Est. in 1921

UNION CHRISTIAN COLLEGE (AUTONOMOUS) ALUVA

Affiliated to Mahatma Gandhi University, Kottayam, India
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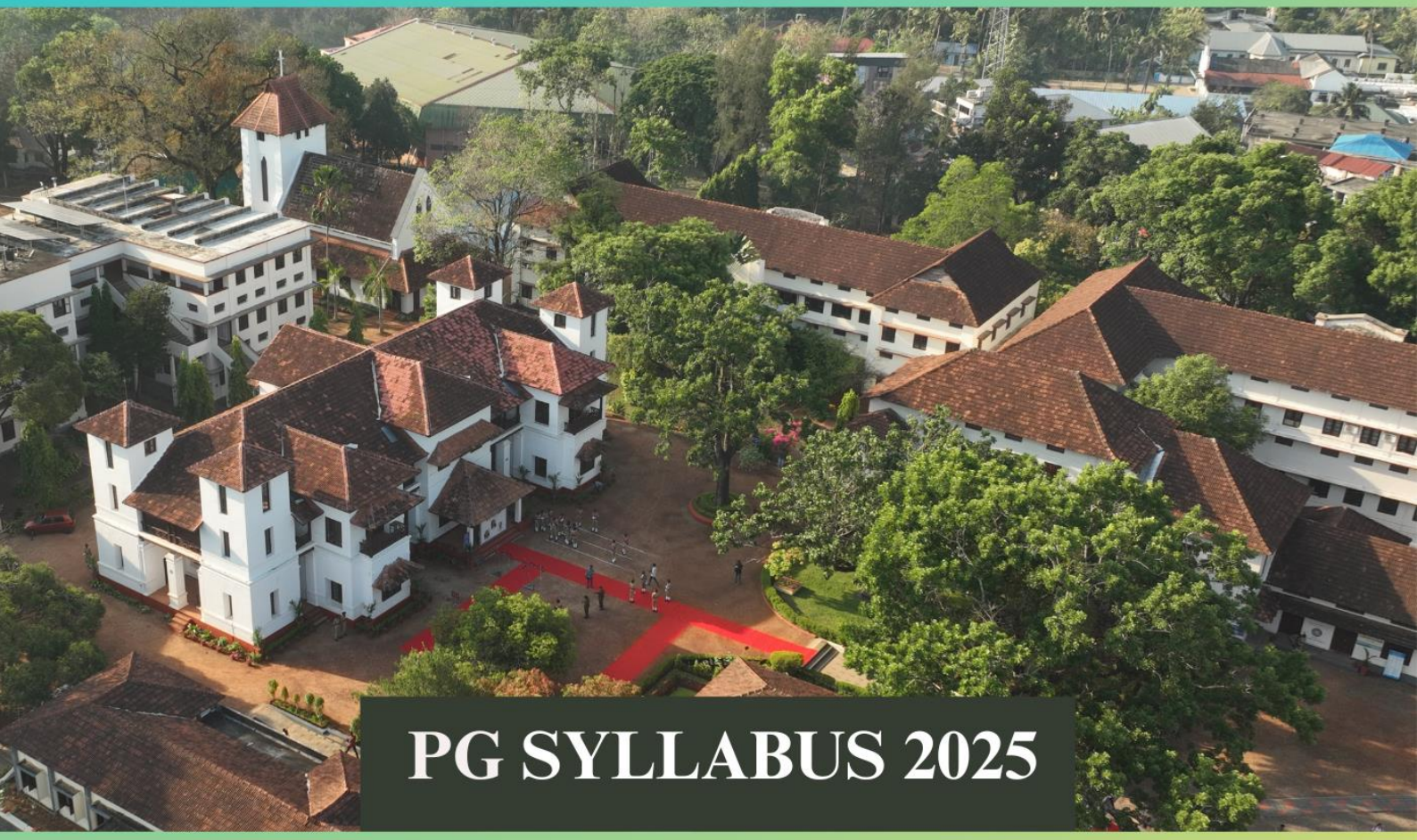
DEPARTMENT OF BOTANY



PG SYLLABUS 2025

POSTGRADUATE PROGRAMME {UCC PGP}
IN BOTANY

Master of Science in Botany

PROGRAMME STRUCTURE AND SYLLABUS
2025-26 ADMISSIONS ONWARDS

BOARD OF STUDIES IN BOTANY (PG)
UNION CHRISTIAN COLLEGE, ALUVA
(Autonomous)

2025

PREFACE

We are pleased to present the syllabus for the Postgraduate Program in Botany, designed to meet the evolving academic and research demands of advanced botanical sciences. This curriculum reflects our commitment to academic excellence, scientific innovation, and the holistic development of postgraduate students in the field of plant sciences. We sincerely acknowledge and thank the Board of Studies in Botany, Mahatma Gandhi University, for the excellent syllabus they have developed.

Botany, as a core discipline of biological sciences, plays a pivotal role in addressing many of the critical challenges of our time—including biodiversity conservation, sustainable agriculture, climate change adaptation, and medicinal plant research. The postgraduate curriculum is therefore carefully structured to deepen students' understanding of advanced plant biology, while also nurturing analytical skills, research aptitude, and scientific reasoning.

This program offers a balanced blend of core theoretical concepts, cutting-edge laboratory techniques, fieldwork, and independent research. Students will explore a wide array of topics ranging from molecular plant biology, plant physiology, taxonomy, ecology, biotechnology, and environmental science to interdisciplinary domains such as bioinformatics and climate science. The inclusion of seminars, project work, and hands-on training ensures a dynamic and engaging academic experience that prepares students for careers in research, academia, industry, and beyond.

We believe that postgraduate education is not just about acquiring knowledge but about fostering a spirit of inquiry and a lifelong commitment to scientific pursuit. It is our sincere hope that this syllabus serves as a strong academic foundation for our students, inspiring them to contribute meaningfully to the scientific community and to the sustainable future of our planet.

Dr.Justin R Nayagam

Chairperson

PG Board of Studies in Botany

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CONTENTS **Pages**

Objectives and Programme outcome

M.Sc. Botany Programme is a two-year post-graduate programme, which deals with basic and advanced study on plants. It is one of the multi-disciplinary fields with great demand in various fields of research and development. The programme envisages developing understanding and knowledge for applying into sectors like agriculture, horticulture, floriculture, biotechnology, genomics, forest and environment. The programme is divided across 4 semesters of 90 days each.

These are exciting times in Biology. The world of Biology has been transformed in the last few decades. There was too much to select from. However, the Board of studies designed the programme envisioning the following objectives:

- To encourage a clear, comprehensive and advanced mastery in the field of Botany.
- To provide basic principles of biological sciences with special reference to Botany and itsapplied branches.
- Enabling the students to explore the intricacies of life forms at cellular, molecular and Nano level.
- To sustain students' motivation and enthusiasm and to help them not only to appreciate the beauty of different life forms but also to inspire them in the dissemination of the concept of biodiversity conservation.
- To develop problem solving skills in students and encourage them to carry out innovativeresearch projects thereby enkindling in them the spirit of knowledge creation.
- To maintain a high level of scientific excellence in botanical research with added emphasis on the role of plants in the structure and functioning of terrestrial and aquatic communities and ecosystem
- To equip students to perform functions that demand higher competence in National/International fields.

THE PROGRAM STRUCTURE

Course code	Title of the course	Teaching hours		Credits
		Theory	Practical	
SEMESTER I				
UCBY010101	Microbiology	27	9	4
	Phycology	45	36	
UCBY010102	Mycology	36	36	4
	Crop pathology	36	18	
UCBY010103	Bryophytes	36	18	4
	Pteridophytes	36	36	
UCBY010104	Gymnosperms and Paleobotany	36	27	3
	Evolution	18	--	
UCBY010105	Microbiology, Phycology, Mycology and Crop Pathology Practical			2
UCBY010106	Bryology, Pteridology, Gymnosperms, and Paleobotany Practical			2
Total		**270**	**180**	**19**
SEMESTER II				
UCBY010201	Anatomy	36	27	4
	Developmental Biology	18	9	
	Horticulture	18	9	
UCBY010202	Cell Biology	27	18	4
	Genetics	27	18	
	Plant Breeding	18	9	
UCBY010203	Plant Physiology	45	36	4
	Biochemistry	27	27	
UCBY010204	Molecular Biology	54	18	3
UCBY010205	Anatomy, Developmental Biology, Horticulture, Cell biology, Genetics and Plant breeding Practical			2
UCBY010206	Plant Physiology, Biochemistry and Molecular biology Practical			2
Total		**270**	**180**	**19**
SEMESTER III				
UCBY010301	Research Methodology	18	9	4
	Micro-technique	18	27	
	Biostatistics	18	9	
	Biophysical Instrumentation	18	18	
UCBY010302	Biotechnology, Bioinformatics and Bio-nanotechnology	72	36	4
UCBY010303	Angiosperm Taxonomy, Economic Botany and Ethanobotany	72	63	4
UCBY010304	Environmental Science	54	18	3
UCBY010305	Research Methodology Micro technique, Biostatistics, Biophysics and Biotechnology and Bioinformatics Practical			2

UCBY010306	Angiosperm Taxonomy, Economic Botany and EnvironmentalScience Practical			2
Total		**270**	**180**	**19**
	SEMESTER IV			
UCBY800401	Elective course I Biotechnology - Plant tissue Culture and Microbial Biotechnology	90	72	4
UCBY800402	Elective course I Biotechnology – Genetic Engineering, Genomics and Immunology	90	54	4
UCBY800403	Elective course I Biotechnology – Genomics, Transcriptomics, Proteomics and Bioinformatics	90	54	4
UCBY800404	Elective course I Biotechnology- Practical Paper I Plant Tissue Culture and Microbial Biotechnology			2
UCBY800405	Elective course I Biotechnology- Practical Paper II Genetic Engineering, Genome Editing, Immunology, Genomics, Transcriptomics, Proteomics and Bioinformatics			2
	Project work			4
	Viva-voce			3
Total		**270**	**180**	**23**

SEMESTER I

FIRST SEMESTER COURSES

UCBY010101	MICROBIOLOGY AND PHYCOLOGY
UCBY010102	MYCOLOGY AND CROP PATHOLOGY
UCBY010103	BRYOLOGY AND PTERIDOLOGY
UCBY010104	GYMNOSPERMS, PALEOBOTANY AND EVOLUTION
UCBY010105	MICROBIOLOGY, PHYCOLOGY, MYCOLOGY AND CROP PATHOLOGY- PRACTICAL
UCBY010106	BRYOLOGY, PTERIDOLOGY, GYMNOSPERMS, AND PALEOBOTANY - PRACTICAL

Total Credits: 19
Total Hours: 450

UCBY010101: Microbiology and Phycology
(Theory 27+45=72 Hrs; Practical 9+36=45Hrs) Credits4

MICROBIOLOGY (27 hrs)

Module 1: Introduction to microbiology (2 hrs)

Milestones in Microbiology, Microbial taxonomy and phylogeny - Major groups and their characteristics (Fivekingdom system and three domain system of classification).

Module 2: Bacteria (7 hrs)

Bacterial morphology. Classification of Bacteria according to Bergey's manual of systematic bacteriology (Brief study up to family). Ultra structure of Gram positive and Gram negative bacteria; cell membrane, cell wall, flagella, pili, fimbriae, capsule and slime, ribosome and endospores. Major groups of Bacteria: Nanobes, VBNC, Spirochetes, Rickettsias, Chlamydias, Mycoplasmas, Actinomycetes, Myxobacteria, Archaebacteria (general account only). Extremophiles - thermophilic, halophilic, acidophilic and alkalophilic bacteria. Nutritional types, Bacterial genome chromosome, plasmids-types of plasmids-R plasmids, Col plasmids and F plasmids

Module 3: Bacterial systematics (4 hrs)

Systematic identification of bacteria: Phenotypic-Morphology, Motility, Colony characters, Biochemical tests (Tests for carbohydrates, proteins and enzymes). Molecular techniques for the identification of bacteria-16SrRNA sequencing. A brief account on metagenome analysis for the identification of non-culturable microbes.

Module 4: Culture of microorganisms (4 hrs)

Sterilization techniques in microbiology-physical and chemical methods(Physical-dry heat and moist heat, radiation, filter sterilization; Chemical-commonly used surface sterilant), Disinfection;Methods of isolation of pure cultures. Types of culture media. Enrichment culture techniques. Maintenance and preservation of pure cultures.

Module 5: Plant–Microbe interactions (2 hours)

Brief study on endophytes- bacteria and fungi, their role in plant growth promotion and secondary metabolite production.

Module 6: Viruses (8 hrs)

Nomenclature and classification-types of viruses-DNA and RNA Viruses, properties of viruses, morphology (symmetry) of viruses; Capsid and their arrangements; types of envelops and their composition, Viral genome. Structure of bacteriophages belonging to 'T' series-ultra structure of TMV. Viral replication: Lytic and Lysogenic cycles - Lytic cycle in T even

phages, and lysogeny in lambda phage. Sub viral particles - prions, viroids, virusoids (brief description only).

Practical (9 hrs)

1. Preparation and sterilization of microbial culture media -Nutrient broth and nutrient agar
2. Inoculation of bacteria-stabbing and streaking
3. Differential staining of bacteria using Gram stain.
4. Endospore staining
5. Isolation of Rhizobium from root nodules.
6. Isolation of microbes from soil: Serial dilution - pour plate/spread plate method.
7. Streak out a bacterial culture on an agar plate and isolation of colonies –Quadrant streaking method
8. Antibacterial assay - disc diffusion/agar well method.

References

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2. Bilgrami, Sinha. *Essentials of Microbiology*.
3. Carpenter P L (1967). *Microbiology*. W B Saunder & Co. Philadelphia.
4. Dube H C (2008). *Fungi, Bacteria and Viruses*. Agrobios.
5. Kanika Sharma (2005). *Manual of Microbiology: Tools and Techniques*. Ane Books.
6. Kumar H D (1990). *Modern concepts of Microbiology*. Vikas public. Delhi.
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8. Monica Cheesbrough. Medical Laboratory Manual for tropical countries. Elsevier, London, UK.
9. Pelczar Michael J, Adams M R, Chan E C S, Krieg Noel R (2000). *Microbiology*. Tata McGraw Hill.
10. Pelczar (1990). *Microbiology*. T M H.
11. Purohit S S (1997). *Microbiology: Fundamentals and application*. Agrobotanical.
12. Powar C B, Daginawala H F (1991). *General Microbiology* Vol II. Himalaya Publishing House.
13. Willey, Presscot's Microbiology IXth Edition
14. Salle A J (1978). *Fundamentals of Bacteriology*. Asia TMH
15. Dubey R C, Maheswari D K (2004). *Microbiology*. S Chand.
16. Sharma P D (2003). *Microbiology*. Restogi pub.
17. F H Kayser, K A Bienz, J Eckert, R M Zinkernagel. *Medical Microbiology.*
18. L R Haahelm, J R Pattison, R J Whitley. *Clinical virology.*
19. Thandavarayan Ramamurthy, Amit Ghosh, Gururaja P. Pazhani, and Sumio Shinoda·Current Perspectives on Viable but Non-Culturable (VBNC) Pathogenic Bacteria. Frontiers in Public Health, 2014; 2: 103.
20. Nanobes and Nanobacteria -SERC. https://serc.carleton.edu/microbelife/ topics/nanobes /index.html

Phycology (45 hrs)

Module 1: Introduction (4 hrs)

History of algal classification. Detailed study of the classification by F. E. Fritsch. Brief

account on the classification (Upto groups and divisions) by Edward Lee (2008). Gene sequencing and algal systematics (Brief study only). Centers of algal research in India. Contributions of Indian phycologists – M O P Iyengar, GS Venkataraman, T V Desikachary.

Module 2: General features of Algae (27 hrs)

Habit, habitat and distribution of Algae. Major characteristics of Cyanophyceae, Chlorophyceae, Xanthophyceae, Bacillariophyceae, Dinophyceae, Phaeophyceae and Rhodophyceae. Range of thallus structure. Algal components: Cell wall, flagella, eye- spot, pigments, pyrenoid, photosynthetic products. Reproduction in algae: Vegetative, asexual and sexual reproduction (development of sex organs not necessary). Major patterns of life cycles in algae and post fertilization stages in Phaeophyceae and Rhodophyceae. Algae and fossil records, special reference to India; a short description on *Rafatazmia chitrakootensis*

Module 3: Ecological and Economic importance of Algae (9 hrs)

Ecological importance of Algae. Primary productivity. Algae in symbiotic association, Ultraviolet radiation absorption by algae. Algae as food, fodder, biofertilizer, medicine, industrial uses and other useful. Algae in experimental studies. (SCP, Biofuel, Live feeds, EPS). Chemically mediated interactions in microalgae: Allelopathy (brief account only). Harmful effects of algae: Algal blooms, causative organisms, symptoms and toxins of major toxic algal blooms (Amnesic Shellfish Poisoning [ASP], Paralytic Shellfish Poisoning [PSP] and Cyanophycean toxins).

Module 4: Algal biotechnology (5 hrs)

Methods and techniques of collection, preservation and staining of Algae. Algal culture:Importance, methods; Algal culture media (Walne's medium)

Practical (36 hrs)

1. Critical study of diagnostic features and identification of the following genera based onmorphological, anatomical and reproductive parts;
   (a) Cyanophyceae - *Gleotrichia, Spirulina, Microcystis, Oscillatoria, Lyngbya, Anabaena, Nostoc, Rivularia, Scytonema*.
   (b) Chlorophyceae - *Chlamydomonas, Volvox, Ecballocystopsis, Ulothrix, Microspora, Ulva,Cladophora, Pithophora. Coleochaeta, Chaetophora, Drapernaldia, Trentepohlia, Fritschiella, Cephaleuros, Oedogonium, Bulbochaete, Zygnema, Mougeotia, Sirogonium, Desmedium, Bryopsis, Acetabularia, Codium, Caulerpa, Halimeda, Chara, Nitella*.
   (c) Xanthophyceae – *Vaucheria.*
   (d) Bacillariophyceae –O*dontella, Navicula.*
   (e) Phaeophyceae - *Ectocarpus, Colpomenia, Hydroclathrus, Dictyota, Padina, Sargassum, Turbinaria.*
   (f) Rhodophyceac - *Brtrachospermum, Gelidium, Amphiroa, Gracilaria, Polysiphonia*.
2. Students are to collect and identify algae from different habitat. Prepare and submit a report of the field work with sufficient photographs of algal collection.

