MAHATMA GANDHI UNIVERSITY

PRIYADARSINI HILLS

KOTTAYAM

KERALA

SYLLABUS FOR UNDER GRADUATE PROGRAMME IN

BOTANY & BIOTECHNOLOGY

UNDER THE RESTRUCTURED CURRICULUM

IN

CHOICE BASED CREDIT SYSTEM (UGCBCS)

(EFFECTIVE FROM 2017 ADMISSIONS)

PREPARED BY:

BOARD OF STUDIES IN BOTANY (UG) AND FACULTY OF SCIENCE, MAHATMA GANDHI UNIVERSITY, KOTTAYAM

B Sc BOTANY PROGRAMME – MODEL III (DUAL CORE)

PROGRAMME DESIGN

The UG programme in Botany (Model – III, Dual core) must include (a) Common courses*, (b) Two different core courses (c) Complementary Courses (d) Open courses (e) Choice based courses (f) Project work and (g) On the job training. No course shall carry more than 4 credits. The student shall select any one Open course in Semester V offered by different departments in the same institution. The number of courses for the restructured programme should contain 10 compulsory courses each for the two core subjects, 1 open course, 1 choice based elective course from the frontier area of the core courses, 14 core practical courses, 1 project work, 8 complementary courses and 4 complementary practical courses. There should be 2 common courses which is English.

PROGRAMME STRUCTURE: SUMMARY OF COURSES AND CREDITS

Sl. No.	Course type	No. of courses	Total credits
1	Common course I - English	2	8
2	Core 1 + Practical	10 + 8	38
3	Core 2 + Practical	10 + 6	36
4	Complementary I + Practical	4 + 2	14
5	Complementary II + Practical	4 + 2	14
6	Open course	1	3
7	Programme elective (Choice based core course)	1	3
8	Project work	1	3
9	OJT	1	1
Total		**52**	**120**
Total credits		120	
Programme duration		6 Semesters	
Minimum attendance required		75%	

*__Course:__ a segment of subject matter to be covered in a semester. Each course is designed variously under lectures / tutorials / laboratory or fieldwork / seminar / project / practical training / assignments/ evaluation etc., to meet effective teaching and learning needs.

SEMESTER-WISE DISTRIBUTION OF COURSES AND CREDITS

Course Title	Hrs/ week	Credits	Course Title	Hrs/ week	Credits
SEMESTER I			**SEMESTER II**		
Common course – English 1	5	4	Common course – English 2	5	4
Botany core course 1	4	2 + 1	Botany core course 2	4	2 + 1
Biotechnology Core Course 1 (IT)	4	2 + 1	Biotechnology core course 3	4	2 + 1
Biotechnology core course 2	4	2 + 1	Biotechnology core course 4	4	2 + 1
Ist Complementary - Biochemistry course 1	4	2 + 1	1st Complementary – Biochemistry course 2	4	2 + 1
2nd Complementary - Zoology course 1	4	2 + 1	2nd Complementary – Zoology course 2	4	2 + 1
Total	**25**	**19**	**Total**	**25**	**19**
SEMESTER III			**SEMESTER IV**		
Botany core course 3	5	3 + 1	Botany core course 4	5	3 + 1
Biotechnology core course 5	5	3 + 1	Biotechnology core course 7	5	3 + 1
Biotechnology core course 6	5	3 + 1	Biotechnology core course 8	5	3 + 1
Ist Complementary - Biochemistry course 3	5	3 + 1	Ist Complementary – Biochemistry course 4	5	3 + 1
2nd Complementary - Zoology course 3	5	3 + 1	2nd Complementary – Zoology course 4	5	3 + 1
Total	**25**	**20**	**Total**	**25**	**20**
SEMESTER V			**SEMESTER VI**		
Botany core course 5	5	3 + 1	Botany core course 8	5	3 + 1
Botany core course 6	5	3 + 1	Botany core course 9	5	3 + 1
Botany core course 7	5	3 + 1	Botany core course 10	6	3 + 1
Biotechnology core course 9	6	3 + 1	Biotechnology core course 10	6	3 + 1
Open course	4	3	Programme elective - Choice based core course	3	3
			Project work	--	3
Total	**25**	**19**	OJT	--	1
			Total	**25**	**23**

SEMESTER-WISE DISTRIBUTION OF CORE COURSES

Sem.	Course category	Course code	Course title	Instr. hrs.*		Credits
				Th.	Pr	
I	Core Bot-1	BO1CRT01	Methodology of Science & Introduction to Botany	36	36	2+1
	Core BT-1	BOBT 1CRT01	Operating system and Office automation	36	36	2+1
	Core BT-2	BOBT 1CRT02	Cell Biology, Developmental biology and Evolution	54	18	2+1
II	Core BO-2	BO2CRT02	Microbiology, Mycology & Plant Pathology	36	36	2+1
	Core BT-3	BOBT 2CRT03	Biophysics & Instrumentation	54	18	2+1
	Core BT-4	BOBT 2CRT04	Molecular Biology & Methods in Molecular Biology	54	18	2+1
III	Core BO-3	BO3CRT03	Phycology & Bryology	54	36	3+1
	Core BT-5	BOBT 3CRT05	Microbiology & Microbial Technology	54	36	3+1
	Core BT-6	BOBT 3CRT06	Immunology	54	36	3+1
IV	Core BO-4	BO4CRT04	Pteridology, Gymnosperms & paleo botany	54	36	3+1
	Core BT-7	BOBT 4CRT07	Animal Biotechnology & Nanotechnology	54	36	3+1
	Core BT-8	BOBT 4CRT08	Plant Biotechnology	54	36	3+1
V	Core BO-5	BO5CRT05	Anatomy, Reproductive botany, Microtechniques	54	36	3+1
	Core BO-6	BO5CRT07	Plant Physiology & Biochemistry	54	45	3+1
	Core BO-7	BO5CRT08	Environmental sciences and Human Rights	54	36	3+1
	Core BT-9	BOBT 5CRT09	Recombinant DNA Technology	54	45	3+1
	Open			72	--	3
VI	Core BO-8	BO6CRT09	Genetics, Plant Breeding and Horticulture	54	45	3+1
	Core BO-9	BO6CRT11	Angiosperm Morphology, Taxonomy & Economic Botany	72	45	3+1
	Core BO-10	BO6CRT13	Biostatistics	54	36	3+1
	Core BT-10	BOBT 6CRT10	Bioinformatics	54	36	3+1
	Elective			54	--	3
	Project	BO6PRT01	Investigatory project work done individually or in groups	--	--	3
	Core BT	-	OJT			1

* 18 instructional hours is equal to one teaching hour per week. BO- Botany: BT- Biotechnology

SEMESTER I

Core course 1 Code: BO1CRT01

METHODOLOGY OF SCIENCE AND AN INTRODUCTION TO BOTANY

(Theory 36 hrs; Practical 36 hrs; Credits 2 + 1)

Objectives:

- Understand the universal nature of science
- Demonstrate the use of scientific method
- To lay a strong foundation to the study in Botany
- Impart an insight into the different types of classifications in the living kingdom.
- Appreciate the world of organisms and its course of evolution and diversity.
- Develop basic skills to study Botany in detail.

Module 1: Introduction to science and the methodology of science (4 hrs)

Scientific method: steps involved - observation and thoughts, formulation of hypothesis; inductive reasoning - testing of hypothesis; deductive reasoning - experimentation - formulation of theories and laws.

Module 2: Experimentation in science (4 hrs)

Selection of a problem - searching the literature – designing of experiments - selection of variables, study area, and a suitable design. Need of control, treatments and replication. Mendel's experiments as an example of moving from observations to questions, then to hypothesis and finally to experimentation. Ethics in science.

Module 3: Origin and evolution of life (10 hrs)

Origin of life on earth from molecules to life - Oparin's hypothesis, Haldane's hypothesis, Miller-Urey experiment, Panspermia, origin of cells and the first organisms. Evolutionary history of Biological diversity – fossil record; geological time scale – major events in each era. Evidences of evolution; theories of evolution - Lamarck, Wallace, Charles Darwin, Hugo De Vries. Neo-Darwinism – major postulates - isolation, mutation, genetic drift, speciation.

Module 4: Diversity of life and its classification (12 hrs)

Diversity of life: two kingdom classification (Carolus Linnaeus, 1735); phylogenetic classification (August W Eichler, 1878); five kingdom classification (R H Whittaker, 1969). Three domains, six kingdom classification, (Carl Woese, 1990) – criteria for classification, general characters of each kingdom. The three domains of life: Archaea, Bacteria, Eucarya – general characters of each.

Diversity of plants: study the salient features of algae, fungi, bryophytes, pteridophytes, gymnosperms and angiosperms.

Module 5: Basic Botanical skills (6 hrs)

Light microscope: dissection and compound microscope – parts and uses. Preparation of specimens for light microscopy - collection and preservation of plant specimens; killing and fixing; killing agents - formalin, ethyl alcohol; fixing agents - Carnoys fluid, Farmer's fluid, FAA; herbarium (brief study only). Whole mounts and sections – hand sectioning – TS, TLS, RLS. Staining plant tissues: purpose; stains - safranine, acetocarmine, crystal violet. Temporary and permanent mounting, mountants.

PRACTICAL (36 hrs)

1. Design an experiment to verify a given hypothesis.
2. Conduct a survey-based inquiry on a given topic (To test the validity of a given hypothesis. E.g., all angiosperm parasites are Dicot plants).
3. Select an important classical experiment and find out the different elements of the methodology of science (e.g., Robert Koch experiment).
4. Conduct field surveys to identify and collect plant specimens to appreciate the diversity of plant kingdom. Submit five preserved specimens (in bottles and/or herbarium) belonging to diverse groups.
5. Identification of plants with vascular elements, plants which produce flowers, fruits, seeds, cone, sporophyll, embryos and study their salient features.
6. Prepare temporary, stained hand sections (TS, TLS, RLS) of plant specimens appropriate for light microscopic studies.

REFERENCES

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12. Michael G Simpson, Plant Systematics (II Edn). Academic press.
13. Eldon D Enger, Frederick C Ross, David B Bailey, 2005. Concepts in Biology. Tata McGraw Hill.
14. Monroe W Strickberger, 1989. Evolution. Jones and Bartlett Publishers.
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SEMESTER II

Core course 2 Code: BO2CRT02

MICROBIOLOGY, MYCOLOGY AND PLANT PATHOLOGY

(Theory 36 hrs; Practical 36 hrs; Credits 2 + 1)

Objectives:

- Understand the world of microbes, fungi and lichens
- Appreciate the adaptive strategies of the microbes, fungi and lichens
- To study the economic and pathological importance of microorganisms

MICROBIOLOGY (Theory 9 hrs; Practical 9 hrs)

Module 1: Introduction (1 hr)

Introduction to microbiology, scope of microbiology.

Module 2: Bacteria (4 hrs)

Bacteria: general characters and classification based on staining, morphology and flagellation. Ultra structure of bacteria. Reproduction - binary fission. Genetic recombination in bacteria - conjugation, transformation and transduction. Economic importance of bacteria.

Module 3: Viruses (2 hrs)

General characters of viruses, viriods and prions. Structure of TMV and Bacteriophage (λ). Multiplication of λ phage – lytic and lysogenic cycle.

Module 4: Applied microbiology (2 hrs)

Isolation and culture of bacteria; media used – general purpose and selective media, applications of bacterial culture (brief study only). Role of microbes: in producing antibiotics, vine, vinegar, curd – role in N_2 fixation, as biofertilizers – role in food spoilage (Brief study only).

PRACTICAL (9 hrs)

1. Gram staining - curd, root nodules.
2. Isolation of microbes from soil through serial dilution and streak plate method.
3. Demonstrate the culture of bacteria.
4. Microbes and type of fermentation - vine, vinegar, curd.

MYCOLOGY (Theory 18 hrs; Practical 18 hrs)

Module 5: Introduction, classification and types of fungi (13 hrs)

General characters of fungi. Classification of fungi - Ainsworth (1973). Distinguishing characters of the different classes of fungi with special reference to reproductive structures and life history of the genera mentioned in each group:

Myxomycotina – *Physarum*; Mastigomycotina – *Albugo*; Zygomycotina - *Rhizopus*; Ascomycotina – Hemiascomycetes - *Saccharomyces*; Plectomycetes - *Penicillium*; Pyrenomycetes – *Xylaria*; Discomycetes - *Peziza*; Basidiomycotina – Teliomycetes – *Puccinia*; Hymenomycetes – *Agaricus*; Deuteromycotina – *Fusarium.*

Module 6: Economic importance of fungi (3 hrs)

Useful and harmful effects of fungi - medicinal, industrial, agricultural, food, genetic studies, spoilage, fungal toxins and diseases. Mycorrhiza: ecto- and endomycorrhiza, significance.

Module 7: Lichens (2 hrs)

General characters, types, general internal structure. Economic and ecological significance of lichens. Structure, reproduction and life cycle of *Parmelia.*

PRACTICAL (18 hrs)

1. Micropreparation and detailed microscopic study of *Rhizopus, Albugo, Saccharomyces, Penicillium, Xylaria, Peziza, Puccinia, Fusarium* and *Parmelia*.
2. Staining and microscopic observation of endomycorrhizal fungus.
3. Investigation of fungal succession on cow dung.

PLANT PATHOLOGY (Theory 9 hrs; Practical 9 hrs)

Module 8: Plant disease development (3 hrs)

History of plant pathology. Classification of plant diseases on the basis of causative organism and symptoms. Host parasite interaction - defence mechanisms in host, mechanism of infection, transmission and dissemination of diseases.

Module 9: Common plant diseases (4 hrs)

Study of following diseases with emphasis on symptoms, cause, disease cycle and control: Bunchy top of Banana, Bacterial blight of Paddy, Root wilt of Coconut, Abnormal leaf fall of Rubber, Root knot disease of Pepper, Leaf mosaic disease of Tapioca, Citrus canker.

Module 10: Control of diseases (2 hrs)

Prophylaxis - quarantine measures, seed certification; Therapeutic - physical therapy, chemotherapy; Biological control and its significance. Fungicides - Bordeaux mixture. Tobacco and Neem decoction (Brief study only).

PRACTICAL (9 hrs)

1. Identify the diseases mentioned in the syllabus with respect to causative organisms and symptoms
2. Submit herbarium preparations of any three of the diseases mentioned.
3. Learn the technique of preparing Bordeaux mixture, Tobacco and Neem decoction.

REFERENCES

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12. Nair M C (eds), 1990. *Mushroom Technical Bulletin* 17. Kerala Agricultural University, Mannuthy.
13. Nita Bahl, 2002. *Hand book on Mushrooms.* Oxford & IBH Publishing C. Pvt.

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SEMESTER III

Core course 3 Code: BO3CRT03
PHYCOLOGY AND BRYOLOGY
(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)

Objectives:

- To study the evolutionary importance of Algae as progenitors of land plants
- Understand the unique and general features Algae and Bryophytes and familiarize it
- To study the external morphology, internal structure and reproduction of different types of Algae and Bryophytes
- Realize the application of Phycology in different fields

PHYCOLOGY (Theory 36 hrs; Practical 27 hrs)

Module 1: Introduction to Phycology and classification of Algae (9 hrs)

Introduction: general characters, habitat diversity, range of thallus structure and pigments in algae; structure of algal flagella. Different types of life cycle and alternation of generations in algae. Classification: by Fritsch (1945); brief introduction to the modern classification by Lee (2009) [up to divisions].

