SEMESTER WISE DISTRIBUTION OF COURSES AND CREDITS

Maharaja's College (Autonomous) M Sc Botany syllabus 2016 Admission onwards

Course	Title	Teaching hrs Theory	Teaching hrs Practical	Credits
	SEMESTER I			
PG1BOTC01	Microbiology + Phycology	27 + 45	9 + 36	4
PG1BOTC02	Mycology + Crop Pathology	36 + 36	36 + 18	4
PG1BOTC03	Bryology + Pteridology	36 + 36	18 + 36	4
PG1BOTC04	Environmental Biology	54	27	3
PG1BOTP01	Practicals of PG1BOTC01+ PG1BOTC02			2
PG1BOTP02	Practicals of PG1BOTC03+ PG1BOTC04			2
	SEMESTER II			
PG2BOTC05	Gymnosperms + Evolution + Developmental Biology	27 + 27 + 18	27 + 0 + 18	4
PG2BOTC06	Cell and Molecular Biology	72	36	4
PG2BOTC07	Plant anatomy + Principles of Angiosperm systematics	36 + 36	36 + 27	4
PG2BOTC08	Genetics + Biochemistry	18 + 36	18 +18	3
PG2BOTP03	Practicals of PG2BOTC05+ PG2BOTC06			2
PG2BOTP04	Practicals of PG2BOTC07+ PG2BOTC08			2
	SEMESTER III			
PG3BOTC09	Research Methodology + Biophysical instrumentation + Biostatistics + Microtechnique	18 + 18 + 18 + 18	9 + 18 + 18 + 27	4
PG3BOTC10	Plant Physiology + Plant Breeding	54 + 18	36 + 9	4
PG3BOTC11	Biotechnology and Bioinformatics	72	27	4
PG3BOTC12	Taxonomy of Angiosperms	54	36	3
PG3BOTP05	Practicals of PG3BOTC09+ PG3BOTC10			2
PG3BOTP06	Practicals of PG3BOTC11+ PG3BOTC12			2
	SEMESTER IV			
PG4BOTC13	Biotechnology/Environmental Science/Microbiology	90	72	4
PG4BOTC14	,,	90	54	4
PG4BOTC15	,,	90	54	4
PG4BOTP07	Practicals of PG4BOTC13			4
PG4BOTP08	Practicals of PG4BOTC14+ PG4BOTC15			
Project				4
Viva				3

SEMESTER I

Course	Title	Teaching hrs Theory	Teaching hrs Practical	Credits
PG1BOTC01	Microbiology and Phycology	27 + 45	9 + 36	4
PG1BOTC02	Mycology and Crop Pathology	36 + 36	36 + 18	4
PG1BOTC03	Bryology and Pteridology	36 + 36	18 + 36	4
PG1BOTC04	Environmental Biology	54	27	3
PG1BOTP01	Practicals of PG1BOTC01+ PG1BOTC02			2
PG1BOTP02	Practicals of PG1BOTC03+ PG1BOTC04			2

Field study: Students are expected to conduct field visit(s) to familiarize with the diversity of life forms dealt in the first semester syllabus. Report of the field visit(s) should be prepared and recorded as part of the practical record.

PG1BOTC01: MICROBIOLOGY AND PHYCOLOGY
(Theory 27 + 45 hrs; Practical 9 + 36 hrs; Credits: 4)

Microbiology (27 hrs)

Module 1:

1. Introduction to microbiology (2 hrs)

(a) Scope of microbiology.

(b) Microbial diversity: Microbial taxonomy and phylogeny - Major groups and their characteristics (Five kingdom system and Three domain system of classification).

2. Bacteria (12 hrs)

(a) Bacterial morphology. Classification of Bacteria according to Bergey's manual of systematic bacteriology.

(b) Ultra structure of Gram positive and Gram negative bacteria; cell membrane, cell wall, flagella, pili, fimbriae, capsule and slime, ribosome and endospores.

(c) Major groups of Bacteria: Spirochetes, Rickettsias, Chlamydias, Mycoplasmas, Actinomycetes, Myxobacteria, Archaebacteria- cell wall characteristics. Extremophiles - thermophilic, halophilic, acidophilic and alkalophilic bacteria.

(d) Nutritional types - Photolithotrophs, Chemolithotrophs, Photoorganotrophs, and Chemo organotrophs.

(e) Bacterial Genetics: Organization and replication of genetic material in bacteria - bacterial chromosome, plasmid. Recombination in bacteria – conjugation-F^+ X F^-, Hfr X F^-, F'X F^- (sexduction), transformation and transduction.

Module 2:

1. Viruses (10 hrs)

(a) Nomenclature and classification based on genome and symmetry, distinctive properties of viruses, morphology (symmetry) and a general account on different kinds of viruses. Capsid and their arrangements, types of envelopes and their composition. Viral genome.

(b) Structure of bacteriophages belonging to 'T' series. Ultra structure of TMV and HIV.

(c) Viral replication: Lytic and Lysogenic cycles - Lytic cycle in T even phages, lysogeny in lambda phage.

(d) Sub viral particles - Prions, Viroids, Virusoids.

2. Culture of microorganisms (3 hrs)

Methods for isolating pure culture of bacteria, types of culture media, enrichment culture techniques, maintenance and preservation of pure cultures.

Practical (9 hrs)

1. Preparation and sterilization of microbial culture media (broth, slant and plate) and inoculation.
2. Differential staining of bacteria using Gram stain.
3. Isolation of *Rhizobium* from root nodules.
4. Isolation of microbes from soil: Serial dilution - pour plate/spread plate method.
5. Streak out a bacterial culture on an agar plate and isolation of colonies.
6. Antibacterial assay - disc diffusion/agar well method.

References

1. Aneja K R (2010) *Experiments in Microbiology, Plant pathology and Biotechnology*. New Age Int. pub. Ltd, New Delhi
2. Aneja K R *et al.* (2010) *Textbook of Basic and Applied Microbiology*. New Age Int. pub. Ltd, New Delhi.
3. Carpenter P L (1967). *Microbiology*. W B Saunders & Co. Philadelphia.
4. Dube H C (2008). *Fungi, Bacteria and Viruses*. Agrobios.
5. Dubey R C, Maheswari D K (2013). *Text book of Microbiology*. S Chand .
6. Kanika Sharma (2005). *Manual of Microbiology: Tools and Techniques*. Ane Books.
7. Kumar H D (1990). *Modern concepts of Microbiology*. Vikas public. Delhi.
8. Lansing M Prescott, Harley, Klein (1999). *Microbiology*.
9. Mohapatra P K (2008). *Textbook of Environmental Microbiology*. International Publishing House, New Delhi

10. Nair L N(2010). *Methods of microbial and plant biotechnology.* New Central Book agency (P) Ltd.
11. Pommerville J C (2010) *Alcamo's Fundamentals of Microbiology*. Jones and Bartlet.
12. Pelczar Michael J, Adams M R, Chan E C S, Krieg Noel R (2000). *Microbiology*. Tata McGraw Hill.
13. Purohit S S (1997). *Microbiology: Fundamentals and application*. Agrobotanical.
14. Powar C B, Daginawala H F (1991). *General Microbiology* Vol II. Himalaya Publishing House.
15. Sharma P D (2014). *Microbiology*. Rastogi Publication.
16. Tortora G J *et al.* (2011). Microbiology. An introduction. Pearson Education
17. Willey J *et al*. (2010)Prescott's Microbiology, McGraw Hill Education

Phycology (45 hrs)

Module 3:

1.Introduction (3 hrs)

(a) History of algal classification. Criterion for algal classification, Detailed study of the classification by F. E. Fritsch and G. M. Smith. Modern Classification-Robert Edward Lee
(b) Centers of algal research in Kerala and India. Contributions of Indian phycologists – M O P
(c) Iyengar, V Krishnamurthy, T V Desikachary.

2. General features of Algae (30 hrs)

(a) Details of habit, habitat and distribution of Algae.
(b) Algal components: Cell wall, flagella, eye-spot, pigments, pyrenoid, photosynthetic products.
(c) Range of thallus structure and their evolution.
(d) Reproduction in algae: Different methods of reproduction, evolution of sex organs.
(e) Major patterns of life cycle and post fertilization stages in Chlorophyta, Xanthophyta, Phaeophyta and Rhodophyta.
(f) Fossil algae.

3. Algal ecology (3 hrs)

(a) Ecological importance of Algae.
(b) Productivity of fresh water and marine environment. Algae in symbiotic association, Algae in polluted habitat, Algal indicators, Algal blooms.

Module 4:

1: Economic importance of Algae (3 hrs)

(a) Algae as food, fodder, biofertilizer, medicine, industrial uses, and other useful products. Harmful effects of algae.
(b) Use of Algae in experimental studies-Modern trends in algal research

2: Algal biotechnology (6 hrs)

(a) Methods and techniques of collection, preservation and staining of Algae.
(b) Algal culture: batch culture and continuous culture, Importance, methods; Algal culture media Walnes medium, BG 11 (Mention only).

Practical (36 hrs)

1. Critical study of diagnostic features and identification of the following genera based on morphological, anatomical and reproductive parts;

(a) Cyanophyceae - *Gloeocapsa, Gloeotrichia, Spirulina, Microcystis, Oscillatoria, Lyngbya, Anabaena, Nostoc, Rivularia, Scytonema*.
(b) Chlorophyceae - *Chlamydomonas, Gonium, Eudorina, Pandorina, Pediastrum, Volvox, Ecballocystis, Tetraspora, Ulothrix, Microspora, Ulva, Cladophora, Pithophora.*
Coleochaete, Chaetophora, Draparnaldia, Draparnaldiopsis, Trentepohlia, Fritschiella, Cephaleuros, Oedogonium, Bulbochaete, Zygnema, Mougeotia
Desmidium, Bryopsis, Acetabularia, Codium, Caulerpa, Halimeda, Neomeris, Chara, Nitella.
(c) Xanthophyceae – *Vaucheria*.
(d) Bacillariophyceae - *Pinnularia*.
(e) Phaeophyceae - *Ectocarpus, Colpomenia, Hydroclathrus, Dictyota, Padina, Sargassum,Turbinaria*.
(f) Rhodophyceac - *Batrachospermum, Gelidium, Amphiroa, Gracilaria, Polysiphonia*.

2. Students are to collect and identify algae from different habitat and prepare a key based on

characters or visit an Algal research station. Prepare and submit a report of the field work/research station visit.

References

1. Chapman V J (1962). *The Algae*. Macmillan & Co. Ltd.
2. Fritsch F E (Vol. I, II) (1977). *The structure and reproduction of Algae*. Cambridge University Press.
3. Gilbert M Smith (1951). *Manual of Phycology*. Chronica Botanica Co.
4. Gilbert M Smith (1971). *Cryptogamic Botany (Vol. 1): Algae and Fungi*. Tata McGraw Hill.
5. Harold C Bold, Michael J Wynne (1978). *Introduction to Algae: Structure and reproduction*.Prentice Hall
6. Lee R E (2008) *Phycology*. Cambridge University Press.
7. M O P Iyengar and T V Desikachary (1981). ICAR Publication.
8. Pringsheim E G (1949). *Pure culture of Algae*. Cambridge University Press.
9. Sambamurty A V S S (2005) A Textbook of Algae. I K International publishers Pvt Ltd.
10. Sharma O P (2011). *Textbook of Algae*. Tata McGraw Hill.
11. Singh V, Pandey P C and Jain D K (2010), *Text book of Botany*, Rastogi Publication.

Online Resources:

http://www.algaebase.org/

http://www.algaterra.org/

http://ucjeps.berkeley.ed

http://www.algalweb.net/search1.htm

http://cfb.unh.edu/phycokey/phycokey.htm

http://www-cyanosite.bio.purdue.edu/

http://fmp.conncoll.edu/Silicasecchidisk/CarolinaKey_Information.html

https://manoa.hawaii.edu/exploringourfluidearth/

http://archives.microbeworld.org/resources/educate.aspx

http://microbe.net/resources/microbiology-web-resources/

PG1BOTC02: MYCOLOGY AND CROP PATHOLOGY
(Theory 36 + 36 hrs; Practical 36 + 18 hrs; Credits: 4)

Mycology (36 hrs)

Module 1: General introduction (3 hrs)

1. General characters of Fungi and their significance.
2. Principles of classification of fungi, Classifications by G C Ainsworth (1973) and AFTOL (Kirk, 2008)

Module 2: Thallus structure and reproduction in Fungi (24 hrs)

1. Mycelial structure and reproduction of;
    a. Myxomycota–Acrasiomycetes, Hydromyxomycetes, Myxomycetes, Plasmodiophoromycetes.
    b. Mastigomycotina - Chytridiomycetes, Hyphochytridiomycetes, Oomycetes.
    c. Zygomycotina - Zygomycetes, Trichomycetes.
    d. Ascomycotina - Hemiascomycetes, Pyrenomycetes, Plectomycetes, Discomycetes, Laboulbeniomycetes, Loculoascomycetes.
    e. Basidiomycotina - Teliomycetes, Hyphomycetes, Gastromycetes.
    f. Deuteromycotina - Blastomycetes, Hyphomycetes, Coelomycetes.
2. Types of fruiting bodies in fungi.

Module 3: Fungal associations and their significance (9 hrs)

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

Practical (36 hrs)

1. Critical study of the following types by preparing suitable micropreparations; *Stemonitis, Physarum, Saprolegnia, Phytophthora, Albugo, Mucor, Aspergillus, Penicillium, Pilobolous, Saccharomyces, Xylaria, Peziza, Phyllochora, Puccinia, Termitomyces, Pleurotus, Auricularia, Polyporus, Lycoperdon, Dictyophora, Geastrum, Cyathus, Fusarium, Alternaria, Cladosporium, Pestalotia, Graphis, Parmelia, Cladonia, Usnea.*
2. Isolation of fungi from soil and water using PDA.
3. Estimation of mycorrhizal colonization in root.
4. Collection and identification of common field mushrooms (5 types).

References

1. Ahamadjian V, M E Hale (1973). *The Lichens*. Academic press.
2. Ainsworth G C, Sparrow K F, Sussman A S (1973) Vol IV. *The fungi: An advanced treatise*. Academic Press.
3. Alexopoulos C J, M Blackwell, C W Mims (1996). *Introductory Mycology* (IV Edn). Wiley Publishers.
4. Dayal R (2000). *Predaceous Fungi*. Commonwealth Publishers.
5. Deacon J (2006). *Fungal Biology* (IV Edn). Blackwell Publishing.
6. Dube H C (1983). *An introduction to fungi.* Vikas Publishers.
7. Dube H C (2013). *An introduction to fungi.* Vikas Publishers.
8. Hale M E (1967). *The Biology of Lichens.* Cambridge University Press.
9. Kanika Sharma (2009). *Manual of microbiology: Tools and techniques*. Ane Books Pvt Ltd.
10. Misra A, P R Agarwal P R (1978). *Lichens.* Oxford and IBH publications Co.
11. Nair L N (2010). *Methods of microbial and plant biotechnology.* New Central Book agency (P) Ltd.
12. Nair M C, Balakrishnan S (1986). *Beneficial fungi and their utilization*. Sci. publications.
13. Sharma O P (2011) *Fungi and Allied Microorganisms*. Tata Mc Graw Hill Pvt ltd.