References

1. Andersen R A (Ed) 2004. *Algal Culturing Techniques*, Elsevier.
2. Bellinger E.G Sigee D C. (2015*). Freshwater Algae Identification, Enumeration and use as Bioindicators.* John Wiley and Sons Ltd.
3. Bold H C, Wynne M J (1978). *Introduction to Algae: Structure and reproduction*. Prentice Hall.
4. Borowitzka M A, Beardall J, Raven J H (2016). The physiology of microalgae. Springer.
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10. Hallegraeff, G.M, Anderson D.M, Cembella A D (2004). *Manual on Harmful Marine Microalgae* UNESCO.
11. ICAR Publications: *Algal monographs*
12. Jha B, Reddy C R K, Rao M R (2009). Seaweeds of India: The diversity and distribution of seaweeds of Gujarat coast. Springer.
13. Kundal P, Mude S M (2009). *Geniculate coralline algae from the Neogene-quaternary sediments in and around Porbandar, southwest coast of India*. Journal geological society of India 74:267-274.
14. Kundal P, Mude S M (2012). *Additional coralline algae from the lower Miocene to late Holocene sediments of the Porbandar group, Gujarat*. Journal geological society of India 79:69-76.
15. Lee R E (2012). *Phycology* 4th edition. Cambridge University Press.
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18. Richardson, K. (1997). Harmful or exceptional phytoplankton blooms in the marine ecosystems. In. Blaxter and Southward (Eds) *Advances in Marine Biology,* 31:301-385. Academic Press
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UCBY010102 MYCOLOGY AND CROP PATHOLOGY

(Theory 36 + 36 = 72 Hrs; Practical 36 + 18 = 56 Hrs) Credits 4

MYCOLOGY (36 hrs)

Module 1: General introduction (2 hrs)

General characters of Fungi and their significance. Principles of classification of fungi, Classifications by C J Alexopoulos and Mims(1979)

Module 2: Thallus structure and reproduction in Fungi (27 hrs)

Mycelial structure and reproduction of Myxomycota – Acrasiomycetes,(Brief introduction only)Hydromyxomycetes, (Brief introduction only) Myxomycetes, Plasmodiophoromycetes. Mastigomycotina - Chytridiomycetes, (Brief introduction only) Hyphochytridiomycetes(Brief introduction only) Oomycetes. Zygomycotina - Zygomycetes, Trichomycetes. Ascomycotina - Hemiascomycetes, Pyrenomycetes, Plectomycetes, Discomycetes, Laboulbeniomycetes, Loculoascomycetes. Basidiomycotina - Teliomycetes, Hyphomycetes, Gastromycetes. Deuteromycotina - Blastomycetes, Hyphomycetes, Coelomycetes. Types of fruiting bodies in fungi.

Module 3: Fungal associations and Fungal Physiology (5 hrs)

Symbionts - Lichens, Mycorrhiza, Fungus-insect mutualism. Parasites - Common fungal parasites of plants, humans, insects and nematodes. Saprophytes - Fungal decomposition of organic matter, coprophilous fungi, cellulolytic fungi, lignolytic fungi. Agricultural significance of Fungi - Mycoparasite, mycoherbicide.

Module4 : Physiology of Fungi (2hrs)

Fungal Metabolic pathways, Secondary metabolic pathways, Mycotoxins Aflatoxins, Amatoxin, Ergot, Fusarin (general account) Antibiotics (Brief introduction only)

Practical (36 hrs)

1. Critical study of the following types by preparing suitable micropreparations; *Stemonitis, Physarum, Saprolegnia, Phytophthora, Albugo, Rhizopus, Aspergillus, Penicillium, Pilobolous, Saccharomyces, Xylaria, Peziza, Phyllochora, Puccinia, Termitomyces, Pleurotus, Auricularia, Polyporus, Lycoperdon, Dictyophora, Geastrum, Cyathus, Fusarium, Alternaria, Pestalotia, Parmelia,Graphis , Usnea, Cladonia.*

2. Isolation of fungi from soil and water by culture plate technique.

3. Staining and microscopicstudy of mycorrhizal colonization in root

4. Collection and identification of common field macro fungi/lichen (10 types).Submit report with photographs.

References

1. C J Alexopoulos, M Blackwell, C W Mims. Introductory Mycology (IV Edn).
2. Jim Deacon (2006). Fungal Biology (IV Edn). Blackwell Publishing.
3. L N Nair (2010). Methods of microbial and plant biotechnology. New Central Book agency (P) Ltd.
4. Kanika Sharma. Manual of microbiology: Tools and techniques.
5. G C Ainsworth, K F Sparrow, A S Sussman. The fungi: An advanced treatise.
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7. M E Hale. The biology of lichens.
8. A Misra, P R Agarwal. Lichens.
9. M C Nair, S Balakrishnan (1986). Beneficial fungi and their utilization. Sci. publ. Jodhpur.
10. V Ahamjian, M E Hale. The Lichens.
11. R Dayal. Predaceous Fungi. Commonwealth Publishers.
12. K.S. Bilgrami and R.N. Verma. Physiology of Fungi 3rd revised edition, Scientific Publishes (India)

CROP PATHOLOGY (36 hrs)

Module 1: Introduction to crop pathology (2 hrs)

Classification of plant diseases based on; Major causal agents - biotic and abiotic, General symptoms.

Module 2: Process of infection and pathogenesis (4 hrs)

Penetration and entry of pathogen into host tissue – mechanical, physiological and enzymatic. Host-parasite interaction, enzymes and toxins in pathogenesis.

Module3: Defense mechanism in plants (4 hrs)

Pre-existing structural and biochemical defense mechanisms, lack of essential nutrients. Induced structural and biochemical defense mechanisms, Inactivation of pathogen enzymes and toxins. Altered biosynthetic pathways. Phytoalexins.

Module 4: Transmission of plant disease (3 hrs)

Spread and transmission of plant diseases by wind, water, seeds and vectors.

Module 5: Plant disease management (8 hrs)

Exclusion, eradication and protection. Chemical means of disease control – common fungicides, antibiotics and nematicides. Biological means of disease control.Biotechnological approaches to disease resistance: Fungi in agricultural biotechnology, control of fungal plant pathogens by mycofungicides. Transgenic approaches to disease resistance.

Module 6: Major diseases in plants (15 hrs)

Cereals: Rice - blast disease, bacterial blight; Wheat - black stem rust disease. Vegetables: Chilly
- leaf spot; Ladies finger - vein clearing disease. Fruits: Banana - bacterial leaf blight, Bunchy top; Mango - Anthracnose; Citrus - bacterial canker; Papaya – mosaic. Spices: Ginger - rhizome rot; Pepper - quick wilt; Cardamom - marble mosaic disease. Oil seeds: Coconut - grey leaf spot, bud rot disease. Rubber yielding: *Hevea braziliensis* - abnormal leaf fall, powdery mildew. Sugar yielding: Sugarcane - red rot; root knot nematode. Cash crops: Arecanut –Mahali disease. Beverages: Tea - blister blight; Red rust; Coffee – leaf rust.

Practical (18 hrs)

1. Identify the diseases mentioned in the syllabus with due emphasis on symptoms and causative organisms by Herbarium/ live specimen.
2. Isolation of pathogens from diseased tissues (leaf, stem, fruit and seed) by blotter / culture methods.
3. Collection and preservation of specimens from infected plants. Submit 5 herbarium sheets/live specimens along with a report.
4. Culture media preparation and sterilization PDA/ Czapek dox's medium

References

1. K S Bilgrami, H C Dube. A text book of modern plant pathology.

2. Gareth Johnes. Plant pathology: principles and practice.

3. R S Mehrotra. Plant Pathology.

4. M N Kamat. Practical plant pathology.

5. V K Gupta, T S Paul. Fungi and Plant disease.

6. Malhotra, Aggarwal Ashok. Plant Pathology.

7. Rangaswamy, A Mahadevan. Diseases of crop plants in India.

8. B P Pandey. Plant Pathology.

9. George N Agrios (2006). Plant pathology (V Edn). Elsevier Academic Press.

UCBY010103: BRYOLOGY AND PTERIDOLOGY

(Theory 36 + 36 = 72 Hrs; Practical 18 + 36= 54 Hrs) Credits: 4

Module 1: Introduction (4hrs)

Diversity in forms habit and habitat. Origin and evolution of bryophytes. Trends in classification of Bryophytes: traditional and modern systems of classification (Rothmaler1951, Goffinet *et al* 2008) Contributions of Indian bryologists (Shiv Ram Kashyap, SK Pande, SC Srivastava). Fossil bryophytes.

Module 2: Ecological significance of bryophytes (3hrs)

Ecological significance of bryophytes with special reference on environmental monitoring. Water relations and regeneration techniques. Symbiotic associations of bryophytes.

Module 3: Economic importance of bryophytes (3hrs)

Economic importance of bryophytes.Cultivation and conservation of bryophytes *with* special note on *In vitro* culture techniques of bryophytes (brief description only).

Module 4: General characters and thallus organization (26 hrs)

General characters and comparative account of sporophyte, gametophyte, their interrelationships, spore dispersal mechanisms of following orders with reference to the types mentioned in the practical (development of sex organs not necessary).Hepaticopsida (Sphaerocarpales, Marchantiales, Jungermanniales and Calobryales)Anthocerotopsida (Anthocerotales).Bryopsida (Sphagnales, Polytrichales and Bryales).

Practical (18 hrs)

1. Detailed study of the structure of gametophytes and sporophytes of the following genera of Bryophytes by suitable micropreparation: *Riccia, Targionia, Cyathodium, Marchantia, Lunularia,Dumortiera, Reboulia, Pallavicinia, Porella, Anthoceros, Notothylas, Sphagnum, Pogonatum.*
2. Students are expected to submit a report of field trip to bryophytes natural habitats to familiarize with the diversity of bryophytes.

References

1. Kashyap S R (1932). *Liverworts of Western Himalayas and the Punjab plains*

(Vol. I & II). Research Co. Publications.

2. Chopra R N, P K Kumar (1988). *Biology of Bryophytes.* Wiley Eastern Ltd.
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6. Richardson D H S (1981). *Biology of Mosses*. Blackwell Scientific publications, Oxford.
7. Shefield W B (1983 – '84). *Introduction to Bryology* (Vol. 1, 2). Jour. Hattori Bot. Lab, Nichinan, Japan.
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9. Udak R (1976). *Bryology in India*. Chronica Botanica Co.
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14. Campbell, Ditt (1940). *The evolution of land plants*. Stanford University Press.
15. Srivastava S N (1992). *Bryophyta*. Pradeep Publications.

PTERIDOLOGY (36hrs)

Module 1: General introduction (2 hrs)

Introduction, general characteristics and origin of Pteridophytes(Anthocerotan theory and algal origin)

Module 2: Classification and evolution of Pteridophytes (9 hrs)

Classification by Smith (1955), Zimmermann (1959) and a brief account of classification by pteridophyte phylogeny Group – PPG-2016 (up to order).Evolution: Telome theory, Stelar evolution in pteridophytes.Heterospory and seed habit in pteridophytes.

Module3: Structure of the plant body (20 hrs)

Distribution, habitat, morphology,anatomy of sporophytic and gametophytic generation and reproduction of the following classeswith reference to the genera mentioned (development of sex organs is not necessary).

Division:

Psilophyta.
Class-
Psilophytopsid
a,
Order –
Psilophytales-Rhynia
Class-Psilotopsida,
Order – Psilotales-Psilotum
Division:
Lycophyta.
Class-
Eligulopsida,
Order lycopodials-
Lycopodium Class-
Ligulopsida
Order-Selaginellales-
Selaginella Order –
Isoetales-Isoetes,
Order – Pleuromeiales-Pleuromeia
Order – Lepidodendrales-Lepidodendron, Lepidocarpon and
Stigmaria Division: Sphenophyta (Calamophyta)
Class- Sphenophyllopsida.
Order – Sphenophyllales-
Sphenophyllum Class-
Calamopsida,
Order – Equisetales-
Equisetum.
Division:Filicophyta.
Class- Eusporangiopsida
Order –Ophioglossales-
Ophioglossum Order –
Marattiales-Angiopteris
Class-
Protoleptosporangiopsida

Order – Osmundales-

Osmunda

Class- Leptosporangiopsida

Order – Filicales-Pteris, Adiantum, Gleichenia and

Lygodium Order– Marsileales-Marsilea

Order – Salviniales-Salvinia and Azolla.

Class- Primopteropsida

Order – Cladoxylales-

Cladoxylon Order –

Coenopteridiales

Module 4: Developmental studies in Pteridophytes (3 hrs)

Development of sporangium, mechanism of spore dispersal. Apogamy and apospory in pteridophytes.

Module 5: Ecological and economic importance (2 hrs)

Ecological significances: Diversity of macro and micro habitats of Pteridophytes in the major ecosystems. Ecological roles by pteridophytes: stabilization of disturbed habitats, prevention of soil and nutrient leaching, micro-habitats for seed/spore germination. Economic importance of pteridophytes: General- as garden plants, as food/food supplements, as medicine, as other useful items. Pollution control phyto-remediation by ferns. Biofertilizer- *Azolla-Anabaena*- model.

Practical (36 hrs)

1. Study of morphology and anatomy of vegetative and reproductive organs using clear whole mounts/sections of the following genera:
   Lycopodium, Isoetes, Selaginella, Equisetum, Psilotum, Angiopteris, Ophioglossum, Osmunda, Marsilea, Salvinia, Azolla, Lygodium, Acrostichum, Gleichenia (Dicranopteris), Pteris and *Adiantum.*
2. Study of fossil pteridophytes with the help of specimens and permanent slides.
3. Field trips to familiarize with the diversity of pteridophytes in natural habitats and submit a report.

References

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UCBY010104: GYMNOSPERMS, PALAEOBOTANY AND EVOLUTION

(Theory: 27 + 09 + 18= 54 hrs; Practical: 27 hrs) Credits: 4

GYMNOSPERMS (27 hrs)

Module 1: Introduction (3 hrs)

General characteristics, distribution and classification of gymnosperms (K R Sporne). Brief account of classification by Christenhusz*et al.*, (2011). Distribution of living gymnosperms in India.

Module 2: Vegetative and reproductive structures of Gymnosperms (20 hrs)

Detailed study of the vegetative morphology, internal structure, reproductive structures, and evolution of the orders and families (with reference to the genera mentioned).

Class Cycadopsida: *Lyginopteris, Lagenostoma, Glossopteris, Medullosa, Caytonia. Bennettites, Williamsonia, Pentoxylon,Cycas, Zamia.* Class Coniferopsida: General account of families under Coniferales, range of form and structure of stem, leaves. Range of form and structure of female cones in Coniferales -*Pinus, Cupressus, Podocarpus, Agathis, Araucaria, Taxus and Ginkgo*.Class Gnetopsida: *Gnetum*. General account of Ephedraceae and Welwitschiaceae

Module 3: Gametophyte development of Gymnosperms (2 hrs)

General account on the male and female gametophyte development in Cycas. Comparative study of male gametophytes of living Coniferales

Module4: Economic importance of Gymnosperms (2 hrs)

Economic importance of gymnosperms; pharmacological importance of *Ginkgo*

Practical (27 hrs)

1. Study the morphology and anatomy of vegetative and reproductive parts of *Cycas, Zamia, Pinus, Cupressus, Agathis, Araucaria, Podocarpus* and *Gnetum.*
2. Study of fossil gymnosperms through specimens and permanent slides.
3. Conduct field trips to familiarize various gymnosperms in nature and field, identification of Indian gymnosperms and submit a report.

References

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19. Srivastava R C (2006). *Diversity, distribution and economic importance of living gymnosperms of India*. Punjab University Research Journal, 56:45-87.

PALEOBOTANY (Theory: 9 hrs; Practical: 9 hrs)

Module 1: Introduction (1 hr)

Evolutionary Time scale: Eras, Periods and Epochs (Including: Meghalayan, Northgrippian and Greenlandian ages).

Module2: Fossils (3 hrs)

Fossils-Definition, types.Fossilization: mode of preservation and their importance. Stages in primate evolution-including *Homo*.

Module 3: Techniques and Preservation (3 hrs)

Techniques in Palaeontology: Mega and Micro-fossils, Nanofossils, Ichnofossils-collection. Reformation and illustration- Binomial Nomenclature. Methods of Plant-fossil studies: Preservation and preparation, age determination: Carbon dating.

Module4: Nomenclature and applied aspects (2 hrs)

Fossil record: Systematic, reconstruction and nomenclature. Fossil records from India. Applied aspects of Paleobotany.

References

1. Agashe S. N. (1995). *Palaeobotany*. Oxford & IBH, New Delhi.
2. Ruap D. M. and Stanley S.M (1999). *Principles of Palaeontology*. W.H. Freeman and Co. Toppan Co. Ltd.
3. Siddiqui, K.A. (2002). *Elements of Palaeobotany*. Kitab Mahal. Allahabad.
4. Stewart, W.N. and Rothwell G.W. (1993). *Palaeobotany and the Evolution of Plants*. Cambridge University Press.
5. Thomas, B.A. & Spicer R.A. (1987). *The Evolution and Palaeobiology of land plants*. Discordies Press, Fortland, USA.

EVOLUTION: (Theory: 18 hrs)

Module 1: Introduction (3 hrs)

Evolution of biomes. Mixing process, intercontinental connections. Climatic zonations, dispersal

opportunities, dispersal availability, sub-climax and climax dispersal. Phylogeny and age of biomes: Interwoven biome phylogeny and biome extension and resurrection.

Module 2: Evidences for evolution (2 hrs)

Morphology, comparative anatomy, embryology, physiology,biochemistry, paleontology and biogeography. Micro and macro-evolution and punctuated equilibrium.

Module3: Natural Selection (3 hrs)

Natural selection and adaptation. Nature of natural selection, limiting factors, origin of races and species, Kins Selectionand Hamilton's Rule. Rate of evolutionary change: Internal and external- factors. Significance of genetic drift in natural selection.

Module 4: Mutation as an Evolutionary Force (3 hrs)

Mutation and genetic divergence. Evolutionary significance of mutations. Genetic assimilations (Baldwin effect). Genetic homoeostasis. Mutation for natural selection. Eugenics and euthenics.

Module 5: Speciation (3 hrs)

Species concept; morphological species, biological species and evolutionary species. Mode of speciation – allopatric, sympatric and parapatric. Types of Speciation-Phyletic and true-speciation. Hybridization (Double cross hybrid of field Corn); Rate of hybridization and introgression in evolution of species. Reproductive isolation: Pre-zygotic and post-zygotic isolation.

Module6: Co-evolution (2 hrs)

Symbiosis. Plant-animal Co-evolution; mutualism, commensalism.Protective - colouration and shape. Mimicry: Batesian and Mullerian mimicry.Molecular tools in phylogeny.