Module 2: Type study (18 hrs)

Salient features, thallus structure and reproduction of algae in the following groups with special reference to the type(s) mentioned: Cyanophyceae - *Nostoc*; Chlorophyceae - *Volvox, Oedogonium, Cladophora, Chara;* Xanthophyceae – *Vaucheria;* Bacillariophyceae - *Pinnularia*; Phaeophyceae – *Ectocarpus, Sargassum*; Rhodophyceae - *Polysiphonia*.

Module 3: Artificial culture and economic importance of Algae (9 hrs)

Algal culture: isolation, cultivation and preservation of micro- and macro-algae. Economic importance of algae: algae as food, SCP, fodder, green manure, role in N_2 fixation, medicine and biofuels. Commercial products from Algae - carrageenin, agar-agar, alginates and diatomaceous earth. Role of algae in pollution studies: as indicators of pollution and as bioremediation agents. Eutrophication – algal bloom; harmful and toxic algal blooms – neurotoxins and parasitic algae.

PRACTICAL (27 hrs)

1. Conduct a field visit to any one of the ecosystems rich in Algae to experience algal diversity. Submit a report with photographs.
2. Make micropreparations of vegetative and reproductive structures of the types mentioned in the syllabus.
3. Algal Culture: isolation and cultivation of micro- and macro-algae in suitable growth media (Demonstration only).
4. Familiarizing the technique of algal collection preservation.

BRYOLOGY (Theory 18 hrs; Practical 9 hrs)

Module 4: General introduction and classification of bryophytes (4 hrs)

Introduction, general characters and classification of bryophytes by Rothmaler (1951); a very brief account of systems and classifications by Goffinet *et al* (2008).

Module 5: Type study (12 hrs)

Distribution, morphology, anatomy, reproduction and life cycle of the following types (developmental details are not required): Hepaticopsida - *Riccia, Marchantia*; Anthocerotopsida - *Anthoceros*; Bryopsida - *Funaria*. Evolution of gametophyte and sporophyte among Bryophytes.

Module 6: Economic importance (2 hrs)

Economic importance of Bryophytes – biological, ecological, medicinal and as potting material.

PRACTICAL (9 hrs)

1. Study the habit, anatomy of thallus and reproductive structures of *Riccia, Marchantia, Anthoceros,* and *Funaria*.

REFERENCES

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2. Fritsch F E, 1935. The structure and reproduction of the algae, Vol. 1 and II. Uni. Press. Cambridge.
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4. Robert Edward Lee, 2008. Phycology. Cambridge University Press,
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6. Vashishta B R. Text Book of Algae. New Delhi.
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16. Vasishta B R. Bryophyta. S Chand and Co. New Delhi.
17. Watson E V, 1971. The structure and life of Bryophytes. Hutchinson University Library, London.
18. Bower F O, 1935. Primitive Land Plants. Cambridge, London.

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SEMESTER IV

Core course 4 Code: BO4CRT04

PTERIDOLOGY, GYMNOSPERMS AND PALEOBOTANY

(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)

Objectives:

- Understand the diversity in habits, habitats and organization of various groups of plants.
- To impart an insight into the modern classifications in lower forms of plants.
- Understand the evolutionary trends in Pteridophytes and Gymnosperms.
- Study the anatomical variations in vascular plants.
- Understand the significance of Paleobotany and its applications.

PTERIDOLOGY (Theory 27 hrs; Practical 27 hrs)

Module 1: General introduction and classification of Pteridophytes (5 hrs)

Introduction, general characters and classification of Pteridophytes up to classes by Smith (1955) and a very brief account of the classification by Christenhusz *et a*l., 2011.

Module 2: Type study (18 hrs)

Study the distribution, morphology, anatomy, reproduction, life cycle and affinities of the following types (Developmental details are not required): Psilophyta - *Psilotum*; Lycophyta - *Lycopodium, Selaginella;* Sphenophyta - *Equisetum;* Pterophyta - *Pteris, Marsilea.* Stelar evolution in Pteridophytes; Heterospory and seed habit.

Module 3: Economic importance (4 hrs)

Importance of Pteridophytes: medicinal, ornamental, as biofertilizer.

PRACTICAL (27 hrs)

1. Habit, TS of stem, LS of strobilus and sections of special structures of the following types: *Psilotum, Lycopodium, Selaginella, Equisetum, Pteris, Marsilea.*

GYMNOSPERMS (Theory 18 hrs; Practical 9 hrs)

Module 4: General introduction and classification of Gymnosperms (5 hrs)

Introduction, General characters, classification of Gymnosperms by Sporne (1965) and a very brief account of the classification by Christenhusz *et al* (2011).

Module 5: Type study (11 hrs)

Distribution, morphology, anatomy, reproduction, life cycle and affinities of the following types (Developmental details are not required): Cycadopsida – *Cycas*; Coniferopsida – *Pinus*; Gnetopsidae – *Gnetum.* Affinities of Gymnosperms with Pteridophytes and Angiosperms.

Module 6: Economic importance of Gymnosperms (2 hrs)

Uses of Gymnosperms: as food, medicine, in industry and as ornamental plants.

PRACTICAL (9 hrs)

1. Study of the habit, TS of leaf and stem, morphology of reproductive structures of *Cycas*, *Pinus* and *Gnetum.*

PALEOBOTANY (Theory 9 hrs)

Module 6: Fossils (6 hrs)

Introduction to paleobotany and its significance. Fossil formation, types of fossils. Study of fossil Bryophyte - *Naiadita lanceolata;* fossil Pteridophytes – *Rhynia, Calamites;* fossil Gymnosperm – *Williamsonia.* Applied aspects of Paleobotany - exploration of fossil fuels.

Module 7: Paleobotany in India (3 hrs)

Brief study of the fossil deposits in India. Important Indian Paleobotanical Institutes, contributions of Indian Paleobotanists - Birbal Sahni.

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28. Sewart W N, 1983. Paleobotany and the Evolution of Plants. Cambridge Uni. Press, London.
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SEMESTER V

Core course 5 Code: BO5CRT05

ANATOMY, REPRODUCTIVE BOTANY AND MICROTECHNIQUE

(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)

Objectives:

- Imparting an insight into the internal structure and reproduction of the most evolved group of plants, the Angiosperm.
- Understand the individual cells and also tissues simultaneously
- Understand the structural adaptations in plants growing in different environment.
- Understand the morphology and development of reproductive parts.
- Get an insight in to the fruit and seed development.
- Understand the techniques used to preserve and study plant materials.

ANATOMY (Theory: 27 hrs. Practical: 18 hrs)

Module 1: Structure and composition of plant cells (8 hrs)

Cell wall: structure of cell wall; sub-microscopic structure - cellulose, micelle, micro fibril and macro fibril; structure and function of plasmodesmata, simple and bordered pits; different types of cell wall thickening in treachery elements; extra cell wall thickening materials. Growth of cell wall - apposition, intussusception. Non-living inclusions in plant cells: food products, secretory products, excretory (waste) products - nitrogenous and non nitrogenous.

Module 2: Organization of tissues (9 hrs)

Tissues: meristematic tissue – characteristic features, functions and classification. Theories on apical organization - apical cell theory, histogen theory, tunica-corpus theory. Permanent tissues - structure and function of simple and complex tissues. Secretory tissues: external secretory tissue - glands and nectaries; internal secretory tissues - laticifers.

Tissue systems: epidermal tissue system - epidermis, cuticle, trichome; stomata – structure, types; bulliform cells. Ground tissue system - cortex, endodermis, pericycle, pith and pith rays. Vascular tissue system - structure of xylem and phloem, different types of vascular bundles and their arrangement in root and stem. .

Module 3: Plant body structure (6 hrs)

Primary structure of stem, root and leaf (dicot and monocot). Normal secondary growth in dicot stem and root. Periderm: structure and development - phellum, phellogen, phelloderm, bark, and lenticels. Anomalous secondary thickening: *Bignonia* stem, *Boerhaavia* stem and *Dracaena* stem.

Module 4: Wood anatomy (4 hrs)

Basic structure of wood - heart wood, sap wood; hard wood, soft wood; growth rings and dendrochronology; porous and non-porous wood; ring porous and diffuse porous wood, tyloses. Reaction wood: tension wood and compression wood.

PRACTICAL (18 hrs)

1. Study of cell types and tissues.
2. Non-living inclusions - starch grains, cystolith, raphides, aleurone grains.
3. Primary structure of stem, root and leaf - Dicots and Monocots.
4. Dissect and identify the stomatal types - anomocytic, anisocytic, paracytic and diacytic.
5. Secondary structure of dicot stem and root.
6. Anomalous secondary structure of *Bignonia* stem, *Boerhaavia* stem, and *Dracaena* stem.

REPRODUCTIVE BOTANY (Theory 18 hrs; Practical 9 hrs)

Module 5: Introduction (2 hrs)

Introduction to embryology, floral morphology - parts of flower.

Module 6: Microsporangium and male gametophyte (4 hrs)

Microsporangium: structure and development of anther, microsporogenesis, dehiscence of anther, structure of pollen. Male gametophyte development.

Module 7: Megasporangium and female gametophyte (6 hrs)

Megasporangium: types of ovules – anatropous, orthotropous, amphitropous, campylotropous, circinotropous. Megasporogenesis – female gametophyte – structure of a typical embryosac, types of embryosacs - monosporic (*Polygonum* type), bisporic (*Allium* type) and tetrasporic (*Peperomia* type).

Module 8: Fertilization (2 hrs)

Mechanism of pollination, agents of pollination, germination of pollen grains; double fertilization.

Module 9: Endosperm and embryo (4 hrs)

Endosperm: types – cellular, nuclear and helobial. Embryogeny, structure of dicot and monocot embryo, seed formation. Polyembryony.

PRACTICAL (9 hrs)

1. Dissect and display parts of different types of flowers.
2. Identification of C.S. of anther, embryo sac and embryo.
3. Identification of various anther types - monothecous, dithecous.
4. Identify the different types of ovules.

MICROTECHNIQUE (Theory 9 hrs; Practical 9 hrs)

Module 6: Preservation of plant specimens, sectioning and mounting (9 hrs)

Introduction to microtechnique: killing and fixing - purpose. Dehydration - purpose, agents used - ethyl alcohol. Sectioning: hand sections, serial section; Microtome - rotary, sledge (application only). Staining technique: principle of staining; stains - hematoxylin, fast green, acetocarmine; vital stains - neutral red, Evans blue; mordants - purpose with examples. Types of staining - single staining, double staining. Mounting and mounting media – purpose, mounting media - glycerine, DPX, Canada balsam. Use of permanent whole mounts; permanent sections; maceration, smear and squash preparation.

PRACTICAL (9 hrs)

1. Familiarize preparation and use of stains, fixatives and mounting media.
2. Preparation of smears and squash.
3. Demonstration of microtome sectioning.
4. Maceration and identification of tracheary elements.
5. Preparation of single stained hand sections (Permanent – demonstration only).

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Core course 6 Code: BO5CRT06
RESEARCH METHODOLOGY, BIOPHYSICS AND BIOSTATISTICS
Theory: 54 hrs; Practical: 45 hrs; Credits: 3 + 1)

Objectives:

- To equip the students to conduct independent research and prepare research reports.
- To make the students acquaint with different tools and techniques used in research work.
- To equip the students with basic computer skills necessary for conducting research.
- To enable the students to have enough numerical skills necessary to carry out research.

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RESEARCH METHODOLOGY (Theory 18 hrs; Practical 18 hrs)

Module 1: Introduction (4 hrs) -

Objectives of research. Types of research - pure and applied. Identification of research problem. Review of literature: purpose, literature sources – names of reputed National and International journals in life science (2 international & 3 national); reprint acquisition - INSDOC, INFLIBNET.

Module 2: Process of research (7 hrs)

Conducting research: define the problem, identify the objective, design the study, collection of data, analysis and interpretation. Preparation of research report: preparation of dissertation - IMRAD system - preliminary pages, introduction and review of literature, materials and methods, results, discussion, conclusion and bibliography.

Module 3: Use of computer in research (7 hrs)

Introduction to MS - WINDOWS and LINUX, application of MS WORD - word Processing, editing tools (cut, copy, paste), formatting tools. MS EXCEL - creating worksheet, data entry, sorting data. Statistical tools (SUM, MEAN, MEDIAN and MODE). Preparation of graphs and diagrams (Bar diagram, pie chart, line chart, histogram). MS-POWERPOINT - presentation based on a biological topic; inserting tables, charts, pictures. Open source and free alternatives to MS Office: Libre Office, Open Office (brief study). Search engines: Google.com; meta search engine – dogpile.com; academic search - Google scholar. Educational sites related to biological science - Scitable, DNAi.

PRACTICAL (18 hrs)

1. Prepare outline of a dissertation (IMRAD system).
2. Prepare a list of references (not less than 10) on a topic in biological science.
3. Review the literature on a given topic.
4. Collect information on a topic related to biological science using the internet.

5. Make a report based on the collected information from the internet (using MS-WORD).
6. Prepare tables/charts/graphs using EXCEL.
7. Prepare a worksheet using a set of data collected and find out the SUM.
8. Prepare a PowerPoint presentation based on the report in Experiment 4.

BIOPHYSICS (Theory 18 hrs; Practical 9 hrs)

Module 4: Introduction (2 hrs)

Introduction to biophysics; branches of biophysics - molecular, cellular, membrane and biomedical instrumentation (scope only).

Module 5: Biophysical instrumentation (16 hrs)

Principle, working and applications of the following:

Microscopy: compound microscope, phase-contrast microscope and electron microscope – SEM. Colorimeter, spectrophotometer. Centrifuge: ultracentrifuge. Chromatography: paper, thin layer and column. Electrophoresis, PAGE. pH meter. Haemocytometer.

PRACTICAL (9 hrs)

1. Measurement of pH and adjusting pH using pH meter.
2. Separation of plant pigments using TLC.
3. Determination of the concentration of a sample solution using colorimeter.
4. Demonstration of column chromatography.
5. Count the number of cells/spores using Haemocytometer.

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BIOSTATISTICS (Theory 18 hrs; Practical 18 hrs)

Module 6: Introduction

Introduction, statistical terms and symbols (Brief study only). Sampling: concept of sample, sampling methods - random and non random sampling. Collection and representation of data: diagrammatic and graphic representation - line diagram, bar diagram, pie diagram, histogram, frequency curve. Measures of central tendency: mean, median, mode, (discrete and continuous series). Measures of dispersion: standard deviation. Distribution patterns: normal distribution, binomial distribution. Tests of significance: Chi-squire test - uses, procedure.

PRACTICAL (18 hours)

1. Collect numerical data, tabulate and represent in different types of graphs and diagrams mentioned in the syllabus.
2. Problems related to mean, median, mode, standard deviation and Chi-square test.