Online resources:
http://www.mushroomexpert.com/major_groups.html
http://www.britmycolsoc.org.uk/library/keys/
http://www.mycokey.com/

Crop Pathology (36 hrs)

Module 4:

1. **Introduction to crop pathology (2 hrs)**
   Classification of plant diseases based on; (a) Major causal agents - biotic and abiotic, (b) General symptoms.
2. **Process of infection and pathogenesis (4 hrs)**
   (a) Penetration and entry of pathogen into host tissue – mechanical, physiological and enzymatic.
   (b) Host-parasite interaction: Recognition and entry processes of different pathogens like bacteria, viruses into plant host cells, alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in plants
3. **Defense mechanism in plants (5 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 and second messengers in plant defense.

Module 5:

1. **Transmission of plant disease (2 hrs)**
   Spread and transmission of plant diseases by wind, water, seeds and vectors.
2. **Plant disease management (8 hrs)**
   Exclusion, eradication and protection. Chemical means of disease control – common fungicides, topical and systemic 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)

1. Cereals: Rice - blast disease, bacterial blight
2. Vegetables: Chilly - leaf spot; Lady's finger - vein clearing disease.
3. Fruits: Banana - bacterial leaf blight; Mango - Anthracnose; Citrus - bacterial canker; Papaya – mosaic.
4. Spices: Ginger - rhizome rot; Pepper - quick wilt.
5. Oil seeds: Coconut - grey leaf spot, bud rot disease.
6. Rubber yielding: *Hevea braziliensis* - abnormal leaf fall, powdery mildew.
7. Sugar yielding: Sugarcane - red rot; root knot nematode.
8. Beverages: Tea - blister blight; Coffee - rust.
9. Masticates: Arecanut: nut fall disease.

Practical (18 hrs)

1. Make suitable micropreparations and identify the diseases mentioned with due emphasis on symptoms and causative organisms.
2. Isolation of pathogens from diseased tissues (leaf, stem and fruit) by serial dilution method.
3. Collection and preservation of specimens from infected plants. Submit 5 herbarium sheets/live specimens along with a report.
4. Tests for seed pathology – seed purity test.
5. Calculation of Spore load on seeds using Haemocytometer.
6. Identification of symptoms from external manifestations

References

1. Bilgrami K S, Dube H C (1990). *A text book of modern plant pathology*. Vikas Publishing House.
2. Gareth Johnes (1987). *Plant pathology: principles and practice.* Prentice Hall.
3. George N Agrios (2006). *Plant pathology* (V Edn). Elsevier Academic Press.
4. Gupta V K, Paul Y S (2004). *Fungi and Plant disease.* Kalyani publishers.
5. Kamat M N. (1971). *Practical plant pathology*. Prakash Publishing House.
6. Malhotra R S, Aggarwal Ashok (2013). *Plant Pathology*. Mc Graw Hill Education Pvt Ltd
7. Mehrotra R S (2003). *Plant Pathology*. Tata McGraw Hill.
8. Pandey B P(2001). *Plant Pathology*. S Chand.
9. Rangaswamy G, Mahadevan A (1998). *Diseases of crop plants in India*. PHI Learning Pvt. Ltd.
10. Sharma P D (2015). *Plant Pathology*. Rastogi Publishers.

PG1BOTC03: BRYOLOGY AND PTERIDOLOGY
(Theory 36 + 36 hrs; Practical 18 + 36 hrs; Credits: 4)

Bryology (36 hrs)
Module 1:

1. **General introduction (4 hrs)**
    a. Introduction to Bryophytes, their fossil history and evolution.
    b. Concept of algal and pteridophytic origin of Bryophytes.
    c. General characters of Bryophytes.
    d. Classification of Bryophytes- G M Smith 1955, W B Schofield (1985), Bryophyte research in Kerala and India.
2. **Ecology and Economic importance of bryophytes (6 hrs)**
    a. Bryophyte habitats. Water relations - absorption and conduction, xerophytic adaptations, drought tolerance, dessication and rehydration, ectohydric, endohydric and myxohydric Bryophytes.
    b. Ecological significance of Bryophytes - role as pollution indicators.
    c. Economic importance of Bryophytes.

Module 2: Thallus structure (26 hrs)

Comparative structural organization of gametophytes and sporophytes in an evolutionary perspective. Asexual and sexual reproductive structures, spore dispersal mechanisms and germination of the following groups with reference to the types mentioned in the practical (development of sex organs not necessary).

a. Hepaticopsida (Sphaerocarpales, Marchantiales, Jungermanniales and Calobryales).
b. Anthocerotopsida (Anthocerotales).
c. 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, Lunularia, Dumortiera, Reboulia, Pallavicinia, Fossombronia, Porella, Anthoceros, Notothylas, Sphagnum, Pogonatum*.
2. Students are expected to submit a report of field trip to natural habitats of bryophytes to familiarize with the diversity of Bryophytes.

References

1. Bonver F O (1935). *Primitive land plants*. MacMillan & Co. Ltd.
2. Campbell, Ditt (1940). *The evolution of land plants*. Stanford University Press.
3. Chopra R N, Kumar P K (1988). *Biology of Bryophytes.* Wiley Eastern Ltd.
4. Chopra R S, Kumar S S (1981). *Mosses of Western Himalayas and adjacent plains*. Chronica Botanica.
5. Dyer A F, Duckett J G (Eds) (1984). *The experimental Biology of Bryophytes*. Academic Press.
6. Goffinet B, Shaw A J (2009). *Bryophytic Biology* (II Edn). Cambridge University Press.
7. Gilbert M S (1974) Cryptogamic Botany Vol II. Tata McGraw Hill.
8. Kashyap S R (1932). *Liverworts of Western Himalayas and the Punjab plains* (Vol. I & II). Research Co. Publications.
9. Kumar S S (1984). *An approach towards phylogenetic classification of Mosses*. Jour. Hattori Bot. Lab. Nichinan.
10. Pandey B P (1994). *Bryophyta.* S Chand and Co. Ltd.
11. Pandey S N, Misra S P, Trivedi P S (2006) *A textbook of Botany. Vol II*. Vikas publishing house pvt ltd
12. Parihar N S (1956). *An introduction to Embryophyta*. Vol I Bryophyta. Surjeeth publications
13. Rashid A (1998). *An Introduction to Bryophyta*. Vikas publishing house Pvt. Ltd.

14. Richardson D H S (1981). *Biology of Mosses*. Blackwell Scientific publications, Oxford.
15. Shefield W B (1983 – '84). *Introduction to Bryology* (Vol. 1, 2). Jour. Hattori Bot. Lab, Japan.
16. Srivastava S N (1992). *Bryophyta*. Pradeep Publications.
14. Udar R (1976). *Bryology in India*. Chronica Botanica Co.
15. Vashishta B R, A K Sinha, A Kumar (2003). *Bryophyta*. S Chand & Co. Ltd.

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Pteridophytes (36 hrs)

Module 3:

1. **General introduction and classification (3 hrs)**
   Introduction, origin, general characteristics and an outline of the classification of Pteridophytes Smith *et al*. (2006)
2. **Structure of the plant body (27 hrs)**
   Distribution, habitat, range, external and internal morphology of sporophytes, spores, mechanism of spore dispersal, gametophytic generation, sexuality, embryogeny of the following classes of Pteridophytes with reference to the genera mentioned (development of sex organs is not necessary):
   (I) Psilopsida (a) Rhyniales; *Rhynia* (II) Psilotopsida (a)Psilotales;*Psilotum*
   (III) Lycopsida (a) Protolepidodendrales; *Lepidodendron* (b) Lycopodiales; *Lycopodium*,(c) Isoetales; *Isoetes* (d) Selaginellales; *Selaginella*.
   (IV) Sphenopsida (a) Hyeniales (b) Sphenophyllales; *Sphenophyllum* (c) Calamitales; *Calamites*
   (d) Equisetales; *Equisetum*.
   (V) Pteropsida (i) Primofilices (a) Cladoxylales; *Cladoxylon* (b) Coenopteridales.
   (ii) Eusporangiatae (a) Marattiales; *Angiopteris* (b) Ophioglossales; *Ophioglossum*.
   (iii) Osmundales; *Osmunda*.
   (iv) Leptosporangiatae (a) Marsileales; *Marsilea* (b) Salviniales; *Salvinia* (c) Filicales; *Pteris*, *Lygodium, Acrostichum, Gleichenia*.

Module 4: Comparative study of Pteridophytes (4 hrs)

Stelar organization, soral and sporangial characters, gametophytes and sporophytes of Pteridophytes in an evolutionary perspective.

Module 5: Ecology and Economic importance (2 hrs)

Ecological and economic significance of Pteridophytes.

Practical (36 hrs)

1. Study of morphology and anatomy of vegetative and reproductive organs using clear whole mounts/sections of the following genera:
Psilotum, Lycopodium, Isoetes, Selaginella, Equisetum, Angiopteris, Ophioglossum, Osmunda, Marsilea, Salvinia, Lygodium, Acrostichum, Gleichenia, Pteris.
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.

References

1. Agashe S N (1995). *Palaeobotany*. Oxford and IBH publishing House.
2. Arnold C R (1977*). Introduction to Palaeobotany*. McGraw Hill Book Com.
3. Chandra S, Srivastava M (Eds) (2003). *Pteridology in the New Millennium*. Khuwar Acad. Publishers.
4. Beddome C R H (1970). *Ferns of south India*. Today & Tomorrows Publ.
5. Dyer A F (1979). *The experimental biology of ferns*. Academic Press.
6. Gifford E M, Foster A S (1989). *Morphology and evolution of Vascular plants* (III Edn). W H Freeman & Co.

7. Khullar S P (2000). *An illustrated fern flora of West Himalayas* (Vol I, II). International Book Distributers.
8. Kubitzki K (1976). *The families and Genera of Vascular plants: Vol. I Pteridophytes*. Vikas publishing house.
9. Rashid A (1976). *An introduction to Pteridophytes*. Vikas Publishing House.
10. Sporne K R (1982). *Morphology of Pteridophytes*. Hutchinson University Press.
11. Surange K R (1964). *Indian Fossil Pteridophytes*. CSIR.
12. Louis J D (1977). *Evolutionary patterns and processes in ferns: Advances in Botanical Research*.
13. Smith, Gilbert (1972). *Cryptogamic Botany* (Vol. II). Tata McGraw Hill publications.
14. Nayar B K, Kaur S (1971). *Gametophytes of homosporous ferns*. Bot. Rev.

PG1BOTC04 : ENVIRONMENTAL BIOLOGY
(Theory 54 hrs; Practical 27 hrs; Credits 3)

Module 1:

1. **Ecology and Environment (1 hr)**
    a. Definition, history and scope of ecology, sub divisions of ecology, ecology vs environmental science.
    b. Interdisciplinary nature of environmental science.
2. **Autecological concepts - Population Ecology (5 hrs)**
    a. Characteristics of populations - size and density, dispersion, age structure, natality and
    b. mortality.
    c. Population growth - factors affecting population growth, environmental resistance, biotic potential, carrying capacity, positive and negative interaction, migration, subsistence density, security and optional density. Ecological consequence of overpopulations.
    d. Genecology - ecological amplitude, ecads, ecotypes, ecospecies, coenospecies, k-selection and r-selected populations.
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, Sorenson's Index of similarity, coefficient of communities.
    c. Dynamic community characteristics - cyclic replacement changes and cyclic no-replacement changes.
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, ecological balance and survival thresholds.

Module 2:

1. **Biosphere and Ecosystem (3 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 world ecosystems: Different aquatic and terrestrial ecosystems with regard to their productivity, biodiversity, energy flow, food chains and trophic levels.
2. **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 in vegetation classification, understanding the key environmental issues and ecosystem management.

Module 3:

1. **Environmental pollution (16 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.

2. **Environmental biotechnology and solid waste management (4 hrs)**
   a. Concept of waste, types and sources of solid wastes including e-waste.
   b. Bioremediation, Phytoremediation, bioaugmentation, biofilms, biofilters, bioscrubbers and trickling filters. Use of bioreactors in waste management.

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

1. Global warming, green house gases, acid rain, ozone depletion. Holistic relationship between air water and land pollution.
2. Factors responsible for climate change, *El-Nino* and *La Nina* phenomenon and its consequences.
3. Effect of climate change on reproductive biology and biogeography.
4. Environmental laws, environmental monitoring and bio indicators, environmental safety provisions in Indian constitution, major environmental laws in free India, ISO-14000.

Module 5: Biodiversity and its conservation (8 hours)

1. Basic principles of resource management, definition and classification of resources, problems of resource depletion, preservation, conservation and restoration, patterns of resource depletion, resource economics and resource overuse.
2. Current biodiversity loss - concept of endemism, rare, endangered and threatened species (RET), key stone species, WCU- account of biodiversity, red data book and hot spots, reasons to stop extinction, methods to save species.
3. Principles of conservation - *ex-situ* and *in-situ* conservation techniques. Biodiversity conservation: Species diversity, community diversity, ecosystem diversity and landscape preservation. Role of biotechnology in conservation of species.
4. 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, dissolved sulphate and nitrite (f) Total alkalinity.

2. 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.

3. Phytoplankton counting using Sedgwick Rafter counter.

4. Field visit to natural ecosystem and identification of trophic levels, food webs and food chains, plant diversity (species and community).

5. Students should be aware of the common environmental problems, their consequences and possible solutions.

References

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SEMESTER II

Course	Title	Teaching hrs Theory	Teaching hrs Practical	Credits
PG2BOTC05	Gymnosperms, Evolution and Developmental Biology	27 + 27 + 18	27 +0 + 18	4
PG2BOTC06	Cell and Molecular Biology	72	36	4
PG2BOTC07	Plant Anatomy and Principles of Angiosperm Systematics	36 + 36	36 + 27	4
PG2BOTC08	Genetics and Biochemistry	18 + 36	18 +18	3
PG2BOTP03	Practicals of PC 5 + PC 6			2
PG2BOTP04	Practicals of PC 7 + PC 8			2

PG2BOTC05: GYMNOSPERMS, EVOLUTION AND DEVELOPMENTAL BIOLOGY
(Theory 27 + 27 + 18 hrs; Practical 27 + 0 + 18 hrs; Credits 4)

Gymnosperms: (27 hrs)

Module 1: Introduction and Economic importance of Gymnosperms (5 hrs)

1. Origin, general characteristics, distribution and classification of Gymnosperms (K R Sporne and C J Chamberlain). Distribution of living gymnosperms in India.
2. Economic significance of Gymnosperms.

Module 2: Study of structure and development of Gymnosperms

1. **Vegetative and reproductive structures (18 hrs)**
   Detailed study of the vegetative morphology, internal structure, reproductive structures, and evolution of the orders and families (with reference to the genera mentioned).
   a. Class Progymnospermopsida: *Aneurophyton*
   b. Class Cycadopsida: *Heterangium, Cycas, Zamia, Pentoxylon*.
   c. Class Coniferopsida: General account of families under Coniferales, range of form and structure of stem, leaves; range of form, structure and evolution of female cones in coniferales such as *Pinus*, , *Cupressus, Podocarpus, Agathis, Araucaria and Ginkgo*.
   d. Class Gnetopsida: *Gnetum*.
2. **Gametophyte development (4 hrs)**
   General account on the male and female gametophyte development in Gymnosperms *Cycas*. *Pinus* and *Gnetum.*

Practical (27 hrs)

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

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Evolution: (27 hrs)

Module 3: Introduction

1. **Concept (4 hrs)**
   The Concept of evolution, preformation theory, Baer's law, biogenetic law, theory of catastrophism, natural selection, artificial selection, sexual selection, mutation theory, isolation theory.
2. **Origin of life (4 hrs)**
   Abiogenesis, Biogenesis experiment of Miller (1953). Theory of Organic evolution -

Biochemical origin of life, place and time of origin and experimental evidences. Concept of Oparin and Haldane.