References

1. Allan C. Hutchinson (2005). *Evolution and the Common Law*. Cambridge University Press.
2. Douglas J. Futuyma (2009). *Evolution*. Sinauer Associates. INC-Publishers. USA.
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5. Hancock J. F (2003). *Plant Evolution and the Origin of Crop Species*. CABI.
6. Herbert H. Ross (1962). *A Synthesis of Evolutionary Theory*. Prentice Hall Of India.
7. Horatio Hacketrt Newmann (1932). *Evolution, Genetics and Eugenics*. University of Chicago press.
8. Katy Human (2006). *Biological evolution: An anthology of current thought.* The Rosen publishing group, Inc.
9. Kenneth V. Kardong (2005). *An introduction to Biological Evolution*. McGraw-Hill publications. New York.
10. Martin Ingrouille and Bill Eddie (2006). *Plants Diversity and Evolution*. Cambridge University Press.
11. Maxtoshi Nei and Sudhir Kumar (2000). *Molecular Evolution and phylogenetics*. Oxford University Press.
12. Monroe W. Strickberger (1990). *Evolution*. Jones and Bartlett publishers.
13. Paul Amos Moody (1970). *Introduction to Evolution*. Harper and Row publishers, Newyork.
14. Roderic D. M. Page and Edward C. Holmes (1998). *Molecular Evolution: A Phylogenetic approach*. Blackwell Science Ltd.
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18. Willis K. J. and J. C. Mc Elwain (2002). *The Evolution of Plants*. Oxford University Press.

MODEL QUESTION PAPERS - THEORY

M. Sc. Botany Degree (C.S.S) Examination I Semester

Faculty of Science

UCBY010101: Microbiology and Phycology

(2019 admissions onwards)

Time: Three hours **Max. Weight: 30**

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. What is metagenomics?
2. Name two parasitic algae
3. Distinguish between valve and girdle of diatoms
4. Comment on nanobes
5. Define Palmelloid stage, cite an example
6. Mention the toxin and causative organism of Amnesic shell fish poisoning
7. Mention major groups and divisions of classification by Lee
8. How will you sterilize bacterial culture medium?
9. Define SCP with suitable examples
10. Distinguish between virions and viriodes

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Describe the thallus structure of Phaeophyceae
12. Describe the ultrastructure of bacterial flagella
13. Comment on algal symbiosis
14. Describe algal cell components
15. Give an account on various sterilization techniques in microbiology
16. Describe major life cycle patterns in Chlorophyceae
17. Explain allelopathy and microalgae
18. What are endophytes? Explain their role in plant growth promotion

(**6 x 2 = 12**)

Section C

(Answer any **two** questions. Each question carries a weight of 5)

19. Give a detailed account on isolation, maintenance and preservation of pure cultures of bacteria
20. Illustrate triphasic life cycle in algae with suitable examples
21. What are algal blooms? describe causative organisms, symptoms and toxins of major toxic algal blooms
22. Explain the life cycle of viruses

(2 x 5 = 10)

M. Sc. Botany Degree (C.S.S.) Examination

I Semester

Faculty of Science

UC**BY010102: Mycology and Crop Pathology**

(2019 admissions onwards)

Time: Three hours **Max. Weight: 30**

Section A

(Answer any **eight** questions. Each question carries a weight of 1)

1. What is sclerotium?
2. What is crozier formation? Give example.
3. Describe the structure of basidium.
4. Distinguish between sporangium and conidium
5. What is meant by coprophilous fungi? Give any two examples
6. Deuteromycetes are also known as fungi imperfecti. Why?
7. What is puckering?
8. What is meant by horizontal resistance?
9. What are the disseminating methods of Bacterial Canker in Citrus Spp.?
10. What are the symptoms of Bunchy top Banana?

(8 x 1 = 8)

SectionB

(Answer any **six** questions. Each question carries a weight of 2)

11. Describe the structure of dolipore septa
12. Write short note on different type of fruiting bodies found in ascomycetes
13. Explain different type of conidial development in Duteromycetes
14. Describe the structure of spermagonium in *Puccinia graminis*
15. Illustrate the life cycle of *Physarum polycephalum*
16. Write short note on the Uredospore survival of *Puccina graminis tritici* in India
17. Writeshort note on the symptoms, causativeorganismand control measures of Mahali disease of Arecanut.
18. What are the resistant verities of paddy against Bacterial blight?

(**6 x 2 = 12**)

SectionC

(Answer any **two** questions. Each question carries a weight of 5)

19. Describe the life cycle of *Puccinia graminis tritici*. with illustrations
20. Explain the classification of Fungi by C. J. Alexopoulos and Mims
21. What are the principles of plant disease control? Explain
22. Describe the symptoms, causative organism and control of Mosaic diseases

(2 x 5 = 10)

M Sc Degree (C.S.S) Examination

First semester

Faculty of science

UC**BY010103:Bryology and Pteridology**

(2019 Admission onwards)

Section A

(Answer any **eight** questions. Each question carries a weight of 1)

1. What are endohydric bryophytes?
2. Explain the term synangium.

3. Define apospory.
4. Name two aquatic ferns.
5. What are gemma cups?
6. Write the ecological significance of bryophytes.
7. What are elaters?
8. Write the significance of heterospory.
9. Explain the term protocorm.
10. Why *Azolla* is considered as a biofertilizer?

(8 x 1 = 8)

Section B

(Answer any six questions, each question carries a weight of 2).

11. Describe *Lepidodendron.*
12. Explain the morphological characteristics of *Psilotum.*
13. Describe vegetative reproduction in bryophytes.
14. Explain the morphology of *Ophioglossum.*
15. Write notes on heterospory and seed habit.
16. Describe the reproductive structure in *Osmunda.*
17. Write notes on conservation and cultivation of bryophytes
18. Write an account of the sporophyte of *Sphagnum.*

(2x6= 12)

Section C

(Answer any two questions, each question carries a weight of 5)

19. Describe the origin and habitat diversity of bryophytes.
20. Describe origin, organization and evolution of stele in pteridophytes.
21. Compare the gametophyte and sporophyte of hepaticopsida and bryopsida.
22. Compare the features of Psilophytales and Psilotales and write notes on the evolutionary significance of these groups.

(2x5=10)

M. Sc. Botany Degree (C.S.S) Examination

I Semester

Faculty of

Science

UCBY01014: Gymnosperms, Palaeobotany and Evolution (2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Mention the orders in class Cycadospsida by Sporne
2. Describe Baldwin effect
3. Name two stem genera of fossil gymnosperms
4. Define mimicry
5. What is yew wood
6. Define copal
7. Write brief note on fossil records from India
8. Define carbon dating
9. Comment on modern coniferales
10. Define cupule

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Mention the similarities and differences of gymnosperms with pteridophytes and angiosperms
12. Distinguish between mutualism and commensalism
13. Comment on the distribution of living gymnosperms in India
14. Describe Kins Selectionand Hamilton's Rule
15. Describe the economic importance of gymnosperms
16. Mention the evolutionary time scale with eras and periods
17. Describe pharmacological importance of *Ginkgo*
18. Significance of genetic drift in natural selection

(6 x 2 = 12)

Section C

(Answer any **two** questions. Each question carries a weight of 5)

19. With suitable diagrams, describe the stelar anatomy of Medullosaceae and Pentoxylaceae
20. Describe the evidences of evolution
21. Describe the salient features of Podocarpaceae and Araucariaceae
22. Write an essay on speciation

(2 x 5 = 10)

MODEL QUESTION PAPERS – PRACTICAL

SEMESTER I - PRACTICAL COURSE I
UC**BY010105: MICROBIOLOGY, PHYCOLOGY, MYCOLOGY AND CROP PATHOLOGY**

Time: 4 hours **Weightage:30**

1. Make suitable micropreparations of A, B and C. Draw labeled diagrams and identify giving reasons. (Total weight 2.5 = Preparation – 1, Diagram – 0.5, Identification with reasons – 1; 2.5 x 3 = 7.5)
2. Write critical notes on D and E.
   (Total weight 1 = Identification – 0.5, Critical note – 1; 1.5 x 2 = 3)
3. Sort out any fouralgae from the algal mixture F and make separate clear mounts. Identify and draw labeled diagrams.
   (Total weight 1.5 = Preparation – 0.5, Identification = 0.5, Diagram – 0.5; 1.5 x 4 = 6)
4. Spot at sight G, H and I.
   (Total weight 1 = Identification 0.5, Part displayed = 0.5; 1 x 3 = 3)
5. Identify the disease in J, K and L and write the causative organism. (Total weight 1 = Identification – 0.5, Causative organism – 0.5; 1 x 3 =3)
6. (a) Isolate Bacteria from the soil sample M by serial dilution and streak out by quadrate method. (Total weight 2 = Working – 1, Procedure – 1)
7. Submit three specimens of plants showing typical disease symptoms (Total weight 1.5 = 0.5 x 3 = 1.5)
8. Practical record
   (Weight = 4)

Key to the questions:

1. A, B, C: Alga, Fungi/Lichen.
2. D, E - Fungi.
3. F – Algal mixture containing five filamentous types.
4. G, H, I – macroscopic or microscopic specimens from algae, fungi/lichen with clear and distinguishable identifying characters.
5. J, K, L – Herbarium or live/dry specimen showing the symptoms of any disease specified in the syllabus
6. M - Supply necessary soil sample.
7. Credit for specimens showing typical symptoms – include a short report on the disease.
8. Awarding 'A grade' for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.

SEMESTER I - PRACTICAL COURSE II
UC BY010106: BRYOLOGY, PTERIDOLOGY, GYMNOSPERMS, AND PALEOBOTANY
Model question paper

Time: 4 hours **Weightage: 30**

1. Make stained micropreparations of specimens A, B, C and D. Drawlabeled diagrams for each and identify giving reasons.
   (Total weight 2.5 = Preparation - 1, Diagram – 0.5, Identification with reasons – 1; 2.5 x 4 = 10)
2. Make stained micropreparations (TS, TLS and RLS) of E. Draw labeled diagram and identify giving reasons.
   (Total weight 5.5 = Preparations – 1 each, Identification with reasons - 1, Diagrams - 0.5 each)
3. Identify at sight F, G, H, I and J.
   (Total weight 1 = Genus identification - 0.5, Part displayed - 0.5; 1 x 5 = 5)
4. Write critical notes on the reproductive structures K and L. (Total weight 3 =

Identification – 0.5, Critical note – 1; 2 x 1.5 = 3)

5. Identify and write a critical note on M

   (Total weight 1.5 = Identification – 0.5, Critical note - 1)

6. Practical record

   (Weight = 5)

Key to the questions:

1. A, B, C, D - Two suitable specimens from Pteridophytes, one from Bryophytes and a Gymnosperm leaf.
2. E–Suitable specimen from Gymnosperms.
3. F, G, H, I, J – Suitable specimens from Bryophytes, Pteridophytes and Gymnosperms; both reproductive and/or vegetative structures; should not exceed two specimens from one group.
4. K, L – Specimens from Bryophytes, Pteridophytes and Gymnosperms.
5. M - Fossil slides/specimens/photographs of types specified in the syllabus; both vegetative and reproductive structures included.
6. Awarding 'A grade' for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly.This also includes field study report(s)/Lab visit report(s), if any.

SEMESTER II

SECOND SEMESTER COURSES

UCBY010201	PLANT ANATOMY, DEVELOPMENTAL BIOLOGYAND HORTICULTURE
UCBY010202	CELL BIOLOGY, GENETICS AND PLANT BREEDING
UCBY010203	PLANT PHYSIOLOGY AND BIOCHEMISTRY
UCBY010204	MOLECULAR BIOLOGY
UCBY010205	PLANT ANATOMY, DEVLOPMENTAL BIOLOGY, HORTICULTURE, CELL BIOLOGY, GENETICS AND PLANT BREEDING - PRACTICAL
UCBY010206	PLANT PHYSIOLOGY, BIOCHEMISTRY AND MOLECULAR BIOLOGY - PRACTICAL

Total Credits: 19
Total Hours: 450

UCBY010201: PLANT ANATOMY, DEVELOPMENTAL BIOLOGY AND HORTICULTURE

(Theory: 36 + 18+ 18= 72 Hrs; Practical:27 + 09 + 09= 45 Hrs) Credits: 4

PLANT ANATOMY (Theory: 36 Hrs; Practical: 27 Hrs)

Module 1: Introduction (1 hr)

Scope and significance of plant anatomy. Role of anatomy in phylogeny.

Module 2: Meristem (4 hrs)

Apical organization: Stages of development of primary meristem and theories of apicalorganization (shoot and root). Origin of branches. Primary Thickening Meristem (PTM) in Monocots. Secretory tissues in plants. Structure and distribution of secretory trichomes (e.g. *Drocera,Nepenthes*), Salt glands, collectors, nectaries, resin ducts and laticifers.

Module 3: Secondary Structure (16 hrs)

Mechanical tissues in plants. Structure and functions. Vascular cambium and cork cambium: Structure and functions. Factors affecting cambial activity. Secondary xylem: ontogeny, structure, components and functions. Origin of vessel in angiosperms and dilation of rays. Axial parenchyma distribution in wood. Secondary phloem: Ontogeny, structure, components and functions. Stelar and extra stelar thickening in angiosperms. Reaction wood, compression wood and tension wood. Factors affecting reaction wood formation. Dendrochronology: Growth rings and their functions. Summer and Spring-wood.Anomalous secondary growth in dicots and monocots. Tyloses: Structure and function. Plant fibers: distribution, structure and commercial importance of coir, jute, and cotton. Root-stem transition in angiosperms.

Module 4: Leaf and Node (4 hrs)

Leaf: ontogeny and structure of leaf. Structure, development and classification of stomata and trichomes. Leaf abscission. Nodal anatomy: unilacunar, trilacunar and multilacunarnodes, nodal evolution; role of nodal anatomy in taxonomy.

Module 5: Reproductive Anatomy (8 hrs)

Floral anatomy: Anatomy of floral parts - sepal, petal, stamen and carpel, vascular anatomy of flower and modifications. Development of epigynous ovary-appendicular and receptacular theory, role of floral anatomy in taxonomy. Fruit and seedanatomy - anatomy of fleshy and dryfruits - follicle, legume and berry. Dehiscence of fruits. Anatomy of seeds.

Module 6: Applied Anatomy (3 hrs)

Research prospects in anatomy. Applications of Anatomy in Systematics (Histotaxonomy) and Pharmacognosy.

Practical (27 Hrs)

1. Study the Anomalous- Primary and Secondary features in: *Bignonia, Amaranthus, Nyctanthes, Piper, Bougainvillea* and *Strychnos*.Study of stomatal types (Anomocytic, anisocytic, paracytic and piacytic) and determination of stomatal index.
2. Study of nodal patterns (Unilacunar. Trilacunar and Multilacunar).

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DEVELOPMENTAL BIOLOGY (Theory: 18 Hrs+ Practical: 9 Hrs)

Module 1: History and Basic Concepts of Development (5hrs)

Overview on the modern era of developmental biology emerged through multidisciplinaryapproaches. Stages of development- zygote, blastula, gastrula, neurula. Cell fate and commitment, potency- concept of embryonic stem cells, differential gene expression, terminal differentiation, lineages of three germ layers, fate map. Mechanisms of differentiation- cytoplasmic determinants, embryonic induction, concept of morphogen, mosaic and regulative development. Pattern formation-axis specification, positional identification (regional specification). Morphogenetic movements. Model organism in developmental biology (Arabidopsis- brief account only)

Module 2: Overview of Plant Development (9 hrs)

Angiosperm life cycle. Anther: microsporogenesis and microgametogenesis. Viability of pollen grains. Pollination, pollen germination, growth and nutrition of pollen tube, pollen morphology, exine sculpturing, pollenkitt NPC formula.Ovule: megasporogenesis and mega gametogenesis. Types of embryosac and development. Fertilization: Double fertilization; embryo development - different types. Endospermdevelopment, types of endosperm, haustorial behavior of endosperm. Xenia and metaxenia. Polyembryony – types and causes. Seed formation, dormancy and germination. Apomixis, parthenogenesis

Module 3: Morphogenesis and Organogenesis in Plants: (4 hrs)

Organogenesis in plants, transition to flowering, floral meristems and floral development. Homeoticgenes in plants.

Practical (9hrs)

1. Embryo excision from young seeds.
2. Identification of different types of ovules, embryos, polyembryony, endosperm, pollen grains, anther growth stages.

References

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HORTICULTURE (Theory: 18 Hrs

Practical: 9 Hrs) Module 1: Introduction (2 hrs)

Introduction to Horticulture; nature and scope. Objectives of horticulture.

Module 2: Principles of Horticulture (4 hrs)

Principles of landscape gardening. Gardening: ornamental and indoor gardens, kids gardens, vertical and roof top gardens. Garden adornments. Propagation methods-layering, budding, grafting, and micropropagation-merits and demerits.

Module 3: Horticulture Applications (6 hrs)

Composting: aerobic, anaerobic and vermicomposting; mist chamber, green house and glass house. Effect of pollution on indoor plants. Commercial products of horticulture. Olericulture: home and market - gardening and truck farming. Seed production.

Module 4: Floriculture (3 hrs)

Introduction, nature and scope. Fresh and dry flower arrangements. Production of Cut flowers, cultivation of orchids, foliage potted plants and bedding plants. Future prospects of floriculture.

Module 5: Modern trends in horticulture (3 hrs)

Bonsai: Selection of plants and making of bonsai. Physical control of plant growth in Bonsai preparation. Preparation of terrarium, aquaponics and arbori culture. Components of high-tech farming.

Practical: (9 Hrs)

1. List out the Garden components in the Photograph.
2. Demonstration of Preparation of a Terrarium.
3. Propagation methods-layering and grafting.

References

1. Adam C.R. (2004). Principles of Horticulture. Elsevier Butterworth-Heinemann.
2. Peter K. V. (2015). *Basics of Horticulture*. New India Publishing Agency, New Delhi.
3. Gupta S.N. (2016). *Instant Horticulture*. Jain Brothers, New Delhi.
4. Tiwari A.K. and R. Kumar (2012). *Fundamentals of Ornamentals, Horticulture and Landscape Gardening*. New India Publishing Agency, New Delhi.

UCBY010202: CELL BIOLOGY, GENETICS AND PLANT BREEDING
(Theory: 27+27+18=72Hrs; Practical: 18+18+9=45 Hrs; Credits: 4)

CELL BIOLOGY (Theory: 27 Hrs; Practical: 18 Hrs)

Module 1: Introduction to plant cells (7 hrs)

Structural organization of plant cell. Plasma membrane – chemical composition, organization, membrane fluidity, dynamic nature.Ultrastructure and functions of mitochondria, peroxisomes, glyoxysomes and chloroplast. Endomembrane system – structure and functions of endoplasmic reticulum, Golgi complex, lysosomes and vacuoles. Transport of materials – biosynthetic (secretory) and endocytic pathway. Chromosomes – organization of chromatin and chromosomes

- histones and nonhistone proteins, nucleosomal organization of chromatin, higher levels of chromatin organization in chromosomes. Heterochromatin and Euchromatin, formation of heterochromatin. Molecular structure of the Centromere and Telomere.