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Core course 7 Code: BO5CRT07
PLANT PHYSIOLOGY AND BIOCHEMISTRY
(Theory 54 hrs; Practical 45 hrs; Credits 3 + 1)

Objectives:

- Acquire basic knowledge needed for proper understanding of plant functioning.
- Familiarize with the basic skills and techniques related to plant physiology.
- Understand the role, structure and importance of the bio molecules associated with plant life.

PLANT PHYSIOLOGY (Theory 36 hrs; Practical 27 hrs)

Module 1: Water relations (6 hrs)

Plant water relations - diffusion, imbibition, osmosis, OP, DPD, TP; water potential - concepts and components (pressure potential, gravity potential, osmotic potential and matric potential). Absorption of water - active and passive, pathway of water movement - apoplastic and symplastic pathway. Ascent of sap - cohesion-tension theory. Transpiration - types, mechanism, theories (Starch-sugar, Proton-K+ ion exchange), significance; antitranspirants. Guttation.

Module 2: Mineral nutrition (3 hrs)

Role of major and minor elements in plant nutrition, deficiency symptoms of essential nutrients; mineral uptake - passive (ion exchange) and active (carrier concept).

Module 3: Photosynthesis (12 hrs)

Photosynthetic pigments, photo excitation - fluorescence, phosphorescence; red drop and Emerson enhancement effect. Photosystems - components and organization; cyclic and non-cyclic photophosphorylation; carbon assimilation pathways - C3, C4 plants - kranz anatomy, CAM. Photorespiration. Factors affecting photosynthesis - Blackmann's law of limiting factors.

Translocation of solutes: pathway of phloem transport, mechanism - pressure flow, mass flow hypothesis; phloem loading and unloading.

Module 4: Respiration (8 hrs)

Respiration: anaerobic and aerobic; glycolysis, Kreb's cycle, mitochondrial electron transport system - components, oxidative phosphorylation, ATPase, chemiosmotic hypothesis. RQ - significance. Factors affecting respiration.

Module 5: Plant growth and development (5 hrs)

Plant hormones: their physiological effect and practical applications - auxins, gibberellins, cytokinins, ABA, and ethylene. Plant movements: tropic movements - geotropism and phototropism; nastic movements - seismonastic and nyctinastic movements. Physiology of flowering - phytochrome, photoperiodism, vernalization.

Module 6: Stress physiology (2 hrs)

Concepts of plant responses to abiotic stresses (water, salt, temperature), biotic stress (pathogens). Allelopathy.

PRACTICAL (27 hrs)

Core Experiments (any four compulsory):

1. Determination of osmotic pressure of plant cell sap by plasmolytic/weighing method.
2. Compare the stomatal indices of hydrophytes, xerophytes and mesophytes (any two).
3. Separation of plant pigments by TLC/Paper chromatography.
4. Measurement of photosynthesis by Wilmott's bubbler/any suitable method.
5. Estimation of plant pigments by colorimeter.

Demonstration experiments:

1. Papaya petiole osmoscope.
2. Demonstration of tissue tension.
3. Relation between transpiration and absorption.
4. Necessity of chlorophyll, light and CO_2 in phytosynthesis.
5. Simple respiroscope.
6. Respirometer and measurement of RQ.
7. Fermentation.
8. Measurement of transpiration rate using Ganong's potometer/Farmer's potometer.

BIOCHEMISTRY (Theory 18 hrs; Practical 18 hrs)

Module 4: Water (3 hrs)

Physical and chemical properties of water, acids and bases; pH - definition, significance; measurement of pH – colorimetric, electrometric (brief study only). Buffers: buffer action, uses of buffers.

Module 5: Carbohydrates (3 hrs)

General structure and functions; classification - mono (glucose and fructose), di (maltose and sucrose) and polysaccharides (starch and cellulose).

Module 6: Proteins (4 hrs)

General structure and classification of amino acids - peptide bond; structural levels of proteins - primary, secondary, tertiary and quaternary; functions of proteins.

Module 7: Lipids (2 hrs)

General features and roles of lipids, types of lipids; fatty acids - saturated and unsaturated; fatty acid derivatives - fats and oils; compound lipids (brief study only).

Module 8: Enzymes (6 hrs)

Classification and nomenclature, mechanism of action. Enzyme kinetics, Michaelis-Menten constant (brief study only). Regulation of enzyme action. Factors affecting enzyme action.

PRACTICAL (18 hrs)

1. General test for carbohydrates - Molischs test, Benedicts's tests, Fehling's test.
2. Colour test for starch - Iodine test.
3. Colour tests for proteins in solution – Xanthoproteic test, Biuret test, Million's test, Ninhydrin test.

4. Action of various enzymes in plant tissues: peroxidase, dehydrogenase.
5. Quantitative estimation of protein using colorimeter.

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Core course 8 Code: BO5CRT08
ENVIRONMENTAL SCIENCE AND HUMAN RIGHTS
(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)

Objectives:

- Acquaint the student with the significance of Environmental Science.
- Make the students aware about the extent of the total biodiversity and the importance of their conservation.
- Help the student to design novel mechanisms for the sustainable utilization of natural resources.
- Enable the students to understand the structure and function of the ecosystems.
- Enable the students to understand various kinds of pollution in the environment, their impacts on the ecosystem and their control measures
- Make the students aware about various environmental laws in India and the role of various movements in the protection of nature and natural resources.

ENVIRONMENTAL SCIENCE (48 hrs)

Module 1: Introduction to ecology (8 hrs)

Ecology: introduction, definition, scope and relevance; sub-divisions of ecology - autecology, synecology and ecosystem ecology**.**

Population: population size, density, natality, mortality, age, rate of natural increase, growth form and carrying capacity, population interactions between species - competition, parasitism, predation, commensalism, protocooperation, mutualism, neutralism.

Community: community concept, biotic community, species diversity, species richness, dominance; growth forms and structure, trophic structure, ecotone, edge effect, habitat, ecological niche, micro-climate, ecological indicators, keystone species**.**

Module 2: Ecosystems (10 hrs)

Structure and function of ecosystems, ecosystem components: abiotic - atmosphere, climate, soil, water; biotic - producers, consumers, decomposers. Productivity - primary and secondary - gross and net productivity - homeostasis in the ecosystem. Concept of energy in ecosystems - energy flow, food chain, food web, trophic levels, trophic structure and ecological pyramids - pyramid of numbers, biomass, energy. Nutrient cycles - biogeochemical cycles of C and N_2.

Ecosystem development: ecological succession, process, climax community, hydrosere, xerosere. Adaptations of plants to environment - xerophytes, hydrophytes, epiphytes, halophytes, mangroves.

Module 3: Biodiversity and its conservation (10 hrs)

Biodiversity: definition, types, examples – endemism - hot spots; hot spots in India - Western Ghats as hot spot. Wetlands and their importance. Biodiversity loss - IUCN threat categories, Red data book; causes and rate of biodiversity loss - extinction, causes of extinction. Conservation: methods - *in-situ*, *ex-situ*. Joint Forest management - people's participation in biodiversity conservation: community reserve, eg. Kadalundi-vallikkunnu. Remote sensing and GIS: introduction, principle, application of remote sensing and GIS in environmental studies and biodiversity conservation (brief account). Ecotourism: ecotourism centers in Kerala - Thenmala and Thattekkad WLS.

Module 4: Environmental pollution (10 hrs)

Environmental studies - definition, relation to other sciences, relevance. Environmental pollution - introduction, definition; Air pollution - air pollutants, types, sources, effect of air pollution on plants and humans, control measures; Water pollution – common pollutants, sources, impact, control measures; water quality standards - DO and BOD; eutrophication. Soil Pollution - causes, sources, solid waste, biodegradable, non-biodegradable, management of solid waste, composting, e – waste. Environmental issues - global warming, greenhouse effect, climate change - causes and impact, ozone layer depletion. Carbon sequestration.

Module 5: Conservation of nature (10 hrs)

Global conservation efforts - Rio Earth summit - Agenda 21, Kyoto protocol, COP15 (15^{th} Conference of the parties under the UN framework convention on climate change) and Paris protocol - major contributions. Conservation strategies and efforts in India and Kerala.

Organizations, movements and contributors of environmental studies and conservation: organizations - WWF, Chipko, NEERI; contributors - Salim Ali, Sunder Lal Bahuguna, Madhav Gadgil, Anil Agarwal, Medha Patkar, Vandana Siva (brief account only).

Environmental Legislation and Laws: Environment (protection) Act 1986, Air (protection and control of pollution) act, 1981 Water (protection and control of pollution) Act, 1974, Wildlife (protection) Act, 1972, Forest (conservation) Act, 1980, Biological Diversity Act (2002) [brief account only].

Module 6: Human rights (6 hrs)

Introduction, meaning, concept and development. Three generations of human rights - civil and political rights, economic, social and cultural rights. Human Rights and United Nations: contributions; main human rights related organizations - UNESCO, UNICEF, WHO, ILO; Declarations for women and children, Universal declaration of human rights. Human rights in India: fundamental rights and Indian constitution, rights for children and women, scheduled castes, scheduled tribes, other backward castes and minorities.

Environment and human rights: right to clean environment and public safety; issues of industrial pollution; prevention, rehabilitation and safety aspect of new technologies such as chemical and nuclear technologies, issues of waste disposal, protection of environment. Conservation of natural resources and human rights: reports, case studies and policy formulation. Conservation issues of Western Ghats – Madhav Gadgil committee report, Kasturi Rangan report. Over-exploitation of ground water resources, marine fisheries, sand mining etc.

PRACTICAL (36 hrs)

1. Estimation of CO_2, Cl, and alkalinity of water samples (Titrimetry)
2. Determination of pH of soil and water.
3. Assessment of diversity, abundance, and frequency of plant species by quadrate method (Grasslands, forests).
4. Study of the most probable number (MPN) of Coliform bacteria in water samples.
5. EIA studies in degraded areas (Sampling, Line transect, Quadrate).
6. Ecological adaptations in xerophytes, hydrophytes, epiphytes, halophytes and mangroves.

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OPEN COURSES

Open course 1 Code: BO5OPT01
AGRI-BASED MICROENTERPRISES
(Theory 72 hrs; Credits 3)

Objectives:

- Provide basic information about the business opportunities in plant sciences.
- Inform the student about sustainable agriculture and organic farming.
- Inculcate an enthusiasm and awareness about ornamental gardening, nursery management and mushroom cultivation.

Module 1: Organic farming and composting techniques (9 hrs)

Advantages of organic manures and fertilizers. Composition of fertilizers – NPK content of various fertilizers. Common organic manures – bone meal, cow dung, poultry waste, oil cakes, organic mixtures and compost. Preparation of compost - aerobic and anaerobic - advantages of both; vermicompost - preparation, vermiwash. Biofertilizers: definition, types – *Trichoderma*, *Rhizobium*, PGPR. Biopesticides – Tobacco and Neem decoction. Biological control.

Module 2: Horticulture and Nursery management (18 hrs)

Soil components. Preparation of potting mixture. Common Garden tools and implements. Methods of plant propagation - by seeds - advantages and disadvantages. Vegetative propagation - advantages and disadvantages. Natural methods of vegetative propagation. Artificial methods - cutting, grafting,

budding and layering. Use of growth regulators for rooting. Gardening - types of garden - ornamental, indoor garden, kitchen garden, vegetable garden for marketing.

Module 3: Food spoilage and preservation techniques (9 hrs)

Causes of spoilage. Preservation techniques - asepsis, removal of microorganisms, anaerobic conditions and special methods – by drying, by heat treatment, by low temperature storage and by chemicals (Food Additives). Preparation of wine, vinegar and dairy products.

Module 4: Mushroom cultivation and Spawn production (9 hrs)

Types of mushrooms - button mushroom, oyster mushroom and milky mushroom, poisonous mushroom – methods of identification. Spawn – isolation and preparation. Cultivation milky mushrooms – using paddy straw and saw dust by polybag. Value added products from mushroom – pickles, candies, dried mushrooms.

Module 5: Plant tissue culture and micropropagation (9 hrs)

Concept of totipotency. Micropropagation: different methods – shoot tip, axillary bud and meristem culture; organogenesis, somatic embryogenesis. Infra structure of a tissue culture laboratory. Solid and liquid media - composition and preparation. Sterilization techniques. Explant - inoculation and incubation techniques. Stages of micropropagation – hardening and transplantation. Packaging and transportation of tissue culture regenerated plantlets.

ON HAND TRAINING (18 hrs)

1. Prepare a chart showing the NPK composition of minimum 6 manures and fertilizers.
2. Identification and familiarization of the following organic manures: cow dung (dry), Coconut cake, Vermicompost, neem cake, organic mixture, bone meal.
3. Preparation of potting mixture.
4. Make a vermicompost pit /pot in the campus/ house of the student.
5. Familiarization of common garden tools and implements.
6. Estimation of germination percentage of seeds
7. Demonstrate the effect of a rooting hormone on stem cutting.
8. Demonstration of T budding and air layering on live plants.
9. Familiarization of garden components from photographs.
10. Preparation of vinegar/dairy product (any two) in class or home.
11. Familiarization of different mushrooms and preparation of a polybag of *Pleurotus* using straw/sawdust.
12. Visit to a well established tissue culture lab, nursery and mushroom cultivation unit.

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Open course 2 Code: BO5OPT02
HORTICULTURE AND NURSERY MANAGEMENT
(Theory 72 hrs; Credits 3)

Objectives:

- Understand the importance of horticulture in human welfare.
- Understand the propagation and cultural practices of useful vegetable, fruit and garden plants.
- Understand the impact of modern technologies in biology on horticultural plants.
- Understand the basic concepts of landscaping and garden designing.
- Inculcate interest in landscaping, gardening and flower and fruit culture.

HORTICULTURE (48 hrs)

Module 1: Introduction (10 hrs)

Introduction to horticulture: definition, history; classification of horticultural plants, disciplines of horticulture. Soil: formation, composition, types, texture, pH and conductivity. Garden tools and implements.

Preparation of nursery bed; manures and fertilizers - farm yard manure, compost, vermicompost, biofertilizers; chemical fertilizers - NPK; time and application of manures and fertilizers, foliar spray.

Irrigation methods - surface, sub, drip and spray irrigations - advantages and disadvantages - periodicity of irrigation.

Module 2: Propagation of plants (10 hrs)

Propagation of horticultural plants - by seeds; seed development and viability, seed dormancy, seed health, seed testing and certification. Growing seedlings in indoor containers and field nurseries, seed bed preparation, seedling transplanting; advantages and disadvantages of seed propagation.

Vegetative propagation - organs used in propagation - natural and artificial vegetative propagation; methods - cutting, layering, grafting and budding; advantages and disadvantages of vegetative propagation; micropropagation.

Module 3: Gardening (10 hrs)

Gardening - ornamental gardens, indoor gardens, kitchen gardens- terrestrial and aquatic gardens - garden adornments; garden designing; garden components - lawns, shrubs and trees, borders, hedges, edges, drives, walks, topiary, trophy, rockery; famous gardens of India. Landscape architecture - home landscape design, urban planning, parks, landscaping and public buildings, industrial and

highway landscaping. Physical control of plant growth - training and pruning - selection of plant, bonsai containers and method of bonsai formation.