3. **Evidences for evolution (5 hrs)**
   Morphology and Comparative anatomy – Embryology, Physiology and Biochemistry, Palaentology, Biogeography. Evolutionary time scale: eras, periods and epochs. Stages in primate evolution including *Homo*.

Module 4: Mutation, Speciation and Theories of evolution

1. **Mutation as an evolutionary force (2 hrs)**
   Mutation and genetic divergence; Evolutionary significance of mutations, genetic assimilations (Baldwin effect), genetic homoeostasis.
2. **Speciation (4 hrs)**
   Genetic drift - Salient features; species concept; subspecies, sibling species, semi species, demes. Types of speciation - Phyletic speciation and True speciation. Mechanism of speciation - Genetic divergences and isolating mechanisms. Patterns of speciation - allopatric, sympatric, quantum and parapatric speciation.
3. **Theories of evolution (8 hrs)**
   a. Lamarckism and Neo-Lamarckism, Darwinism and Neo-Darwinism; Mutation theory of De-Vries and the modern mutation theory.
   b. Modern synthetic theory of evolution, molecular evolution, concepts of natural evolution, molecular divergence and molecular clocks; molecular tools in phylogeny. Plant evolution.

References

1. George Ledyard Stebbins (1971). *Process of Organic evolution*. Prentice-Hall of India.
   Gurbachan S Miglani (2002). *Modern Synthetic theory of evolution*. Narosa.
2. Katy Human (2006). *Biological evolution: An anthology of current thought.* The Rosen publishing group, Inc.
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4. Monroe W Strickberger (1990). *Evolution*. Jones and Bartlett publishers.
5. Roderic D M Page, Edward C Holmes (1998). *Molecular Evolution: A phylogenetic approach*. Blackwell Science Ltd.

Developmental Biology (18 hrs)

Module 5: Basic concepts and Developmental studies in plants

1. **Basic concepts of developmental Biology: (3 hrs)**
   An overview of plant and animal development , Potency, Commitment, Specification, Induction, Competence, Determination and Differentiation; Morphogenetic gradients, Cell-fate and Cell lineages, Stem cells , Genomic equivalence and the cytoplasmic determinants , Imprinting. Mutants and transgenics in analysis of development .
2. **Development in flowering plants: (11 hrs)**
   a. Angiosperm life cycle.
   b. Anther: Structure and development, microsporogenesis, male gametophyte development . Palynology: Pollen morphology, exine sculpturing, pollen kit, NPC formula. Applications of palynology - palynology in relation to taxonomy. Viability of pollen grains. Pollination, pollen germination, growth and nutrition of pollen tube.
   c. Ovule: Structure, ontogeny and types. Megasporogenesis. Embryosac – development, types, ultrastructure, and nutrition of embryosac . Female gametophyte development .
   d. Fertilization: Double fertilization; embryo development - different types. Endosperm development, types of endosperm, haustorial behavior of endosperm [7]. Xenia and metaxenia. Polyembryony – types and causes .
   e. Seed formation, dormancy and germination . Apomixis, Parthenogenesis,
3. **Morphogenesis and organogenesis in plants: (4 hrs)**
   Shoot and root development . Leaf development and Phyllotaxy. Transition to flowering, floral meristems and floral development, ABC model of flower development. Homeotic genes in plants. Senescence, programmed cell death and hypersensitive response in plants.

Practical (18 hrs)

1. Study of pollen morphology.
2. Embryo excision from young seeds.
3. Pollen germination study.
4. Identification of different types of embryos, polyembryony, endosperm types, types of pollen grains, anther growth stages and types using permanent slides.

References

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PG2BOTC06 : CELL AND MOLECULAR BIOLOGY
(Theory 72 hrs; Practical 36 hrs; Credits: 4)

Module 1: Eukaryotic cell structure, Cell communication Cell signaling

1. **Intracellular compartments (6 hrs)**
    a. Major intracellular compartments in eukaryotic cells (brief study only). Detailed structure of mitochondria, chloroplast, peroxisomes and glyoxysomes with reference to their functional interrelationship. Genetic systems in mitochondria and chloroplast, endosymbiont hypothesis on the evolution of mitochondria and chloroplast.
    b. Structural organization of cell membranes.
    c. Chemical composition; structure and function of membrane carbohydrates, membrane proteins and membrane lipids. Membrane functions.
2. **Cell communication and Cell signaling (6 hrs)**
    a. Cell communication: general principles, Signaling molecules and their receptors, external and internal signals that modify metabolism, growth, and development of plants.
    b. Receptors: Cell surface receptors – ion-channel linked receptors, G-protein coupled receptors, and Tyrosine-kinase linked receptors (RTK), Steroid hormone receptors.
    c. Signal transduction pathways. Second messengers, Regulation of signaling pathways. Bacterial and plant two-component signaling systems.

Module 2: Life cycle of the cell (6 hrs)

1. Cell growth and division. Phases of cell cycle, cell cycle control system; extracellular and intracellular signals. Cell cycle checkpoints – DNA damage checkpoint, centrosome duplication checkpoint, spindle assembly checkpoint. Cyclins and Cyclin-dependent kinases, Regulation of plant cell cycle.
2. Cell division – mitosis and meiosis (brief study only). Molecular mechanism of crossing over-homologous recombination, Holliday model, Double strand break repair model. Significance of meiosis in generating genetic variation.
3. Programmed cell death – molecular mechanism and control.

Module 3: 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, myosins.

Module 4: Genetic material and chromosome organization in eukaryotes (11 hrs)

1. Identification of DNA as genetic material: Transformation experiment, Hershey Chase experiment. RNA as the genetic material in some viruses.
2. Important features of Watson and Crick model of DNA structure, Chargaff's rules, preferred tautomeric forms of bases.
3. Alternative conformations of DNA – types of right handed and left handed helices, DNA triplex and quadruplex, circular and linear DNA, single-stranded DNA.
4. Structure and function of different types of RNA - mRNA, tRNA, rRNA, SnRNA, and Micro RNA, RNA tertiary structures. Ribozymes – Hammerhead ribozyme ,
5. c-value paradox, DNA renaturation kinetics, Tm, Cot curve. Unique and Repetitive DNA – mini- and microsatellites.
6. Structure of chromatin and chromosomes- histones and nonhistone proteins, nucleosomal organization of chromatin, higher levels of chromatin structure. Heterochromatin and Euchromatin, formation of heterochromatin. Chromosomal packing and structure of metaphase chromosome. Molecular structure of the Centromere and Telomere.

Module 5: DNA replication, repair and recombination (10 hrs)

1. DNA replication- Unit of replication, enzymes and proteins involved in replication (in both prokaryotes and eukaryotes). Structure of the replication origin (in both prokaryotes and eukaryotes), priming (in both prokaryotes and eukaryotes), replication fork, fidelity of replication
2. Process of replication – initiation, elongation and termination, Replication in the telomere –telomerases.
3. Recombination-Homologous and non homologous recombination, molecular mechanism of homologous recombination, Site-specific recombination, transposition – types of transposons.
4. DNA repair mechanisms: Direct repair, excision repair – base excision repair and nucleotide excision repair (NER), eucaryotic excision repair – GG-NER, TC-NER. Mismatch

repair, Recombination repair – homologous recombination repair, nonhomologous end joining, SOS response –Translection DNA polymerase.

Module 6: Gene expression (20 hrs)

1. **Mechanism (20hrs)**
   (a) Gene - Concept of gene; structural and genetic definitions – complementation test, Gene families.
   (b) Transcription in prokaryotes:
      i.Initiation – promoter structure, structure of RNA polymerase, structure and role of sigma factors.
      ii.Elongation – elongation complex, process of RNA synthesis.
      iii.Termination – rho-dependent and rho-independent termination .
   (c) Transcription in eukaryotes: 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) Translation: Important features of mRNA – ORF, RBS ,Fine structure, composition and assembly of procaryotic and eukaryotic ribosomes. tRNA charging, initiator tRNA.
   (f) Stages in translation:
      i. Initiation – formation of initiation complex in prokaryotes and eukaryotes, initiation factors in prokaryotes and eukaryotes ,Kozak sequence.
      ii. Elongation – process of polypeptide synthesis, active centers in ribosome – 3-site model peptidyl transferase, elongation factors.
      iii. Termination – process of termination, release factors, ribosome recycling. Translational proof reading.
   (g) Genetic code: Cracking the genetic code – simulation synthetic polynucleotides and mixed copolymers, synthetic triplets, Important features of the genetic code ,proof for the triplet code, Exceptions to the standard code.
   (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 .
2. **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, transcriptional activators and repressors involved in chromatin remodelling, 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, RNA interference, micro RNA. Role of small RNA in heterochromatization and gene silencing

Practical (36 hrs)

1. Study of meiosis in *Rhoeo*/*Chlorophytum* by smear preparation of PMCs.
2. C mitosis
3. Work out problems based on DNA structure, replication, gene expression and genetic code.

References

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PG2BOTC07: PLANT ANATOMY AND PRINCIPLES OF ANGIOSPERM SYSTEMATICS
(Theory 36 + 36 hrs; Practical 36 + 27 hrs; Credits 4)

Plant Anatomy (36 hrs)

Module 1: Introduction (6 hours)

1. Scope and significance of plant anatomy, interdisciplinary relations.
2. Meristems**:** Apical organization- Stages of development of primary meristem and theories of apical organization, origin of branches and lateral roots. Primary thickening meristem (PTM) in monocots. Reproductive apex in angiosperms.
3. Secretory tissues in plants: Structure and distribution of secretory trichomes (*Drocera, Nepenthes*), salt glands, colleters, nectaries, resin ducts and laticifers. Structure of bark and distribution pattern of laticifers in *Hevea brasiliensis.*

Module 2: Secondary structure (10 hrs)

1. Vascular cambium and cork cambium: Structure and function, factors affecting cambial activity.
2. Secondary xylem and phloem: Ontogeny, structure and function. Lignification patterns of xylem.
3. Reaction wood: Compression wood and tension wood. Factors affecting reaction wood formation.
4. Anomalous secondary growth in dicots and monocots.
5. Wood: Physical, chemical and mechanical properties.
6. Plant fibers: Distribution, structure and commercial importance of coir, jute, and cotton.

Module 3: Anatomy

1. **Leaf and Node (6 hrs)**
    a. Leaf: Initiation, plastochronic changes, ontogeny and structure of leaf. Structure, development and classification of stomata and trichomes. Krantz anatomy, anatomical peculiarities in CAM plants. Leaf abscission.
    b. Nodal anatomy: Unilacunar, trilacunar and multilacunar nodes, nodal evolution.
    c. Root-stem transition in angiosperms.
2. **Reproductive anatomy (6 hrs)**
    a. Floral Anatomy: Anatomy of floral parts - sepal, petal, stamen and carpel; Floral vasculature (*Aquilegia and Pyrola*). Vascular anatomy. Development of epigynous ovary - appendicular and receptacular theory.
    b. Fruit and seed anatomy: Anatomy of fleshy and dry fruits - follicle, legume, berry. Dehiscence of fruits. Structure of seeds. Anatomical factors responsible for seed dormancy and drought resistance.
3. **Ecological and Applied anatomy (6 hrs)**
    Morphological and structural adaptations in different ecological groups - hydrophytes, xerophytes, epiphytes and halophytes.
4. **Applied anatomy (2 hrs)**
    Applications of anatomy in systematics (histotaxonomy) and Pharmacognosy. Research prospects in anatomy.

Practical: (36 hrs)

1. Study of cambia - non storied and storied.
2. Study the anomalous primary and secondary features in, *Amaranthus, Boerhaavia, Mirabilis*, *Nyctanthes*, *Piper* and *Strychnos.*
3. Study of stomata, trichomes, and laticifers. Determination of stomatal index.
4. Study the anatomical peculiarities of C4 and CAM plants (Leaf/Stem).
5. Study of nodal patterns.
6. Prepare a histotaxonomic key.
7. Study the pericarp anatomy of a legume, follicle and berry.
8. Identification of wood - soft wood and hard wood.

References

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21. Vasishta P C (1994). *Plant anatomy*. Pradeep publications.
22. Wardrop A B (1961). *The structure and formation of reaction wood in Angiosperm: Problems of tree physiology*. Recent advances in Botany (Vol II). University of Toronto press.
23. Wardrop A B (1964). *Reaction wood Anatomy in Arborescent angiosperms*. Formation of wood in forest trees (Ed, Zimmerman). Academic press, New York.

Principles of Angiosperm Systematics (36 hrs)

Module 4: Introduction

1. **Scope significance and concept of Taxonomy (4 hrs)**
   Historical background of classification - Artificial, natural and phylogenetic systems, APG system. Importance of taxonomy.
   Evolution of theories of biological classification-essentialism, nominalism and empiricism
2. **Concepts of Taxonomic hierarchy (4 hrs)**
   Species/Genus/Family and other categories; species concept and intraspecific categories - subspecies, varieties and forms.
3. **Phylogeny of Angiosperms (8 hrs)**
   Important phylogenetic terms and concepts: Plesiomorphic and Apomorphic characters; Homology and Analogy; Parallelism and Convergence; Monophyly, Paraphyly and Polyphyly. Phylogenetic tree - Cladogram and Phenogram.
4. **Data sources of Taxonomy (4 hrs)**
   Concepts of character; Sources of taxonomic characters - Anatomy, Cytology, Phytochemistry and molecular taxonomy.

Module 5: Concept and principles of assessing relationships (8 hrs)

1. Phenetic - Numerical Taxonomy - principles and methods; Cladistics - Principles and methods.
2. Chemotaxonomy, basic concepts of genome analysis – bar coding.

Module 6: Botanical nomenclature and Morphology of Angiosperms (8 hrs)

1. History of ICBN, ICN, aims and principles, rules and recommendations: rule of priority, typification, author citation, retention, rejection and changing of names, effective and valid publication.
2. Flower- Modified shoot, primitive flower, progressive sterilization of floral parts, Types and evolution of stamens, carpels and placentation. Morphology of fruits.

Practical (27 hrs)

1. Morphology of leaf: Leaf attachment, Stipules, Patterns of leaf, Phyllotaxy, Shapes of leaf lamina, bases, margins and tips, Venation.
2. Inflorescence: Racemose - Simple raceme, Compound raceme, Spike, Spikelet, Catkin, Spadix, Corymb, Simple umbel, Compound umbel, Panicle, Capitulum. Cymose - Solitary cyme, Mono-, Di- and polychasial cyme. Special types - Cyathium, Verticillaster, Hypanthodium, Coenanthium.
3. Morphology of stamens: Mono-, Di- and Polyadelphous; Epipetalous, Syngenesious, Synandrous, Polyandrous, Didynamous, Tetradynamous, Basifixed, Dorsifixed, Versatile.
4. Morphology of carpels: Apocarpous, Syncarpous, Gynostegium. Placentation - Marginal, Parietal, Axile, Free central, Basal and Pendulous.
5. Morphology of fruits: Berry, Drupe, Hesperidium, Pepo, Balausta, Amphisarca, Achene, Follicle, Capsule, Legume, Lomentum, Nut, Caryopsis, Cypsela, Samara, Cremocarp, Siliqua, Carcerule, Regma. Aggregate fruits; Composite fruits - Sorosis and Syconus; Pome.
6. Workout plant specimens collected locally for vegetative and reproductive characters.
7. Workout nomenclatural problems regarding priority and author citations.