Module 2: Cell signaling (6 hrs)

Cell communication - general principles. Signaling molecules and their receptors; external and internal signals that modify metabolism, growth, and development of plants.Receptors: cell surface receptors - ion-channel linked receptors (Voltage-gated ion channels and Ligand-gated ion channels in neurons), G-protein coupled receptors (β-adrenergic receptor), Tyrosine-kinase linked receptors (Insulin receptor), and Steroid hormone receptors (Estrogen receptor). Signal transduction pathways, second messengers, regulation of signaling pathways. Bacterial and plant two-component signaling systems (Brief study).

Module 3: Cell interaction (4 hrs)

Extra cellular matrix, Cell adhesion molecules - cadherins, integrins, selectins, fibronectins, laminin and Immunoglobin superfamily. Cell-cell adhesions (Junctional and non-junctional adhesive mechanisms; occluding junctions, anchoring junctions, communicating junctions (Connexons and plasmodesmata).

Module 4: Cytoskeleton (3 hrs)

Functions of cytoskeleton; Structure, assembly, disassembly and regulation of filaments involved – actin filaments (microfilaments), microtubules, and intermediate filaments. Molecular motors – kinesins, dyneins, and myosins.

Module 5: Cell cycle and its regulation (7 Hrs)

Phases of cell cycle, mitosis and meiosis (Brief study), Spindle formation and its disintegration, Mechanisms of chromosome movement and separation during anaphase, Role of cohesins and condensins. Role of motor proteins. Cell cycle control mechanisms - extracellular an intracellular signals. Cell cycle checkpoints – DNA damage checkpoint, centrosome duplication checkpoint, spindle assembly checkpoint - role of cyclins and cyclin dependent kinases. Apoptosis – process of programmed cell death, extrinsic and intrinsic pathways of apoptosis.

Practical (18 hrs)

1. Identification of different stages of mitosis and study of morphology of metaphase chromosomes from Onion root meristems (Recorded by photomicrographs).
2. Identification of different stages of meiosis from suitable plant material (Recorded by photomicrographs).
3. Microscopic observation (Chloroplast).
4. Study of mitotic index from suitable plant material.

References

1. Gerald Karp (2014). *Cell Biology* (VII Edn). Wiley.
2. Gerald Karp (2008). *Cell and Molecular biology: Concepts and experiments* (V Edn). John Wiley & Sons
3. George Plopper, David Sharp, Eric Sikorski (2015). *Lewin's Cells* (III Edn). Jones and Bartlett Learning.
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9. David E Sadava (2009). Cell biology: Organelle structure and function. CBS.

GENETICS (Theory: 27Hrs; Practical: 18 Hrs)

Module 1: Genetics - From "Factors" to "Genes" and gene interactions (6 hrs)

Introduction to Mendelian genetics and principles of inheritance; Extensions of Mendelism (Brief study).Model organisms in Genetics - *Arabidopsis thaliana, Neurospora crassa, E. coli, Drosophila melanogaster* and *Caenorhabditis elegans* (Brief study).Linkage, crossing over and chromosome mapping in eukaryotes. Cytoplasmic inheritance, multiple alleles,quantitative inheritance, QTL; Penetrance and expressivity, Sex determination in plants and animals, X- chromosome inactivation in mammals – dosage compensation.

Module 2: Human Genetics and Cancer (9 hrs)

Inheritance of traits in Humans - Pedigree analysis(Nail Patella Syndrome and ABO locus) , genetic disorders in humans - autosomal recessive - ADA deficiency, Sickle cell anemia; autosomal dominant - Huntington's chorea, familial

hypercholesterolemia; inborn errors of metabolism - phenylketonuria, Alkaptonuria, Albinism. Cancer - a genetic disease; Cancer and cell cycle, oncogenes, chromosome rearrangements and cancer (Philadelphia Chromosome), Tumour suppressor genes, causes of cancer, properties of cancer cells, types of cancer, Genetic pathways to cancer

Module 3: Mutations (4 hrs)

Classification and types: Chromosomal mutations - changes in structure and number; Gene mutations, Effect of different mutagens on the structure of DNA.

Module 4: Population Genetics (8 hrs)

Emergence of evolutionary theory and population genetics; Concepts in population genetics - Gene pool, Gene frequency, genotype frequency; Hardy Weinberg's Law and its applications; Exceptions to Hardy-Weinberg's Principle; Factors affecting gene frequency - Mutation, selection, migration, natural selection and Genetic drift (Bottle neck effect and Founder effect); Populations in Genetic equilibrium - balancing selection, mutation-selection balance, mutation drift balance. Speciation - pre-zygotic and post-zygotic isolation (Brief account); modes of speciation - Allopatric, sympatric and parapatric.

Practical (18 Hrs)

1. Workout problems related to linkage, crossing over and gene mapping, human pedigree analysis, Cytoplasmic Inheritance, Multiple alleles and quantitative inheritance.
2. Work out problems in population genetics-gene and genotype frequency, Hardy-Weinberg equilibrium.

References

1. Benjamin Lewin (2000). *Genes VII*. Oxford university press.
2. Daniel L Hartl, Elizabeth W Jones (2009). *Genetics: Analysis of genes and genomes* (VII Edn). Jones and Bartlett publishers.
3. Gardner E J, Simmons M J, Snustad D P (1991). *Principles of Genetics* (III Edn). John Wiley and Sons Inc.
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PLANT BREEDING (Theory: 18 Hrs; Practical 9 hrs)

Module 1: Introduction (2 hrs)

Objectives of plant breeding, important achievements and future prospects.

Domestication and centers of origin of cultivated plants.

Module 2: Hybridization (3 hrs)

Hybridization-role and methods, inter-varietal, inter-specific and inter-generic crosses. Incompatibility and male sterility in plant breeding (brief account). Back-cross breeding. Heterosis, inbreeding depression.

Module 3: Idiotype breeding (2 hrs)

Role and methods, applications of idiotype breeding.

Module 4: Breeding for resistance (3 hrs)

Breeding for biotic (disease) and abiotic (drought) stresses; loss due to diseases, disease development, disease escape, disease resistance, vertical and horizontal-resistances of biotic stress; methods of breeding for disease resistance.

Module 5: Mutation breeding (6 hrs)

Mutagens and crop improvement. Spontaneous and induced mutations, effects of mutation. Physical and chemical mutagens; principles and working of gamma gardens, methods of mutation breeding, mutations in oligogenic traits, mutations in polygenic traits, limitations of mutation breeding, achievements of mutation breeding.Role of mutation in plant breeding.

Module 6: Modern breeding methods (2 hrs)

Modern trends in plant breeding: Tissue culture technologies (DNA marker-assisted Selection (MAS) - a brief study only).

Practical: (9 Hrs)

1. Hybridization techniques in self and cross pollinated plants.
2. Estimation of pollen sterility through in-vitro germination/staining-technique.
3. Visit a Plant Breeding station to familiarize with breeding programmes. Submit a report of the visit.

References

1. Allard R. W. (1995). *Principles of Plant Breeding*. John Wiley and Sons, Inc.
2. Denis Murphy (2007). Plant Breeding and Biotechnology. Cambridge University Press.
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8. Shukla.R.S. and P.S.Chandel (1974). Cytogenetics, Evolution, Biostatistics and Plant Breeding. S.Chand and Company Ltd. New Delhi.
9. Singh B. D. (1996). *Plant Breeding: Principles and methods*. Kalyani Publications.

UCBY010203: PLANT PHYSIOLOGY AND BIOCHEMISTRY

(Theory 45+27 =72 Hrs; Practical 36+27=63 Hrs; Credits: 4) PLANT PHYSIOLOGY (Theory: 45 Hrs; Practical: 63 Hrs)

Module 1: Transport and Translocation of water and solutes (8 hrs)

(a) Absorption and translocation of water, apoplast and symplast, pathways of water uptake and transport, xylem transport, passive and active transport. Aquaporins. Water pathway in the leaf – driving force of transpiration, leaf anatomy for regulating transpiration. Stomatal biology – light dependent stomatal opening. Soil-plant-atmosphere continuum.

(b) Absorption of minerals: Soil characters influencing nutrient availability – size and charge of soil particles, soil pH. Mechanism of entry of minerals into roots.

(c) Transport of ions, solutes and macromolecules: Electrical properties of membranes, Membrane potential. Transport across cell membranes: Passive – diffusion, facilitated diffusion, membrane channels; plasmodesmata, porins, ion channels – gated channels, structure and working of K^+ ion channels. Active transport: Carrier proteins; P-type H^+ ATPase, ABC transporters.

Module 4: Photosynthesis (12 hrs)

(a) Light harvesting complexes: PS I, PSII; Structure and composition of reaction centers. Basic principles of light absorption, excitation energy transfer, mechanism of electron transport, photooxidation of water, proton electrochemical potential – photophosphorylation.

(b) Structure and function of RuBisco, CO_2 fixation – Calvin cycle. Photorespiration, role of photorespiration in plants. CO_2 concentrating mechanisms – algal and cyanobacterial pumps, C4 cycle, CAM pathway. Synthesis of starch and sucrose, photosynthetic quantum yield and energy conversion efficiency. Transport of photoassimilates – phloem loading and unloading, mechanism of phloem translocation – pressure flow. Thylakoid ET inhibitors, Photoinhibition and its tolerance mechanism.

Module 5: Respiration (10 hrs)

Three stages of respiratory metabolism (brief study only). Plant mitochondrial electron transport and ATP synthesis – organization of electron transfer complexes (complex I – IV). ATPase (Complex V) – detailed structure of F1 and Fo subunits, binding change mechanism of ATP synthesis. Comparison of mitochondrial and chloroplast ATP synthesis. Cyanide resistant pathway - alternative oxidase, its regulation and significance. Rotenone-insensitive pathway in plants.

Module 6: Nitrogen metabolism: (4 hrs)

N cycle. N fixation processes. Biological N fixation – structure of nitrogenase complex, reduction of N. Symbiotic N fixation – nodule formation, nodulin gene and nodulation genes, leghaemoglobin. Nitrate and ammonium assimilation. Transport of amides and ureides.

Module 7: Stress physiology (4 hrs)

Plant stress - biotic and abiotic. Stress sensing mechanisms in plants. Acclimation and adaptation mechanisms in plants.

Module 8: Sensory photobiology (4 hrs)

Plant photoreceptors - phytochromes, cryptochromes and phototropins, their function and mechanism of action. Photoperiodism and biological clocks – circadian rhythms. Floral induction and development.

Module 9: Plant growth regulators (3 hrs)

Physiological effects and mechanism of action of plant growth hormones. Role of elicitors in growth regulation.

Practical (36 hrs)

1. Measurement of Photosynthesis - Hill Reaction.
2. Estimation of proline in plant tissues under various abiotic stresses.
3. Estimation of phenol in plant tissues affected by biotic stress.
4. Determination of peroxidase activity in plant tissues affected by biotic/abiotic stresses.
5. Estimation of free amino acids in senescing leaves to understand the source to sink transformation phenomenon.
6. Determination of osmotic potential by tissue weight method.
7. Separation of photosynthetic pigments by TLC/paper chromatography and calculating the Rf value
8. Demonstration of amylase activity and GA effect in germinating cereal seeds.
9. Estimation of total chlorophyll and study of absorption pattern of chlorophyll solution.
10. Separation and collection of leaf pigments by silica gel column chromatography.
11. Determination of nitrate reductase activity.
12. Extraction and estimation of leghaemoglobin from root nodules.

References

1. Lincoln Taiz, Eduardo Zeiger, Ian Max Moller, Angus Murphy (2015). Plant Physiology and development (VI Edn). Sinaeur Associates, Inc. Publishers.
2. Lincoln Taiz, Eduardo Zeiger (2002). *Plant physiology* (II Edn). Sinaeur Associates, Inc. Publishers.
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(II Edn). Oxford
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BIOCHEMISTRY (Theory: 27 Hrs; Practical 27 Hrs)

Module 1: Introduction (2 hrs)

Acid and Bases, ionisation of water, dissociation of acids, Henderson-Hasselbalch equation, pKa.

Buffers - Common buffers (acetate, citrate and phosphate), buffer action, buffer capacity. Measurement of pH.

Module 2: Carbohydrates (4 hrs)

General structure and biological importance of carbohydrates. Monosaccharids and Oligosaccharides: classification and structure with common examples. Polysaccharides: Classification, structure and functions - starch, cellulose. Glycoproteins and glycolipids.

Module 3: Lipids (5 hrs)

(a) Classification, important biological functions. Structure of fatty acids, triglycerides, waxes, Phosphoglycerides and Sterols. Lipids with biological specific activities – steroids and isoprenoids. (b) Lipid metabolism in oilseeds – Oxidation of fatty acids, glyoxylate cycle, gluconeogenesis.

Module 4: Amino acids and proteins (5 hrs)

Classification and structure of aminoacids, peptide bond. Structure and functions of protein – primary, secondary, tertiary and quaternary structure. Ramachandran plot, alpha helix and beta conformations. Protein degradation in cells (brief account).

Module 5: Enzymes (7 hrs)

(a) Classification and naming, IUB system.
(b) Mechanism of enzyme action. Measurement and expression of enzyme activity, factors affecting enzyme activity.
(c) Enzyme kinetics - Michaelis-Menten kinetics, Lineweaver-Burk plot.
(d) Regulation of enzyme activity. Enzyme inhibition
(e) Co-enzymes and co-factors, Ribozymes and Abzymes.
(f) Enzyme technology - isolation and purification of enzymes, modifying enzymes for stability (brief study).

Module 6: Secondary metabolites (4 hrs)

Classification, Biosynthesis and functions of terpenoids, alkaloids and phenolics.

Practical (27 Hrs)

1. Preparation of buffers-Citrate and Phosphate-various strengths.
2. Quantitative estimation of reducing sugar.
3. Separation of amino acids by TLC.

4. Quantitative estimation of protein (Lowry's method).
5. Preparation of Molar, Normal, Percentage and PPM solutions and their dilutions
6. Estimation of total phenolics in plant tissue
7. Isolation and estimation of amylase from germinating seeds.

References

1. Jeremy M Berg, John L Tymoczko and Lubert Stryer (2012). Biochemistry (VII Edn). W H Freeman
2. David L Nelson, Michael M Cox (2013). Lehninger Principles of Biochemistry (VI Edn). Macmillan International.
3. T A Brown (2018). Biochemistry. Viva Books.
4. Arti Nigam, Archna Ayyagari. Lab Manual in Biochemistry Immunology and Biotechnology (2007) Tata McGraw Hill Pvt. Ltd.
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UCBY010204: MOLECULAR BIOLOGY
(Theory 54 hrs; Practical 18 hrs; Credits: 3)

Module 1: Nucleic acids (6 hrs)

(a) Molecular structure of DNA: Watson and Crick model, alternative conformations, DNA triplex and quadruplex, imotif. DNA supercoiling – Topoisomerases.

(b) Structure, Diversity and Versatility of RNA: Primary, secondary, tertiary and quaternary structure of RNA. RNA as genetic material – plus, minus, double stranded RNA. Catalytic RNA: Ribozymes – Discovery, structure, mechanism and functions; HDV ribozyme, hammerhead ribozymes, self-splicing introns, RNaseP, RNase MRP, Peptidyl transferase. Noncoding RNA: Structure and biological roles of rRNA, tRNA, tmRNA, siRNA miRNA, piRNA, lncRNA (Xist, HOTAIR) and circular RNA.

Module 2: Organization of the Genome (4 hrs)

(a) Genome organization in viruses, bacteria, and eucaryotes. Organellar genome – structure and organization, important organellar genes.

(b) Eucaryotic nuclear genome: c-value paradox, DNA renaturation kinetics, Tm, Cot curve. Unique and Repetitive DNA – mini- and microsatellites.

Module 3: Replication of the Genome (6 hrs)

(a) RNA replication: By RNA-dependent RNA polymerase, retroviral RNA replication.

(b) DNA replication: Unit of replication, enzymes and proteins involved in replication (in both procaryotes and eucaryotes). Structure of the replication origin (in both procaryotes and eucaryotes), priming (in both procaryotes and eucaryotes), replication fork, fidelity of replication. Process of replication – initiation, elongation and termination. Replication in the telomere - telomerase.

Module 4: Gene Expression (15 hrs)

(a) Gene: Concept of gene; structural and genetic definitions – complementation test.

(b) Transcription in procaryotes: Initiation – promoter structure, structure of RNA polymerase, structure and role of sigma factors. Elongation – elongation complex, process of RNA synthesis. Termination – rho-dependent and rho-independent termination.

(c) Transcription in eucaryotes: Types, structure and roles of RNA polymerases. Promoters – important features of class I, II, & III promoters. Enhancers and silencers. General transcription factors and formation of pre-initiation complex. Elongation factors, structure and function of transcription factors.

(d) Post-transcriptional events: Split genes, splicing signals, splicing mechanisms of group I, II, III, and tRNA introns. Alternative splicing, exon shuffling, *cis*- and *trans*-splicing. Structure, formation and functions of 5' cap and 3' tail of mRNA, RNA editing, mRNA export.

(e) Genetic code: Important features of the genetic code, proof for the triplet code, Exceptions to the standard code.

(f) Translation: Important features of mRNA – ORF, RBS. Fine structure, composition and assembly of procaryotic and eukaryotic ribosomes. tRNA charging, initiator tRNA.

(g) Stages in translation: Initiation – formation of initiation complex in procaryotes and eucaryotes, initiation factors in procaryotes and eucaryotes, Kozak sequence. Elongation – process of polypeptide synthesis, active centers in ribosome - 3-site model, peptidyl transferase, elongation factors. Termination – process of termination, release factors, ribosome recycling.

(h) Protein sorting and translocation: Cotranslational and posttranslational – signal sequences, SRP, translocon. Membrane insertion of proteins. Post-translational modification of proteins. Protein folding – self assembly, role of chaperones in protein assembly.

Module 5: Control of Gene Expression (10 hrs)

(a) Viral system: Genetic control of lytic and lysogenic growth in λ phage, lytic cascade.

(b) Procaryotic system: Transcription switches, transcription regulators. Regulation of transcription initiation; Regulatory proteins - activators and repressors. Structure of *Lac* operator, CAP and repressor control of *lac* genes. Regulation after transcription initiation – regulation of amino acid biosynthetic operons - attenuation of trp operon, riboswitches.

(c) Eucaryotic system: Changes in chromatin and DNA structure – chromatin compaction, mechanism of action of activators and repressors, gene amplification, gene rearrangement, alternate splicing, gene silencing by heterochromatization, and DNA methylation. Effect of regulatory transcription factors on transcription. Post-transcriptional control – mRNA stability. Small RNA mediated control.