Module 4: Floriculture (6 hrs)

Introduction, commercial floriculture - jasmine, orchid, anthurium, rose, gladiolus; production of cut flowers, quality maintenance, packing, marketing. Flower arrangements - basic styles - upright and slanting - japanese ikebana, dry flower arrangement.

Module 5: Olericulture (4 hrs)

Olericulture - types of vegetable growing - home gardens and market gardens; cultivation practices of leafy vegetable (Amarathus), tuber (Potato), fruit (Tomato), flower (Cauliflower).

Module 6: Pomology (4 hrs)

Pomology - cultivation of fruit crops - mango, banana and pine apple - preparation of land, spacing, planting, irrigation, hormones, harvest and storage. Factors affecting duration of storage. Principles of preservation - temporary and permanent - agents for fruit preservation. Preparation of pickles, jams, jellies and squashes using locally available fruits.

Module 7: Gardening – additional features (4 hrs)

Garden friends - honey bees, ladybirds, frogs, spiders, earthworms, centipedes and millipedes. Garden foes - pests, pathogenic fungi, bacteria, virus. Control measures - pesticides and fungicides; neem tobacco decoction. Hazards of chemical pesticides; equipments used in controlling horticultural pests - sprayers, dusting equipments - sterilization, fumigation.

Weeds - annual, perennial; weed control - prevention, eradication - hand weeding, tillage, burning, mowing, biological control, use of herbicides - selective and non selective - mechanisms involved in herbicidal actions.

NURSERY MANAGEMENT (6 hrs)

Module 1: Nurseries (6 hrs)

Nursery: definition, types; management strategies - planning, layout, budgeting - production unit, sales unit. Plant growing structures - green houses, fernery, orchidarium, arbetorium.

ON HAND TRAINING (18 hrs)

1. Preparation of potting mixture of known combination and potting in earthern pots/poly bags.
2. Preparation of nursery beds.
3. Preparation of compost/vermicompost using different substrates.
4. Working knowledge and identification of garden tools and implements.
5. Practical knowledge in different plant propagation techniques listed in syllabus.
6. Cultivation of a vegetable/ornamental plant/fruit crop listed in the syllabus.
7. Practice of different pruning operations (top dressing, shaping and topiary) in the following plants: (1) Bougainvillea (2) Phyllanthus.
8. Visit a well established nursery and submit report.

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Open course 3 Code: BO5OPT03
ECOTOURISM
(Theory 72 hrs; Credits 3)

Objectives:

- Make the students to opt various ecotourism programs in the self employment stream
- Make the students aware of the usefulness of ecotourism in the conservation of natural resources.
- Help the students to assess various ecotourism programs

Module 1: Introduction (4 hrs)

Definition, concept, introduction, history, relevance and scope.

Module 2: Key principles and characteristics of ecotourism (4 hrs)

Nature area focus, interpretation, environmental sustainability practice, contribution to conservation, benefiting local communities, cultural respect, customer satisfaction, responsible marketing.

Module 3: Components of Ecotourism (12 hrs)

Travel, tourism industry, biodiversity, local people, cultural diversity, resources, environmental awareness, interpretation, stake holders, capacity building in ecotourism.

Module 4: Ecotourism terms (10 hrs)

Adventure tourism, certification, commercialization chain, cultural tourism, canopy walkway, conservation enterprises, ecosystem, ecotourism activities, ecotourism product, ecotourism resources, ecotourism services, endemism, ecolabelling, ecotourism "lite", geotourism, greenwashing, stakeholders, sustainable development, sustainable tourism, leakages

Module 5: Ecotourism resources in India and Kerala (14 hrs)

Major ecosystems vegetation types and tourism areas in Kerala. Festivals and events, entertainment, overview, culture, famous destinations, sightseeing, historical monuments, museums, temples, national parks & wildlife sanctuaries, hill stations, waterfalls, rivers, reaches, wildlife watching and bird watching sites, agricultural sites, tribal areas, tribal museums, tribal arts, rural handicrafts, tribal medicines, archeological sites, adventure sports, sacred groves, mountains, etc.

Module 6: Forms of Ecotourism in India and Kerala (8 hrs)

Eco regions, eco places, waterfalls in Kerala and India, eco travel, dos and don't on eco travel, eco trips. Potential of ecotourism in Kerala. Community based ecotourism, ecotourism and NGOs.

Module 7: Ecotourism Planning (16 hrs)

Background, objectives, strategy, design of activities, target groups, opportunities, capacity building, threats, expectations positive and negative impacts, strength and weakness, benefits and beneficiaries,

stakeholders, linkages, economics, ecotourism auditing. Problems with ecotourism. Carrying capacity of ecotourism. ecotourism facilities – Green report card. Ecotourism management – issues.

Module 8: Ecotourism and livelihood security (4 hrs)

Community, biodiversity conservation and development – Eco-development committees.

REFERENCES

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SEMESTER VI

Core course 9 Code: BO6CRT09

GENETICS, PLANT BREEDING AND HORTICULTURE

(Theory 54 hrs; Practical 45 hrs; Credits 3 + 1)

Objectives:

- Imparting an insight into the principles of heredity
- Understand the patterns of inheritance in different organisms
- Understand the inheritance pattern of nuclear and extra nuclear genes
- Understand the methods of crop improvement
- Understand the importance of horticulture in human welfare
- Develop skill in gardening technique among students

GENETICS (Theory 27 hrs; Practical 27 hrs)

Module 1: Origin and development of Genetics (3 hrs)

Genetics as a science: origin - experiments of Mendel with *Pisum sativum*, general terminology used in genetics. Principles of inheritance, Mendelian laws - monohybrid and dihybrid cross, test cross and backcross.

Module 2: Exceptions to Mendelism (10 hrs)

Modification of Mendelian ratios: incomplete dominance - *Mirabilis*; Co-dominance - MN blood group in man; Lethal genes – pigmentation in Snapdragon..

Geneic interaction: epistasis, (a) Dominant - fruit colour in summer squashes (b) Recessive - coat colour in mice; Complementary genes - flower colour in sweet pea. Non-epistasis - comb pattern in Fowls. Multiple alleles – ABO blood groups in man; self sterility in *Nicotiana*.

Module 3: Linkage of genes (3 hrs)

Linkage and crossing over: chromosome theory of linkage; crossing over - types of crossing over, mechanism of crossing over. Linkage map - 2 point cross, interference and coincidence.

Module 4: Determination of sex (6 hrs)

Sex determination: sex chromosomes and autosomes; chromosomal basis of sex determination; XX-XY, XX-XO mechanism; sex determination in higher plants (*Melandrium album*). Sex linked

inheritance: X-linked - Morgan's experment e.g. eye colour in *Dorsophila*, Haemophilia in man; Y-linked inheritance; sex limited and sex influenced inheritance. Pedigree analysis.

Module 5: Quantitative inheritance (2 hrs)

Quantitative characters: polygenic inheritance, continuous variation - kernel color in wheat, ear size in maize.

Module 6: Extra-chromosomal inheritance (2 hrs)

Extra chromosomal inheritance: chloroplast mutation - variegation in 4O'clock plant; mitochondrial mutations in yeast. Maternal effects - shell coiling in snail; infective heredity - kappa particles in *Paramecium*.

Module 7: Population genetics (1 hr)

Concept of population, gene pool, Hardy-Weinberg principle (brief).

PRACTICAL (18 hrs)

1. Students are expected to work out at least two problems each from: monohybrid, dihybrid, back-cross and test cross; all types of modified Mendelian ratios mentioned in the syllabus.

PLANT BREEDING (Theory 13 hrs; Practical 9 hrs)

Module 1: Introduction to plant breeding (1 hr)

Introduction and objectives of plant breeding. Plant breeding centers in Kerala, their achievements – CPCRI, CTCRI, RRII.

Module 2: Plant introduction (2 hrs)

Plant introduction: domestication - centers of origin - procedure of plant introduction - quarantine regulations, acclimatization, agencies of plant introduction in India, major achievements.

Module 3: Selection (2 hrs)

Plant Selection: mass, pure-line, clonal.

Module 4: Hybridization (4 hrs)

Hybridization: types, procedure, important achievements. Heterosis in plant breeding, inbreeding depression, genetics of heterosis and inbreeding depression. Handling segregating generation - pedigree method, bulk method, back cross method. Disease resistance breeding.

Module 5: Mutation breeding and polyploidy breeding (2 hrs)

Mutation breeding: methods, applications and important achievements. Polyploidy breeding: methods and applications.

Module 6: Tissue culture as method in plant breeding (2 hrs)

Application of meristem culture, embryo culture and pollen culture in plant breeding. Role of tissue culture in the creation of transgenic plants.

PRACTICAL (9 hrs)

1. Emasculation and bagging.
2. Demonstration of hybridization in plants.
3. Estimation of pollen sterility/viability.

HORTICULTURE (Theory 14 hrs; Practical 18 hrs)

Module 1: Introduction (3 hrs)

Introduction to horticulture - definition, history. Classification of horticultural plants. Disciplines of horticulture - pomiculture, olericulture, floriculture, arboriculture.

Garden implements - budding knife, secateurs, hedge shear, hand cultivator, sprayers, lawn mower, garden rake, spade.

Irrigation methods: surface, sub, drip and spray irrigations; mist chambers - advantages and disadvantages.

Module 2: Plant propagation: (5 hrs)

Seed propagation: seed testing and certification, seed bed preparation, seedling transplanting, hardening of seedling; advantages and disadvantages of seed propagation. Vegetative propagation: natural and artificial; artificial methods - cutting, layering, grafting and budding, micro-propagation; advantages and disadvantages of vegetative propagation.

Module 3: Gardening (6 hrs)

Types of garden: brief study on ornamental garden, indoor garden, kitchen garden, aquatic garden, vertical garden, medicinal garden, terrace garden, terrarium.

Garden designing: garden components - lawns, shrubs and trees, borders, topiary, hedges, edges, walks, drives.

Physical control of plant growth: training and pruning. Bonsai - selection of plant - bonsai containers and method of bonsai formation.

Plant growing structures: green house, orchidarium, conservatory; Potting mixture – components.

PRACTICAL (18 hrs)

1. Approach grafting (demonstration only), budding (T, patch), air layering.
2. Identification of different garden tools and their uses.
3. List out the garden components in the photograph of the garden given.
4. Visit to established horticultural/agricultural/ornamental/kitchen gardens and observe the components there.

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Core course 10 Code: BO6CRT10

CELL AND MOLECULAR BIOLOGY

(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)

Objectives:

- Understand the ultra structure and functioning of cell in the sub-microscopic and molecular level.
- Get an idea of origin, concept of continuity and complexity of life activities.
- Familiarization of life processes.
- Understand the basic and scientific aspect of diversity.
- Understand the cytological aspects of growth and development.
- Understand DNA as the basis of heredity and variation.

CELL BIOLOGY (Theory 27 hrs; Practical 27 hrs)

Module1: Ultra structure of cell components (8 hrs)

Cell biology through ages: a brief history of cell biology. Cytosol - chemical composition. Composition, structure and function of plasma membrane - fluid mosaic model.

The ultra-structure of a plant cell with structure and function of the following organelles: Endoplasmic reticulum, chloroplasts, Mitochondria, Ribosomes, Dictyosomes, Microbodies - peroxisomes and glyoxisomes, lysosomes and vacuole. Cytoskeleton - microtubules and microfilaments.

Ultra structure of nucleus: nuclear envelope - detailed structure of pore complex, nucleoplasm - composition, nucleolus.

Module 2: Chromosomes (6 hrs)

Chromosomes: introduction, chromosome number, autosomes and allosomes, morphology - metacentric, submetacentric, acrocentric and telocentric. Structure - chromatid, chromonema, chromomere, centromere and kinetochore, telomere, secondary constriction and nucleolar organizer. Chromatin fibres: heterochromatin and euchromatin. Karyotype and ideogram.

Chemical composition of chromatin: histones and non-histones, arrangement of proteins and DNA in chromatin - the 10 nm fibre (nucleosome model), 30 nm fibre (solenoid model) and central axis with radial loops of 300 nm fibre.

Special type of chromosomes: giant chromosomes (salivary gland chromosomes, Lamp brush chromosomes), supernumerary chromosomes (B chromosome).

Module 3: Cell division (6 hrs)

Cell cycle - definition, different stages – interphase (G1, S and G2) and division phase. Mitosis: karyokinesis and cytokinesis, significance of mitosis. Meiosis: stages - first meiotic division (reduction division) and second meiotic (equational division), structure and function of synaptonemal complex, significance of meiosis; comparison of mitosis and meiosis.

Module 4: Chromosomal aberrations (4 hrs)

Numerical: heteroploidy; euploidy – haploidy; polyploidy – autopolyploidy, allopolyploidy (*Raphanobrassica*); aneuploidy - monosomy, trisomy (Fruit morphology in Datura), nullisomy (*Triticum*). Numerical chromosomal abnormalities in man: Down‘s syndrome, Klinefelter‘s syndrome, Turner‘s syndrome.

Structural: deletion (Cri-du-chat syndrome), duplication (Bar eye in Drosophila), inversions (paracentric and pericentric) and Translocations (Robertsonian translocation).

Module 5: Mutation (3 hrs)

Mutation: definition, importance. Types of mutations: somatic and germinal; spontaneous and

induced; chromosomal and gene or point mutations. Molecular basis of mutation: frame shift, transition, transversion and substitution. Mechanism of mutation induction: base replacement, base alteration, base damage, errors in DNA replication. Mutagens: physical - non-ionizing and ionizing radiations; chemical - base analogs, alkylating agents, deaminating agents.

PRACTICAL (27 hrs)

1. Make acetocarmine squash preparation of onion root tip to identify mitotic stages.
2. Study the mitotic index of onion root tip cells (Demonstration only).
3. Study of the different stages of meiosis and identification of different substages of prophase I using photomicrographs or pictures.
4. Identify and study the chromosomal anomalies, patterns and karyotype in man such as Down's syndrome, Turner's syndrome and Klinefelter's syndrome.

MOLECULAR BIOLOGY (Theory 27 hrs; Practical 9 hrs)

Module 6: The genetic material (8 hrs)

Molecular biology: a brief historical prelude. Identification of DNA as genetic material: direct evidences – transformation experiment by Avery *et al*.; Hershey and Chase Experiment. Evidences for RNA as genetic material in some viruses.

Nucleic acids: DNA and RNA, important features of Watson and Crick model of DNA; Chargaff's rule. Alternate forms of DNA - comparison of A, B and Z forms. Structure and function of different types of RNA - tRNA, mRNA, rRNA, snRNA, miRNA.

Module 7: Replication of DNA (4 hrs)

Semiconservative replication of DNA - Messlson and Stahl's experiment; process of semiconservative replication with reference to the enzymes involved in each step.

Module 8: Gene expression (8 hrs)

Gene expression: concept of gene, split genes, one gene one enzyme hypothesis, one gene one polypeptide hypothesis, the central dogma, reverse transcription. Details of transcription in prokaryotes and eukaryotes; hnRNA, splicing, release of mRNA. Translation - initiation, elongation and termination. Genetic code and its features, wobble hypothesis.