References

1. Taylor D V, L J Hickey (1997). *Flowering plants: Origin, evolution and phylogeny*. CBS Publishers & Distributors.
2. Cole A J (1969). *Numerical Taxonomy*. Academic Press.
3. Cronquist A (1981). *An Integrated system of classifications of flowering plants*. Columbia University Press.
4. Davis P H, Heywood V M (1973). *Principles of Angiosperm Taxonomy*. Robert E Kereiger Publ.
5. Davis P H, V H Heywood (1991). *Principles of Angiosperm Taxonomy*. Today and Tomorrow Publications.
6. Gurcharan Singh (2004). *Plant Systematics: Theory and practice*. Oxford and IBH Publishing.
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8. Henry A N, Chandrabose M (1980). *An aid to the International Code of Botanical Nomenclature*.
9. Heywood V H, D M Moore (Eds) (1984). *Current concept in Plant Taxonomy*.
10. *International Code of Botanical Nomenclature* (latest)
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12. Lawrence George H M (1951). *Taxonomy of vascular plants*. Oxford and IBH Publ. Co. Pvt. Ltd.
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15. Sivarajan V V (1991*). Introduction to Principles of Plant Taxonomy*. Oxford IBH.
16. Stace C A (1989). *Plant Taxonomy and Biosystematics*. Etwaed Arnold.
17. Stuessy T F (2002). *Plant taxonomy: The systematic Evaluation of comparative data*. Bishen Singh, Mahendra Pal Singh. Dehradun.
18. Takhtajan A L (1997). *Diversity and Classification of Flowering Plants*. Columbia Univ. Press.
19. Wendy B Zomlefer (2006). *Guide to Flowering Plant Families*. Overseas Press India Private Ltd.
20. Woodland D W (1991). *Contemporary Plant Systematics*. Prentice Hall.

PG2BOTC08 : GENETICS AND BIOCHEMISTRY
(Theory 18 + 36 hrs; Practical 18 + 18 hrs; Credits 3)

Genetics (18 hrs)

Module 1:

History of Genetics (2 hrs)

Transmission genetics, Molecular genetics and Population genetics (brief introduction). Mendelism – basic principles (brief study). Extensions of Mendelism, penetrance and expressivity of genes. Non-Mendelian inheritance – cytoplasmic inheritance. Sex determination in animals and plants.

Module 2:

1. **Linkage and genetic mapping (6 hrs)**
    a. Linkage and Crossing over - Stern's hypothesis, Creighton and McClintock's experiments, single cross over, multiple cross over, two-point cross, three-point cross, map distances, gene order, interference and co-efficient of coincidence.
    b. Haploid mapping (*Neurospora*), Mapping in bacteria and bacteriophages. Inheritance of traits in humans; pedigree analysis, determination of human genetic diseases by pedigree analysis, genetic mapping in human pedigrees.
2. **Quantitative genetics (2 hrs)**
   Polygenic inheritance, QTL mapping, effect of environmental factors and artificial selection on polygenic inheritance.

Module 3:

1. **Genetics of Cancer (3 hrs)**
   Genetic basis of cancer. Proto-oncogenes, oncogenes, conversion of proto-oncogenes to oncogenes. Tumor suppressor genes – functions, role of p53. Viral oncogenes.
2. **Population genetics (5 hrs)**
    a. Gene pool, allele and genotype frequency. Hardy-Weinberg law and its applications, estimation of allele and genotype frequency of dominant genes, codominant genes, sex-linked genes and multiple alleles. Genetic equilibrium, genetic polymorphism.
    b. Factors that alter allelic frequencies; (i) mutation (ii) genetic drift - bottle neck effect and founder effect (iii) migration (iv) selection (v) nonrandom mating, inbreeding coefficient.

Practical (18 hrs)

1. Workout problems related to linkage, crossing over and gene mapping, human pedigree analysis.
2. Workout problems in population genetics - gene and genotype frequency (monogenic frequency only), Hardy Wienberg equilibrium.

References

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4. Strickberger (2005). *Genetics* (III Edn). Prentice Hall of India Pvt. Ltd.
5. William S Klug, Michael R Cummings (1994). *Concepts of Genetics*. Prentice Hall.
6. Robert J Brooker (2009). *Genetics: Analysis and principles* (III Edn). McGraw Hill.
7. Daniel L Hartl, Elizabeth W Jones (2009). *Genetics: Analysis of genes and genomes* (VII Edn). Jones and Bartlett publishers.
8. D Peter Snustad, Michael J Simmons (2010). *Principles of genetics* (V Edn). John Wiley and Sons.

Biochemistry (36 hrs)

Module 4:

1. **pH and Buffers (4 hrs)**
    a. Acids and bases, strength of acids – strong acids, weak acids. Ionization of water – Kw, pH . Dissociation of acids – pKa, Henderson-Hasselbalch equation.
    b. Buffers – definition, chemical composition, requirements for a good buffer, buffer action, buffer capacity.
    c. Measurement of pH – colorimetric methods and electrometric method.
2. **Carbohydrates (4 hrs)**
   Structure and Biological Functions, Monosaccharides: Classification, structure, ,Oligosaccharides: Structure, formation; common examples – sucrose, lactose, Polysaccharides: Classification, functions – structure of cellulose, starch and glycogen, Sugar derivatives: Glycoproteins, proteoglycans, mucoproteins, Lectins .
3. **Lipids (4 hrs)**
   Classification, properties, functions, Structure of fatty acids, essential fatty acids, Storage lipids – triglycerols. Structural lipids – membrane lipids. Lipid biosynthesis, fat breakdown – β oxidation

Module 5:

1. **Amino acids (3 hrs)**
   Structure and classification of amino acids. Pathways of amino acids biosynthesis,
2. **Proteins (5 hrs)**
    a. Classification of proteins based on structure and functio. Oligo- and polypeptides. Primary structure – peptide bond. Secondary structure – Ramachandran plots, α-helix, β sheet. Tertiary structure – forces that stabilize tertiary structure.
    b. Quaternary structure, domains, motif and folds.
    c. Protein sequencing – Edman method. Functions of proteins.
3. **Enzymes (10 hrs)**
    a. Principles of catalysis: Activation energy of a reaction. General characters of enzymes specificity, catalytic power, regulation. IUB system of enzyme classification and naming.
    b. Mechanism of enzyme activity: Formation of ES complex, acid-base catalysis, covalent catalysis, metal ion catalysis, proximity and orientation effect, strain and distortion theory. Factors affecting enzyme activity.
    c. Enzyme Kinetics: Michaelis-Menton kinetics, Lineweaver-Burk plot. Mechanism of multi substrate reaction – Ping Pong, Bi-Bi mechanism.
    d. Regulation of enzyme activity: Allosteric effect, control proteins, reversible covalent modification, proteolytic activation. Enzyme inhibition – reversible and irreversible inhibition, competitive, non-competitive, uncompetitive inhibition, dixon plot.
    e. Cofactors and coenzymes: Essential ions, Coenzymes; structure and role of metabolite coenzymes. – ATP; structure and role of vitamin derived coenzymes – NAD^+, $NADP^+$, FAD, FMN, TPP, PLP, Biotin, Isozymes.

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Module 6:

1. **Nucleotide metabolism (2 hrs)**
    a. Functions of nucleotides.
    b. Nucleotide biosynthesis by *de novo* pathways and salvage pathways.
2. **Secondary metabolites (4 hrs)**
   Classification, biosynthesis, and functions of terpenoids, alkaloids, phenolics, flavonoids, coumarins .

Practical (18 hrs)

1. Preparation of buffers of various strength and pH.
2. Differentiating sugars based on osazone formation.
3. Quantitative estimation of reducing sugar using Dinitro salicylic acid (DNS) or Anthrone.
4. Separation and analysis of lipids and amino acids by TLC.
5. Quantitative estimation of protein by Lowry's method.
6. Preparation of molal, molar, normal and percentage solutions and their dilutions.
7. Estimation of total phenolics.
8. Estimation of catalase activity.
9. Isolation and assay of amylase enzyme from germinating Pea seeds/appropriate plant material.

References

1. Bob B Buchanan, Wilhelm Gruissem, Russel L Jones (2000). *Biochemistry and molecular biology of plants*. L K International Pvt. Ltd.
2. Carl Branden, John Tooze (1999). *Introduction to protein structure* (II Edn). Garland Publishing.
3. David T Plummer (1998). *An introduction to practical biochemistry*. Tata Mc Graw Hill.
4. Donald Voet, Judith G Voet (2011). *Biochemistry* (IV Edn). John Wiley & Sons Inc.
5. H Robert Horton, Laurence A Moran, Raymond S Ochr, J David Rawn, K Gray Scrimgeour (2002). *Principles of Biochemistry* (III Edn). Prentice Hall.
6. Jeremy M Berg, John L Tymoczko, Lubert Stryer, Gregory J Gatto Jr. (2007). *Biochemistry*. W H Freeman and company.
7. Michael M Cox, David L Nelson (2008). *Lehninger Principles of biochemistry* (V Edn). W H Freeman and company.
8. Reginald H Garrett, Charles M Grisham (2005). *Biochemistry*. Thomson Brooks/Cole.
9. Robert K Murray, David A Bender, Kathleen M Botham, Peter J Kennelly, Victor W Rodwell, P Anthony Weil (2009). *Harper's Illustrated Biochemistry* (XXVIII Edn). Mc Graw Hill.
10. S Sadasivam, A Manickam (1996). *Biochemical methods* (II Edn). New age international Publishers.

SEMESTER III

Course	Title	Teaching hrs Theory	Teaching hrs Practical	Credits
PG3BOTC09	Research Methodology, Biophysical instrumentation, Biostatistics and Microtechnique	18 + 18 + 18 + 18	9 + 18 + 18 + 27	4
PG3BOTC10	Plant Physiology and Plant Breeding	54 + 18	36 + 9	4
PG3BOTC11	Biotechnology and Bioinformatics	72	27	4
PG3BOTC12	Taxonomy of Angiosperms	54	36	3
PG3BOTP05	Practicals of PC 9 + 10			2
PG3BOTP06	Practicals of PC 11 + 12			2

PG3BOTC09: RESEARCH METHODOLOGY, BIOPHYSICAL INSTRUMENTATION, BIOSTATISTICS AND MICROTECHNIQUE
(Theory 18 + 18 + 18 + 18 hrs; Practical 9 + 18 + 18 + 27 hrs; Credits: 4)

Research methodology (18 hrs)

Module 1:

1. **Introduction (2 hrs)**
   Need for research, stages of research; Generation of a research problem, Research design-principles, execution of work, interpretation of results.

a. **Review of literature (6 hrs)**

   a. Library: (i) Structure of a scientific library, journals (current and back volumes), books, Digital library and E books
      (ii) Catalogue: Types of catalogues - Card catalogue, computerized catalogue (iii) Classification of books (Universal Decimal System).
   b. Journals: Indexing journals, H-index, abstracting journals, research journals, review journals, e-journals. Impact factor of journals, NCBI-Pub Med.
   c. Other sources of references: (i) Reprints - acquisition and filing (ii) Secondary storage devices - pen drive, external hard drive, DVD and CD ROM, Cloud Storage (iii) Internet, open access initiative, INFLIBNET, INSDOC. Google Scholar
   d. Preparation of index cards: Author index and subject index; Open source bibliography management system.

Module 2:

1. **Presentation and publication of research outcomes (8 hrs)**

   a. Preparation of a dissertation: (i) Consolidation and analysis of data, photographs, illustration, tables and graphs (ii) Preparation of the outline (iii) Preparation of manuscript - introduction, review of literature, materials and methods, results, discussion, bibliography (methods of citing references, style manuals, arrangement of references), summary (iv) Guidelines for a scientific presentation- Preliminary pages - title page, certificates, acknowledgements, and contents page. Research ethics, plagiarism and detection by software's-ithenticate and turniton
   b. Preparation of research paper and short communications.
   c. Preparation of review articles.
   d. Proof reading - standard abbreviations for proof correction.
   e. Presentation of research findings in seminars and workshops.

2. **Preparation of project proposals (2 hrs)**
   (a)Title, Introduction, literature review and abstract (b) Aim and scope (c) Present status (d) Location of experiments (e) Materials and methods (f) Justification (g) Expected outcome (h) Time schedule (g) Estimated date of completion (h) budget (i) References (j) Funding agencies.

Practical (9 hrs)

1. Visit a scientific library or documentation centre and submit a report.
2. Prepare a project proposal.
3. Prepare an outline of dissertation and research paper.
4. Prepare a list of references.
5. Present a published project in the class with the help of LCD projector and submit the CD for evaluation.
6. Prepare the final project in accordance with this paper.

References

1. Anderson J, Durston B H, Poole (1970). *Thesis and assignment writing*. Wiley eastern.
2. Bedekar V H (1982). *How to write assignment and research papers, dissertations and thesis*. Kanak publications.

3. Bercy R (1994). *The research project, how to write it*. Rutledge, London.
4. Day R.A (1979). *How to write and publish a scientific paper*. Cambridge University press.
Joseph Gibaldi (2000). *MLA Handbook for writers of research papers*. Affiliated East West Press Pvt. Ltd.
7. Kothari (2004). *Research Methodology*. New Age International.
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.

Online Resources

http:// www.opengate.com

Biophysical Instrumentation: (18 hrs)

Module 3:

1. **Microscopy (8 hrs)**
   Principles of microscopy. Types of microscopes - simple and compound; Stereo microscope, Phase contrast microscope, Fluorescence microscope, Polarization microscope, Confocal microscope and electron microscope (TEM, SEM and E-SEM).Different fixation and staining ethnic for EM. Freeze-etch and freeze-fracture methods for EM. Image processing methods in Microscopy. Micrometry. Microscope Image data Acquisition and Analysis
2. **Principles and applications of instruments (10 hrs)**
   a. Basic principles and applications of; (i) pH meter (ii) UV-visible spectrophotometers, fluorescence, circular dichroism, vibration spectroscopy(general introduction only) NMR and ESR Spectroscopy
   (iii)Centrifuges (Table top centrifuge and ultra centrifuge).
   b. Chromatography: Principles and application; paper, TLC, Column chromatography, GC, HPLC.
   c. Electrophoresis: SDS PAGE
   d. X-ray crystallography. Molecular structure determination using X-ray diffraction and NMR molecular analysis using light scattering, different types of mass spectrometry and surface plasma resonance methods.
   e. Radiolabelling techniques-detection and measurement of different types of radioisotopes normally used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive materials, safety guidelines.
   f. Photogrammetry and satellite image processing.

Practical: (18 hrs)

1. Micrometry: Calibrate the ocular micrometer stage micrometer on a light microscope and measure the size of an object (e.g., diameter of spore/pollen grains, width of algal filaments).
2. Calibrate the pH meter and test the pH of different sample solutions.
3. Estimate the concentration of the given sample using calorimeter or spectrophotometer.
4. Prepare a plant extract and perform TLC.

References

1. Ackerman E A, Ellis L E E, Williams L E (1979). *Biophysical Science*. Prentice-Hall Inc.
2. Arora, M.P(2011).*Biophysics*. Himalaya Publishing House
3. Bajpai, P.K. (2008). *Biological Instrumentation and Methodology*. S.Chand and Company Pvt. Ltd.
4. Banerjee, Pranab kumar (2012). *Introduction to Biophysics*. S.Chand and Company Pvt. Ltd.
5. Chang R (1971). *Basic principles of spectroscopy*. McGraw Hill.
6. Garry D Christian, James E O'reilvy (1986). *Instrumentation analysis*. Alien and Bacon, Inc.