Module 6: Recombination (5 hrs)

Homologous and nonhomologous recombination, molecular mechanism of homologous recombination. Site-specific recombination, transposition - types of transposons.

Module 7: Epigenetic inheritance (4 hrs)

Genomic imprinting, Cytosine methylation, Histone code, ncRNA and epigenetics

Module 8: Mutation repair (5 hrs)

DNA repair mechanisms: Direct repair, Excision repair – base excision repair and nucleotide excision repair. Mismatch repair, Recombination repair – homologous recombination repair, nonhomologous end joining, SOS response – Transletion DNA polymerase.

Practical (18 hrs)

1. Work out problems based on DNA structure, replication, gene expression and genetic code (Genetic code chart may be brought for reference during examination).

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MODEL QUESTION PAPERS– THEORY

M Sc Botany Degree (CSS) Examination

II Semester

Faculty of Science

UCBY010201: PLANT ANATOMY, DEVELOPMENTAL BIOLOGY AND HORTICULTURE

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **eight** questions. Each question carries a weight of 1)

1. What is meant by Abiogensis?
2. Write brief notes on
   a)Moleculae clock b) Eras
3. Describe the economic importence of Plant fibers.
4. Describe the structure and fuction of wood parenchyma.
5. Describe the horticultural implement used for weeding.
6. What is double fertilization?
7. What is tension wood?
8. Describe different parts of stem apex.
9. What is meant by collateral and open vascular bundle?
10. Define hydrophytes. Give any two anatomical characters.

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Write a note on evolutionary time – scale?
12. Describe the structure and development ofstomata.
13. What is Krantz anatomy? Mention its significance.
14. Write a brief note on the following:
    (a) Apomixis (b) Polyembryony (c) Xenia
15. What are the developmental changes in shoot apex leading to floral induction?
16. Write a brief note on different type of gardening.
17. What is meant by genetic drift?
18. What is pagoda?

(6 x 2 = 12)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. Describe various theories to explain the meachanism of evolution.
20. With suitable example and illustration describe various anomalous primary and secondary structure in the stem of angiosperms.
21. Write an essay on olericulture.
22. Write an essay on morphogenesis and organogenesis in plants.

(2 x 5 = 10)

M Sc Botany Degree (CSS) Examination
II Semester
Faculty of Science
UCBY010202: CELL BIOLOGY, GENETICS AND PLANT BREEDING
(2025 onwards)

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **eight** questions. Each question carries a weight of 1)

1. What is apoptosis?
2. Write a brief description on cell adhesion molecules.
3. What are the functions of telomere?
4. What is the genetic significance of the fact that gametes contain half the chromosome complement of somatic cells?
5. Differentiate between heterochromatin and euchromatin.
6. Explain the relationships between the following pairs of genetic terms:
   (a)Genotype and phenotype (b) Gene and trait (c) Allele and gene (c) Gene and chromosome
7. What causes phenylketonuria?
8. What is dosage compensation?
9. What causes inbreeding depression?
10. Differentiate between vertical and horizontal resistance.

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Draw the diagram of a bivalent chromosome and label the following parts: centromere, sister chromatids, nonsister chromatids, homologous chromosomes, and chiasma.
12. Describe the self-assembly and the dynamic structure of cytoskeletal filaments.
13. Describe the endosymbiont hypothesis on the origin of chloroplast and mitochondria.
14. Quoting suitable examples, explain genetic drift.
15. Write an account on tumor-suppressor genes.
16. Describe the structure and functions of glyoxysomes and peroxisomes.
17. Explain the concept, “Centres of origin.”
18. Describe the methods used for breeding disease resistance in plants.

(6 x 2 = 12)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. Describe the chemical composition, structural organization and the dynamic nature of plant cell membrane.
20. What are cell-cycle checkpoints? Describe the principal checkpoints in the cell cycle.
21. What is Hardy-Weiberg equilibrium? Describe the conditions for Hardy-Weinberg equilibrium.
22. Write an account on the modern trends in plant breeding.

(2 x 5 = 10)

M Sc Botany Degree (CSS) Examination

II Semester

Faculty of Science

UCBY010203: PLANT PHYSIOLOGY AND BIOCHEMISTRY

(2025 onwards)

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Define the following;
   (a) Km (b) pKa (c) Vmax (d) Kw
2. What are isozymes?
3. Derive Henderson-Hasselbalch equation
4. Classify monosaccharides based on the number of C atoms.
5. What is RQ? Give the RQ for different substrates
6. Given an account of the role of Gibberellins
7. What is the membrane potential and how is it generated?
8. What is the role of the antenna complex in the light-dependent reactions of photosynthesis?
9. What is the function of leghemoglobin during Nitrogen fixation?
10. What are ABC transporters?

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Write a brief account on the different methods of regulation of enzyme activity
12. Describe the following terms which are related to protein structure;
    (a) Quaternary structure (b) α-helix (c) Peptide unit (d) Hydrogen bonds
13. Describe buffer action citing suitable examples

14. Write brief descriptions on;
    (a) Aquaporin (b) Active transport (c) Light harvesting complexes (d) Glycolysis
15. Explain the mechanism of electron and proton transport in the thylakoid membrane
16. Write an account on soil-plant-atmosphere continuum.
17. Explain the rotenone-insensitive pathway in plants.
18. Describe the mechanism of entry of minerals into the roots of plants.

(6 x 2 = 12)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. What is Ramachandran plot? Describe the structural details and principles based on which Ramachandran plots are constructed. Add a note on its applications.
20. With the help of a diagram, describe the detailed structure of ATPase complex. Write the binding change mechanism of ATP synthesis.
21. What are the stresses to which plants are commonly exposed? Describe the stress tolerance mechanisms found in plants.
22. Compare and contrast between C3 and C4 photosynthesis.

(2 x 5 = 10)

M Sc Botany Degree (CSS) Examination
II Semester
Faculty of Science
UC**BY010204: MOLECULAR BIOLOGY**
(2025 onwards)

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **eight** questions. Each question carries a weight of 1)

1. In what sense does attenuation provide a “fine tuning” mechanism for operons that control amino acid biosynthesis?
2. Describe the function and importance of the 3’ to 5’ exonuclease activity of DNA polymerases
3. Explain the opposite polarity of the double stranded DNA.
4. What is SRP?
5. Explain the role of the following enzymes/proteins;
   (a) Rho protein (b) Sigma factor (c) Gyrase (d) Tus protein
6. What is histone code?
7. Explain the function of translation polymerase.
8. Comment on the role of chaperones in protein assembly.
9. What is ARS?
10. ‘Ribosome is a ribozyme’. Comment.

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Describe the experimental methods used to crack the complete genetic code.
12. Describe the phenomenon of RNAi? How is RNAi involved in gene regulation?
13. Describe the genetic control of the entry of a Lambda phage into lytic or lysogenic growth.
14. Write briefly on the following;

(a) Shine-Dalgarno sequence (b) Kozak sequence (c) Amber codons (d) DNA quadruplex

15. What are transposons? Write a brief account on the types of transposons.
16. Write a brief account on ribozymes.
17. What are the functions of miRNA?
18. Describe how telomerase help maintain the structure of telomere.

(6 x 2 = 12)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. Describe the various modifications that the eukaryotic pre-mRNA usually undergoes.
20. Compare the following;
    (a) Eucaryotic and prokaryotic promoters (b) Eucaryotic and prokaryotic Ribosomes (c) Eucaryotic and prokaryotic RNA polymerases (d) Eucaryotic and prokaryotic DNA polymerases
21. Write a comparative account of the molecular events taking place in the 5' – 3' synthesis of RNA during transcription and the 5' – 3' synthesis of DNA during the replication of DNA.
22. Describe the different methods of control of gene expression in eucaryotes.

(2 x 5 = 10)

MODEL QUESTION PAPERS – PRACTICAL
SEMESTER II - PRACTICAL COURSE I
UCBY010205: ANATOMY, DEVLOPMENTAL BIOLOGY, HORTICULTURE, CELL BIOLOGY, GENETICS AND PLANT BREEDING

Time: 4 hours **Weightage: 30**

1. Make suitable micropreparation of specimen A. Draw diagrams, identify giving reasons. (Total weight 3.5 = Preparation – 1, Identification with reasons – 1.5, Diagram – 1)
2. Describe and compare the stomatal type in the materials B and C. (Total weight 3 = Identification of stomatal types with reasons – 1 x 2, Comparison – 1)
3. Describe the nodal feature of the material D. (Total weight 2 = Identification of nodal type – 1, Description – 1)
4. Dissect embryo from the given seeds E. (Weight = 1.5)
5. Write critical notes on F. (Weight = 1.5)
6. Demonstrate grafting/layering in material G. (Weight = 2)
7. Prepare a smear of the given anther F and identify any two stages of meiosis I. (Total weight 2.5 = Preparation – 1, Identification with reasons – 1, Diagram – 0.5; 2 x 2.5 = 5)
8. Workout the problems H and I. (Weight = 3; 2 x 3 = 6)
9. Estimate pollen sterility in the given sample J. (Total weight 1.5 = Working – 1, Calculation – 0.5)
10. Practical record (Weight = 4)

Key to the questions:

1. A – Stem showing anomalous growth, prescribed in the syllabus.
2. B, C – Leaves having distinct types of stomata
3. D - Nodal segments having type of node specified in the syllabus
4. E - Seeds with young embryos – maximum credit for earliest stages
5. F - Permanent slide/Photograph of embryo types, polyembryony, endosperm types, pollen grains, anther developmental stages, types of ovules etc.
6. G – Whip and Tongue, Approach, Wedge, and air layering.
7. H - Supply fresh flower buds of *Rhoeo* or *Chlorophytum.*
8. H, I - Problems related to Linkage mapping and population genetics.
9. J – Germination method
10. Awarding 'A grade' for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly.This also includes field study report(s)/Lab visit report(s), if any.

SEMESTER II - PRACTICAL COURSE II

UCBY010206: PLANT PHYSIOLOGY, BIOCHEMISTRY AND MOLECULAR BIOLOGY

Time: 4 hours **Weightage: 30**

1. Conduct the experiment A

(Total weight 9 = Principle, procedure and graph, if any – 3, Working – 4, Result – 1, Comments/Interpretation – 1)

2. Assay of amylase enzyme from germinating seeds/Appropriate plant material B.

Or

Estimate the amount of protein in the given sample B using Lowry's method

(Total weight 9 = Principle and procedure – 2, Preparation of standard graph – 3, Working – 2, Calculation – 1, Result – 1)

3. Comment on C and D.

(Total weight 3; 1. 5 x 2 = 3)

4. Work out problems E and F.

(Weight 3; 2 x 3 = 6)

5. Practical record

(Weight = 3)

Key to the questions:

1. A – Draw lots from the list of physiology experiments provided. A minimum of 5 experiments from the list should be included in the lots.
2. B – Draw lots; Students are expected to do the complete experiment, preparation of standard graph, preparation of extract on their own. Give the tissue, sample and reagents necessary. Supply stock solution only for the preparation of standard graph.
3. C, D – Reagents, chemicals
4. E, F – Problems related to DNA structure/replication/gene expression/genetic code. Students are allowed to bring a copy of genetic code chart showing codons and corresponding amino acids.
5. Awarding 'A grade' for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly.This also includes field study report(s)/Lab visit report(s), if any.

List of plant physiology experiments (Question 1)

1. Separate pigments of the given leaf sample by column chromatography. Collect the pigment fragments and submit. Comment on the result.
2. Separate amino acids by TLC and identify ___
3. Determine the osmotic potential of the given plant tissue from the values corresponding to change in weight of the tissue. Comment on the result.
4. Estimate the proline content in the control (e.g., seeds germinated in fresh water) as well as the treated (e.g., seeds germinated in 50mM NaCl) sample. Comment on the result.
5. Estimate the phenol content in plant tissues affected by biotic stress and compare the same with non affected portions. Comment on the result.

6. Determine peroxidase activity in plant tissues affected by biotic/abiotic stresses. Comment on the result.
7. Estimate free amino acids in senescing leaves and compare the same with young leaves. Comment on the result.
8. Estimate the total chlorophyll in shade leaves and sun leaves and comment on the result
9. Estimate the leghaemoglobin in the root nodules

SEMESTER III

THIRD SEMESTER COURSES

UCBY010301	RESEARCH METHODOLOGY, MICRO-TECHNIQUE, BIOSTATISTICS AND BIOPHYSICAL INSTRUMENTATION
UCBY010302	BIOTECHNOLOGY, BIOINFORMATICS AND BIO-NANOTECHNOLOGY
UCBY010303	ANGIOSPERM TAXONOMY,ECONOMIC BOTANY AND ETHANOBOTANY
UCBY010304	ENVIRONMENTAL SCIENCE
UCBY010305	RESEARCH METHODOLOGY MICROTECHNIQUE, BIOSTATISTICS, BIOPHYSICS AND BIOTECHNOLOGY NAD BIOINFORMATICS PRACTICAL
UCBY010306	ANGIOSPERM TAXONMY, ECONOMIC BOTANY AND ENVIRONMENTAL SCIENCE PRACTICAL

Total Credits: 19
Total Hours: 450

UCBY010301: RESEARCH METHODOLOGY, MICROTECHNIQUE,BIOSTATISTICS AND BIOPHYSICAL INSTRUMENTATION

(Theory: 18+18+18+18= 72 Hrs; Practicals: 09+27+09+18 = 63Hrs) Credits:4

RESEARCH METHODOLOGY (Theory: 18 Hrs)

Module 1: Introduction (3 hrs)

Need for research, objectives of research, types of research, stages of research; generation of a research problem, execution of work; interpretation of results: Analysis of data, interpretation and conclusions. Research ethics. Intellectual property rights (IPR): Copy right and patenting-*Brief account.*

Module 2: Review of literature (6 hrs)

Library: Structure of a Scientific Library, Journals (Current and Back-volumes), Books. Catalogue: Types of catalogues- card catalogue, computerized catalogue.Classification of books (Universal decimal system). Journals: indexing journals, abstracting journals, research journals, review journals, e- journals. Impact factor of journals; h-Index; NCBI, PubMed, Medline. Other sources of references:reprints-acquisition and filing.Internet, open access initiative, INFLIBNET, INSDOC, N-list and Shodhganga. Preparation of index cards: author index and subject index. Open source bibliography. Management system, citation management tools (*E.g.Mendeley, EndNot*).

Module 3: Preparation of project report and Dissertation/Thesis (3 hrs)

Project report. Dissertation/Thesis: Selection of problem and its relevance; available information collected; Execution of experimental programmes; Writing dissertation (*IMRAD-System*): General Format; General principles in writing: Preliminary pages - title page, certificates, acknowledgements, and contents page. Main text of the Dissertation/Thesis: title, introduction, review of literature, material(s) and method(s), heading(s), result(s): table(s) and illustration(s), marginal indicator(s), caption(s), camera ready copy; discussion, summary and conclusion; references, abstract(s) and appendix.

Module 4: Preparation of Project Proposals,Presentation and Publication of Research Outcomes (6 hrs)

(a) Preparation of project proposal:title, introduction, literature review and abstract; aim and scope; present status; location of experiments; materials and methods; justification; expected outcome; date of commencement; estimated date of completion; estimated cost; references; funding agencies.

(a) Presentation and publication of research outcomes:

(i) Statistical analysis by using software (*Eg: - SPSS*).(ii) Preparation of research paper and short communications.(iii) Preparation of review articles.(iv) Proofreading-standard abbreviations for proof correction. (v) Presentation of Research findings in Seminars and Workshops.

Practical (9 Hrs)

1. Visit a scientific library or documentation center and submit a report.
2. Prepare a project proposal.
3. Prepare an outline of dissertation and research paper.
4. Prepare a list of references.

References

1. Anderson J., Durston B. H. and Poole (1970). *Thesis and assignment writing*. Wiley eastern.
2. Bedekar V. H. (1982). *How to write assignment and research papers, dissertations and thesis*.
3. Bercy R. (1994). *The research project, how to write it*. Rutledge, London.
4. Clifford Hawkins and Marco Sorghi. *Research: How to plan and speak about it and write about it*. Narosa Publishing Company.
5. Day R. A. (1979). *How to write and publish a scientific paper*. Cambridge University press.
6. Joseph Gibaldi (2000 & 2009). *MLA- Handbook for writers of research papers*. Affiliated East-West Press Pvt.Ltd, New Delhi.
7. Judith Bell. *How to complete your research project successfully*. UBS Publishers and Kanak publications.
8. Krishnakumar K. (1981). *An introduction to cataloguing practice*. Vikas Publishing house.
9. Parshar R. G. (1989). *Index and indexing systems*. Me dallion press New Delhi.
10. Victoria E. McMillan (1997). *Writing papers in the biological sciences* (II Edn). Bedford books.
11. Vijay Upadhaya and Arvind Shende (2014). *Research methodology*. S. Chand and Company Pvt.Ltd. Newdelhi.

MICROTECHNIQUE (Theory: 18 Hrs)

Module 1: Killing and Fixing (3 hrs)

Principles and techniques of killing and fixing; properties of reagents, fixation images; properties and composition of important fixatives - Carnoy's Fluid, FAA, FPA, Chrome acetic acid fluids, Zirkle- Erliki fluid.

Module 2: Dehydration, Clearing, Embedding and Sectioning (5 hrs)

Dehydration: Principles of dehydration, properties and uses of important dehydrating and clearing agents - alcohols, acetone, xylol, glycerol, chloroform, dioxan. Dehydration Methods: (i) Tertiary-butyl alcohol method. (ii) Alcohol-xylol method. Embedding: Paraffin embedding. Sectioning: Free hand sections – Prospects and problems; sectioning in rotary microtome, sledge microtome and cryotome.

Module 3: Staining (5 hrs)

Principles of staining; classification of stains, protocol for preparation of; (i) Natural stains - Haematoxylin and Carmine (ii) Coal tar dyes – Fast green, Orange G, Safranine, Crystal violet, Cotton Blue and Oil Red O.Techniques of staining: (i)

Single staining; Staining with Safranine or crystal violet. Double staining; Safranine-Fast green method, Safranine-Crystal violetmethod.Triple staining; Safranine-Crystal Violet-Orange G method. Histochemical localization of starch, lipid and lignin.

Module 4: Whole mounts (5 hrs)

Principles and techniques of whole mounting, TBA/Hygrobutol method, Glycerine-xylol method. Staining of whole mount materials (haematoxylin, fast green or Safranine-fast green combination). Significance of whole mounts. Techniques of smear, squash and maceration.Mounting: Techniques, common mounting media used - DPX, Canada balsam,Glycerin jelly and Lacto phenol. cleaning, labeling and storage of slides.