Module 9: Regulation of gene expression (5 hrs)

Regulation of gene expression in prokaryotes: operon concept, indicible and repressible systems, negative control and positive control. Lac operon, catabolic repression. Tryptophan operon, attenuation. Regulation in eucaryotes (brief account only).

Module 10: Genetics of cancer (2 hrs)

Genetic basis of cancer – brief description of proto-oncogenes and oncogenes, tumour suppressor genes; characteristics of cancer cells.

PRACTICAL (9 hrs)

6. Work out elementary problems based on DNA structure, replication, transcription and translation and genetic code.

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Core course 11 Code: BO6CRT11
ANGIOSPERM MORPHOLOGY, TAXONOMY AND ECONOMIC BOTANY
(Theory 72 hrs; Practical 45 hrs; Credits 3 + 1)

Objectives:

- Acquaint with the aims, objectives and significance of taxonomy.
- Identify the common species of plants growing in Kerala and their systematic position.
- Develop inductive and deductive reasoning ability.
- Acquaint with the basic technique in the preparation of herbarium.
- Familiarizing with the plants having immense economic importance.

ANGIOSPERM MORPHOLOGY

Module 1: Leaf, Inflorescence and Fruit morphology (13 hrs)

Leaf Morphology: types, venation, phyllotaxy. Morphology of flower: flower as modified shoot; detailed structure of flowers - floral parts - their arrangement, relative position - symmetry, aestivation and placentation types - cohesion and adhesion. Floral diagram and floral formula. Inflorescence: racemose types - simple raceme, corymb, umbel, spike, spadix, head and catkin; cymose types - simple cyme; monochasial - scorpoid and helicoid, dichasial and polychasial; special type - cyathium, hypanthodium, verticillaster, thyrsus and panicle. Fruits: simple - fleshy, dry - dehiscent, schizocarpic, indehiscent, aggregate, multiple (sorosis and syconus).

TAXONOMY

Module 2: Principles of Plant systematics (12 hrs)

Aim, scope, significance and components of taxonomy. Types of classification - artificial (brief account), natural – Bentham and Hooker (Detailed account) and Phylogenetic (Brief account). Angiosperm phylogeny group system (introduction only). Plant nomenclature - binomial, ICBN/ICN principles - rule of priority and author citation. Interdiciplinary approach in taxonomy -

Cytotaxonomy and Chemotaxonomy. Herbarium technique – importance of herbarium; preparation of herbarium and their preservation. Important herbaria in India, BSI.

Module 3: Detailed study of families (30 hrs)

Study the following families of Bentham and Hooker's System with special reference to their vegetative and floral characters; special attention should be given to common and economically important plants within the families: Annonaceae, Nymphaeaceae, Malvaceae, Rutaceae, Anacardiaceae, Leguminosae (Mimosaceae, Caesalpiniaceae and Fabaceae), Combretaceae, Myrtaceae, Cucurbitaceae, Umbelliferae (Apiaceae), Rubiaceae, Compositae (Asteraceae), Sapotaceae, Apocynaceae, Asclepiadaceae, Solanaceae, Convolvulaceae, Scrophulariaceae, Acanthaceae, Verbenaceae, Labiatae (Lamiaceae), Amaranthaceae, Euphorbiaceae, Orchidaceae, Palmae (Arecaceae), Graminae (Poaceae).

ECONOMIC BOTANY AND ETHNOBOTANY (Theory 9 hrs; Practical 9 hrs)

Module 4: Economic botany (12 hrs)

Study the following groups of plants with special reference to the botanical name, family and morphology of the useful part and uses: Cereals - Rice, Wheat; Millets Ragi; Pulses - Green gram, Bengal gram, Black gram; Sugar yielding plants – Sugarcane; Fruits - Apple, Pineapple, Orange, Mango and Banana; Vegetables - Bittergourd, Ladies finger, Carrot and Cabbage; Tuber crops - Tapioca; Beverages - Tea, Coffee; Oil yielding plants - Ground nut, Coconut, Gingelly; Spices – Cardamom, Pepper, Cloves, Ginger; Timber yielding plants - Teak wood and Rose wood; Fibre yielding plants - Coir, Jute, Cotton; Rubber yielding plants - Para rubber; Gums and Resins - White damer, Gum Arabic, Asafoetida; Insecticide yielding Plants - Tobacco and Neem.

Module 5: Ethnobotany (5 hrs)

Introduction, scope and significance of ethnobotany. Study of the following plants used in daily life by tribals and village folks for food, shelter and medicine: Food - *Artocarpus heterophylla*, *Corypha*; Shelter - *Bambusa*, *Ochlandra* and *Calamus*; Medicine – *Curcuma longa*, *Trichopus zeylanicus* and *Alpinia galanga.*

PRACTICAL (45 hrs)

1. Identify the following inflorescence and fruits with reference to their morphological specialities: (a) Inflorescence - simple raceme, spike, corymb, head, simple cyme, cyathium and hypanthodium. (b) Fruits - simple - (fleshy) - berry drupe, pepo, hespiridium. Dry indehiscent - nut. Dry dehiscent - legume, capsule (loculicidal). Aggregate.
2. Preparation of floral formula and floral diagram from floral description (of families studied).
3. Identify the families mentioned in the syllabus by noting their vegetative and floral characters.
4. Students must describe the floral parts, draw the L.S., floral diagram and write the floral formula of at least one flower from each family.
5. Prepare herbarium of 25 plants with field notes.
6. Conduct field work for a period of not less than 5 days under the guidance of a teacher and submit field report.
7. Study the finished products of plants mentioned in the syllabus of economic botany with special reference to the morphology of the useful part, botanical name and family.
8. Identify and describe the ethnobotanical uses of the items mentioned in the syllabus.

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Core course 12 Code: BO6CRT12
BIOTECHNOLOGY AND BIOINFORMATICS
(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)

Objectives:

- Understand the current developments in the field of Biotechnology and Bioinformatics.
- Equip the students to carry out plant tissue culture.
- Introduce the vast repositories of biological data knowledge.
- Equip to access and analyze the data available in the databases.

BIOTECHNOLOGY (36 hrs)

Module 1: Plant tissue culture (6 hrs)

Biotechnology - an overview; plant tissue culture - basic concepts, totipotency, differentiation, de-differentiation and re-differentiation. Tissue culture media: components, role of plant growth regulators in tissue culture. Preparation of MS medium; sterilization of equipments, glassware and culture medium, surface sterilization of explants.

Module 2: Applications of plant tissue culture (10 hrs)

Micropropagation, methods - axillary bud proliferation, adventitious regeneration – shoot organogenesis and somatic embryogenesis - direct and indirect; meristem culture. Stages of micropropagation, hardening and transplantation. Advantages and disadvantages of micropropagation - somaclonal variations. Embryo culture, callus and cell suspension culture, *in vitro* production of haploids - anther and pollen culture; uses of haploids. Protoplast culture: isolation of protoplast, culture methods, applications; protoplast fusion - cybrids. Artificial seeds, advantages and disadvantages. *In vitro* production of secondary metabolites; cell immobilization, bioreactors (brief study only).

Module 3: Recombinant DNA technology and its applications (10 hrs)

Steps in rDNA technology, cloning vectors and their desirable properties; plasmids, cosmids, phage vectors, Phasmids, YAC and BAC; structure and applications of pBR322, M13 and Ti plasmid. Cutting and joining of DNA molecules - Restriction endonucleases and ligases - ligation techniques. Transformation and selection of transformants - using antibiotic resistances markers and complementation.

Achievements of recombinant DNA technology: in medicine (Human insulin and gene therapy); in agriculture – Bt cotton; in environmental cleaning - super bugs.

Module 4: Techniques in rDNA technology (10 hrs)

DNA isolation, agarose gel electrophoresis, southern hybridization, autoradiography. DNA finger printing and its applications. PCR and its applications. DNA sequencing by Sanger's dideoxy method. Uses of refrigerated centrifuges, UV trans-illuminator, gel documentation system and Laminar Air Flow chamber (brief account only).

GENOMICS AND BIOINFORMATICS (18 hrs)

Module 4: Genomics (4 hrs)

A brief account on genomics and proteomics; major findings of the following genome projects – *E. coli*, Human, *Arabidopsis thaliana*.

Module 5: Basic bioinformatics (7 hrs)

An introduction to bioinformatics, objectives and applications of bioinformatics. Biological data bases: types - primary, secondary and composite databases; nucleotide sequence databases – NCBI (GenBank), EMBL, DDBJ; Protein Sequence databases - SWISS-PROT, PIR; Protein structure database – PDB; bibliographic database – PubMed.

Module 6: Sequence analysis and molecular phylogeny (7 hrs)

Sequence analysis tools - BLAST and FASTA, Molecular visualisation tool - RASMOL (basic commands), Sequence alignment - Scoring matrices, global and local alignment, Pairwise and multiple sequence alignment; common software used in alignment - CLUSTAL W & CLUSTAL X. Molecular phylogeny - homologs, orthologs and paralogs; phylogenetic tree - rooted and unrooted tree, advantages of phylogenetic tree, use of PHYLIP software.

PRACTICAL (36 hrs)

1. Preparation of nutrient medium – Murashige and Skoog medium (Demonstration only).
2. Sterilization and inoculation of plant tissue in culture media.
3. Establishing shoot tip, axillary bud cultures (Demonstration only).
4. Immobilization of whole cells or tissues in sodium alginate.
5. Isolation of DNA from plant tissue.
6. Agarose gel elecotrophoresis of the isolated DNA (Demonstration only).
7. Familiarise the instruments included in the syllabus such as Autoclave, laminar air flow chamber, UV- trans-illuminator, PCR machine, Electrophoresis apparatus, centrifuge etc. and prepare short notes with diagrammatic sketch or photographs.

8. Familiarizing GENBANK, DDBJ, ENA, SWISS-PROT and PDB databases (Demonstration only).
9. Analysis of structural features of proteins using RASMOL.
10. Local alignment of sequences using BLAST (Demonstration only).
11. Retrieving a few research papers related to genetic engineering from PubMed (Demonstration only).

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PROGRAMME ELECTIVE COURSES

Programme elective course 1 Code: BO6PET01

AGRIBUSINESS

(Theory 54 hours; Credit 3)

Objectives:

- Inculcate and impart an idea about the business opportunities in the field of plant sciences.
- Develop an entrepreneurial mindset and also to stick on to the core subject among the Botany students.
- Give an idea about the need of sustainable development and organic farming.
- Harness the opportunities and potentials in the field of ecotourism, processing technology and food sciences.

Module 1: Entrepreneurship (2 hrs)

Basic qualities of an Entrepreneur. Financial assistance from Banks, role of Institutions like MSME Training Institute, Khadi and village industries board, self help groups, Co-operative sector, Kudumbasree projects and microenterprises.

Module 2: Value added food products (8 hrs)

Preparation and preservation techniques, causes of spoilage of food. Principles of preservation - asepsis, removal of microorganisms, anaerobic situation and special methods - drying, thermal processing - pasteurization, sterilization and canning - low temperature, use of chemical preservatives

and food additives. Preparation of wine, vinegar, pickles, jam, jelly, syrups, sauce, dry fruits, dairy products - cheese, butter, yoghurt, paneer.

Module 3: Processing techniques (8 hrs)

Processing of latex: centrifuged latex products and galvanized rubber products. Processing, storage and marketing of Cocoa, Coconut (Copra ,Coir and Tender coconut), Rice (par boiled, raw rice and rice flour), Pepper, Cardamom, Ginger, Arrowroot, Tapioca, Cashew, Mango, Jack fruit, Guava, Grapes, Lemon, Papaya, Musa, Garcinia.

Module 4: Nursery management (6 hrs)

Preparation of potting mixtures, polybags. Plant growing structures - green houses, shaded houses, polyshed, mist chamber, sprinkling system, drip irrigation. Modern strategies in propagation by root initiation of cutting, layering technique, budding and grafting technique; micropropagation. Planting, transplanting and hardening of seedlings, after care of seedlings. Packing and transport of seedlings.

Module 5: Organic farming and composting techniques (6 hrs)

Organic manures and fertilizers, composition of fertilizers. NPK content of various fertilizers and preparation of fertilizer mixtures. Common organic manures - bone meal, cow dung, poultry waste, oil cakes, organic mixtures and compost. Preparation of compost - aerobic and anaerobic - advantages and limitations. Vermicompost - preparation; Vermiwash - preparation. Biofertilizers - definition and preparation of different types - Trichoderma, Rhizobium, PGPR, PSB, mycorrhiza. Application of biofertilizers. Biopesticides, Tobacco and Neem decoction. Biological control of disease and pests.

Module 6: Cultivation of vegetables, fruits and medicinal plants (6 hrs)

Types - home gardening, market gardening and truck gardening. Packing and transporting of vegetables. Organic farming of fruit crops - packing and transporting of fruits. Induction of flowering and weed control. Cultivation of medicinal and aromatic plants of common use and great demand.

Module 7: Floriculture and Apiculture (6 hrs)

Floriculture: problems and prospects of floriculture in Kerala. Scope of growing Anthurium, Orchids and Jasmine in Kerala. Common cut flowers - Rose, Gerbera, Gladiolus, Aster, *Chrysanthemum*, Anthurium and Orchids. Common leaves used in flower arrangement - *Cyprus, Podocarpus*, *Asparagus*, Palms, Cycads and Ferns.

Apiculture: scope and significance. Structure, installation and maintenance of an Apiarium. Extraction, processing, preservation and marketing of honey.

Module 8: Flower arrangement (4 hrs)

Types - Western, Eastern (Japanese/ Ikebana) and modern. Wases, flower holders and floral foam. Wase life of flowers and leaves. After care of flower arrangements – Bouquets. Packing and maintenance of flowers and leaves.

Module 9: Ornamental garden designing (4 hrs)

Garden components. Lawn preparation by seeds, seedling and turfing. Maintenance of garden by Irrigation, Pruning, Repotting. Disease and Pest control.

Module 10: Mushroom cultivation and farming (4 hrs)

Mushrooms: significance, nutritive value. Types of Mushrooms – Button – *Pleurotus, Volvorella*. Spawn production, storage and marketing. Growth of Mushrooms on paddy straw and saw dust by poly bag. Mushroom growing structures and maintenance of humidity. Pests and defects of mushrooms. Storage, transporting and marketing of mushrooms.

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Programme elective course 2 Code: BO6PET02

PLANT GENETIC RESOURCES MANAGEMENT

(Theory 54 hours; Credit 3)

Objectives:

- Acquaint the student with the history and evolution of crop plants, and their diversity.
- Familiarize the student with the available plant genetic wealth and the measures adopted for the conservation of these resources.
- Help the student to identify the crop plants and their wild relatives.
- Help the student to explore the potentialities of various underutilized plants to project as the future food prospects.
- Understand the significance of modern technology to locate the distribution of endangered species.

Module 1: Introduction (5 hrs)

Introduction - historical developments in crop botany, Centers of origin - Vavilovian concept - primary and secondary centers. Exploration and collection of genetic resources - importance of wild relatives of crop plants and their genetic diversity in crop improvement.

