,classification systems developed by Carolus Linnaeus, Bentham and Hooker, Adolf Engler, Charles E. Bessy, John Hutchinson, Armen L. Takhtajan, Arthur Cronquist and, R.M.T. Dahlgren and Robert F. Thorne.

UNIT II.: Botanical Nomenclature and Plant Identification

History of nomenclature, polynomial and binomial systems, salient features and major provisions of the ICN, effective and valid publication, rank of taxa, rule of priority and its limitation, typification, author citation, rejection of names, names of hybrids and cultivated plants, kinds of Type method; Naming a new species; Species concept.

Methods, taxonomic literature (floras, icons, monographs, revision and journals); Taxonomic keys – dichotomous (indented, bracketed), polyclave

UNIT III:. Numerical taxonomy

Phenetic methods in taxonomy [Taxometrics]: principles, construction of taxonomic groups, OUTs, unit characters, character coding, measurement of resemblances, cluster analysis, phenons and ranks.

UNIT IV: Molecular Systematics and Phylogeny

Definitions and terms- primitive and advanced, homology and analogy, parallelism and convergence, monophyly and polyphyly;Plant genomes: nuclear, mitochondrial, chloroplast; Molecular markers.

The nature of phylogeny; How we depict phylogeny?; The importance of homology, Polarizing characters of homology; Rooting Trees; The problem of homoplasy.

UNIT V:.Angiosperm Phylogeny Groupand Contributions

Components and concepts; General characteristics; Evolutionary history; Basal angiosperms and Magnoliids; Basal monocots; Petaloid monocots; Commelinids; Basal eudicots and Caryophyllids; Rosids; Asterids.

Contributionsof: van Rheede, J.D. Hooker, William Roxburgh, Nathaniel Wallich, Richard Henry Beddome, E.K.JanakiAmmal, K.M. Mathew, Cecil J.Saldhana, V.V.Sivarajan.

Lab (BOPDLD21)

1. Study of atleast 20 locally available families of flowering plants.
2. Identification of genus and species of locally available wild plants using Floras and herbarium.
3. Semipermanent pollen preparations by acetolysis method and study of different pollen morphotypes.
4. Practical based on numerical taxonomy.
5. Describing new taxon, deposition of type, Latin diagnosis and abbreviations used in citations.
6. Preparation of checklist of a particular area.
7. Preparation of key of atleast 10 species of any family.
8. Preparation of 20 herbarium sheets alongwith filed notes of the above families.
9. Programming DELTA of atleast 5 species with images.

Any additional practical/s based on theory syllabus will be added whenever necessary.

Reading:

1. Angiosperm Phylogeny Group 2003. An update of the Angiosperm Phylogeny Group

classification for the orders and families of flowering plants: APG II. Botanical Journal of the Linnaean Society 141: 399-436.

2. Crawford, D.J. 2003. Plant Molecular Systematics. Cambridge University Press,Cambridge, UK.
3. Cronquist, A. 1981. An integrated system of classification of flowering plants. ColumbiaUniversity Press, New York.
4. Judd, W.S., C.S. Campbell, E.A. Kellogg, P.F.Stevens and M.J. Donoghue 2002. PlantSystematics: A phylogenetic Approach. Sinauer Associates, Inc., Massachusetts.
5. Radford, A. E., W.C. Dickison, J.R. Massey and C.R. Bell 1974. Vascular PlantSystematics. Harper and Row, New York.
6. Semple, C. and M.A. Steel 2003. Phylogenetics. Oxford University Press, Oxford.
7. Simpson, M.G. 2006. Plant Systematics. Elsevier, Amsterdam.
8. Stuessy, T.F. 2009. Plant Taxonomy: The systematic Evaluation of Comparative Data.Columbia University Press, New York.

DISCIPLINE SPECIFIC ELECTIVE

Discipline Specific Elective 23: Plant Diversity, Uses and Conservation

Course code: BOPDTD23

(Credits: Theory-3, Practical-2)

Learning Outcome –

To learn about the diversity in plants their uses.

To know about Process of Plants conservation and its significance.

The study will support interest and awareness towardsplant diversity, uses and their conservation.

The study will focus on Importance of plant diversity.