7. Gurdeep R C *et al.,* (2002). *Spectroscopy*. Himalaya Publishing House.
8. Henry B Bull (1971). *An Introduction to physical biochemistry*. F A Devis Co.
9. Mahadevan A, Sridhar R (1996). *Methods in Physiological Plant Pathology*. Sivakmi Publications.
10. Pattabhi and Gautham, N (2009). *Biophysics II Ed*, Narossa Publishing House.
11. Perkampus H (1992). *UV-VIS Spectroscopy and its applications*. Springer-Verlag.
12. Roy R N (2013). *A textbook of Biophysics,*New Central Bookj Agency (P0 Ltd.
13. Salle A J (1974). *Fundamental principles of Bacteriology*. McGraw Hill.
14. Sharma Y R (2013).*Elementary Organic Spectroscopy*, S.Chand and Company Pvt. Ltd.
15. Stanford J R (1975). *Foundation of Biophysics*. Academic press.
16. Wilson and Walker (2011). *Biochemistry and Molecular Biology*,Cambridge University Press.

Biostatistics (18 hrs)
Module 4

1. **Basic principles of Biostatistics (2 hrs)**
   Methods of collection and classification of data; Primary and secondary data, qualitative and quantitative data. Representation of data-graphical representation.
2. **Measures of central tendency (3 hrs)**
   a. Mean
   b. Median
   c. Mode
3. **Measures of dispersion (3 hrs)**
   Mean deviation, Standard deviation, variance, standard error, co-efficient of variation.
4. **Probability (2 hrs)**
   Probability - Definition, mutually exclusive events – sum rule, independent events – product rule. Probability of unordered combination of events. frequency distribution, binomial, poisson, Normal
5. **Tests of significance (3 hrs)**
   Statistical inference – estimation - testing of hypothesis - t-test, Chi square test (goodness of fit, independence or association), F-test, ANOVA.
6. **Correlation and Regression (2 hrs)**
   Linear regression and correlation (simple and multiple).
7. **Design of experiments (3 hrs)**
   (a) Experimental designs: Principles - replication and randomization.
   (b) Common designs in biological experiments: Completely randomized design, randomized block design, Latin square design, Factorial design. Latest statistical software packages-Instat, SPSS, 'R', Matlab (brief introduction only)

Practical (18 hrs)

1. Analysis of data to find the mean, median and mode.
2. Analysis of a given data for mean deviation and standard deviation.
3. Test the significance of a given data using t test, X^2 test, F-test and ANOVA. Manual and using software instat
4. Analysis of a set of data for correlation/regression.
5. Determine probability for different types of events.

References

1. Chandel R S (1975). *A handbook of Agricultural statistics*. Achal prakashan Mandir.
2. Gomez K A, Gomez A A (1984). *Statistical procedures for agricultndural research*. John Wiley & sons
3. Gupta S P (1984). *Statistical methods*. S Chand and company.
4. Mariappan (2013). *Biostatistics-An introduction*. Pearson Education.
5. Panse V G, Sukathme P V (1995). *Statistical methods for Agricultural workers*. ICAR.
6. Robert J Brooker (2009). *Genetics: analysis & principles* (III Edn). McGraw Hill.

Microtechnique (18 hrs)

Module 5:

1. **Killing and fixing (2 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.
2. **Dehydration, clearing, embedding and sectioning (5 hrs)**
   a. 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.
   b. Embedding: Paraffin embedding.
   c. Sectioning: Free hand sections – Prospects and problems; Sectioning in rotary microtome - sledge microtome and cryotome.
3. **Staining (3 hrs)**
   a. 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.
   b. Techniques of staining: (i) Single staining; Staining with Safranine or crystal violet (ii) Double staining; Safranine-Fast green method, Safranine-Crystal violet method (iii) Triple staining; Safranine-Crystal violet-Orange G method.
   c. Histochemical localization of starch, protein, lipid and lignin.

Module 6:

1. **Specimen preparation for transmission electron microscopy (3 hrs)**
   Material collection, fixing, dehydration, embedding, sectioning (glass knife preparation, grid preparation, ultra microtome) and staining.
2. **Whole mounts (5 hrs)**
   a. 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.
   b. Techniques of smear, squash and maceration.
   c. Mounting: Techniques, common mounting media used - DPX, Canada balsam, Glycerine jelly and Lactophenol. 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, Carnoy's 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 following categories should be included;
(a) Free hand sections (single/double stained).
(b) Serial sections (single/double stained).
(c) Wood sections and whole mounts.

References

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

PG3BOTC10: PLANT PHYSIOLOGY AND PLANT BREEDING
(Theory 54 + 18 hrs; Practical 36 + 9 hrs; Credits: 4)

Plant physiology (54 hrs)

Module 1:

1. **Plant water relations (6 hrs)**
   Structure and properties of water. Water transport – diffusion, bulk flow. Osmosis – water potential. Water absorption by root, pathways of water uptake and transport, xylem and phloem transport, passive and active transport. Aquaporins. Water pathway in the leaf – driving force of transpiration, leaf anatomy for regulating transpiration. Control of stomatal mechanism. Soil-plant-atmosphere continuum.
2. **Absorption of minerals (2 hrs)**
   Soil characters influencing nutrient availability – size and charge of soil particles, soil pH. Entry of minerals into roots; bulk flow, diffusion . Role of Mycorrhizae in nutrient uptake.
3. **Transport of ions, solutes and macromolecules (5 hrs)**
   Electrical properties of membranes, Membrane potential. Transport across cell membranes: Passive diffusion, facilitated diffusion, membrane channels; gap junctions, porins, ion channels – gated channels, structure and working of K^+ ion channels. Active transport: Carrier proteins; Na^+K^+ pump, ABC transporters.

Module 2:

1. **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 Benson cycle Photorespiration, role of photorespiration in plants. CO_2 concentrating mechanisms – algal and cyanobacterial pumps, C4 cycle, CAM pathway. Photoprotective mechanisms. Formation and mobilization of chloroplast starch. Sucrose biosynthesis, 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. Effect of CO2 and temperature on photosynthesis.
2. **Respiration (10 hrs)**
   a. Three stages of respiratory metabolism (brief study only). Plant mitochondrial electron transport and ATP synthesis – structure of electron transfer complexes (complex I – IV). ATPase - 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.
   b. Lipid metabolism in oilseeds – glyoxylate cycle, gluconeogenesis.

Module 3:

1. **Nitrogen metabolism: (5 hrs)**
   Nitrogen cycle. N_2 fixation processes. Biological N_2 fixation – structure of nitrogenase complex, reduction of N_2. Symbiotic Nitrogen fixation – nodule formation, leghaemoglobin . Nitrate and ammonium assimilation. Transport of amides and ureides.
2. **Stress physiology (5 hrs)**
   Response of plants to biotic (pathogen and insects) and abiotic (water, temperature – low and high, salt, oxygen deficiency, heavy metal and air pollution) stresses. Mechanisms of resistance to biotic stress and tolerance to abiotic stress.
3. **Sensory photobiology (4 hrs)**
   Structure, function and mechanisms of action of phytochromes, cryptochromes , and phototropins. Photoperiodism and biological clocks – circadian rhythms. Floral induction and development .
4. **Plant growth regulators (5 hrs)**
   Biosynthesis, storage, breakdown, transport, physiological effects, and mechanism of action of plant growth hormones, elicitors.

Practical (27 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. Taiz L, Zeiger E (2002). *Plant physiology* (II Edn). Sinaeur Associates, Inc. Publishers.
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Plant Breeding (18 hrs)

Module 4:

1. **Introduction (3 hrs)**
   Objectives of plant breeding, important achievements and future prospects. Genetic variability and its role in plant breeding. Domestication and centers of origin of cultivated plants.
2. **Systems of reproduction in plants (3 hrs)**
   Reproductive systems and pollination control mechanisms; Sexual reproduction - Cross and self pollination; asexual reproduction, Incompatibility and Male sterility, their types.
3. **Hybridization (3 hrs)**
   Hybridization - role and methods, Inter-varietal, inter specific and inter generic crosses. Back-cross breeding. Heterosis, Inbreeding depression.

Module 5:

1. **Breeding for resistance (3 hrs)**
2. **11**
   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.
2. **Mutation breeding (4 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 mutations in Plant Breeding.

3. **Modern breeding methods (2 hrs)**
   Modern trends in plant breeding.

Practical: (9 hrs)

1. Hybridization techniques in self and cross pollinated plants
2. Visit a plant breeding station to familiarize with breeding programmes. Submit a report of the visit.

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PG3BOTC11: BIOTECHNOLOGY AND BIOINFORMATICS
(Theory 72 hrs, Practical 27 hrs; Credits: 4)

Module 1: Biotechnology

1. **Introduction (1 hr)**
   Introduction to classical and modern biotechnology.
2. **Microbial biotechnology (5 hrs)**
   Commercial production of metabolites using bioreactors. Submerged and solid state fermentation . Microbes in production of enzymes, antibiotics, biopolymers, bioethanol, organic acids, SCP , Microbial oxidative transformations .

Module 2: Tissue culture (3 hrs)

a. Brief history and important milestones in plant tissue culture .
b. Types of cultures: organized structures - meristem, shoot tip, node, embryo, root cultures ; unorganized structures - callus, suspension and protoplast cultures

3. **Culture protocol (4 hrs)**
   General composition of the culture. 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 and hardening.
4. **Cytodifferentiation and Morphogenesis (5 hrs)**
   Cellular totipotency. Differentiation of cells in callus - tracheid formation, chloroplast differentiation . Factors influencing vascular differentiation. Organogenic differentiation: factors influencing shoot bud differentiation, induction of organogenic differentiation.
   Techniques and stages of micropropagation.Advantages and disadvantages of micropropagation. Applications of tissue culture.

Module 3: Genetic engineering

1. **Introduction(9 hrs)**
   Basic principles, tools and techniques; Restriction endonucleases – naming, types and cut patterns. Ligases – reaction, methods of blunt end joining - linkers and adaptors. Vectors – necessary properties of a vector , shuttle vectors, expression vectors . Vector type, maximum insert size, applications and limitations of plasmid, phage, cosmid, and artificial chromosomes-BAC and YAC, Plant based vectors-Ti vector . Creation of recombinant DNA. Methods of screening and selection of recombinant cells – , reporter systems – selectable marker-antibiotic resistance, screenable marker-*blue white screening*, GFP
2. **Steps in rDNA technology for production of recombinant protein (6 hrs)**
   Isolation and purification of vector and the DNA to be cloned , creation of recombinant vector, Tranformation- preparation of competent host cells, introduction of recombinant DNA into host cell –Selection of transformed cells, identification of recombinant cells – insertional inactivation. Expression of foreign genes in host cells.
3. **Applications of genetic engineering (2 hrs)**
   Applications of genetic engineering – in genetic studies, agriculture- molecular pharming-gene addition and gene subtraction, and medicine- drugs and recombinant proteins, gene therapy, Stem cell-ESC monoclonal antibody (brief study citing specific examples)
4. **Advanced tools and techniques (17 hrs)**
   a. cDNA synthesis, artificial DNA synthesis (brief study) . Construction of genomic and cDNA library-significance.
   b. PCR - Procedure and applications, variants of PCR - Real time PCR and its applications.
   c. Automated DNA sequencing, pyrosequencing, whole genome shot gun sequencing. In vitro mutagenesis and its application.
   d. Blotting techniques - procedure and applications of Southern, Northern, Western blotting.
   e. Procedure and applications of DNA profiling, Footprinting.
   f. Procedure and applications of RNAi, ELISA, RIA, Immunoprecipitation, flow cytometry, FISH , GISH, PFGE.

Module 4 Genomics and proteomics (7 hrs)

1. Genome, genomics, and proteomics. Structural genomics - genome sequencing strategies - Molecular markers- RAPD, RFLP, AFLP.
2. Functional genomics – Genome annotation-structural and functional annotation, gene

expression study using microarrays , functional annotation of genes .

3. Proteomics -Methods of proteomics mass spectrometry, Genome engineering Pharmacogenomics, metabolomics

Module 5: Bioinformatics (9 hrs)

1. Introduction, aim and importance of bioinformatics .
2. Databases: primary and secondary databases. DNA sequence databases - Genbank, DNA databank, Nucleotide sequence databank, ENA (EMBL Bank) . Specialized databases- OMIM, KEGG, Flybase. Protein databases - SWISS-PROT, PDB.. Sequence alignment: Significance; local sequence alignment, BLAST, FASTA. Global sequence alignment - Claustal W.

Module 6: Societal issues in biotechnology (4 Hrs)

1. Need for regulation, regulatory agency in India – GEAE.
2. Patents – issues relating to patenting living organisms, their genes and other bioresources. Potential impact of GMOs on the ecosystem. GM food – effect on health and environment.
3. Ethical problems of rDNA technology.
4. Economic issues. Potential misuse of modern molecular biology tools and techniques, bioweapons with example, bioterrorism.

Practical (27 Hrs)

1. 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. Multiple sequence alignment and creation of phylogenetic trees using MEGA.
6. Production of amylase by solid state and submerged fermentation.
7. Workout problems related to genetic engineering

References

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PG3BOTC12: TAXONOMY OF ANGIOSPERMS
(Theory 54 hrs; Practical 36 hrs; Credits 3)

Module 1: Classification (5 hrs)

Major systems of angiosperm classification with special emphasis on the conceptual basis of the classifications of; (i) Linnaeus (ii) Bentham & Hooker (iii) Engler & Prantl (iv) Bessey (v) Takhtajan (vi) APG.

Module 2: Tools of Taxonomy (4 hrs)

Functions of field study, herbarium, botanical gardens, BSI, Floras/Taxonomic literature and GIS (Geographic Information System). Construction of taxonomic keys – indented and bracketed - their utilization. Digital resources, electronic keys, DELTA, Digital Herbarium, Scientific plant illustrations and description, Floral imaging, Macrophotography.

Module 3: Angiosperm diversity with special reference to Tropical flora (43 hrs)

Study of the following families (Bentham & Hooker) in detail with special reference to their salient features, interrelationships, evolutionary trends and economic significance.

1. Runnunculaceae 2. Magnoliaceae 3. Annonaceae 4. Cruciferae (Brassicaceae) 5. Polygalaceae 6. Caryophyllaceae 7. Guttiferae (Clusiaceae) 8. Malvaceae 9. Tiliaceae 10. Geraniaceae 11. Rutaceae 12. Rhamnaceae 13. Vitaceae 14. Sapindaceae 15. Fabaceae 16. Caesalpiniaceae 17. Mimosaceae 18.Rosaceae 19. Lythraceae 20. Melastomaceae 21.Cucurbitaceae 22. Apiaceae 23. Aizoaceae 24. Rubiaceae 25. Compositae (Asteraceae) 26. Campanulaceae 27. Myrsinaceae 28. Sapotaceae 29. Loganiaceae 30. Oleaceae 31. Apocynaceae 32. Asclepiadaceae 33. Boraginaceae 34. Convolvulaceae 35. Solanaceae 36. Scrophulariaceae 37. Acanthaceae 38. Verbenaceae 39. Lamiaceae 40. Polygonaceae 41. Aristolochiaceae 42. Lauraceae 43. Loranthaceae 44. Euphorbiaceae 45. Orchidaceae 46. Dioscoriaceae 47. Zingiberaceae 48. Araceae 49. Cyperaceae 50. Poaceae.