Module 2: Plant genetic resources (10 hrs)

Major threats to the genetic resources: human interference and deforestation, alien invasive plants, over exploitation of resources. Endemism and biodiversity hot spots. Conservation of genetic resources: in situ - biosphere reserves, national parks and wildlife sanctuaries; ex situ - in vivo - botanic gardens, field gene banks; in vitro - seed banks - short term, medium term and long term storage of seeds, tissue culture storage and cryopreservation.

Module 3: Study of biodiversity (5 hrs)

Remote sensing: principle, concept of remote sensing and components of remote sensing, application of remote sensing in conservation of endangered plants and habitat studies; IUCN - role and activities. Documentation of endangered and threatened plants - red data book.

Module 4: Ethnobotany and conservation (4 hrs)

Ethnobotany in relation to conservation of genetic resources: mythology and conservation of ecosystems, sacred groves and their role in the conservation of gene pool; taboos for conservation of selected plant species.

Module 5: Regulations and rules (4 hrs)

Role of Governmental and non-governmental organizations in plant genetic resource management; Governmental organizations - regional – TBGRI and KFRI; national - BSI and NBPGR; International – IPGRI (IBPGR) and ICRISAT; Non-Governmental Organizations - WWF and MNHS.

Module 6: Crop plants of Kerala (18 hrs)

Important Crop plants of Kerala - taxonomy and uses and cultivation of, food crops - Rice, Tapioca; Vegetables - Elephant foot yam, Cow pea, Bitter gourd; Spices. Ginger, Black pepper, Nutmeg, Cardamom; Medicinal plants - Vasaka, Aloe; Plantation crops – Rubber, Coffee; cashew, Coconut and Tea; Fruits - Banana, Pineapple and Mango.

Module 7: Unexploited and underutilized plants (9 hrs)

Underutilized plants and its importance for future food requirements. Botany and uses of the following under exploited edible plants - Vegetables - *Averrhoa bilimbi* (Bilimbi, Chemmeenpuli, Irumbampuli), *Averrhoa carambola* (Carambola apple, Chathurappuli), *Dioscorea esculenta* (Cherukizhangu, Nanakizhangu), *Canavalia gladiate* (Sword bean, Valpayar), *Psophocarpus tetragonolobus* (Winged bean, Chathurapayar), (Sessile joyweed), *Sauropus androgynus* (Velicheera, Chikurmanis, Sauropus), *Ipomoea turbinate* (Nithya Vazhuthana); Fruits; *Artocarpus heterophyllus* (Jack, Plavu, chakka), *Artocarpus hirsutus* (Anjili, Ayani, Wild jack), *Aporosa cardiosperma* (Vetti), *Spondias pinnata* (Ambazham, Hog plum), *Syzygium cumini* (Njara, Njaval, Black plum), *Flacourtia montana* (Kattuloovika). Millets - *Echinochloa crus-galli* (Barnyard grass, Indian Barnyard Millet)

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Programme elective course 3 Code: BO6PET03
PHYTOCHEMISTRY AND PHARMACOGNOSY
(Theory: 54 hours; Credit 3)

Objectives:

- Understand the structure and function of basic secondary metabolites in medicinal and aromatic plants.
- Familiarize with the common separation and characterization techniques used in phytochemistry
- Understand the basic officinal part present in the common medical plants and their use in ayurvedic formulations

PHYTOCHEMISTRY

Module 1: Introduction (2 hrs)

Introduction to phytochemical approaches: morphological, organoleptic, microscopic - to study drug and aromatic plants.

Module 2: Extraction of phytochemicals (4 hrs)

Extraction and chacterisation techniques: cold extraction, hot extraction - soxhlet-clevenger apparatus; Solvents - petroleum ether, chloroform, ethanol, water. Separation techniques - TLC, Column, HPLC. Characterization techniques - GC/MS, HPTLC, UV Spectra, IR Spectra.

Module 3: Effect of phytochemicals (10 hrs)

Study of the drug plants and their active principles. Alkaloids - introduction, properties, occurrence, structure, classification, functions, and pharmacological uses.
Triterpenoids. Introduction, properties, occurrence, classification, functions and pharmacological uses.
Phenolics. Quinines - benzoquinones, napthoquinones, anthraquinone, and coumarins.

Module 4: Plants of importance (20 hrs)

Study of the following plants with special reference to habit, habitat and systematic position and morphology of the useful part; organoleptic, anatomical and chemical evaluation of the officinal part; phytochemistry and major pharmacological action of plant drugs and ayurvedic formulations made using the plant: *Tinospora cordifolia, Papaver somniferum, Aegle marmelos, Punica granatum, Adhatoda vasica, Withania somnifera, Achyranthes aspera, Asparagus racemosus, Sida acuta, Carica papaya, Azadirachta indica, Phyllanthus neruri, Datura stramonium, Aloe veera, Tylophora indica,, Acorus calamus.*

Module 5: Aromatic plants and their uses (10 hrs)

Study of the following aromatic plants - volatile oils and methods of extraction *Vetiveria zizanoides, Cinnamomum zeylanica, Sysygium aromaticum, Santalum album, Eucalyptus, Ocimum bacilicum, Rosa, Mentha piperita, Cympopogon, Cananga, Pelargonium.*

PHARMACOGNOSY

Module 6: Pharmocognosy (4 hrs)

Introduction, tools for identifying adulteration; methods in pharmocognosy - microscopy, phytochemical methods - study of starch grains of maize, wheat, rice, potato, curcuma.

Module 7: Ethnomedicine (4 hrs)

Traditonal plant medicines as a source of new drugs – The process of modern drug discovery using ethnopharmacology – Taxol, Artemisinin, Galathamine and Flavopyridole as examples of drug discovery based on ethanopharmacological approach. Jeevani-Pushpangadan model of benefit sharing.

Suggested additional topics:

1. Basic principles in spectroscopy - UV, NMR, IR etc.
2. Use of secondary metabolites for protection against pathogens, herbivores.

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COMPLEMENTARY COURSES FOR MODEL I B Sc ZOOLOGY

SEMESTER I

Complementary course 1 Code: BO1CMT01
CRYPTOGAMS, GYMNOSPERMS AND PLANT PATHOLOGY
(Theory 36 hrs; Practical 36 hrs; Credits 2 + 1)

Objectives:

- Acquire fundamental knowledge in plant science and to make the student to understand that Botany is an integral part of the human life and developments.
- Foster and encourage an attitude of curiosity, appreciation and enquiry of various life forms of plants.
- Understand the identifying characters of the different types included in the syllabus.
- Understand the diversity of plants with respect to Algae, Fungi, Lichens, Bryophytes, Pteridophytes and Gymnosperms.

CRYPTOGAMS (27 hrs)

Module 1: Algae (13 hrs)

General characters of algae and their classification up to classes (F E Fritsch); range of thallus variation in Algae. Reproduction and life history of the following groups with reference to the types mentioned: Cyanophyceae - *Nostoc*; Chlorophyceae - *Oedogonium* (*Volvox*, *Spirogyra*, *Cladophora* - vegetative features only); Phaeophyceae – *Sargassum;* Rhodophyceae – *Polysiphonia.*

Economic importance of Algae: food, industry, medicine, biofertilizers; algal bloom.

Module 2: Fungi and lichens (9 hrs)

General characters and outline on the classification of fungi by Ainsworth. General characters, thallus structure, reproduction and life history of the following groups with reference to the types mentioned: Zygomycotina – Rhizopus; Ascomycetes – *Xylaria;* Basidiomycetes – *Puccinia.*

Economic importance of Fungi: as food, industry, decomposition of organic matter. Fungal toxins and human health.

Lichens: Classification based on thallus morphology. Usnea - morphology and anatomy of vegetative and reproductive structure. Economic importance of lichen: food, industry, medicine.

Module 3: Bryophytes (2 hrs)

General characters of Bryophytes. Morphology, anatomy, reproduction and life cycle of *Riccia*.

Module 4: Pteridophytes (3 hrs)

General characters of Pteridophytes. Morphology, anatomy (stem), reproduction and life cycle of *Selaginella*.

Module 5: GYMNOSPERMS (4 hrs)

General characters of Gymnosperms. Morphology, anatomy (leaf let), reproduction and life cycle of *Cycas*.

PLANT PATHOLOGY (5 hrs)

Module 6: Plant diseases (5 hrs)

Classification of plant diseases on the basis causative organism and symptoms. Study the following diseases with special emphasis on causative organism, symptoms and control measures:

(i) Nut fall of Arecanut (ii) Bacterial blight of Paddy (iii) Leaf mosaic of Tapioca.

PRACTICAL (36 hrs)

1. Micropreparation and identification preparation of the following:

(i) Algae: vegetative structure of *Nostoc*, *Volvox*, *Spirogyra*, *Oedogonium*, *Cladophora*, *Polysiphonia*. Vegetative and reproductive structure of *Sargassum*.

(ii) Fungi: vegetative and reproductive structure of *Rhizopus*, *Xylaria*, *Puccinia*.

(iii) Lichen: morphology of Usnea thallus and Apothecium.

(iv) Bryophytes: *Riccia* thallus anatomy.

(v) Pteridophytes: *Selaginella* - anatomy of stem and morphology of strobilus.

(vi) Gymnosperms: *Cycas* - Anatomy of leaflet, morphological features of megasporophyll, microsporophyll and ovule.

2. Identify plant diseases mentioned in the syllabus.

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8. Gangulee H C, Kar A K, 1993. College Botany Vol. II. New Central Book Agency, Calcutta.
9. Kanika Sharma, 2009. Manual of Microbiology. Ane Books Pvt. Ltd.
10. Mamatha Rao, 2009. Microbes and Non-flowering plants: Impact and applications. Ane Books Pvt. Ltd.
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14. Pandey B P, 2007. College Botany Vol. II. S Chand and Company.
15. Sharma P D, 2003. Microbiology, Plant Pathology and Biotechnology. Rasthogy Publications.
16. Vasishta B R. Bryophyta. S Chand and Co. New Delhi.

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SEMESTER II

Complementary course 2 Code: BO2CMT02

PLANT PHYSIOLOGY

(Theory 36 hrs; Practical 36 hrs; Credits 2 + 1)

Objectives:

- Make the students realize the importance of all physiological processes which take place in plants.
- Understand the mechanism of various physiological processes related to plant life.

Module 1: Water relations (11 hrs)

Plant water relations: Physical aspects of water absorption - Diffusion, DP, DPD. Imbibition. Osmosis - OP, Exosmosis, Endosmosis, Plasmolysis. Water potential and its components. Mechanism of water

absorption by root - active and passive absorption. Movement of water towards xylem by apoplast and symplast pathway. Ascent of sap – theories - transpiration pull theory, root pressure theory; guttation.

Transpiration: types, mechanism of transpiration and stomatal movement (K^+ - ABA theory), significance and factors affecting transpiration, antitranspirants.

Module 2: Mineral nutrition (4 hrs)

General account on Micro and macro nutrients. Absorbable form, function and deficiency symptoms of the following mineral nutrients: N, P, K, Mg, B, Fe, Zn.

Module 3: Photosynthesis and translocation of photosynthate (15 hrs)

Basic requirements of Photosynthesis: Light - PAR; organs and site of photosynthesis; chloroplast. Photosynthetic pigments, photosynthetic unit; red drop and Emerson's enhancement effect; two pigment systems.

Mechanism of photosynthesis: light dependent reaction - cyclic and non cyclic photo phosphorylation. Light independent reaction (dark reactions) C3 cycle, brief account on C4 and CAM Cycles. Factors affecting photosynthesis. Photorespiration (brief study only).

Translocation of photosynthate and organic solutes: path of translocation, mechanism of translocation (Pressure Flow Hypothesis).

Module 4: Growth and Development (6 hrs)

Seed dormancy - causes of seed dormancy - methods of breaking dormancy. Germination of seeds - physiological changes. Growth: Phases of growth, plant growth regulators - auxins, gibberellins, cytokinins, abscissic acid and ethylene and their physiological role (brief study only). Photoperiodism - definition, short day plants, long day plants, day neutral plants. Vernalization.

PRACTICAL (36 hrs)

Core Experiments:

1. Demeonstration of osmosis using potato tuber osmoscope/Papaya petiole osmoscope.
2. Separation of leaf pigments by paper chromatography.
3. Compare the stomatal indices of hydrophytes and xerophytes.

Demonstration experiments:

1. Measure the rate of transpiration by Ganong's potometer.
2. Relationship between transpiration and absorption.
3. Measurement of growth using Arc Auxanometer.
4. Demonstration of geographic curvature using Clinostat.
5. Evolution of oxygen during photosynthesis.
6. Mohl's half leaf experiment.
7. Light screen experiment.

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2. Jain V K, 2008. Fundamentals of Plant Physiology. S Chand and Co.
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4. Kumar and Purohit. Plant Physiology: Fundementals and Applications. Agrobotanical Publishers.
5. Malik C P, 2002. Plant Physiology. Kalyani publishers.
6. Mukherjii S, Ghosh AK, 2005. Plant Physiology. New Central Book Agency, Culcutta.
7. Noggle G R, Fritz G J. Introductory Plant Physiology. Prentice Hall of india.
8. Pandey S N, Sinha B K, 2006. Plant physiology. Vikas Publishing House, New Delhi.
9. Salisbury F B, Ross C W, 1992. Plant Physiology. CBS publishers and Distributers, New Delhi.

10. Sinha A K, 2004. Modern Plant Physiology. Narosa publishing House, New Delhi.
11. Srivastava H S, 2004. Plant physiology and Biochemistry. Rasthogi publications.
12. Verma V, 2007. Text Book of Plant Physiology. Ane Books Pvt. Ltd.
13. Verma S K, Mohit Verma, 2006. A Text book of Plant physiology, Biochemistry and Biotechnology. S Chand and Co.

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SEMESTER III

Complementary course 3 Code: BO3CMT03
ANGIOSPERM TAXONOMY AND ECONOMIC BOTANY
(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)

Objectives:

- Acquaint the student with the objectives and components of Taxonomy.
- Help the student to understand the systems of classification of angiosperms.
- Help the student to identify the common angiosperm species of Kerala.
- Familiarize the student with plants of immense economic importance.

ANGIOSPERM TAXONOMY (36 hrs)

Module 1: Morphology (10 hrs)

Leaf - simple, compound; venation and phyllotaxy. Flower as a modified shoot, structure of flower - floral parts, their arrangement, relative position; cohesion and adhesion of floral parts, symmetry of flowers; types of aestivation and placentation; floral diagram and floral formula. Inflorescence: racemose - simple, spike, spadix, catkin, corymb, umbel and head; cymose - simple, monochasial-helicoid and scorpoid; special types – cyathium, verticillaster. Fruits: outline on the classification; Simple: Fleshy - drupe, berry, hesperidium; Dry - Dehiscent - legume, capsule; Indehiscent - Caryopsis, Cypsella, Schizocarpic - lomentum, carcerulus, regma, cremocarp with examples. Aggregte. Multiple: sorosis, syconus. (Examples should be from families prescribed in the syllabus).

Module 2: Plant classification and Herbarium techniques (8 hrs)

Importance of plant classification, types of classification - artificial, natural and phylogenetic (brief account only); binomial nomenclature; ICBN (Brief account only). Bentham and Hooker‘s system of classification (up to series) and its merits and demerits. Cytotaxonomy and chemotaxonomy (brief account only). Herbarium techniques; importance of herbarium.