Unit I: Plant diversity and its scope:

Plant diversity and Ecology –What is, its scope and significance, Plant diversity in genetic, species and ecosystem level, Plant association and their social structure, Factorsplaying role in plant growth and development, Forest a major source of plant diversity of varied purpose like food, fodder, fuel and medicine etc. Hydrophytic diversity, Physico-chemical characters of water. Herbs, Shrubs, Trees and climbers. Plant Population and community, Seed diversity structure, germination and dispersal, Plant Modifications.

Unit II: Medicinal Plants Diversity:

Diversity and uses of Medicinal plants following their potential application for treatment of different diseases, Role of plants in relation to Human Welfare, Ethnobotany basic concepts and significance, Tribes and Medicinal plants, Traditional knowledge on Medicinal plants, TKDL, Herbal preparation modes and uses, CGMPB and NMPB.

Unit III: Threats for Plant Diversity:

Plants existence to local environment**.** Factors/Reasons for loss of plant diversity, Sustainable Development. Role of plant diversity in ecological management. TKDL, Hot spots, Alien invasive /Exotic plant species.

Unit IV: Medicinal plants Research:

Botanical gardens/Herbal gardens and herbaria, Research centers associated with Medicinal plants – CIMAP. NBPGR, NBRI, Phytochemicals present in different Medicinal plants. Utilization of varied plant parts among the tribes.

Unit V: Plant diversity Conservation and Management:

Plant conservation and its requirements in current scenario.Efforts for plant diversity conservation, In-situ and Ex-situ conservation methods, IUCN,UNEP, NBPGR. Role of tribes for conserving plants diversity conservation,Plants Ethical and aesthetic values. People's awareness and Sustainable development.

Lab (BOPDLD22)

1. To study about Herbaceous Plants diversity
2. To study about Climber Plants diversity
3. To study about Shrub Plants diversity
4. To study about Trees diversity
5. To study on Medicinal plants diversity
6. To study on different types seeds
7. To study on different types of seed dispersal mechanisms.
8. To study on different factors associated with seed germination
9. To study on Invasive /Exotic plants
10. To study on Hydrophytes.

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. Trivedi P. C. and Sharma N. 2010. Plant resource utilization and conservation, Pointer Publishers. Jaipur.
3. Singh J. S. Singh S. P. and Gupta S. R. 2006. Ecology, Environment and resource conservation, Anamya Publication, New Delhi.
4. Das A. P. and Pandey A. K. 2007. Advances in Ethnobotany, Bishen Singh Mahendra Pal Singh, Dehradun.
5. S. K. Jain 1989. Methods and Approaches in ethnobotany. Society of ethnobotanists, Lucknow, India.

6. S. K. Jain 1990. Contributions of Indian Ethnobotany, Scientific publishers, Jodhpur.

7. P. D. Sharma, Ecology and environment, Rastogi Publications, Meerut.

OPEN ELECTIVE

OPEN ELECTIVE

Open Elective 1: Ecosystem Services and Biodiversity

Course code: OPNBO01

(Credits: Theory-3, Practical-2)

Learning outcomes:

The field of ecosystem services presents a major new organizing framework for conservation and natural resources management that is being applied in diverse places globally. Ecosystem services are the conditions and processes through which natural and managed ecosystems, and their constituent species, sustain and fulfill human life. These services range from the provision of food and clean drinking water to climate regulation and flood mitigation torecreational activities and spiritual fulfillment, and much more. While these services from natureunderpin our lives, most have been undervalued historically in land use, economic, and policydecisions. In extreme cases, the value of ecosystem services is only recognized after they are lost.

In this course, we will examine the linked ecological, economic, and institutional challenges towards better characterizing the contribution of ecosystem services to human wellbeing, and the development of methodologies and institutions for integrating ecosystem services into decision making. We will critically examine how these approaches are being advanced through research and practice by pioneering efforts in the academic, public, private, and nonprofit sectors.

Develop depth of knowledge about the theoretical foundations of the field ofecosystem services by linking concepts from ecology, geography, economics, and socialscience (and other pertinent areas).

Examine monetary and non-monetary methods for “valuing” nature and critically assesstheir assumptions and utility.