Module 4: Ethnobotany: (2 hrs)

Scope and importance of ethnobotany, sources and methods of ethnobotanical studies. Benefit sharing- *Trichopus zeylanicus*

Practical (36 hrs)

1. Work out a minimum of two members from each family with suitable sketches and description in technical terms.
2. Study of local flora, construction of keys and use of floras in the identification up to species.
3. Preparation of dichotomous keys based on 4 sample plant materials from the same family.
4. Students should familiarize with all the economically/ethnobotanically important plants of the families mentioned in the syllabus.

Field study: A field study for not less than 5 days under the guidance and supervision of teachers and preparation of a minimum of 25 herbarium specimens of different categories with supporting field book.

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SEMESTER IV

Elective	PE course	Course title	Teaching hrs Theory	Teaching hrs Practical	Credits
Microbiology	PG4BOTC13	Food, Agricultural and Environmental microbiology	90	72	4
	PG4BOTC14	Clinical microbiology	90	54	4
	PG4BOTC15	Industrial microbiology	90	54	4
Biotechnology	PG4BOTC13	Tissue culture and Microbial biotechnology	90	72	4
	PG4BOTC14	Genetic engineering	90	54	4
	PG4BOTC15	Genomics, Proteomics and Bioinformatics	90	54	4
Env Science	PG4BOTC13	Basic concepts in Environmental studies	90	72	4
	PG4BOTC14	Natural resources and their management	90	54	4
	PG4BOTC15	Environmental monitoring and management	90	54	4
Practical	PG4BOTP07	Practicals of PE 1			2
	PG4BOTP08	Practicals of PE 2 + 3			2
Others	Project				4
	Viva				3

PROGRAMME ELECTIVE - MICROBIOLOGY
PG4BOTC13: FOOD, AGRICULTURAL AND ENVIRONMENTAL MICROBIOLOGY
(Theory 90 hrs; Practical 72 hrs; Credits 4)

Food Microbiology (35 hrs)

Module 1: Food - a substrate for microorganisms (15 hrs)

1. Factors influencing microbial activity in food, chemical changes brought about by microbes, microbes important in food microbiology.
2. Microbial flora of fresh food and their spoilage – cereals, sugar and sugar products, fruits, vegetables, poultry, eggs, shell fish and fin fish, milk and milk products, beverages, bread and canned foods.
3. Fermented milk - butter milk, cultured butter milk, Yoghurt, Kefir; Cheese production; bread; oriental food; Sauerkraut.

Module 2: Food preservation, Food borne diseases and Food quality (20 hrs)

1. General principles of food preservation: (1) aseptic handling (2) high temperature - boiling, steam under pressure, pasteurization and sterilization (3) low temperature – freezing and refrigeration (4) Dehydration (5) Osmotic pressure - in concentrated sugars with brine (6) chemicals, organic acids, smoking (7) radiation - UV and ionization.
2. Diseases caused by spoiled foods, diseases caused by food additives. Food borne diseases caused by bacteria - Salmonellosis, Gastroenteritis, Shigellosis, Listeriosis, Staphylococcal food poisoning, Botulism, Travellers' diarrhoea. Fungal intoxication - Aflatoxin and related components. Virus intoxication.
3. Microbial examination of food - Microscopic techniques, culture techniques. Microbiological criteria for food control. Enforcement and control agencies – international agencies, federal agencies, state agencies, professional societies, private agencies, processing industry and agencies of co-operative programmes.

Agricultural microbiology (20 hrs)

Module 3: Microbes as Biofertilizers and Biopesticides (20 hrs)

1. Microbes as biofertilizers - Bacteria, Fungi, Algae. Production of Biofertilizers - strain selection and preparation of biofertilizers. Green manuring. Microbes producing antimicrobial agents, siderophores.
2. Nitrogen fixing microbes – free living organotrophs, free living prototrophs, diazotrophs. Association of microbes with grasses, legumes, nodulation in nitrogen fixation legumes; nif gene - Azolla-Anabaena.
3. Phosphate solubilizers – Bacteria and Fungi as phosphate solubilizers. Mycorrhizal relationship – definition, forms and distribution of mycorrhiza. Ecto- and Endomycorrhiza. Vesicular and Arbuscular Mycorrhiza, Ericaceous, Orchidaceous Mycorrhiza. Physiology and function of mycorrhiza. Nutrient uptake and other effects. Carbon flow in mycorrhizal plant association. Production of mycorrhizal biofertilizers.
4. Microbial herbicides, Bacterial insecticides - use of *Pseudomonas*, *Bacillus thuringiensis* and Viral insecticides. Entomopathogenic fungi. Bioconversion, Bioinsecticide, biopolymers and biosurfactants.

Environmental Microbiology (35 hrs)

Module 4: Microbial Biodiversity and Methods in Microbiology (12 hrs)

1. Nature as a habitat of microbes, microbial diversity in various ecosystems.
2. Isolation and cultivation of microbes from environment - serial dilution and pour plate method, spread plate method, streak plate method, isolation using selective or enrichment media. Methods of culturing anaerobes. Culture characteristics of microbes. Bacterial

growth curve, staining techniques. Biochemical tests for bacterial identification - Carbohydrate fermentation, Triple sugar-Iron agar test, IMVIC test, Litmus Milk reactions, Hydrogen sulphide test, Catalase test, Oxidase test. Uncultivable microbes.

Module 5: Role of microbes in environment (18 hrs)

1. Soil as a habitat for microbes. Factors influencing soil microbial growth. Microorganisms and the formation of different soils – Tropical soil, Temperate soil, Bog soil, Cold moist area soil, Desert soil, Geologically heated hyperthermal soil.
2. Microbes and their role in fresh water, brackish water and marine environments. Contamination of aquatic environment by pathogenic microbes. Detection of Coliform bacteria - membrane filtration technique, Colilert defined substrate test, Multiple tube fermentation test. Quantification of Coliforms - MPN test.
3. Waste water treatment - primary, secondary and tertiary treatment.
4. Role of microorganisms in Carbon, Nitrogen, Phosphorus, Iron and Sulphur cycles. Microbes - as pollution indicators. Biological magnification. Biodegradation of recalcitrants, Jetfacts, paper, computer chips, paints, textiles, leather, rubber, metal, concrete, wood. Role of microbes in the disposal of waste and production of organic compost, biogas. Microbial leaching; Microbial bio-films. Bio-deterioration and biodegradation of petroleum, xenobiotics- recalcitrant halocarbons, haloalkyl propellants and solvents, halobenzenes, halophenols, PCBs, heavy metals and microbial plastics.

Module 6: Environmental biotechnology (5 hrs)

1. Microbes in biotechnology, bioremediation - microbial and enzymatic; *in situ* and *ex situ.*
2. Bio-augmentation – principles, enzymes used in bio-augmentation, bio-filtration-bio-filters, microorganisms used in filters, mechanism of bio-filtration, phyto-extraction and phyto transformation.
3. Genetically modified microbes - benefits and hazards. Metagenomics.

Practical (72 hrs)

1. Isolation of microbes by serial dilution and pour plate/spread plate technique.
2. Isolation of microbes by streak plate method.
3. IMVIC test.
4. Oxidase test.
5. Catalase test.
6. Litmus milk test.
7. Hydrogen Sulphide test.
8. Carbohydrate fermentation test.
9. Multiple Tube Fermentation test.
10. Methylene blue reductase test for milk.
11. Motility by hanging drop method.
12. Detection of siderophore production by bacteria.
13. Estimation of Mycorrhizal colonization in roots.
14. Isolation of Azotobacter from soil.

References

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PROGRAMME ELECTIVE - MICROBIOLOGY
PG4BOTC14: CLINICAL MICROBIOLOGY
(Theory 90 hrs + Practical 54 hrs; Credits 4)

Module 1: Introduction to Immunology (16 hrs)

1. Introduction, Types of immunity - innate and acquired immunity, cellular and humoral immunity. Physical and physiological barriers in immunity, phagocytosis, inflammatory response. Components of adaptive immunity - B cells and T cells.
2. B lymphocytes, T lymphocytes – T_H, T_C, T_S cells, Natural killer cells, mononuclear phagocytes. Structure and development of B cell (BCRs) and T cell (TCRs) receptors; Structure of CD4, CD8, MHC-I, MHC-II molecules.

Module 2: Antigens and antibodies (22 hrs)

1. Types of antigens, super antigens, auto antigens, haptens, antigen variation by bacteria. Basic structure of immunoglobulins, different classes of immunoglobulins and their function.
2. Antigen antibody interaction *in vivo* - toxin neutralization, opsonization, immune complex formation, viral neutralization, adherence inhibition. Antigen antibody interaction *in vitro* - agglutination, complement fixation, ELISA, immunodiffusion, immunoblotting, flow cytometry, immunofluorescence, immunoelectrophoresis, immunoprecipitation, neutralization, radioimmunoassay, serotyping.

Module 3: Immune disorders (9 hrs)

1. Hypersensitivity – Acute Rheumatic Fever, Grave's disease, Systemic lupus erythematosus, Type 1 Diabetes mellitus, Multiple Sclerosis, Rheumatoid Arthritis, Transplantation rejection.
2. Imunodeficiencies – SCID, AIDS.

Module 4: Viral diseases (18 hrs)

1. Epidemiology of common viral diseases in humans. Major human viruses: HIV, Hepatitis B and C, their salient properties. Isolation and maintenance of viruses, methods for detection and assay, phage typing.
2. Anti-viral strategies: Prevention and control of viral diseases: Host specific and nonspecific defense mechanisms (molecular level) involved in resistance to virus infections and recovery. Role of interferon in viral infections. Contributions of various host defense mechanisms in viral infections. Viral Chemotherapy: Nucleoside analogs, reverse transcriptase inhibitors, protease inhibitors.
3. Vaccines - subunit vaccines, anti-idiotype vaccines, DNA vaccines and edible vaccines. Interferon and antiviral drugs.

Module 5: Bacterial diseases (19 hrs)

1. Epidemiology of common bacterial diseases in humans- *Streptococcal pharyngitis*, *Tuberculosis*, *Helicobacter pylori* infection. Normal microbiota of human body; host-parasite relationship in baterial pathogenicity: non-specific mechanisms of host defense, mechanism of bacterial virulence, genetics of bacterial virulence; chemotherapy.
2. Antibiotics - origin, classification, chemistry and mode of action; semi synthetic antibiotics. Antibiotic resistance in bacteria, mechanism of antibiotic resistance. Common bacterial vaccines.
3. Diagnosis of infectious diseases: Microbial culture, Microscopy, Biochemical test, PCR.

Module 6: Fungal and protozoan diseases in humans (6 hrs)

1. Epidemiology of common fungal disease- Candidiasis.
2. Protozoan diseases in humans- Malaria.

Practical (54 hrs)

1. Blood group determination - slide agglutination test.
2. Identification of different types of WBC.
3. Radial immuno diffusion test using suitable antigen and antibody.
4. Double diffusion agar assay (Ouchterlony technique).
5. Staining of bacteria - Gram staining.
6. Spore staining of bacteria.
7. Staining of capsule in bacteria.
8. Staining of lipid granules in bacteria – Burdon's method.
9. Antibiotic sensitivity test for bacteria.

References

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PROGRAMME ELECTIVE - MICROBIOLOGY
PG4BOTC15: INDUSTRIAL MICROBIOLOGY
(Theory 90 hrs; Practical 54 hrs; Credits 4)

Module 1: Introduction and strain improvement strategies (11 hrs)

1. Range of fermentation- microbial biomass, microbial enzymes, microbial metabolites and transformation processes.
2. Isolation of industrially important microorganisms - primary and secondary screening. Detection and assay of fermentation products – physical-chemical, biological assays. Preservation of microbes – storage at reduced temperature, storage in dehydrated forms.

Module 2: Fermentation

1. **Types (7 hrs)**
   Solid state fermentation and submerged fermentation; batch, continuous and fed batch fermentation. Homo- and hetero fermentation. Aerobic and anaerobic fermentation. Static and stirred fermentations.
2. **Media(6 hrs)**
   Typical media, media formulation; water, energy and carbon source, nitrogen sources, minerals and vitamins, buffers, precursors, metabolic regulators, oxygen requirement.
3. **Bioreactors (12 hrs)**
   Brief study on stirred tank fermenter, air-lift fermenter, packed tower fermenter, tray fermenter, rotary drum fermenter.

Module 3: Microbial fermentation (13 hrs)

1. Sterilization - media, fermenter, air.
2. Inoculum preparation, inoculation.
3. Aeration, agitation, pH control, temperature control, antifoam agents.
4. Process parameter optimization: One factor at a time and statistical optimizations (brief study only).
5. Scale up of fermentation (lab scale, pilot plant, industrial scale).

Module 4: Downstream processing (12 hrs)

1. Separation of microbial cells – Filtration, precipitation, centrifugation.
2. Cell disruption – liquid shear, freezing-thawing, ultrasonication, osmotic shock, enzyme treatment.
3. Concentrating and purifying the products - ultrafiltration, crystallization, solvent precipitation, reverse osmosis, chromatography.

Module 5: Production of industrially important products (24 hrs)

1. Antibiotics - Penicillin, Streptomycin.
2. Amino acids - Lysine, Glutamic acid.
3. Enzymes - Amylase, Cellulase, Pectinase.
4. Organic acids - Lactic acid, Acetic acid, Gluconic acid.
5. Biofuels – Bio-ethanol, Bio-butanol.
6. Biopolymers - PHB, PLA.
7. Alcoholic beverages - Wine, Beer.
8. Microbial cells - SCP, Baker's yeast.

Module 6: Immobilization of cells and enzymes (5 hrs)

Methods of cell and enzyme immobilization. Applications of immobilized cells and enzymes.

Practical (54 hrs)

1. Screening and isolation of microbes for production of organic acids and enzymes.
2. Preparation and maintenance of stock cultures (Bacteria and Fungi).
3. Preparation of fungal spore inoculum and enumeration of spores by Hemocytometer.
4. Preparation of bacterial inoculum by measuring OD and enumeration of bacterial cells by serial dilution and pour plate (or spread plate) method.
5. Solid state and Submerged fermentation for amylase (or any other enzyme) production and quantification of product by suitable assay methods.

6. Optimization of process parameters for enzyme production in submerged fermentation.
7. Partial purification of amylase (or any other enzyme) produced by microbial fermentation using acetone precipitation.
8. Lab level production of metabolites (Wine, Vinegar).
9. Immobilization of yeast cells and sugar fermentation using immobilized cells.
1

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PROGRAMME ELECTIVE - BIOTECHNOLOGY
PG4BOTC13: TISSUE CULTURE AND MICROBIAL BIOTECHNOLOGY
(Theory 90 hrs; Practical 72 hrs; Credits 4)

Tissue culture (53 hrs)

Module 1:

1. **Tissue culture regeneration of plants (13 hrs)**
   a. Adventitious regeneration: Direct regeneration, indirect regeneration (1). Factors influencing adventitious regeneration; genotype, explant – orientation of explant, position on mother plant.
   b. Somatic embryogenesis: General aspects (2, 3, 8), initiation of embryogenic cultures, maturation of somatic embryos, regeneration of plants, factors regulating somatic embryogenesis (2, 3, 8), differences between somatic and zygotic embryos. Encapsulation of somatic embryos (2), synthetic seed production; desiccated and hydrated types (2, 3). Applications and limitations of synthetic seeds (2, 3).