Module 3: Angiosperm families (18 hrs)

Study of the following families of Bentham and Hookers system of classification with special reference to major identifying characters and economic importance: Annonaceae, Malvaceae, Rutaceae, Leguminosae (Mimosaceae, Caesalpiniaceae and Fabaceae), Apiaceae (Umbelliferae), Rubiaceae, Asteraceae (Compositae), Apocynaceae, Lamiaceae (Labiatae), Euphorbiaceae, Arecaceae (Palmae), Poaceae (Gramineae).

ECONOMIC BOTANY (18 hrs)

Module 4: Classes of economically important plants (10 hrs)

Classification of economically important plants based on their uses. Study of the following groups of plants with special reference to their botanical name, family, morphology of useful part, economic products and uses: Cereals - Paddy, Wheat; Pulses - Green gram, Bengal gram; Tuber crops -

SEMESTER-I

Semester I Core course BO 1 Code: BO1CRT01

METHODOLOGY OF SCIENCE AND AN INTRODUCTION TO BOTANY

(See model I syllabus)

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Semester I Core course BT 1 Code: BOBT1CRT01

OPERATING SYSTEMS AND OFFICE AUTOMATION

(Theory 36 Hours; Practical 36 Hours; Credits 2 + 1)

Objectives:

- To understand the basic operation systems of the Computer and Office Automation.
- To access information in advanced biological sciences using internet
- To develop essential computer skills to solve biological problems
- To apply algorithmic principles to solve biological problems.

Theory (36 Hours)

Module1: Introduction to computers (3 hrs)

Input and output devices. Storage devices: Hard Disk, Diskette, Digital tape, CD – ROM, DVD (capacity and access time). Main Circuit board of a PC: chips, Ports Expansion slots. Memory: Register, buffer, RAM, ROM, PROM, EPROM, EEPROM. Types of processing: Batch, Real time, online, offline

Module 2: History – Evaluation, Generation of computers I, II, III, IV, V (2 hrs)

Classification of computers (Main Frames, mini computers, microcomputers, special purpose) - Comparison with respect to memory, power, cost, size. Modern computers: The mini computers, Main Frame computers, parallel processing computer and the super computer.

Module 3: Introduction to operating systems (5 hrs)

Operating system concept. Windows 98/XP. Windows server NT / 2007. Unix/ Linux and servers.

Module 4: Data processing and presentation (7 hrs)

Introduction. MS Office (Word, Excel, Power Point).

Module 5: Computer viruses (1 hr)

An overview of computer viruses. What is a virus? Virus symptoms, How do they get transmitted? What are the dangers? General Precautions.

Module 6: Computer Networking (4 hrs)

Introduction to networking: Various terminologies, Associated hardware device, gadgets (Router, Switch etc) tools, services and resource. Network topologies and protocols: LAN, WAN and MAN World Wide Web www, Network security: Fire walls.

Module 7: Internet searches (3 hrs)

Search Engines: Google, Yahoo etc. Concept of text based searching. Searching Medline, bibliographic databases.

Module 8: Algorithms, Flow charts and Programming concepts (6 hrs)

Algorithms: Concepts and Definition. Converting Algorithms to Flow charts. Coding: Flow charts to programmes. Comparing algorithms, flow charts and programs.

Module 9: Data Bases (5 hrs)

Introduction and need of databases; Types of Databases. Basic concepts in Data Abstraction, Data models, Instances and schemes, ER Model, Network data model (Basic concepts), Hierarchial data Model (Basic concept), multimedia data bases (Basic concepts and Applications). Text databases, Overview of biological databases.

PRACTICAL (36 hrs)

1. Computer – Getting familiar with hardware, booting and operating
2. Operating Systems – DOS, Windows 98/XP, UNIX etc.
3. File handling: copy, rename, delete type etc.
4. Directory: Structure, make, rename, move directory
5. Scanning of viruses and using antivirus programme.
6. Word processing (Microsoft word) Creating, saving and operating a document, editing, inserting, deleting, formatting, moving, copying text, Find and replace, spell checker, Grammar checker.
7. Document Enhancement (Borders, Shading, Header, Footer) Printing Document (Page Layout, Margins)
8. Introduction to the use of wizards and templates, working with graphics (Word Art), Working with table, charts, inserting files (Pictures, Databases, and Spreadsheets)
9. Use of internet – Downloading and installing software / programme on Windows 98/ XP, (Acrobat Rader, Post Script viewer etc)
10. Searching, Surfing on the www
11. Spread sheet application (Microsoft Excel)
12. Worksheet Basics: Entering information in a worksheet, saving and opening a worksheet, editing, copying, moving data, inserting, deleting, moving column and rows, clearing and formatting cells, printing worksheet
13. Usage of multimedia –Creation of computer presentation with graphics (Microsoft Power Point) Creation of slides, photoshop, Rapid presentation design using wizard.

REFERENCES

1. Introduction to computers, Data processing and networking
2. Computer fundamentals – PK Singha
3. Introduction to Bioinformatics – Artwood

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Semester I Core course BT 2 Code: BOBT1CRT02

CELL BIOLOGY, DEVELOPMENTAL BIOLOGY AND EVOLUTION

(Theory 54 Hours; Practical 18 Hours; Credits 2 + 1)

Objectives:

- To understand the ultra structure and functioning of the cell at submicroscopic and molecular level.
- To provide an idea of origin, concept of continuity and complexity of life activities.
- To appreciate developmental biology as one of the most exciting areas of contemporary biology.
- To understand the concept of unification of genomic, developmental, organismal, population and natural selection approaches to evolutionary change.
- To understand the process of evolution this acts through inherited changes in the development of organism.
- To relate embryonic development with life history evolution, adaptation and responses to and integration with environmental factors.

CELL BIOLOGY (27 hrs)

Module 1: History of cytology (9 hrs)

Historical account of cell biology: Cell theory and protoplasm theory, Cell: Physio-chemical nature of plasma membrane and cytoplasm, prokaryotic and eukaryotic cell. structural organization and function of intracellular organelles – cell wall, nucleus, mitochondria, ribosome, dictyosomes, microbodies, golgibodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure and function of cytoskeleton and its role in motility.

Module 2: Chromosomes (10 hrs)

Chromosome morphology - fine structure, Dupraw model, Nucleosome model; chemical organization of nucleosome-nucleoproteins, karyotype and idiogram. Special types of chromosomes- salivary gland, lampbrush and B chromosome.

Organization of genes and chromosomes: operon, interrupted genes, structure of chromatin and chromosomes, unique and repetitive DNA, heterochromatin, euchromatin, transposons.

Numerical aberrations of chromosomes - Aneuploidy and euploidy. Structural aberrations of chromosomes - deletion, duplication, inversion and translocation and their meiotic behaviour.

Mutations: spontaneous and induced. Mutagens - physical and chemical mutagens. Chromosomal and point mutations. Molecular mechanism of mutation: transition, transversion and substitution.

Module 3: Cell division and cell cycle (8 hrs)

Cell division and cell cycle: mitosis and meiosis, cell cycle regulation, steps and control of cell cycle. Stem cells - definition, sources and applications. Interaction of cells with their environment, cell signaling.

DEVELOPMENTAL BIOLOGY (18 hrs)

Module 4: Introduction (4 hrs)

Introduction to developmental biology: basic concepts of development, potency, commitment, specification, induction, competence, determination and differentiation; genomic equivalence and cytoplasmic determinants: imprinting mutants and transgenics in analysis of development.

Module 5: Gametogenesis (14 hrs)

Gametogenesis, fertilization and early development: Animal development: oogenesis, fertilization, embryonic cleavage divisions: blastulation, gastrulation and morphogenesis; Development of model organisms – Drosophila and Caenorhabditis; maternal and zygotic gene activity in development.

Plant development: microsporogenesis and megasporogenesis; Embryogenesis (brief account only), establishment of symmetry in plants, seed formation and development of seedling, shoot and root meristem, leaf development, development of model organism – Neurospora and Arabidopsis.

EVOLUTION (9 hrs)

Module 6: NeoDarwinism, Molecular evolution (9 hrs)

Neo Darwinism - Reproductive isolation, mutation, genetic drift, speciation. Variation and evolution, hybridization and evolution, polyploidy and evolution. Mutation and evolution. Molecular evolution: concepts of neutral evolution, molecular divergence and molecular clocks; molecular tools in phylogeny: classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence. Paleontological evidences: Geological time scale; eras, periods and epoch; major events in the evolutionary time scale; origin of organisms: major groups of plants and animals; stages in primate evolution.

PRACTICAL (18 hrs)

1. Examination of different kinds of cells - Prokaryotic and eukaryotic cell
2. Blood grouping
3. Cell counting methods:
4. Haemocytometer: WBC, RBC
5. Differential counting using Leishman's stain
6. Micrometry: Calibration using ocular micrometer, Finding out average cell size
7. Squash Preparation, Study of mitotic stages.
8. Measurement of Chromosome length.
9. Staining of mitochondria.

REFERENCES

1. Lodish et al.2004. Molecular Cell Biology. (Scientific American Book)
2. Eduard Gasque – "Manual of Laboratory Expts in Cell Biol." W. C. Wilson Pub.
3. Alberts et al. 2002. The Biology of the Cell
4. Cooper & Hausman .2004. The Cell – A Molecular Approach
5. Maheaswari, P. 1950. An introduction to embryology of Angiosperms. Mc Graw Hill.
6. Balinsky, B.I., 1965. An Introduction to embryology, W.B. Saunders company
7. Bodemer, L.W., 1968. Modern Embryology, Winston Inc. USA
8. Dodd H I, Dodd J M, 1978. The biology of metamorphosis, In Physiology of amphibia, Vol. 3. Academic press, N.Y
9. Gilbert, S.F., 1997. Developmental Biology, 5th Edn, Sinauer, Associates, Massachusettes.
10. George, M. Malacinski (ed) 1988. Developmental genetics of higher organisms, Macmillan Publishing Co.
11. Tamarin, R., 1991, Principles of Genetics, 3rd edition.
12. Vasudeva Rao, 1994. Developmental Biology: A modern synthesis, Oxford & IBH, New Delhi
13. De Robertis, E.D.P. and Robertis, E.M.F. 1991. Cell and molecular biology. Lea and Febiger
14. Dobzhansky, B. 1961. Genetics and the origin of species. Coloumbia University Press. NY.

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SEMESTER-II

Semester II Core course BO 2 Code: BO2CRT02

MICROBIOLOGY, MYCOLOGY AND PLANT PATHOLOGY

(See model I syllabus)

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Semester II Core course BT 3 Code: BOBT2CRT03

BIOPHYSICS AND INSTRUMENTATION

(Theory 54 Hours; Practical 18 Hours; Credits 2 + 1)

Objectives:

- To understand rules, principles and models of atomic structure.
- To develop skills in separating different biomolecules.
- To apply various spectroscopic methods to characterize biomolecules.

Module 1: Atomic structure (5 hrs)

Historical account, significance 2nd and 3rd postulate of Bohr's model, derivatives of radius and energy value. Quantization of energy levels. Using Rydburg's constant, atomic spectra in signature of the element. Bohr-sommerfeld model. Vector atom model, quantum numbers. Selection rules. Paulis exclusion principles. Emission spectra with respect to NA atom to understand selection rules.

Module 2: Spectroscopy (12 hrs)

Definition - Electromagnetic wave, electromagnetic spectrum, application of each region of EM spectrum for spectroscopy. Introduction to molecular energy levels, excitation, absorption, emission. Rotational spectra. Energy levels of rigid diatomic molecules. Vibrational and rotational spectra. Energy levels of diatomic vibrating molecules, rotational vibrational spectroscopy, IR spectroscopy, principle, constructing and working of IR spectrometer. Application of IR spectroscopy to biomolecules. Electro spectroscopy: UV-Visible spectroscopy: Principle, construction and working of colorimeter, spectrophotometer and fluorometer, Application to biomolecules (proteins, DNA, Hb, chlorophyll), Raman Spectra.

Module 3: Radioactivity (10 hrs)

Nucleus - properties. Nuclear forces. Nuclear models (liquid drop and shell model), radioactive nucleus. Revision of nuclear radiation and their properties - alpha, beta and gamma. Half-life - physical and biological. Handling and standardization of alpha, and beta emiting isotopes. Radioimmunoassay, Radiopharmaceuticals and its uptake - dosimetry and detection Principle-construction and working of pen and batch dosimeter. GM counter, Scintillation counter (solid and liquid).

Module 4: Thermodynamics as applied to biological system (5 hrs)

Enthalpy, entropy, free energy, Gibb's free energy (G), Helmholtz free energy (A). Chemical potential, half cell potential. Redox potential, structure and bioenergetics of mitochondria and chloroplast.

Module 5: Cell membrane (8 hrs)

Organization of plasma membrane, Mass transport, diffusion, basics, passive and active transport, membrane potential. Nernst equation. Passive electrical properties of cell (capacitance and resistance). Active electrical properties. Electrical model (equivalent) of cell membrane. Depolarization,

hyperpolarization of membrane (neuronal). Generation of active potential. Types of biopotentials. Biopotential measurement instruments.

Module 6: Thermoregulation (2 hrs)

Thermometric properties and types of thermometers (clinical, thermocouple, bimetallic, platinum resistance, thermistor-thermometers). Body temperature and its regulation.

Module 7: Bioinstruments (6 hrs)

Concepts - analytical techniques, analytical method, procedure and protocol, principle construction, working and application for analysis of biomolecules of following instruments: pH meter, centrifuge (RCF, sedimentation concept),different types of centrifuges, Mass spectroscopy (Bainbridge mass spectrometer), Atomic absorption spectrometer (AAS), Nuclear magnetic resonance spectrometer (NMR), XRD.

Module 8: **Electron microscope (6 hrs)**

Concept of vacuum working electron gun, construction and working of SEM, TEM, STEM, sample preparation.

PRACTICAL (18 hrs)

1. Spectral properties (Colorimetric or UV/Visible Spectral analysis of colouring pigments- Beta cyanin, Anthocyanin, Xanthine, Lycopene, Curcumin, capsicin)
2. Separation Techniques: Chromatography (PC, TLC and Column), GC & HPLC, HPTLC (Demonstration only).
3. Electrophoretic separation of protein.

REFERENCES

1. Perspective of Modern Physics - Arthur Beisen (Mc Graw Hill)
2. Nuclear Physics: an introduction: SB Patel (New Age International)
3. Introduction to Atomic Spectra: HE White (Mc Graw Hill)
4. Text Book of optics and atomic physics: P P Khandelwal (Himalaya publications)
5. Molecular Cell Biology: Lodish, Berk, Matsudora, Kaiser, Kriegen (WH Freeman and Co.)
6. Biophysics: Cotrell (Eastern Economy Edition).
7. Clinical Biophysics: Principles and Techniques: P Narayanan (Bhalani Publ., Mumbai).

Biophysics: Pattabhi and Gautham.