Practical (27 Hrs)

1. Students are expected to be thorough with the following techniques.

(a) Preparation of semi-permanent slides.
(b) Preparation of permanent slides.
(c) Preparation of whole mounts.
(d) Maceration.
(e) Preparation of fixatives (FAA, Carnoys'fluid).
(f) Preparation of dehydration series (Alcohol, Acetone, TBA).
(g) Preparation of paraffin blocks.
(h) Preparation of serial sections.

2. Candidates should prepare and submit 10 permanent slides in which the followingcategories should be included:

(a) Free hand sections (single/double stained).
(b) Serial sections (single/double stained).
(c) Wood sections and whole mounts.

References

1. Johanson D A (1940). *Plant microtechnique*. McGraw Hill co.
2. John E Sass (1967). *Botanical Microtechnique*. Oxford IBH Publ. Company.
3. Gray (1964). *Handbook of Basic Microtechnique*. McGraw Hill co.
4. Prasad M K, M Krishna Prasad (1983). *Outlines of Microtechnique*. Emkay Publications.
5. Geoffrey A Meek (1976). *Practical electron microscopy*. John Willey and sons.
6. Krishnamurthy K V (1987). *Methods in Plant Histochemistry*. S Viswanathan printers, Anand book depot, Madras.
7. Toji Thomas (2005). *Essentials of botanical microtechnique* (II Edn). Apex infotechpublishing company.

BIOSTATISTICS (Theory18 Hrs)

Module 1: Introduction to Statistics (4 hrs)

Basic principles and methods of Biostatistics: data collection, Primary and Secondary data. Tools for data collection and presentation. Measures of central tendency and dispersion.

Module 2: Probability, Correlation and Regression (5 hrs)

Probability - Definition, Mutually exclusive and Independent events. Binomial and Normal - distribution.Linear Regression and Correlation (*Simple and Multiple*).

Module 3: Design of experiments (4 hrs)

Experimental Designs: Principles -Replication, Randomization and Local control.Common designs in Biological experiments: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD), Factorial Design (FD).

Module 4: Tests of Significance (5 hrs)

Statistical Inference-Estimation-Testing of Hypothesis: - t-Test, Chi-square Test (Goodness of fit, Independence or Association, Detection of Linkages), F-test, ANOVA.

Practical (9 Hrs)

1. Test the significance of a given data using t-Test, Chi square -test.
2. Analysis of a set of data for Correlation / Regression (Scatter diagram).
3. Determine the probability for different types of events.

References

1. Chandel R. S. (1975). *A handbook of Agricultural statistics*. Achal prakashan Mandir.
2. Gomez K. A. and Gomez A. A. (1984). *Statistical procedures for agricultndural research*. John Wiley and sons.
3. Gupta S. P. (1984). *Statistical methods*. S Chand and company. New Delhi.
4. Panse V. G. and Sukathme P. V. (1995). *Statistical methods for Agricultural workers*. ICAR. New Delhi.
5. Panse.V.G. and P.V. Sulchatme (1995). *Statistical Method for Agricultural workers*. Indian Council of Agricultural Research, New Delhi.
6. Robert J. Brooker (2009). *Genetics: analysis & principles* (III Edn). McGraw Hill.
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8. Thomas M. Little and F. Jackson Hills (1978). *Agricultural Experimentation*. Johnwiley and sons, Newyork.

BIOPHYSICAL INSTRUMENTATION (Theory 18 Hrs)

Module 1: Introduction to Microscopy (3 hrs)

Parts of Microscope, Principles of Microscopy.Types of Microscopes- Simple and Compound; Stereo Microscope, Phase contrast Microscope, Fluorescence Microscope. Electron Microscopy (Eg: TEM, SEM, and E-SEM-*Brief account*).

Module 2: Principles and Applications of Instruments (6 hrs)

Micrometry.Basic principles and applications of pH meter, colorimeter,UV–Visible spectrophotometer and centrifuges (E.g. Table top and ultra centrifuge). Flow cytometry.Immunoassay system-RIA and ELISA.Cryobiology- Lyophilisation and its applications.Auto radiography and Liquid Scintillation counter.

Module 3: Basic Principles and Applications of Chromatography (4 hrs)

Types of Chromatography**:** Paper, TLC, Column chromatography, ion exchange chromatography, GCMS, HPLC, HPTLC and LCMS.

Module 4: Basic principles and applications of Electrophoresis and Spectroscopy (5 hrs)

Electrophoresis: Agarose gel Electrophoresis, SDS PAGE, Pulse Field Gel Electrophoresis. Fluorescence, UV, IR, ORD, Visible, NMR, ESR, and Atomic Absorption.

Practical: (18 Hrs)

1. Micrometry; calibrate the ocular and stage micrometre on a light microscope and measure an object.
2. Calibrate the pH meter and measure the pH of different samples.
3. Estimate the concentration of the given sample using colorimeter or spectrophotometer.
4. Separate plant pigments by TLC or Column chromatography.

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UCBY010302: BIOTECHNOLOGY, BIOINFORMATICS AND BIONANOTECHNOLOGY

(Theory 72 Hrs; Practical 36 Hrs; Credits: 4)

BIOTECHNOLOGY (54 hrs)

Module 1: Bioprocess Technology (5 hrs)

(a) Introduction to classical and modern biotechnology. Microbial biotechnology**:** Mode of operation of a bioprocess – basic concepts of batch, fed batch and continuous operation of a bioprocess.

(b) Basic design and construction of various types of bioreactors used in bioprocesses.

(c) Commercialproduction of metabolites using bioreactors. Submerged and solid state fermentation. Microbes in production of enzymes, antibiotics, biopolymers, bioethanol, organic acids, SCP.

Module 2: Plant tissue culture (12 hrs)

(a) Brief history and important milestones in plant tissue culture. Types of cultures: organized structures - meristem, shoot tip, node, embryo, root cultures; unorganized structures - callus, suspension and protoplast cultures. Cellular totipotency. Differentiation of cells in callus - tracheid formation, chloroplast differentiation. Factors influencing vascular differentiation. Organogenic and embryogenic differentiation.

(b) Culture protocol:General composition of the culture media; solid and liquid media – gelling agents. Preparation and standardization of MS medium for shoot and root differentiation. Sterlization of medium, glasswares, instruments, plant material, transfer area. Preparation of explants and inoculation, incubation. Pattern of growth and development, subculturing.

(c) Micropropagation:Methods – shoot tip and nodal segment culture, stages of micropropagation. Advantages and disadvantages of micropropagation. Applications of tissue culture.

Module 3: Genetic engineering (15 hrs)

(a) Important steps in Gene cloning:Basic principles of gene cloning.Isolation and purification of DNA from cells (Brief study). Isolation of DNA fragments of interest, creation of recombinant DNA – introduction into host cells, selection and screening of recombinants, propagation of recombinants.

(b) Tools and techniques: Restriction endonucleases, Ligases. Vectors – necessary properties of a vector, types of vectors based on origin; shuttle vectors, expression vectors.

(c) Plant transformation**:** *Agrobacterium tumefaciens* mediated gene transfer in plants - details of vector system based on *A. tumefaciens*, binary vector and cointegrate vector. Steps involved in *Agrobacterium* mediated gene transfer to plants. Plant transformation by direct transfer of DNA (Vectorless methods) - microprojectiles, electroporation, microinjection, chemical, lipofection.

(d) Applications of genetic engineering -in genetic studies, agriculture, and medicine (brief study citing specific examples)

Module 4: Genome editing (3 hrs)

Introduction, scope, methods and applications

Module 5: Advanced tools and techniques in Biotechnology (10 hrs)

(a) cDNA synthesis, artificial DNA synthesis – solid-phase synthesis.

(b) PCR - Procedure and applications, variants of PCR - Real time PCR and reverse transcriptase PCR and their applications.

(c) Automated DNA sequencing.

(d) In vitro mutagenesis, site directed mutagenesis.

(e) Blotting techniques - procedure and applications of southern, northern, western, and dot blotting. Microarray (gene chip) technology and its applications.

(f) Procedure and applications of DNA profiling, Footprinting.

(g) Procedure and applications of FISH and GISH

Module 6: Genomics (5 hrs)

Introduction to genome, genomics, transcriptomics and proteomics. Structural genomics - genome sequencing strategies. Genome annotation – structural and functional annotation, gene expression study using microarrays.

Module 7: Societal concerns with biotechnology (4 hrs)

Harm to the environment - potential impact of GMOs on the ecosystem; GM food – effect on health and environment. Misuse of modern molecular biology tools and techniques, bioweapons, bioterrorism. Ethical issues relating to rDNA techniques. Patents – issues relating to patenting living organisms, their genes and other bioresources.

BIOINFORMATICS (13 hrs)

Module 1:Methods, tools and applications of bioinformatics (3 hrs)

(a) Databases: Organization, primary and secondary databases. DNA sequence databases - Genbank, EMBL & DDBJ. Protein databases - SWISS-PROT, PDB. Sequence alignment: Significance; Global Alignment, pair wise analysis, Scoring Matrices (an introduction). Database similarity search – query sequence search; BLAST – Algorithm and different versions. FASTA. Multiple sequence analysis dynamic programming.

(b) Molecular Phylogeny: molecular clock hypothesis. Phylogenetic Trees, Terminology in Phylogenetic tree. Tree drawing Methods. Cladogram and Phylogram. Significance of Molecular Phylogeny.

(c) Structural Bioinformatics: Molecular structure viewing tool – Rasmol; Protein structure prediction – Secondary Structure prediction (Chou Fasman method), Tertiary structure prediction (Homology modeling).

Module 2 Advanced tools and techniques in Biotechnology (10 hrs)

(a) cDNA synthesis, artificial DNA synthesis – solid-phase synthesis. Construction of genomic and cDNA library.

(b) PCR - Procedure and applications, variants of PCR - Real time PCR and reverse transcriptase PCR and their applications.

(c) Automated DNA sequencing.

(d) *In vitro* mutagenesis, site directed mutagenesis.
(e) Blotting techniques - procedure and applications of southern, northern, western, and dot blotting. Microarray (gene chip) technology and its applications.
(f) Procedure and applications of DNA profiling, Footprinting.
(g) Procedure and applications of FISH and GISH

BIONANOTECHNOLOGY (5 Hrs)

Module 1: Introduction to nanoparticles and nanotechnology (3 hrs)

(a) An overview on concepts, strategies and tools. Types of nanoparticles and their relative merits and demerits.
(b) Method of biological synthesis of Zn and Ag nanoparticles – plant extract, bacteria and fungi.

Module 2: Applications of bionanotechnology (2 hrs)

Use of nanoparticles in agriculture, medicine and environment. Impact of NPs on germination and seedling emergence, parameters in various crops. Effect of NPs on gene expression. Translocation and accumulation of NPs in plant tissues and organs.

Practical (36 Hrs)

1. Production of amylase by solid state and submerged fermentation.
2. Preparation of the stock solutions of MS medium.
2. Preparation of MS medium from stock solutions.
3. Isolation, preparation, sterilization and inoculation of different explants like shoot tip, node, anther, embryo and cambium.
4. DNA isolation from coconut/onion/cauliflower and separation using agarose gel.
5. Blast search with Protein Sequence (*Magnolia latahensis*sequence)
6. Blast search with Nucleic Acid Sequence (Neanderthal man's Paleo DNA)
7. Phylogenetic tree creation with the help of CLUSTAL X, W or MUSCLE and tree drawing tools.
8. Creation of phylogentic trees for selected families ofEudicots
9. Molecular docking (using either free or commercialSoftware)

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UCBY010303:ANGIOSPERM TAXONOMY, ECONOMIC BOTANYAND ETHNOBOTANY

(Theory - 72 Hrs;Practical - 63 Hrs; Credits: 4)

Module 1:Introduction (6 hrs)

Scope and significance of taxonomy. Major classification systems with emphasis on conceptual basis of classifications of (i) Linnaeus (ii) Bentham & Hooker (iii) Engler & Prantl (iv) Bessey

(v) APG (brief synoptic account – current views).

Module 2:Units of classification and Phylogeny of Angiosperms(9hrs)

(a) Taxonomic hierarchy

(b) Concept of taxa: Concept of species: taxonomic, biological & phylogenic species. Concept of genus, family and infraspecific categories - subspecies, variety, forma.

(c) Phylogenetic terms: Premitive and advanced; Homology & Analogy; Parallelism and convergence; monophyly & polyphyly; phylogenetic tree(brief study).

(d) Numerical taxonomy and Cladistics – methodologies of study.

Module 3:Data sources of taxonomy (brief account): **(5hrs)**

(a) Concept of character

(b) Sources of taxonomic characters: Anatomy, cytology, phytochemistry, Molecular taxonomy, DNA barcoding.

Module 4:Methodology of Identification of plants(9 hrs)

(a) Usage of floras; Preperation of indented and bracketed keys

(b) Brief accounts on Flora of the British India, Flora of the Presidency of Madras, Hortus Malabaricus. Important Floras of Kerala

(c) Familiarization of Technical terms associated with the following: Habit, Habitat; Root, Stem, Leaf, Inflorescence; Bract & bracteoles; Flowers; Fruits and Seeds**.**

Module 5: **Tools of Taxonomy(3 hrs)**

Field study, Herbarium and Virtual herbarium, Important Botanical gardens; BSI; Botanical literature (Journals- print and online, Floras, Revisions,Monographs, Indices).

Module 6:Botanical Nomenclature (**4 hrs)**

(a) History of Botanical nomenclature and code

(b) Aims and principles of botanical nomenclature

(c) Study of major provisions of the code (ICN): Typification; Author citation; rule of priority; Effective and valid publication – as per the current code; Retention, rejection and choice of names.

Module 7:Study of angiosperm diversity (**27 hrs**)

Study of following families with reference to tropical flora, as per Bentham and Hooker's concept in detail with economic importance of members:

1.Ranunculaceae 2. Magnoliaceae 3. Annonaceae 4. Polygalaceae 5.Caryophyllaceae 6.Clusiaceae 7. Malvaceae8.Tiliaceae 9. Geraniaceae 10.Rutaceae 11. Vitaceae 12. Sapindaceae 13. Leguminosae 14. Myrtaceae

15.Melastomaceae 16. Lythraceae 17. Cucurbitaceae 18. Aizoaceae 19. Apiaceae 20. Rubiaceae 21. Asteraceae 22.Campanulaceae 23. Myrsinaceae 24. Sapotaceae 25. Oleaceae 26. Apocynaceae 27.Asclepiadaceae 28.Boraginaceae 29. onvolvulaceae 30. Solanaceae 31.Scrophulariaceae 32. Acanthaceae 33. Verbenaceae 34. Lamiaceae 35. olygonaceae 36. Aristolochiaceae 37. Lauraceae 38.Euphorbiaceae 39. Orchidaceae 40. Zingiberaceae 41. Liliaceae 42. Araceae 43. Cyperaceae 44.Poaceae.

Module 8:Economic Botany (6 hrs)

(a) Importance of economic botany. Important Plantation crops of Kerala and brief study on their various products - Rubber, Cardamom, Tea, Coffee, Coconut, Catechu.

(b) Major food plants: **Cereals**: Rice, wheat, maize, oats. **Millets**:Sorgum, Perl millet, Ragi, Italian millet. **Pulses**: Pigeon pea, Garden pea, Black gram, Green gram, Bengal gram. **Sugar**: Sugar cane.**Fruits**: Banana, Mango, Jack fruit, Apple, Pineapple, Orange, Lemon. **Vegetables**: All common vegetables used in traditional Keralakitchen. **Oil plants**: Coconut, Ground nut, Gingelly. **Spices**: Cardamom, Pepper,Ginger, Clove, Cinnamon, Coriander, Fennel, Fenugreek. **Fibre:** Coir, Jute, Cotton.

(c) **Gums and Resins**: White Damar, Gum Arabic, Asafoetida.

(d) **Medicinal plants**: Liquorice, Indian Sarsaparilla, Chitraka(*Plumbago*), Serpntine, Aswagandha, Asafoetida, Greater galanga,Turmeric, Mango ginger, Garlic, Ginger, Asoka tree, Vasaka, Indian Aloe, Holy Basil, Bel, Betel, Pepper, Belleric, Myrobalan, Chebulic myrobalan, Neem, Apple of peru(*Datura*).

Module 9: Ethnobotany (**3 hours)**

Importance, sources and methods; important tribal people of Kerala; plants used by them such as *Trichopus zeylanicus, Ochlandra travancorica, Dendrocalamus strictus, Gloriosa superba, Emilia sonchifolia, Andrographis paniculata*.

Practical (**63 Hrs)**

1. Workout a minimum of 2 members from each family with suitable sketches and description in technical terms of locally available plants. Record reasons assigned for Class, subclass, series/order, family and draw at least one species from each family in the record.
2. Identification of local flora using Flora of Presidency of Madras- J. S. Gamble.
3. Conduct study tour for not less than 5 days to study angiosperm diversity and collect plants from diverse habitats belonging to plant families specified above and also visit important botanical gardens and institutions of taxonomic research and submit a report.
4. Preperation of 25 herbarium specimens from the plant families of study and submit.
5. Study of preperation of dendrogram using a suitable software (of a family or Genus of study).
6. Workout nomenclatural problems regarding priority and author citations.
7. Familiarization of morphological terms form live specimens; specimens of economic botany from families of study.

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UCBY010304: ENVIRONMENTAL SCIENCE
(Theory 54 Hrs; Practical 27 Hrs; Credits 3)

Module 1: Introduction to Ecological Science (2 hrs)

Definition, history and scope of ecology, Interdisciplinary nature of environmental sciences.

Module 2: Autecological concepts - Population Ecology (5 hrs)

(a) Characteristics of populations - size and density, dispersion, age structure, natality and mortality.

(b) Population growth - factors affecting population growth, environmental resistance, biotic potential, carrying capacity, positive and negative interaction, migration, subsistence density. Ecological consequence of overpopulations.

(c) Genecology - ecological amplitude, ecads, ecotypes, ecospecies, coenospecies,

Module 3: Synecological concepts - Community ecology (5 hrs)

(a) Ecological processes of community formation, ecotone, edge effect. Classification of communities - criteria of classification, dynamic system of classification by Clement.

(b) Special plant communities - quantitative, qualitative and synthetic characteristics of plant communities, coefficient of communities; Sorenson's Index of similarity.

(c) Dynamic community characteristics - cyclic replacement changes and non-cyclic replacement changes.

Module 4: Dynamic Ecology - Ecological succession (3 hrs)

(a) The concept, definition and reasons of succession. Classification of succession: Changes - autogenic and allogenic, primary and secondary, autotrophic and heterotrophic.

(b) Retrogressive changes or the concept of degradation, concept of climax or stable communities, resilience of communities.