Identify and use methodologies and tools to integrate ecosystem services into decisionmaking in the public, private, and non-profit sectors.

Critically examine policy efforts to design effective payment for ecosystem servicesprograms and other institutional approaches for restoring and protecting ecosystemservices.

Identify key research-action areas and new frontiers of research-action in the field of ecosystem services.

Empower students to integrate ecosystem services into decision-making in leadership positions across the public, private, and non-profit sectors.

Strengthen student's written and oral communication skills for engaging policymakers, communities, the general public, and other audiences

Unit I: Introduction to Ecosystem Services:

Definition and Key concept; classification; ecosystem functions and services. Ecological sustainability and impacts of human interventions on ecosystems caused by land use, climate change, pollution, hazardous chemicals, acidification, harvesting / exploitation and introduction of species and organisms.

Unit II: Biodiversity

The role of biodiversity in the provision of ecosystem services.

Unit III: Ecosystem services **I**

Valuing ecosystem services.

Unit IV: Ecosystem services II

Paying for ecosystem services.

Unit V: Ecosystem services III

Governing for ecosystem services

Lab (BOPDLO2)

1. Identification and characterization of ecosystem services of a nearby forest/ grassland/ pond ecosystem.
2. To identify and characterize various drivers impacting ecosystem services in of an ecosystem.
3. To study the change in quantity and quality of ecosystem services due to varying degree of product extraction and other disturbances.
4. Quantification of various types of services as classified in the Millennium Assessment Goal of forest ecosystem
5. Field Trip :To understand use of ecology and conservation theory in informing habitat and species assessment, and their relevance to ecosystem services and biodiversity targets, current conservation management techniques, methods to

assess and manage biodiversity, and data collection techniques and to determine the potential of the habitats on site to support notable and protected species.

Suggested Readings:

1. Ecosystem Services from concept to practice, by Jetske Bouma and Pieter Van Beukering, 2015. Cambridge University Press, UK.
2. Ecosystem Services - Concept, Methods and Case Studies, by Karsten Grunewald and Olaf Bastian, 2015, Springer.
5. Conserving and Valuing Ecosystem Services and Biodiversity – Economic, Institutional and Social Challenges, by K. N. Ninan, 2009.Earthscan, publishing for Sustainable future, London.
6. The law and policy of ecosystem services by Ruhl, J. B., Kraft, Steven E., and Lant C. L. Island Press, 2007, University of Michigan, ISBN: 1559630949
7. Payments for Ecosystem Services: Getting Started: a Primer. United States. Agency for International Development, Katoomba Group, Forest Trends, 2008, ISBN: 9789280729252
8. Ecosystem services certification: Opportunities and constraints by Meijaard, E., Sheil, D., Guariguata, M.R., Nasi, R., Sunderland, T.C.H., Putzel, L.,
9. Center for International Forestry Research (CIFOR) Bogor, Indonesia, 2011, ISBN: 978-602-8693-59-2
10. MA: Millennium Assessment, Ecosystem and Human Well-being. A frame work for Assessment. Washington, DC: Island Press; 2003
11. MA: Millennium Assessment, Ecosystem and Human Well-being.Current State and trends. Volume 1, Washington, DC: Island Press; 2005
12. MA: Millennium Assessment, Ecosystem and Human Well-being.Scenarios. Volume 2, Washington, DC: Island Press; 2005
13. MA: Millennium Assessment, Ecosystem and Human Well-being.Policy responses. Volume 3, Washington, DC: Island Press; 2005
14. MA: Millennium Assessment, Ecosystem and Human Well-being.Multiscale Assessments. Volume 4, Washington, DC: Island Press; 2005.
15. Bouma and Van Beukering (2015) Ecosystem services: from concept to practice, CambridgeUniversity Press

16. Ruhl, Kraft, and Lant (2007) The Law and Policy of Ecosystem Services, Island Press• Kareiva, Tallis, Ricketts, Daily, and Polasky, eds. (2011) Natural Capital: Theory andPractice of Mapping Ecosystem Services, Oxford University Press
17. Daily, ed. (1997) Nature's Services: Societal Dependence on Natural Ecosystems, IslandPress
18. Daily and Ellison (2002) The New Economy of Nature, Island Press