2. **Somaclonal variation (8 hrs)**
   Isolation of somaclonal variants (1, 3, 14), molecular basis of somaclonal variation. Origin of somaclonal variation – pre-existing variability, *in vitro* induced variability; Reasons – changes in ploidy level,changes in chromosome structure, gene mutations, gene amplifications, changes in extra nuclear genes, activation of transposable elements, DNA methylation (3). Applications of somaclonal variation (1, 3, 14).

3. **Protoplast culture (8 hrs)**

   a. Isolation and purification of protoplasts (1, 2, 3, 8, 9, 14, 39), culture of protoplasts, cell division and callus, formation, plant regeneration (1, 2, 3, 8, 9, 14, 39).
   b. Protoplast fusion (somatic hybridization) – chemical, mechanical, electrofusion (1, 2, 3, 9, 39). Selection, isolation of heterokaryons (1, 2, 3, 9, 39), cybrids and their applications (1, 2, 3, 9, 39).
   c. Applications of protoplast culture (2, 3, 9, 39).

Module 2: Production of ploidy variants (12 hrs)

1. Haploids: Androgenesis (1, 3, 8, 9, 14) - pretreatment of anther/pollen grains, media and growth regulators, Induction and stage of pollen development, regeneration, androgenic embryos, factors affecting androgenesis (1, 3). Microspore culture - protocol, advantages over anther culture (3, 9, 14).
2. Gynogenesis: Developmental stage at inoculation, *in vitro* maturation of embryo sacs, origin of embryos, triggering factors – pretreatment, medium. Uses and limitations of haploid plants.
3. Triploids: importance of triploid plants, conventional production of triploid plants, endosperm culture - advantages and limitations (3, 38).

Module 3: Production of secondary metabolites (6 hrs)

Culture conditions for producing secondary metabolites (1, 3, 9), selection of high yielding lines, elicitation, immobilization of cells (1, 2 3). Hairy root culture – advantages of using hairy root culture, establishment of hairy root culture and production of secondary metabolites (3, 9).

Module 4: Germ plasm conservation (6 hrs)

Importance, methods of conservation: *In situ* and *ex situ* conservation. *In vitro* conservation, short and medium term storage, cryopreservation technique – importance of cryopreservation, pretreatment, freezing methods, cryoprotectants, vitrification (1, 2, 3, 9, 21, 22).

Microbial Biotechnology (37 hrs)

Module 5:

1. **Microbial technology (16 hrs)**
    a. Screening of microbes for metabolite production (29, 31, 34) . Selection of media, sterilization of media (28, 31, 34).
    b. Bioreactors – airlift, stirred tank, bubble column, rotary drum (7, 12, 15, 31, 32, 33).
    c. Fermentation process - batch, fed batch, continuous fermentation (29). Process control during fermentation - pH, aeration, agitation, temperature, foam control (29, 31). Downstream processing (29, 33).
    d. Large scale production of antibiotics - penicillin, streptomycin (10, 13, 16, 28, 31), industrial chemicals - ethanol, acetone, butanol, lysine (10, 11, 16, 28, 30, 31).
    e. Microbial insecticides (4, 10, 15).
    f. Commercial production of enzymes and their uses - amylase, cellulase, polygalacturonase (6, 28, 31, 35).

2. **Cell and enzyme technology (5 hrs)**
    a. Cell immobilization: Methods, advantages and applications (4, 7).
    b. Enzyme immobilization: Preparation (6), applications (5, 6).
    c. Enzymes as biosensors (35).
    d. Enzyme engineering (7).

Module 6:

1. **Tissue engineering and Stem cell technology (6 hrs)**
    a. Regenerative medicine, methods and applications of tissue engineering (4, 13).
    b. Stem cells – embryonic stem cell and adult stem cells – potential applications (13).

2. **Module 10: Bioremediation and Phytoremediation (10 hrs)**
    a. Importance and advantages of bioremediation, bioaugmentation (4, 13, 36), pollutants that can be cleaned.
    b. Cleaning reactions - aerobic and anaerobic biodegradation (4, 13, 37), organisms used for bioremediation (4, 13, 37), cleaning strategies for water and soil - *in situ* and *ex situ* technologies (4, 13, 37).
    c. Bioremediation of radioactive wastes (13).
    d. Phytoremediation - importance (13, 36, 37). Use of GMOs in bioremediation (13).

Practical (72 hrs)

1. Isolation and fusion of plant protoplasts (39).
2. Preparation of synthetic seeds.
3. Preparation of selective medium for drought or salinity resistance. Preparation of MS soild medium
   from stock solutions containing auxin and cytokinin, NaCl or PEG, and inoculation.
4. Cell immobilization.
5. Application of immobilized yeast cells for ethanol production.
6. Isolation of microbes producing organic acids.
7. Find out the uninucleate stage of anther and anther culture.
8. Dissect out an embryo from any seed and culture it on a suitable solid medium.
9. Cell plating technique.

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PROGRAMME ELECTIVE - BIOTECHNOLOGY
PG4BOTC14: GENETIC ENGINEERING
(Theory 90 hrs; Practical 54 hrs; Credits 4)

Module 1:

1. **Working with Nucleic acids (3 hrs)**
   Isolation and purification of DNA (genomic and plasmid) and RNA (8, 9, 18, 14).

2. **Chemical synthesis of DNA (11 hrs)**
   Phosphodiester, phosphotriester, and phosphite-triester method of DNA synthesis (Brief study only) (9,10). Phosphoramidite method, automated DNA synthesis (9, 10, 17).
   Artificial genome synthesis (27, 28).
   Procedure of cDNA synthesis, reverse transcriptase PCR (16).

3. **Modern cloning vectors (10 hrs)**
   M13 (2, 9), pUC, artificial chromosomes – YAC, BAC, PAC (1, 2, 9), HAC, (9) – important features,
   construction and applications of each (1, 2, 9).

Module 2:

1. **Gene library (12 hrs)**
   a. Genomic and cDNA library (9, 20, 25).
   b. Procedure for the construction of a genomic library using phage λ system (9, 20).
   c. Identification of desirable clones from library – hybridization probing, colony and plaque
      hybridization probing, immunological screening (9, 16, 20, 25).
   d. Locating and isolating a gene – *insitu* hybridization, positional cloning, chromosome walking and jumping (19, 21, 22).

2. **Plant transformation (10 hrs)**
   a. *Agrobacterium tumefaciens* mediated gene transfer in plants - details of vector system based on *A.tumefaciens*, binary vector and cointegrate vector (9, 30). Steps involved in *Agrobacterium* mediated gene transfer to plants (18, 30).
   b. Plant transformation by direct transfer of DNA (Vectorless methods) - microprojectiles,
      electroporation, microinjection, chemical, lipofection (9, 18, 30).
   c. Details of the creation of Bt plants, Golden rice, *Flavr Savr* Tomato.

3. **Advanced transgenic technology (5 hrs)**
   Inducible expression systems – examples, site-specific recombination for *in vivo* gene manipulation, gene targeting, gene silencing using antisense RNA and RNAi (2, 9, 21). *In vitro* mutagenesis - site-directed
   mutagenesis (3, 9, 13, 21).

Module 3:

1. **Gene therapy (8 hrs)**
   Approaches to gene therapy (9) - somatic cell and germline therapy (1, 9), vectors used in gene therapy (2, 9,18, 19, 25). *In vivo* and *ex vivo* therapy (2, 9). Gene therapy of SCID (1, 2, 9), Cystic fibrosis (2, 9, 18, 19, 25), gene augmentation therapy (2, 9). Problems and fears associated with gene therapy.

2. **Protein engineering (5 hrs)**

Applications of protein engineering (2, 10, 23, 24, 31, 33), protein modification by site-directed mutagenesis, combinatorial methods (2, 10, 24, 31).

3. **Biosensors (6 hrs)**
   Design and operation (23, 29), types (23). Applications - medical, food and agriculture, industrial, pollution monitoring (23, 29). GMOs as biosensors (24).

Module 4: Immunology (10 hrs)

Generation of antibody diversity (8, 23). Production and uses of monoclonal antibodies (8, 23), antibody engineering (8). Vaccines: Basic strategies, inactivated and live attenuated pathogens, subunit vaccines, recombinant vaccines (e.g., Hepatitis B vaccine), DNA vaccines (2, 6, 7, 8, 9, 10, 16, 24, 32).

Modern approaches to vaccine development - edible vaccines (9, 10, 16).

Module 5: Applications of rDNA technology (10 hrs)

1. Uses of GM microbes: Bacteria and yeast (2, 9, 10) - producing useful proteins (2, 10), basic genetic research.
2. Applications of GM animals: In basic research, producing novel proteins; disease studies, prevention
3. and cure diseases (2, 9, 10). Uses of transgenic plants: Herbicide, insect and disease resistance, stress
4. resistance. Genetic engineering for increasing nutritional and other novel qualities in plants (2, 9, 10).

Practical (54 hrs)

1. Isolation of plant genomic DNA and its quantification (14).
2. Isolation of plasmids and its purification (14), by by minipreparation and midipreparation (15).
3. Isolation of bacterial genomic DNA and its quantification by using UV spectrophotometer (14).
4. Separation of DNA by agarose gel electrophoresis (14).
5. Extraction and quantification of protein by Bradford method (14).
6. Separation of proteins by PAGE.
7. PCR.

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PROGRAMME ELECTIVE - BIOTECHNOLOGY
PG4BOTC15: GENOMICS, PROTEOMICS AND BIOINFORMATICS
(Theory 90 hrs; Practical 54 hrs; Credits 4)

Module 1: Structural genomics (25 hrs)

1. Basic steps in genome sequencing (3). Shot gun sequencing of small genomes (17). Map based
   sequencing: Hierarchial shot gun sequencing (clone-by-clone approach) - steps involved; Whole genome
   shot gun approach - steps involved (1, 2, 3, 11, 17, 28).
2. Genome mapping: Genetic mapping and physical mapping (2, 10, 12, 17). Cytogenetic and linkage map (brief study only) (2, 10). Molecular markers – RFLP, RAPD, AFLP, SSLP, SNP (2, 9, 10, 13, 17).Construction of linkage maps using molecular markers – E.g., RFLP maps (2, 17). Physical mapping – restriction mapping, STS, SNP, EST (1, 2, 10, 11, 12, 17, 23, 28).
3. Sequence assembly – methods used (13, 17).
4. Next generation sequencing strategies - Pyrrosequencing (14, 17, 28).
5. Important findings of the completed genome projects: Human genome project (6, 11, 12, 13, 16, 17, 23, 25, 28), Rice genome project, Arabidopsis genome project (16), *E. coli* genome project (16, 17), Wheat genome project, Tomato genome project.

Module 2: Functional genomics (12 hrs)

1. Transcriptome (1, 17, 27), expression profiling (mRNA profiling) (1, 3, 27). Gene expression analysis using dot blotting and microarrays (2, 3, 9, 10, 27, 28). Fabrication of microarrays – spotted arrays, *in situ* synthesis (1, 2, 27).
2. Chromatin immunoprecipitation (ChIP) and its applications (2, 3).
3. Determination of gene functions - knock out and knock down mutants, antisense RNA and RNAi, gene overexpression (3, 10, 17, 19, 28, 29).

Module 3: Comparative genomics (7 hrs)

Orthologs and Paralogs (1, 3), gene identification by comparative genomics (1), comparative genomics as a
tool in evolutionary studies (1, 13). Metagenomics (27) .

Module 4: Proteomics (8 hrs)

Proteome, proteomics (8, 17, 19, 26, 27). Separation and identification of cellular proteins by 2D gel
electrophoresis and mass spectrometry (1, 2, 5, 8, 9, 12, 16, 17, 19, 26, 27). Protein expression analysis using Protein microarray (1, 2, 3, 9, 12, 26, 27), protein localization using GFP (3, 9), other applications of GFP.

Module 5: Bioinformatics (27 hrs)

1. Submission and retrieval of databases – BankIt, ENTREZ.
2. Sequence analysis – significance (21, 22). Methods of sequence alignment – paired sequence alignment, multiple sequence alignment, scoring matrices (7, 15, 20, 21, 22). Sequence comparison – dot matrix method, dynamic programming for sequence alignment; Global - Needleman Wunch algorithm; Local –Smith Waterman algorithms. Database similarity search – query sequence search; BLAST - different versions; FASTA - different versions (7, 20, 21, 22). Tools for multiple sequence alignment – CLUSTAL X/W (20, 21, 22).
3. Gene prediction strategies (1, 2, 7, 17, 21 22), ORF search, gene prediction programs – Grail/Exp,
   GENSCAN, ORF finder (1, 2, 7, 17, 21 22). RNA secondary structure prediction; Protein structure and function prediction - tools used (7, 21, 22). Protein visualization tool - Rasmol.

4. Applications of bioinformatics in evolutionary studies – molecular phylogenetics, molecular clock (2, 9, 10, 15, 17, 21 22, 29). Construction of phylogenetic trees - tool Phylip (2, 8, 15, 17, 21 22).
5. Computer assisted drug design - concept, methods and practical approaches. Various computational methods applied to design drugs (21, 22, 24). Bioinformatics for enzyme and protein design (21, 22).

Module 6: Ethical, legal, and social impact of modern biotechnology (11 hrs)
Genome data availability – Problems with public availability of sequence data (3 p 313), privacy concerns,
legal problems, gene and DNA sequence patenting, patenting transgenics (27), stem cell research - EST,
gene therapy – problems and concern over germline gene therapy (18, 27). Biosafety (18).

Practical (54 hrs)
1. Protein visualization using Rasmol (supply structure of a few proteins downloaded from PDB).
2. Multiple sequence alignment using CLUSTAL X (give DNA or protein sequence).
3. Phylogenetic analysis by Phylip (give some protein or DNA sequence data).
4. Locate specific sequences like TATA box, promoters, start signals, stop signals etc. in a DNA sequence using computer programmes (22) e.g., *E. coli* promoter, human promoter.
5. Multiple sequence alignment and ontology based database searches on selected plant cytoskeletal
genes to decipher the molecular phylogeny of cytoskeleton genes – record the results.
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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PROGRAMME ELECTIVE – ENVIRONMENTAL SCIENCE
PG4BOTC13: BASIC CONCEPTS IN ENVIRONMENTAL STUDIES
(Theory 90 Hrs; Practical 72 Hrs; Credits 4)

Module 1: History and Natural environment

1. **History (5 hrs)**
   History of development of environmental science, scope and significance of environmental studies.
   Concept of the sustainable world.
2. **Natural environment (10 hrs)**
   a. Origin and structure of earth – primary differentiation and formation of core, mantle, crust,
   atmosphere and hydrosphere.
   b. Physical environment: Lithosphere, Hydrosphere, Atmosphere.
   c. Biological environment: Biosphere – hierarchies in the biosphere.

Module 2: Earth and its atmosphere (20 hrs)

1. Land and water systems: Weathering and erosion process, types and formation of soils and soil
   profile. Physical, chemical and biological properties of soil. Causes, effects and control of earthquakes,volcanoes, landslides, floods and storms. Groundwater – occurrence, chemistry; salt water intrusion.
2. Aquatic environment: Hydrologic cycle, diversity of aquatic habitats. Aquatic food web and factors
   affecting primary productivity.
3. General characteristics of freshwater environment: Lentic systems; Lakes – origin and classification,ecological zonation, water circulation, physical and chemical characteristics and biotic communities, fertility and productivity. Lotic systems - Ecology of streams and rivers.
4. General characteristics of marine environment: Ocean - chemistry of sea water, circulation and
   ecological zonation in sea, marine biota, primary productivity, coral reefs and marine resources.
5. Estuaries: Types, biotic communities and productivity; environmental significance of estuaries.
   Mangroves.
6. Wetlands: Classification, productivity and ecosystem properties.
7. Eutrophication: Causes and consequences, methods of control.