Module 5: Biosphere and Ecosystem (7 hrs)

(a) Significance of habitat, biodiversity, ecological niche, trophic level, primary and secondary productivity, food chains, food webs, ecological pyramids, energy flow and nutrient cycles.

(b) Comparative study of the major tropical ecosystems: Tropical rain forests, Wetlands and tropical coastal ecosystems. Special emphasis to tropical coastal ecosystems: Conservation and management of tropical coastal ecosystems: The values of coastal ecosystems, issues of coastal ecosystems in the tropics, goals for conservation and management of tropical ecosystems: Providing for resilience, maintain/restore connectivity, protect water quality, conservation and recovery of Species-at-Risk, understanding the socio- economic context.

Module 6: Phytogeography (5 hrs)

(a) Definition, principles governing plant distribution, factors affecting plant distribution, theories of distribution, different types of distribution of vegetations on the earth, continuous and discontinuous distribution.

(b) Climate, vegetation and botanical zones of India.

(c) Remote sensing: Definition and data acquisition techniques. Application of remote sensing, geospatial variability and geotagging.

Module 7: Environmental pollution (10 hrs)

(a) Definition and classification.

(b) Water pollution: Water quality parameters and standards, different types of pollutants and their consequences. Types of water pollution, prevention and control - water shed management, waste water treatment. Waste water treatment with aquatic macrophytes.

(c) Air pollution: Air quality standards and index, ambient air monitoring using high volume air sampler, types and sources of air pollutants, air pollution and human health hazards, control of air pollution.

(d) Noise pollution.

(e) Radioactive and thermal pollution: Causes and hazardous effects, effective management.

Module 8: Environmental biotechnology and solid waste management (4 hrs)

Concept of waste, types and sources of solid wastes including e-waste. Bioremediation, Phytoremediation, bioaugmentation, biofilms, biofilters, bioscrubbers and trickling filters. Use of bioreactors in waste management.

Module 9: Global environmental problems and climate change (4 hrs)

(a) Global warming, green house gases, acid rain, ozone depletion. Holistic relationship between air water and land pollution.

(b) Factors responsible for climate change, *El-Nino* and *La Nina* phenomenon and its consequences.

(c) Effect of climate change on biogeography.

(d) Environmental laws, environmental monitoring and bio indicators, environmental safety provisions in Indian constitution, major environmental laws in India, ISO-14000.

(e) Disaster management; preparedness and planning

Module 10: Biodiversity and its conservation (9 hours)

(a) Biodiversity- definition, the number of known plants in the world (upto groups), current biodiversity loss - concept of endemism, rare, endangered and threatened species (RET), key stone species, IUCN account of biodiversity, red data book and hot spots, reasons to stop extinction, methods to save species.

(b) Principles of conservation - *ex-situ* and *in-situ* conservation techniques. Biodiversity conservation: Species diversity, community diversity, ecosystem diversity. Role of biotechnology in conservation of species.

(c) The natural longevity of species, rain forests as centres of diversity, ecological restoration

(d) Ecotourism - positive and negative impacts.

Practical (27 hrs)

1. Analysis of water quality for; (a) Dissolved CO_2 (b) Dissolved oxygen (c) COD (d) Total dissolved minerals (e) Quantitative estimation of dissolved chloride ions and dissolved sulphate (f) Total alkalinity.
2. Quantitative estimation of dissolved silicate, dissolved sulphate, nitrite and total alkalinity.
3. Physico-chemical analysis of soil: (a) Total water soluble mineral ions (b) estimation of soil organic carbon (Walkey and Black method).
4. Quantitative and qualitative community analysis. Carry out a project on species structure and the frequency, abundance, density of different species and similarity index of different communities in a natural system. Students must be able to explain the structure of vegetation from the given data on the above mentioned characteristics.
5. Phytoplankton counting using Sedgwick Rafter counter.
6. Field visit to natural ecosystem and identification of trophic levels, food webs and food chains, plant diversity (species and community) and submit a report.
7. Students should be aware of the common environmental problems, their consequences and possible solutions.

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MODEL QUESTION PAPERS – THEORY

M Sc Botany Degree (CSS) Examination
III Semester
Faculty of Science
UCBY010301: RESEARCH METHODOLOGY, MICROTECHNIQUE,BIOSTATISTICS AND BIOPHYSICAL INSTRUMENTATION

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Describe the structure of scientific library.
2. Describe the principle and technic of fixing. Write the composition of FAA.
3. Give brief account of different type of journals.
4. Describe Primary and Secondary data.
5. Describe quantitative and qualitative data.
6. Write the principle and use of Phase contrast microscope.
7. Why is a statistical test necessary to determine the exceptability of an observed set of data?
8. Write the preparation of hematoxylin.
9. What are the use of colorimeter?
10. List out different type of microtomes used in microtechnique.

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Write an essary on literature survey and its importance in research.
12. What are a different stages of research?
13. Write note on permanent whole mount preparation.
14. What are histochemical stain? Write its significance.
15. Describe the principles of electron microscopy.
16. How chi-square test is used for the detection of linkages?
17. Describe the basic principles and applications of ELISA.
18. Write a short essay on electrophoresis.

(6 x 2 = 12)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. Prepare a sample project proposal on environment problem for submission to UGC.
20. Describe various steps in making permanent serial sections.
21. Describe experimental designing used for different types of study.
22. Write an essay on different types of electron microscope.

(2 x 5 = 10)

M Sc Botany Degree (CSS) Examination

III Semester

Faculty of Science

UCBY010303: ANGIOSPERM TAXONOMY, ECONOMIC BOTANYAND ETHNOBOTANY

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Describe the primitive characters Magnoliaceae.
2. Explain the pliesiomorphic and apomorphic characters.
3. Write an account on androecium of Orchidaceae.
4. Write the binomials and families of the following:
   (a) Tea (b) Chinese Potato (c) Rose wood (d) Cane
5. With the suitable example describe the medicinal importants of Apocymaceae.
6. Give the family name and economic products of the following plants:
   (a) *Mentha arvelsis* (b) *Lagenaria vulgaris* (c) *Cymbopogon citrates* (d) *Foeniculum vulgare.*
7. What is herbariam? How herbariam is labeled?
8. What is Ethnobotany?
9. Give any two plant products used by tribals for stomac ache.
10. What is BSI? Write its functions.

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Critically evaluate the Engler's system of classification.
12. Compare the families of Verbenaceae and Lamiaceae.
13. Explained different type of keys used for plant identification.
14. Write the economic importance of family Cucurbitaceae.
15. Explain the floral characters of Euphorbiaceae.
16. Comment on the systematic position and effenity of the following genera.
    (a) *Nyctanthes*(b) *Coleus* (c) *Luffa*
17. Describe the advanced floral characters in the families of disciflorae.
18. Comment on the economic importance of the following:
    (a) *Saccharum officinarum* (b) *Dalbergia sissoo* (c) *Adhatoda vasica* (d) *Cinnamomum camphora*

(6 x 2 = 12)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. Critically evaluate the system of classification of angiosperm by Hutchinsom and compare it with B&H classification.

20. Describe the floral features of Umbelliferae and Guttiferae.
21. Compare and vegetatitve and floral features of the families of Bicarpellatae and write note on its evolutionary trends.
22. Critically evaluate the phonetic and cladistic approaches in plant systematic.

(2 x 5 = 10)

M Sc Botany Degree (CSS) Examination
III Semester
Faculty of Science
UCBY010304: BIOTECHNOLOGY, BIOINFORMATICS AND BIONANOTECHNOLOGY
(2025 onwards)

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Differentiate between stirred tank and airlift bioreactors.
2. Define the following;
   (a) Totipotency (b) Synseeds (c) Haploids (d) Stem cells
3. What is androgenesis?
4. What are the causes of somaclonal variation?
5. Name four industrial chemicals produced by using microbial activities. Write the names of the microorganisms involved in each.
6. Describe the importance of using tissue culture in producing secondary metabolites.
7. What is enzyme engineering? What are the applications of it?
8. Briefly describe bioaugmentation.
9. How are triploids produced?
10. How do we produce stem cells?

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Write an account on the procedure and applications of hairy root culture.
12. Giving suitable examples, discuss downstream processing.
13. What are cybrids? How are they produced? Discuss the use of cybrids in crop improvement programmes.
14. Citing suitable examples, discuss the importance of GMOs in bioremediation
15. Describe the procedure of plant protoplast isolation and purification.
16. Briefly describe the prospects and future of stem cell research.
17. What is germplasm? Describe the methods of germplasm conservation. Add a note on the importance of tissue culture as a method of germplasm conservation
18. Write an account on the methods and applications of cell immobilization.

(6 x 2 = 12)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. Describe the procedure and applications of;
    (a) Cryopreservation (b) Protoplast culture (c) Microspore culture (d) Cellulase production
20. What is enzyme immobilization? Describe the steps involved and the potential applications. Add a note on enzyme engineering.
21. Write an essay on bioremediation.
22. Describe the various tissue culture techniques used to produce ploidy variants in plants.

(2 x 5 = 10)

M Sc Botany Degree (C.S.S) Examination

III Semester

Faculty of Science

Course Code- UCBY010304: Environmental Science

(2025 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Define the scope of ecology
2. What is biotic potential?
3. Describe ecads and ecotypes
4. Define consociation and formation
5. What is meant by resilience of communities?
6. Define primary production
7. Describe discontinuous distribution with suitable example
8. What is smog?
9. Define phytoremediation
10. Define key stone species

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. What is ecotone and edge effect
12. What are wetlands, why they are known as *biological supermarkets* and *kidneys of landscapes*

13. Describe the community classification by Clement
14. Describe geospatial variability and geotagging
15. Mention the factors affecting plant distribution
16. Comment on disaster management
17. Mention the causes and effects of radioactive pollution
18. Distinguish between *El-Nino* and *La Nina* phenomenon

(**6 x 2 = 12**)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19. Global warming and its impacts
20. Explain remote sensing and its applications
21. Illustrate tropical coastal ecosystems
22. Elaborate biodiversity and principles of conservation

(**2 x 5 = 10)**

MODEL QUESTION PAPERS - PRACTICAL
UCBY010305: RESEARCH METHODOLOGY, MICROTECHNIQUE, BIOSTATISTICS, BIOPHYSICS AND BIOTECHNOLOGY

Time: 4 hours **Weightage:30**

1. Viva voce based on the project proposal submitted by the student.
   (Total weight 2: project proposal – 1; Viva – 1)
2. Prepare a double stained micropreparation of material A and mount it as a permanent slide.
   (Total weight 4: Sectioning and staining – 3; Mounting – 1)
3. Prepare serial sections of B and mount on a glass slide
   (Total weight 3: Microtome sectioning – 2; Mounting – 1)
4. Permanent slides
   (Weight 4)
5. Workout problemsC and D.
   (Weight 2 x 2 = 4)
6. Determine the size of the given filament/pollen/spore D using micrometer
   (Total weight 2: Calibration – 0.5; Measurement, calculation and result – 1.5)
7. Prepare _ml liquid medium (MS) containing __µM Cytokinin and ___µM Auxin. Write down the protocol for the same with calculations. Adjust the pH of the medium as specified.
   (Total weight 4: Calculation and protocol – 2; Preparation - 2)
8. Draw a phylogenetic tree using the gene sequence data file with the help of CLUSTAL X/W or MUSCLE and tree drawing tool
   (Total Weight 3: MSA - 1.5; Phylogenetic tree - 1.5)

   OR

   Blast search with the given protein sequence (e.g. *Magnolia latahensis* sequence)
   (Total Weight 3: BLAST Search - 2.5; Downloading first 10 results - 0.5)
9. Practical record.
   (Weight 4)

Key to the questions:

1. Submit a project proposal by each student; conduct a Viva voce based on it.
2. A – Fresh plant material suitable for taking hand sections
3. B – Embedded paraffin blocks, mounting the ribbon in a minimum of two rows.
4. Permanent slides prepared by the student as specified in the syllabus and certified by the head of the department
5. C – Problem from Probability/Chi-square test/t-test.
6. Give necessary samples
7. Supply stock solutions necessary to prepare MS medium.
8. Centre should provideprocessedtext file containing phylogenetically related gene sequences in FASTA format. Tools for MSA such as CLUSTAL and MUSCLE create output files. Such output files are the source files for the creation of Phylogenetic trees using tools like NJ Plot or Dendroscope

OR

Download protein sequences like Magnolia latahensisrbcL gene from genbank and save it in each desktop.

9. Awarding 'A grade' for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly.This also includes field study report(s)/Lab visit report(s), if any.

UC**BY010306: ANGIOSPERM TAXONOMY, ECONOMIC BOTANY AND ENVIRONMENTAL SCIENCE**

Time: 4 hours **Weightage:30**

1. Identify the families of the given specimens A and B.
   (Total weight 2.5: Identification up to series with reasons – 0.5; Identification up to cohort with reasons – 0.5; Identification of the family with reasons – 1.5; 2 x 2.5 = 5)
2. Identify the given material C up to genus.
   (Total weight 3: Identification up to family with reasons – 1; Identification of genus with author citation – 1; Genus key – 1)
3. Identify the given material D up to species.
   (Total weight 4: Identification up to family – 0.5; Identification of genus with author citation – 1; Genus key – 0.5; Identification of species with author citation – 1; Species key – 1)
4. Describe the given material E in technical terms. Draw L.S of the flower, floral diagram and write the floral formula.
   (Total weight 3: Vegetative characters – 0.5; Floral characters – 0.5; LS – 1; Floral diagram – 0.5; Floral formula – 0.5)
5. Prepare an artificial key to identify the 4 specimens given, F, G, H, I.
   (Weight 2)
6. Write the Economic/ethnobotanicalimportance of the materials J, K, L and M.
   (Weight 0.5: 0.5 x 4 = 2)
7. Herbarium and field book.
   (Weight 2)
8. Identification of herbarium specimens N and O.
   (Total weight 2: genus 0.5; species - 0.5; 1 x 2 = 2)
9. Quantify nitrite /silicate/sulphate in the given sample Pusing Spectrophotometer/ Colorimeter.
   (Total weight 3: Working – 1; Procedure – 1; Result and Comments – 1)
10. Practical record

(Weight = 4)

Key to the questions:

1. A, B – Plant materials for family identification
2. C – Material for genus identification
3. D – Material for species identification
4. E - Give a plant twig complete with vegetative and floral features.

5. F, G, H, I – Supply appropriate specimens to prepare a key.
6. Raw or finished products of economically/ethnobotanically important plants
7. Herbarium (25 nos) and field book certified by the head of the department and submitted the student.
8. N, O - Write the binomials of the two herbarium specimens selected randomly by the examiner.
9. P - Supply suitable water samples
10 Awarding 'A grade' for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly.This also includes field study report(s)/Lab visit report(s), if any.

SEMESTER IV

FOURTH SEMESTER COURSES

PROGRAMME ELECTIVE - BIOTECHNOLOGY				
Course code	Title	Teaching Hrs.		Credits
		Theory	Practical	
UCBY800401	Plant tissue culture and Microbial biotechnology	90	72	4
UCBY800402	Genetic engineering, Genome editing and Immunology	90	72	4
UCBY800403	Genomics, Transcriptomics, Proteomics and Bioinformatics	90	72	4
UCBY800404	Plant tissue culture and microbial biotechnology - Practical			2
UCBY800405	Genetic engineering, Genome editing and Immunology & Genomics, Transcriptomics, Proteomics and B- Practical			2
	Project work			4
	Viva-voce			3

Total Credits: 23

Total Hours: 450

PROGRAMME ELECTIVE - BIOTECHNOLOGY

UC**BY800401. PLANT TISSUE CULTURE AND MICROBIAL BIOTECHNOLOGY**

(Theory 90 hrs; Practical 72 hrs; Credits 4)

Module 1: Tissue culture regeneration of plants (10 hrs)

(a) Adventitious shoot regeneration: Direct and indirect regeneration; factors influencing adventitious regeneration.

(b) Somatic embryogenesis: Direct and indirect, initiation of embryogenic cultures and regeneration of plants; factors regulating somatic embryogenesis. Synthetic seed production - protocol, types of synthetic seeds. Applications and limitations of synthetic seeds.

Module 2: Somaclonal variation (8 hrs)

Origin of somaclonal variation. Reasons for somaclonal variation – molecular basis. Applications of somaclonal variation.

Module 3: Embryo and meristem culture (3 hrs)

Methodology and applications.

Module 4: Protoplast culture (8 hrs)

(a) Isolation, purification and culture of protoplasts. Regeneration of plants from protoplasts. Significance of protoplast culture.

(b) Protoplast fusion (somatic hybridization) – chemical, mechanical, electrofusion. Isolation and selection of heterokaryons, regeneration and analysis of somatic hybrids; Cybrids. Applications of protoplast culture and somatic hybridization.

Module 5: Production of ploidy variants (12 hrs)

(a) Haploids: In vitro androgenesis – protocol for anther and microspore culture, advantages, applications. **Gynogenesis** - Developmental stage at inoculation, *in vitro* maturation of embryo sacs, origin of embryos, triggering factors – pretreatment, medium. Uses and limitations of haploid plants.

(c) Triploids: importance of triploid plants, conventional production of triploid plants, endosperm culture - advantages and limitations.

Module 6: In vitro germplasm conservation (6 hrs)

Importance of *in vitro* conservation. Short and medium term storage of germplasm, Cryopreservation technique – importance and methodology of cryopreservation. DNA banking for germplasm conservation.

Module 7: Production of secondary metabolites (6 hrs)

Culture conditions for producing secondary metabolites, selection of high yielding lines, elicitation. Hairy root culture – advantages of using hairy root culture, establishment of hairy root culture and production of secondary metabolites. Biotransformation.

Module 8: Cell and enzyme technology (5 hrs)

(a) Cell immobilization: Methods, advantages and applications.

(b) Enzyme immobilization: Methods and applications. Enzymes as biosensors. Enzyme engineering,

Module 9: Microbial technology (16 hrs)

(a) Screening of microbes for metabolite production - selection of media, strain improvement. Bioreactors – airlift, stirred tank, bubble column, rotary drum. Fermentation process - batch, fed batch, continuous fermentation. Process control during fermentation - pH, aeration, agitation, temperature, foam control. Downstream processing.

(b) Large scale production of antibiotics - penicillin, streptomycin; industrial chemicals - ethanol, acetone, citric acid; SCP – *Spirulina* and *Chlorella*; Biofertilizers – *Azotobacter* and *Rhizobium*; Bioinsecticides – *B. thuringeansis*, NPV. Commercial production of enzymes and their uses - amylase, cellulase, polygalacturonase.

Module 10: Tissue engineering and Stem cell technology (6 hrs)

Regenerative medicine, methods and applications of tissue engineering. Stem cells – embryonic stem cell and adult stem cells – production and applications.