Module 3: Weather and Climate (20 hrs)

1. Definitions and scope of climatology, weather and climate. Components of climate system.
2. Earth's thermal environment, earth intercepts solar radiation, seasonal variation in intercepted
   solar radiation. Air temperature in relation to altitude. Global circulation of air masses, wind and
   earth's rotation on ocean currents, influence of temperature on moisture content of air, global
   pattern of precipitation, influence of topography on regional pattern of precipitation.
3. Classification of climate - Koppen's classification and Thornthwaite's scheme, climatic types and
   zones.
4. Global climatic phenomena - *El Nino* and *La Nina*, causes and factors of climate change. Effect of
   climate change on ecosystems and human life. Organisms and microclimate.
5. Climate of India: Climatic regions of India, tropical monsoon climate-onset, rain bearing systems,

break in the monsoon, retreat of monsoon. Monsoon in Kerala - oceanic and continental influence.
6. Climate change – causes and effects.

Module 4: Ecosystems (15 hrs)

1. Ecosystem organization: Structure and function of ecosystem components. Processes in ecosystem: Primary production – methods of measurement, global pattern, controlling factors. Nutrient cycles, energy flow, biogeochemical cycles, trophic relations, productivity and ecological efficiencies.
2. Structure, function, and characteristics of; (i) Forests and tundras – temperate and tropical forests,
   arctic and alpine forests (ii) Deserts – arid and semi-arid (iii) Grassland and savannas (iv) Coastal and marine (v) coral reefs (vi) Wetlands – lakes, rivers, estuaries (vii) Mangroves

Module 5: Population ecology (10 hrs)

1. Population characteristics, population growth, carrying capacity, population regulation, population
   interactions, population differentiation.
2. Modeling population growth, competition and coexistence, mutualism, predation, herbivory,
   parasitism. Evaluating the controls on population size. Trends in human population growth. Problems with overpopulation.

Module 6: Biosphere interactions (10 hrs)

Communities and ecosystems: Structure, types and characters of communities, community gradients.
Global pattern of species richness, species diversity. Community organization – ecological niche.

Practical (72 hrs)

1. Qualitative and quantitative study of freshwater/marine planktons
2. Soil texture using micrometry from two different sites. Principle and explanation
3. Determination of moisture content.
4. Determination of soil pH from at least three different locations and correlate it with the soil type
5. Determination of Chloride, calcium, magnesium, potassium and phosphorous.
6. Estimation of primary productivity in two different aquatic ecosystems and interpretation of the results. Compare the results of Dark and Light bottle method and Chlorophyll method.
7. Study of biodiversity in Forest/Grass land and Pond/River and report the species richness, abundance
and animal interactions. Calculate frequency, abundance, evenness and diversity indices.
8. Identification of plants growing in different habitats and studying their adaptations

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PROGRAMME ELECTIVE – ENVIRONMENTAL SCIENCE
PG4BOTC14: BASIC CONCEPTS IN ENVIRONMENTAL STUDIES
(Theory 90 Hrs; Practical 54 Hrs; Credits 4)

Module 1: Natural resources and their management (4 hrs)
Natural resources – renewable and nonrenewable. Preservation, conservation, and restoration of resources. Recycling, reuse, and substitution.

Module 2: Principles of resource management –

1. **Water resources (8 hrs)**
   Distribution of water resources, threats to water resources. Principles and approaches to surface water management, watershed management – catchment infiltration models, rainwater harvesting and storage, recharging of ground water. Management of degraded water resources. Drinking water quality and water treatment - desalination, ion-exchange, reverse osmosis, and disinfection of water.
2. **Energy resources (10 hrs)**
   a. Energy sources – resource and reserves. Current national and global energy scenario.
   b. Fossil fuels: Oil, Coal, Natural gas, Shale – sources, exploration, exploitation; environmental consequences of overexploitation.
   c. Nuclear energy: Nuclear fission and fusion, nuclear minerals, nuclear fuel cycle, nuclear fuel production, nuclear reactors. Advantages and disadvantages of nuclear power. Environmental consequences – safety, terrorism, waste disposal and management.
   d. Renewable and alternate energy sources – solar energy and isolation, photovoltaic cells; hydropower; tidal power; wind power; geothermal energy; ocean energy; fuel cells – advantages and disadvantages, environmental consequences.
   e. Bio-energy: biomass as energy source, biomass production, energy farming, biomass conversion processes – thermochemical and biochemical. Biodiesel. Environmental consequences of biomass resource harnessing.
3. **Land resources (4 hrs)**
   Land as a resource, land degradation and its causes, desertification – causes and prevention.
4. **Food resources (5 hrs)**
   Food sources, effect of agriculture on the environment. World food problems, methods and strategies to alleviate food problems.
5. **Mineral resources (5 hrs)**
   Mineral resources: Formation of mineral deposits. Types of mineral resources, environmental impact of mineral exploration, mining, processing and utilization. Conservation of mineral resources.
6. **Biological resources (34 hrs)**
   a. **F**orests as biological resources – importance, types of forests, deforestation, reforestation, conservation of forests.
   b. **B**iodiversity and its importance: Types of biodiversity - wild biodiversity, agro-biodiversity, domesticated biodiversity. Values of biodiversity, ecosystem functions and biodiversity,mobile links and valuating ecosystem services. Drivers of biodiversity loss. Tools and techniques for biodiversity estimation: Biodiversity indices; methods of biodiversity monitoring.
   c. **U**ses of biodiversity – source of food, medicine, raw material, aesthetic and cultural values.
      Threats to biodiversity; natural and anthropogenic, species extinctions, IUCN threat categories, red data book. Extinction: Types, Causes – population growth, overconsumption, pollution, climate change. Ecological extinction, biological extinction. Principles and strategies for biodiversity conservation - *In-situ* conservation: sanctuaries, biosphere reserves, national parks, nature reserves,

preservation plots. *Ex-situ* conservation: botanical gardens, zoos, aquaria, homestead garden; herbarium; *In-vitro* Conservation: germplasm and gene Bank; tissue culture: pollen and spore bank, DNA bank. GEF-World Bank initiatives. Biodiversity hotspots and their characteristics, global distribution. National and international programmes for biodiversity conservation. CITES and TRAFFIC, Indian Biodiversity Act 2002 and Rules.

d. **B**iological Invasions: Introduction -Elton's hypothesis – Invasion patterns and process -biological attributes for invasion: Reproductive potential, Allelopathy -Phenotypic plasticity -fitness to the new environment. Hypotheses for invasion success: Natural enemy hypothesis -evolution of invasiveness hypothesis, empty niche hypothesis, novel weapon hypothesis, disturbance hypothesis and Propagule pressure hypothesis. Invasive alien species of India (plants and animals).
e. **I**mpacts and management of invasions: Impacts of exotics on biodiversity, productivity,nutrient cycling. Management: Bio-control programmes, mechanical and chemical control -Positive utilization.
Quarantine and EIA of biological invasion.

Module 3: Environmental economics (10 hrs)

1. Definition, scope and basic theories of environmental economics; sustainable growth.
2. Economics of natural resources, environment cost-benefit analysis.
3. Agricultural development and environment: Modern agriculture and its impact on environment –
monoculture plantations, use of insecticides, pesticides, chemical fertilizers, hybrid seeds, water
consumption, desertification, watershed problem, soil erosion, deforestation, depletion of biodiversity.
Sustainable agriculture – alternate methods in agriculture.
4. Industrial development and environment: impact of modern large scale industries on environment, problems related to modernization and urbanization. Green policies of industrialization.

Module 4: Society and Environment (10 hrs)

1. Social perspectives of environment – Global and Indian issues.
2. Social impacts of growing human population and affluence, production and distribution of food,
3. hunger, poverty, malnutrition, famine.
4. Social impacts of water crisis, global climate change, ozone depletion, nuclear accidents, acid rain,
5. consumerism and waste products.
6. Problems related to major dams and other developmental projects, resettlement and rehabilitation.
7. Environment and human health – epidemiological issues.

Module 5: Environmental ethics (4 hrs)

Importance and need of environmental ethics. Moral relation among humans, nonhumans, and natural
environment. Position of humans in the world, human responsibility to care the world, animal rights.

Practical (54 hrs)

1. Water Quality Analysis:
a. Determination pH, Electrical conductivity, Alkalinity, Salinity, Hardness, Nitrate, Phosphate and Silica.
b. Determination of total dissolved salts (TDS).
2. Toxicity Analysis of Water: For Chlorine, H2S, Ammonia, Copper and Chromium.

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PROGRAMME ELECTIVE – ENVIRONMENTAL SCIENCE
PG4BOTC15: ENVIRONMENTAL MONITORING AND MANAGEMENT
(Theory 90 Hrs; Practical 54 Hrs; Credits 4)

Module 1:

1. **Environmental Management (10 hrs)**
    a. Concepts, strategies and basic principles of environment management. Management of physical, social, and economic environment. Concepts and scope of environmental planning, regional planning and management. Cost-benefit analysis and Resource economics.
    b. Environmental modeling: Simulation modeling, input-output modeling, Linear programming,
    c. Software and resource management.
    d. Tool box for environmental management – An overview of Ecological foot prints, SEA, Ecological Economics, conflict resolution strategies. Eco-funds.
    e. Environmental auditing and Standards - Eco labeling and certification, accreditation – need, objectives and benefits; Corporate social responsibility and Corporate environmentalresponsibility, ISO standards for environmental management systems (EMS) -ISO 14000, 14001 and 26001; OHSAS 18001.

2. **Ecosystem Management (10 hrs)**
    a. An overview -Population, Resources and Ecosystem management -Exponential growth in human numbers and the implications.
    b. (b) Major management concepts and methodologies: The five basic laws of Ecology and their relevance for ecosystem management; paradigm shifts in the management of Ecosystems - influence of economics in ecology.
    c. (c) Management practices for various ecosystems: grasslands, forests, mountains, wetlands and coastal areas.
    d. Environmental planning and management of; waste lands, reclaimed lands, mining areas, human settlements, industrial lands and agricultural lands.
    e. Eco-restoration/remediation; local knowledge and management systems; environmentally sound

    management of Biotechnologies; the common property resources and their management.
3. **Solid waste Management (8 hrs)**
    Municipal solid wastes (MSW) - quantities and characteristics, waste collection and transport, waste processing, resources recovery and recycling, incineration, pyrolysis, aerobic and anaerobicsystemscomposting, vermicomposting and sanitary landfills and biodigesters (Biogas). Management of plastic and e-waste. Better management strategies (any two model case studies).

Module 2: Toxicology (12 hrs)

1. Definition, scope and history of Toxicology, Acute and chronic toxicity, selective toxicity, dose,
    synergism and antagonism.
2. Toxic chemicals in the Environment – Air, water and Soil. Biochemical aspects of As, Cd, Pb, Hg,
    CO, O3, PAN, pesticides, MIC, Dioxins, Furans and carcinogens in air, Bioaccumulation & biomagnification.
3. Occupational toxicology - hazardous chemicals, disorders exposing from chemical exposure at
    work, assessment of occupational hazards.
4. Dose-Response relationships: Graded response, quantal response, Time action curves, Threshold

Limit value (TLV); LC50; Margin of safety; Toxicity curves; Cumulative toxicity and LD50 & CTF.

5. Toxicity testing: Bioassay – Definition, purpose, criteria for selection of test organism, methodology,estimation of LC50, Limitation and importance of Bioassay, Acute Toxicity (single); Sub acute Toxicity; Chronic Toxicity; Teratogenicity, Carcinogenicity and Mutagenicity.
6. Bio-monitoring of Toxic Chemicals - Objectives, programs and parameters, concepts of bio indicators. Bio-transformation of Xenobiotics

Module 3: Environmental Impact Assessment (10 hrs)

1. Introduction, definition, history, aim, principles, concept and scope. Baseline data collection,
   Methods and steps – Ad hoc method, checklist method, matrices, Map overlays method, network
   method, index method.
2. Impact assessment and impact evaluation: E1A Processes, Stages, E1A Statement. Environment
   management plan - Risk assessment and disaster management programme. National Policy on EIA.

3. Regulatory Framework: Environmental Impact Assessment Notification 2006 and Coastal Zone
   Notification 1991; Environmental Clearance Process in India; Legislative requirements (discharge
   requirements and area restrictions); Environmental Appraisal procedure for mining, industrial, thermal power, nuclear power and multipurpose river valley projects. EIA case studies. Life Cycle Assessment (LCA) and its significance.

Module 4: Remote Sensing and GIS (15 hrs)

1. Principles and concepts of Remote Sensing. Electromagnetic spectrum; spectral characteristics of
   surface features (rocks, soils, vegetations, water). Space imaging -Landsat, SPOT, IRS, NOAA, Seasat, ERS, RADARSAT, INSAT. Satellites and their sensors, geometry and radiometry.
2. Digital Image Processing: Principles, Image Rectification and restoration, Image enhancement and
   Mosaicing. Image classification. Supervised, Unsupervised, Ground truth data and training set
   manipulation, Classification accuracy assessment.
3. Geographical Information System (GIS): Basic principles and terminologies, Raster and vector data, Map projection, Topology creation, Overlay analysis, Data structure and Digital cartography; Software used in GIS Surveying: Leveling, Triangulation, Geodetic survey; Global Positioning System (GPS) - Basic principles, Applications to environmental studies.

Module 5:

1. **Environment versus Development (5 hrs)**
   Dominance of man on earth. Limits of growth. Industrial revolution and resource utilization,
   environmental consequences. Modern agriculture and green Revolution - environmental impacts.
   Conflicts of interest - mega developmental projects and issues of 3 Rs, environment and development.
2. **Sustainable Development (10 hrs)**
   a. Principles of sustainability - Reliance on solar energy, biodiversity, population control, nutrient cycling. Sustainability indicators. Our Common future and the idea of Sustainable Development - Concepts and dimensions. Basic needs - Imperatives relating to sustainable development. Johannesberg

b. Conference 2002 and follow up.Conference on sustainable development. Securing Sustainable futures -Millennium development goals and strategies; the earth charter; need and scope for evolving participatory, community based environmental management strategies. Education for sustainability. Building sustainable societies and lifestyles.
c. Ecological Foot Print analysis and its significance. Environmental concerns in traditional societies.

Module 6: Environmental laws and policies (10 hrs)

a. Historical background of environmental law and policy in India.
b. The salient features of the following acts and rules: The water (Prevention and control of pollution) act, 1974; The air (Prevention and control of pollution) act, 1981; The environmental (Protection) act, 1986; The public liability insurance act, 1991; The wildlife protection act, 1972; The forest conservation act, 1980; The biodiversity act, 2002; The hazardous wastes (Management and handling) rules, 1989; The noise pollution (Regulation and control) rules, 2000. Manufacture, storage and import of hazardous chemicals rules 1989, Biomedical waste (Management and Handling) rules 1998.

Practical (54 hrs)

1. Estimation of BOD and COD of polluted water.
2. Isolation and Enumeration of microorganisms in soil (TBC or TMC) - Types of Bacteria and fungi.
3. Bacteriological quality testing of water and waste water.

a. Presumptive Coliform test b. Confirmatory Coliform test.

Field Study: (Three/four days) Visit at least one Institution engaged in environment/conservation research and a sanctuary/national park and an industrial/polluted area. Submit a report of the study conducted in a ~10 page write up/print out giving the dates, methodology, results and references. Include photgraphs of the activity.

References

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