Module 11: Bioremediation (10 hrs)

Importance and advantages of bioremediation, bioleaching, xenobiotics, organisms used for bioremediation. Cleaning strategies for water and soil - *in situ* and *ex situ* technologies. Bioremediation of radioactive wastes. Use of GMOs in bioremediation.

Practical (72 hrs)

1. Isolation of explants, establishment, subculture and maintenance of callus.
2. In vitro morphogenetic studies in any one plant system
3. Study of the morphology of callus cells – callus smear prelaration, histological aspects, microtomy.
4. Isolation and fusion of plant protoplasts.
5. Preparation of synthetic seeds.
6. Preparation of selective medium for drought or salinity resistance. Preparation of MS medium from stock solutions containing auxin and cytokinin, NaCl or PEG, and inoculation.
7. Cell immobilization.
8. Application of immobilized yeast cells for ethanol production.
9. Isolation of microbes producing Organic acids/Enzymes.
10. Find out the uninucleate stage of pollen for anther culture.
11. Dissect out an embryo from any seed and culture it on a suitable solid medium.
12. Cell plating technique.

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PROGRAMME ELECTIVE - BIOTECHNOLOGY

UCBY800402: GENETIC ENGINEERING, GENOME EDITING AND IMMUNOLOGY

(Theory 90 hrs; Practical 54 hrs; Credits 4)

Module 1: Important tools and techniques in gene cloning (18 hrs)

(a) DNA cutting and modifying enzymes: restriction endonucleases – types, mode of action; alkaline phosphatase, polynucleotide kinase, S1 nuclease, exonucleases, Ligases.

(b) In vitro DNA ligation strategies: Joining with ligases – adaptors, linkers and homopolymer tailing; topoisomerases, and site-specific recombinase

(c) Vectors: plasmid vectors, phage vectors and artificial chromosomes – BAC, YAC, PAC, HAC – important features, construction and applications of each.

(d) Cloning strategies: Genomic libraries, preparation of DNA fragments for cloning. Bacterial transformation, *in vitro* phage packaging and transfection.

(e) Selection and screening of recombinants: insertional inactivation, complementation of defined mutation, microarray techniques, immunological screening for expressed genes. Reporter systems – *Lac Z* system, GFP.

Module 3: Gene library (10 hrs)

(a) Genomic and cDNA library. Procedure for the construction of a genomic library using phage λ system. Identification of desirable clones from library – hybridization probing, colony and plaque hybridization probing, immunological screening. Locating and isolating a gene - *in situ* hybridization, positional cloning, chromosome walking and jumping.

Module 4: Advanced transgenic technology (6 hrs)

Inducible expression systems – trtracycline expression system; site-specific recombination for *in vivo* gene manipulation, gene targeting, gene silencing using antisense RNA and RNAi. RNAi therapy.

Module 5: Applications of rDNA technology (10 hrs)

(a) Uses of GM microbes: Bacteria and yeast– production of useful proteins, basic genetic research. Applications of GM animals: In basic research, producing novel proteins; disease studies, prevention and cure diseases.

(b) Uses of transgenic plants: Herbicide, insect and disease resistance, stress resistance. Genetic engineering for increasing nutritional and other novel qualities in plants, pharming.

Module 6: Genome editing (12 hrs)

(a) Process of genome editing: basic principle and steps involved in genome editing.

(b) Genome editing methods: Meganucleases, ZFN, TALEN, CRISPR/Cas9.

(c) Applications of genome editing: tool to study gene function, in genetic engineering, in gene therapy.

Module 7: Gene therapy (8 hrs)

Approaches to gene therapy- somatic cell and germline therapy, vectors used in gene therapy. *In vivo* and *ex vivo* therapy. Gene augmentation therapy. Problems and fears associated with gene therapy.

Module 8: Protein engineering (5 hrs)

Approaches to protein engineering - protein modification by site-directed mutagenesis, combinatorial methods. Applications of protein engineering.

Module 9: Biosensors (6 hrs)

Design and operation, types. Applications - medical, food and agriculture, industrial, pollution monitoring. GMOs as biosensors.

Module 10: Immunology (14 hrs)

(a) Innate and acquired immunity. Cells and molecules involved in innate and acquired immunity, humoral and cellular immunity, Antigens, Epitopes. Structure, function and types of antibody molecules.

(a) Generation of antibody diversity. Antigen-antibody interactions. Antigen processing and presentation. Activation and differentiation of B cells – formation, role. T cells – types, roles, T cell receptors. Primary and secondary immune modulation, complement system, pattern recognition receptors – toll-like receptors. MHC molecules. Cell-mediated effector functions, inflammation, hypersensitivity and autoimmunity, congenital and acquired immunodeficiencies.

(b) Production and uses of monoclonal antibodies, antibody engineering.

(c) Vaccines: Basic strategies, inactivated and live attenuated pathogens, subunit vaccines, recombinant vaccines (e.g., Hepatitis B vaccine), DNA vaccines. Modern approaches to vaccine development - edible vaccines.

Practical (54 hrs)

1. Identification of chemicals/reagents, tools, techniques, and procedures used in genetic engineering.
2. Work out problems based on restriction digestion of DNA, gel separation pattern etc.
3. Isolation of plant genomic DNA and its quantification.
4. Isolation of plasmids and its purification, by minipreparation and midipreparation.
5. Isolation of bacterial genomic DNA and its quantification by using UV spectrophotometer.
6. Separation of DNA by agarose gel electrophoresis.
7. Extraction and quantification of protein by Bradford method.
8. Separation of proteins by PAGE.
9. Conduct PCR.

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PROGRAMME ELECTIVE - BIOTECHNOLOGY

UCBY800403: GENOMICS, TRANSCRIPTOMICS, PROTEOMICS AND BIOINFORMATICS

(Theory 90 hrs; Practical 54 hrs; Credits 4)

Module 1: Genome mapping (12 hrs)

a. Genome map – definition, types, and significance in genomics.
b. Cytogenetic map – types (Brief study)
c. Genetic mapping – basic principles for the construction of linkage maps. Markers for genetic mapping – genes, biochemical markers, molecular markers. Construction of linkage maps using molecular markers - RFLP, RAPD, AFLP, SSLP, SNP.
d. Physical mapping – restriction mapping, STS mapping, EST.

Module 2: Genome sequencing (14 hrs)

(a) Basic steps in genome sequencing. Shot gun sequencing of small genomes. Hierarchical shot gun sequencing. Whole genome shot gun approach.
(b) Sequence assembly – methods used.
(c) Next generation sequencing strategies: Preparation of sequencing library. Reversible terminator sequencing (Illumina sequencing), Pyrrosequencing, 454 sequencing, ion torrent method, SOLiD. Third and Fourth generation sequencing.
(e) Important findings of the completed genome projects: Human genome project, Rice genome project, Arabidopsis genome project, *E. coli* genome project, Wheat genome project.

Module 3: Genome annotation (11 hrs)

(a) Structural annotation: by computer analysis of sequence data and experimental techniques
(b) Functional annotation: by computer based methods and experimental methods

Module 4: Comparative genomics (5 hrs)

Orthologs and Paralogs, gene identification by comparative genomics, comparative genomics as a tool in evolutionary studies. Metagenomics.

Module 5: Transcriptomics (5 hrs)

Components of the transcriptome. Methods of transcriptome analysis and its importance in genome annotation.

Module 4: Proteomics (8 hrs)

Proteome, proteomics. Protein profiling – steps in protein profiling. Protein sequencing. Protein expression analysis using protein microarray, protein localization using GFP.

Module 5: Bioinformatics (27 hrs)

(a) Internet and WWW. National Centre for Biotechnology Information – SRS. Computational Biology and Bioinformatics. Database organization and function. Types of databases based on the data storage pattern. Submission to and retrieval from databases – BankIt and sequin. Secondary Databases (PROSITE, PRINTS, BLOCKS).
(b) Sequence Analysis: Global Alignment, pairwise analysis, Scoring Matrices (an introduction), Database similarity search – query sequence search; BLAST –

Algorithm and different versions; FASTA. Multiple Sequence Analysis dynamic programming for sequence alignment. Tools for multiple sequence alignment – CLUSTAL X/W.

(c) Structural Bioinformatics: Molecular Structure viewing tool – Rasmol; Protein structure prediction, secondary structure prediction - Chou Fasman method and other Bioinformatics tools for secondary structure prediction; Tertiary structure prediction - comparative modeling, Abinitio prediction, Homology modeling.

(d) Gene prediction strategies, ORF search, gene prediction programs – Grail/Exp, GENSCAN, ORF finder. RNA secondary structure prediction.

(e) Computer assisted drug design - concept, methods and practical approaches. Brief study about Docking tools, AutoDock, molegro virtual docker, GOLD.

(f) Applications of bioinformatics in evolutionary studies, molecular clock hypothesis. Molecular Phylogeny – Gene and Species tree. Molecular evolution and Kimuras theory, Phylogenetic Trees, Terminology in Phylogenetic tree. Tree drawing Methods. Cladogram and Phylogram, Significance of Molecular Phylogeny.

Module 6: Ethical, legal, and social impact of complete genome analysis (8 hrs)

Genome data availability – Problems with public availability of sequence data, privacy concerns, legal problems, gene and DNA sequence patenting, patenting transgenics.

Practical (54 Hrs)

1. Blast search with Protein sequence (e.g. *Cytochrome C*sequence)
2. Blast search with Nucleic Acid Sequence (e.g *Magnolia latahensis* & Neanderthal man Paleo DNAs)
3. Carry out multiple sequence alignment using the given DNA sequences.
4. Phylogenetic tree creation with CLUSTAL X, W and MUSCLE and tree viewing tools. NJ Plot, Tree View, MEGA
5. Creation of phylogentic trees for selected families of Eudicots
6. Molecular structure viewing - use of Rasmol (supply structure of a few proteins downloaded from PDB).
7. Locate specific sequences like TATA box, promoters, start signals, stop signals etc. in a DNA sequence using computer programmes e.g., *E. coli* promoter, human promoter.
8. Laboratory/Industry visit: Students are expected to conduct a visit to a sophisticated biotechnology laboratory/research centre/biotechnology industry to have an idea on the type of work going on there. A report of the visit should be prepared and submitted.

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MODEL QUESTION PAPERS - THEORY

M Sc Botany Degree (CSS) Examination

IV Semester

Faculty of Science

Programme Elective - Biotechnology

UC**BY800401. PLANT TISSUE CULTURE AND MICROBIAL BIOTECHNOLOGY**

(2025 onwards)

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Differentiate between stirred tank and airlift bioreactors.
2. Define the following;
   (a) Totipotency (b) Synseeds (c) Haploids (d) Stem cells
3. What is androgenesis?
4. What are the causes of somaclonal variation?
5. Name four industrial chemicals produced by using microbial activities. Write the names of the microorganisms involved in each.
6. Describe the importance of using tissue culture in producing secondary metabolites.
7. What is enzyme engineering? What are the applications of it?
8. Briefly describe bioaugmentation.
9. How are triploids produced?
10. How do we produce stem cells?

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Write an account on the procedure and applications of hairy root culture.
12. Giving suitable examples, discuss downstream processing.
13. What are cybrids? How are they produced? Discuss the use of cybrids in crop improvement programmes.
14. Citing suitable examples, discuss the importance of GMOs in bioremediation
15. Describe the procedure of plant protoplast isolation and purification.
16. Briefly describe the prospects and future of stem cell research.
17. What is germplasm? Describe the methods of germplasm conservation. Add a note on the importance of tissue culture as a method of germplasm conservation
18. Write an account on the methods and applications of cell immobilization.

(6 x 2 = 12)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. Describe the procedure and applications of;
    (a) Cryopreservation (b) Protoplast culture (c) Microspore culture (d) Cellulase production
20. What is enzyme immobilization? Describe the steps involved and the potential applications. Add a note on enzyme engineering.
21. Write an essay on bioremediation.
22. Describe the various tissue culture techniques used to produce ploidy variants in plants.

(2 x 5 = 10)

M Sc Botany Degree (CSS) Examination

IV Semester

Faculty of Science Programme Elective - Biotechnology

UCBY800402: GENETIC ENGINEERING, GENOME EDITING AND IMMUNOLOGY

(2025 onwards)

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Where does T DNA come from, and how is it used in making transgenic plants?
2. Name the key tools for accomplishing the tasks of recombinant DNA technology. Also mention the functions of each tool.
3. Explain the purpose of selectable marker genes in cloning experiments.
4. Explain how edible vaccines work?
5. Distinguish between genomic library and cDNA library
6. What are the advantages of Bt plants?
7. Explain what is meant by the following terms in relation to genetic engineering;
   (a) Transformation (b) Polylinkers (c) Lipofection (d) Expression vectors
8. Write the important features in pUC.
9. What is antibody engineering?
10. Comment on gene augmentation therapy.

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Describe the following;
    (a) BAC (b) DNA probes (c) Electroporation (d) TALEN
12. Highlight any four areas where genetic modification of plants has been useful.
13. What is a recombinant DNA vaccine? Give two examples
14. Explain the gene therapy strategy applied to treat a patient suffering from ADA deficiency.
15. You have identified a useful gene in bacteria. Make a flow chart of the steps that you would follow to transfer this gene to a plant.
16. Describe the important applications of Biosensors.
17. Describe the steps involved in the creation of a genomic library.
18. Comment on RNAi therapy.

(6 x 2 = 12)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. What is monoclonal antibody? How is monoclonal antibody produced in large scale? What are the uses of it?
20. Describe the following;
    (a) Plaque hybridization (b) Biopharming (c) *In vitro* mutagenesis (d) Artificial chromosomes
21. 'Genes could be silenced using RNA'. Explain the methods used with examples.
22. Describe the methods and applications of genome editing.

(2 x 5 = 10)

M Sc Botany Degree (CSS) Examination
IV Semester
Faculty of Science Programme Elective - Biotechnology
UCBY800403: GENOMICS, TRANSCRIPTOMICS, PROTEOMICS AND BIOINFORMATICS
(2025 onwards)

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **eight** questions. Each question carries a weight of 1)

1. What is multiple sequence alignment? Where is it useful?
2. What is a DNA marker? Give two examples.
3. Explain how some of the Restriction enzymes produce "sticky ends" while DNA is cut?
4. Write a brief note on metagenomics.

5. Explain the following terms related to drug design;
   (a) GOLD (b) ORF (c) SOLiD (d) EST
6. What is STS?
7. Distinguish between a physical map and a genetic map.
8. How is GFP useful for protein localization in a living cell?
9. What are secondary databases? Give examples.
10. What is cladogram?

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Describe the major findings of HGP.
12. What is comparative genomics? How is it useful in determining the evolutionary relationships between organisms?
13. Explain the features of GENSCAN.
14. Explain the working and important features of BLAST?
15. What are the applications of genome sequencing?
16. Describe the following;
    (a) Microarrays (b) Immunoprecipitation (c) Knock down mutants (d) SNP
17. Describe the different genome sequencing strategies
18. Describe the strategies adopted for sequence assembly.

(6 x 2 = 12)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. Describe the methods adopted for the annotation of the genome sequence.
20. Write an essay on the ethical, legal, and social issues generated by large-scale sequencing of genomes.
21. Explain the application of bioinformatics in evolutionary studies
22. Write an essay on the different types of genome mapping techniques.

(2 x 5 = 10)

MODEL QUESTIONS – PRACTICAL

ELECTIVE - BIOTECHNOLOGY

UC**BY800404: PLANT TISSUE CULTURE AND MICROBIAL BIOTECHNOLOGY**

Time: 4 hours **Weightage:30**

1. Selective isolation of amylase producing microbes from environment
(Total weight 6:Procedure – 2; Experiment – 2; Comment/Interpretation – 2)

2. Isolate early stage embryo from the given material in aseptic conditions and inoculate in the medium
(Total weight 5:Procedure – 2; Isolation – 1; Inoculation – 2)

3. Prepare synthetic seeds by inserting somatic embryo/zygotic embryo/axillary bud/apical meristem in Sodium alginate
(Total weight 5: Procedure – 2; Working/Preparation - 3)

4. Select the anther in appropriate stage for anther culture. Write down the selection criteria for the flower bud.
(Total weight 4: selection criteria – 1; Preparation – 3)

5. Comment on A, B, C, D, E and F.

6. (Weight 1; 1 x 6 = 6)

7. Practical record
(Weight 4)

Key to the questions:

1. Preparation of plates and isolation of microbe has to be done 2-3 days before exam.
2. Give appropriate seeds
3. Give necessary reagents and materials
4. Give appropriate inflorescence
5. A, B, C, D, E, F - Chemicals, Instruments, Photographs/Diagrams related to tissue culture/microbial biotechnology procedures specified in the syllabus
6. Awarding 'A grade' to the record of practical work shall be considered only if all the practicals specified in the syllabus are completely done and recorded properly.This also includes field study report(s)/Lab visit report(s)/Industry visit report(s), if any.

SEMESTER IV - PRACTICAL COURSE II

UCBY800405: GENETIC ENGINEERING, GENOME EDITING, IMMUNOLOGY, GENOMICS, TRANSCRIPTOMICS, PROTEOMICS AND BIOINFORMATICS

Model question paper

Time: 4 hours **Weightage: 30**

1. Find out the phylogenetic relationship of *Homo sapiens neanderthalensis* Cytochrome Cprotein sequence with other 5 organisms.
   (Total weight 5: Processing of the source file containing FASTA format – 1; MSA output – 2; Tree Creation - 2)
2. Blast search with the given nucleotide sequence (e.g.*Magnolia latahensis* sequence). Using the same sequences, carry out multiple sequence alignment.
   (Total weight 5: Identification and FASTA sequence of phylogenetically related organisms – 1.5; BLAST SEARCH – 1.5; MSA output – 3)
3. Isolation DNA from the given plant material.
   (Total weight 5: protocol – 1; Isolation – 4)
4. Separate Nucleic acid by agarose gel electrophoresis
   (Total weight 5: Running efficiency – 3; Band vision – 2)
5. Comment on A, B, C and D
   (Weight 1.5; 1.5 x 4 = 6)
6. Practical record
   (Weight = 4)

Key to the questions:

1. Draw a phylogenetic tree using the gene sequence data file with the help of CLUSTAL X/W or MUSCLE and tree drawing tool Centre can provide raw genesequences of phylogenetically related organisms as a Text file.
2. Download protein sequences like Magnolia latahensisrbcL gene from genbank and save it in each desktop. Then use Clustal X/MUSCLE
3. Supply necessary tissue samples
4. Supply pure samples of DNA/RNA, and necessary buffer
5. A, B, C, D - Vectors, procedures or equipments (photographs) used in genetic engineering
6. Awarding ‘A grade’ to the record of practical work shall be considered only if all the practicals specified in the syllabus are done completely recorded properly. This also includes field study report(s)/Lab visit report(s)/Industry visit report(s), if any.