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Semester II Core course BT 4 Code: BOBT2CRT04

MOLECULAR BIOLOGY AND METHODS IN MOLECULAR BIOLOGY
(Theory 54 Hours; Practical 18 Hours; Credits 2 + 1)

Objective:

- To familiarize with the genetic make up and control of cells at molecular level
- To familiarize with the modern tools and techniques associated with molecular biology research

Module 1: Identification of DNA as genetic material (4 hrs)

Introduction to heredity and the genetic material, characteristics of genetic material, the molecular basis of heredity, Early studies of DNA [works of F. Miescher, Albert Kossel, Phoebus Levene, Erwin Chargaff] DNA as the source of genetic information. The discovery of transforming principle

[Griffith's experiment], Identification of the transforming principle [Avery, MacLeod and McCarty's experiment]; [Hershey and Chase experiment], Watson and Crick's discovery of the structure of DNA, discovery of RNA as the genetic material in some viruses [Heinz Fraenkal-Conrat's experiment].

Module 2: DNA structure (3 hrs)

The structure of DNA, Primary structure; structure of ribose and deoxyribose sugars, Structure of N bases, structure of nucleosides and nucleotides, phosphodiester bond and structure of a polynucleotides, Secondary Structure; structure of DNA double helix, different secondary structures [A, B and Z] , circular DNA.

Module 3: Replication of DNA (10 hrs)

Suspected forms of DNA replication, conservative, dispersive and semi conservative, Meselson and Stahl's experiment. Requirements for replication; template, raw materials, enzymes and other proteins,direction of replication, mechanism of replication, Bacterial DNA replications, bacterial DNA polymerase, eukaryotic DNA replication, DNA polymerase, location of replication within the nucleus, DNA synthesis at the ends of chromosomes, telomerases. Modes of replication, theta replication, rolling circle replication, linear eukaryotic replication. Recombination; Holliday model, enzymes required for recombination.

Module 4: Gene expression (16 hrs)

Transcription, the structure of RNA, types of RNA, mRNA, tRNA, rRNA, snRNA, snoRNA, miRNA, requirements for transcription, the subscribed and unsubscribed strands of DNA, experiments by Julius Marmu, transcription factors.

Promoters; bacterial and eukaryotic, RNA polymerase; bacterial and eukaryotic, the process of bacterial transcription, the process of eukaryotic transcription, RNA processing; split genes, exons, introns (group I, II and nuclear types).

Messenger RNA, early studies of mRNA, Brenner, Jacob and Meselson's experiment, Pre-mRNA processing in eukaryotes, addition of 5' cap and 3' polyA tail, RNA splicing, spliceosome, the process of splicing in different groups of introns, nuclear location of splicing, mRNA editing, guide RNAs (gRNAs). Structure of tRNA, modified bases in tRNA, clover leaf model of tRNA, tRNA genes structure and processing, rRNA; rRNA gene structure and processing, small interfering RNAs, experiment of Fire and Mellow, RNA interference (RNAi).

Translation, the genetic code, breaking the genetic code, experiments of Nirenberg and Matthaei and Nirenberg and Leder, Contributions of H G Khorana in connection with the breaking of the genetic code, characteristics of the code, The process of translation, polyribosomes, RNA-RNA interaction in translation, mRNA surveilence; non-sense mediated mRNA decay, non-stop mRNA decay, stalled ribosome, translation inhibitors.

Module 5: Control of gene expression (4 hrs)

Gene regulation, principles of gene regulation, levels of gene control, gene regulation in bacterial cells; operon concept, negative and positive control, inducible and repressible operons, *lac* operon of E.coli, *trp* operon of *E.coli*, attenuation and anti-termination. Gene regulations in eukaryotes; chromatin structure, DNase I hypersensitivity, histone acetylaltion, DNA methylation, Alternative splicing of mRNA, RNA silencing.

Module 6: Mutation and repair of DNA (4 hrs)

Mutations, definition, importance of mutation, Types of mutations, gene mutations, types of gene mutations, causes of mutations, DNA repair, mismatch repair, direct repair, base-excision repair, nucleotide excision repair, photoreactivation, SOS response.

Module 7: Genetics of Cancer (4 hrs)

Cancer genetics, the nature of cancer, cancer as a genetic disease, role of environmental factors in cancer, genetic changes that contribute to cancer, oncogenes and tumor suppressor genes, changes in

chromosome number and structure, genomic instability, DNA repair genes, changes in patterns of DNA methylation, genes that promote vascularisation and the spread of tumors.

Module 8: Methods in Molecular Biology (9 hrs)

DNA sequencing; Sanger's dideoxy method, working of automated DNA sequencer, Gene synthesis; work of Khorana, working of automated nucleic acid synthesizer Polymerase chain reaction; An Overview ,Components and Conditions for PCR Optimization, Primer Design, Isolation of Nucleic Acids for PCR Amplification, Site-Directed Mutagenesis by PCR, Restriction Enzyme Analysis of PCR Products, Cloning of PCR Products, Symmetric PCR, Asymmetric PCR, Inverse PCR, Anchored PCR, RT-PCR, RT-PCR Applications Research Applications of PCR, Non-isotopic Probe Synthesis and Detection by Chemiluminiscence RAPD, RFLP, AFLP, DNA finger printing, DNA foot printing.

PRACTICAL (18 hrs)

1. Isolation of plant genomic DNA
2. Quantification of DNA
3. Isolation of plasmid DNA
4. Documentation of DNA by agarose gel electrophoresis

REFERENCES

1. Molecular biology of the gene, JD Watson, 2007, Addison-Wesley
2. Molecular Biology, RF Weaver, 2007, McGraw Hill
3. Biochemistry and molecular biology, TA Swanson, 2006, Lippin Cott Williams & Wilkins
4. Laboratory investigation in cell and molecular biology, A Bergman, 2001, John Wiley and sons
5. Molecular Biology of cancer: mechanisms, target and therapeutics, L pecorino, 2005, Oxford University press.

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SEMESTER III

Semester III Core course BO 3 Code: BO3CRT03

PHYCOLOGY AND BRYOLOGY

(See model I syllabus)

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Semester III Core course BT 5 Code: BOBT3CRT05

MICROBIOLOGY AND MICROBIAL BIOTECHNOLOGY

(Theory 54 Hours; Practical 36 Hours; Credits 3 + 1)

Objectives:

- To identify different types of microbes and their crucial roles in various bioprocesses
- To apply various microbial processes/systems/activities, which have been used for the development of industrially important products/processes.

MICROBIOLOGY (39 hrs)

Module 1: (3 hrs)

Definition Brief classification of microbes: bacteria, archaea, protozoa, algae, fungi, viruses History of microbiology, Golden age of microbiology, Germ theory, Koch's postulates. Economic importance of microbes

Module 2: (8 hrs)

Observing microorganisms Microscopy: compound light microscope, darkfield microscope, phase contrast microscope, fluorescent microscope, confocal microscope, scanning electron microscope, transmission electron microscope, scanning acoustic microscope. Preparing smears for microscopy. Staining, differential staining, Gram staining, acid fast staining, special stains, negative staining for capsules, endospore staining, flagella staining. Morphology of bacteria Size range of bacterial cells, shape and arrangement of bacterial cells. Methods to classify bacteria: biochemical methods, serological testing, phage typing, fatty acid profiling using FAME, ribotyping and rRNA sequencing Bergey's manuel, examples and characteristics (brief account) of gram negative bacteria, gram positive bacteria, bacteria with unusual properties, gram positive filamentous bacteria with complex morphology Structure of bacterial cell Structures external to cell wall: Glycocalyx Cell wall: composition, structure, function, cell wall and Gram staining mechanism. Flagella: structure of flagella, different types of arrangements of flagella. Fimbriae and pili. Structures internal to cell wall. Plasma membrane, composition, structure and function Spheroplast, cytoplasm, ribosome, nucleoid, plasmid, inclusions, endospores.

Module 3: (12 hrs)

Culturing Bacteria, Nutritional requirements, nutritional types of bacteria: phototrophs, chemotrophs, autotrophs, heterotrophs, obligate parasites, Bacteriological Media: selective media, differential media, media for characterization of bacteria, Solid and semi solid media, broth, Physical conditions required for growth: temperature, pH, oxygen, cultivation of aerobic and anaerobic bacteria, candle jar, anaerobic jar, CO_2 generating packet, CO_2 incubator, Batch culture, continuous culture, enrichment culture, pure culture, methods to obtain pure culture: streak plate method, serial dilution method, use of special media, Preserving bacterial culture: Glycerol stock, deep freezing, lyophilisation, Growth of bacterial cultures: binary fission, budding (eg. *Pseudomonas acidophila*), fragmentation (eg. *Nocardia*), Bacterial growth kinetics, Growth curve, different phases, Measurement of bacterial growth: direct microscopic count, serial dilution, pour plate, spread plate and plate count, membrane filter count, turbidometric method, dry weight method, most probable number method, Quorum sensing.

Module 4: (8 hrs)

Control of microbial growth, Sterilization, methods of sterilization, Heat treatment: thermal death point, thermal death time, moist heat and dry heat, autoclave, design, operation, pasteurization, flaming, hot air oven, low temperature treatment, Filtration: membrane filters, Chemical methods: phenols, bisphenols, biguanides, halogens, alcohols, compounds of heavy metals, soaps and detergents, acid anionic sanitizers, quaternary ammonium compounds, chemical preservatives; SO2, sodium benzoate, sorbic acid, calcium propionate, sodium nitrate, Antimicrobial drugs: drugs inhibiting cell wall synthesis, drugs inhibiting protein synthesis, drugs causing injury to plasma membrane, drugs inhibiting nucleic acid synthesis, drugs inhibiting the synthesis of essential metabolites, penicillins, penicillinase resistant penicillin, penicillin and β-lactamase inhibitors, cephalosporins, bacitracin, vanomycin, tetracyclines, sulfonamides. Antifungal Drugs: agents affecting fungal sterols, agents affecting fungal cell walls, agents inhibiting nucleic acid synthesis

Antiviral Drugs: nucleoside and nucleotide analogues, enzyme inhibitors, reverse transcriptase inhibitor, protease inhibitors, interferons, Determination of the efficiency of a drug: disk diffusion assay, broth dilution test and determination of minimal inhibitory concentration

Module 5: Genetic recombination in Bacteria (3 hrs)

Genetic recombination in bacteria: transformation, conjugation and transduction.

Module 6: Viruses (5 hrs)

Viruses: Characteristics of viruses, size range, host range, Classification of viruses, Structure of viruses: general morphology, nucleic acids, capsid and envelope, Culturing bacteriophages in the

laboratory, culturing animal viruses: in living animals, in embryonated eggs, in cell cultures: Viral multiplication: Multiplication of bacteriophages; lytic cycle, lysogenic cycle, multiplication of animal viruses, differences in the multiplication strategies of DNA and RNA viruses, Viruses and cancer, DNA and RNA oncogenic viruses

MICROBIAL BIOTECHNOLGY (15 hrs)

Module 7: (3 hrs)

Introduction, scope and historical developments, importance of microbes in industry; microbial biomass, microbial enzymes, microbial metabolites and microbial recombinant products.Isolation, screening and genetic improvement of industrially important organisms.

Module 8: (6 hrs)

Fermentation, Definition, chronological development of fermentation industry, Submerged fermentation and solid state fermentation, Media for industrial fermentation, major components, water, carbon sources, nitrogen sources, minerals, chelators, oxygen requirement, rheology, foaming and antifoaming agents. Medium optimization: one factor at a time approach, factorial approach, fractional factorial approach: statistical design of experiments, Plackett-Burman design and response surface method. Fermenter, functions of a fermenter, Design of a biofermenter, body constructon, types of fermenters: Waldhof type, tower type, air lift type, packed tower type , sterilization of the fermenter, aeration, porous sparger, orifice sparger, nozzle sparger, probes. Recovery of fermentation products, foam separation, precipitation, filtration, centrifugation

Module 9: (3 hrs)

Primary metabolism products, production of industrial ethanol as a case study; Secondary metabolites, bacterial antibiotics production; Recombinant DNA technologies for microbial processes; Strategies for development of industrial microbial strains with scale up production capacities; metabolic pathway engineering of microbes for production of novel product for industry.

Module 10: (3 hrs)

Microbial enzymes, role in various industrial processes, Bio-transformations, Bioaugmentation with production of vitamin C as a case study, Microencapsulation technologies for immobilization of microbial enzymes. Industrial biotechnology for pollution control, treatment of industrial and other wastes, biomass production involving single cell protein; Bioremediation of soil; Production of eco-friendly agricultural chemicals, biopesticides, bio-herbicides, bio-fertilizers, bio-fuels, etc.

PRACTICAL (36 hrs)

1. Isolation of bacteria through serial dilution and plating technique
2. Gram staining technique
3. Acid fast staining technique
4. Identification of bacteria using biochemical tests
5. Preparation of the growth curve of a bacterium using turbidometric method
6. Disk diffusion assay and determination of antimicrobial activity of medicinal plant extracts

REFERENCES

1. Kun LY. 2006. *Microbial Biotechnology*. World Scientific.
2. Tortora et al. 2008. Microbiology an introduction, Pearson Education
3. Michael J Pelczar et al. 2000. TATA McGraw Hill
4. PF Stanbury et al. 2008. Elsevier.

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Semester III Core course BT 6 Code: BOBT3CRT06

IMMUNOLOGY

(Theory 54 Hours; Practical 36 Hours; Credits 3 + 1)

Module 1: (12 hrs)

Introduction to immunology. Types of immunity: nonspecific- physiological and cellular barriers, acquired immunity- characteristics, Antigen, Haptens and Adjuvants, Antibody. Structure and types of immunoglobulins, distribution and function.

Module 2: (15hrs)

Organs of immune system - primary and secondary. Cells of immunsystem. Immuneresponse. Humoral and cell mediated immunity. MHC structure and function. Autoimmunity and hypersensitivity.

Module 3: (9hrs)

Antigen-antibody interactions: Affinity, avidity, cross reactivity, Precipitation reaction: radial immune diffusion, Ouchterlony double diffusion. Aagglutination reaction, agglutination titer, Incomplete agglutinins, complement fixation, ELISA. Immunocytochemistry.

Module 4: (9 hrs)

Transplant immunity. Immunology of malignancy. Immunohaematology. Blood groups and blood grouping. A, B, Rh antigens and antibodies, Rh typing. Bombay group,

Module 5: (9 hrs)

Immunization: Passive and active .Vaccines, types and applications. DNA vaccines, Polyclonal antibodies and monoclonal antibodies.

PRACTICAL (36 hrs)

1. Slide agglutination test
2. Bacterial agglutination test
3. Haemagglutination test
4. Precipitation in tube-Capillary test
5. Precipitation in gel-Immunodiffution (Demonstration only)
6. Immunoelectrophoresis (Demonstration only)
7. Blood grouping by slide agglutination method

REFERENCES

1. Essential Immunology - Ivan M. Roitt and Peter J delves, Blackwell Publishing
2. Immunology - Thomas J. Kindt, Barbara A. Osborne, Richard A. Goldsby, and Janis Kuby, W H Freeman and Co.
3. Immunobiology - Charles A. JanewayJr., Paul Travers, Mark Walport and Mark J. Shlomchik, Garland Publishing.
4. Essential Clinical Immunology – Helen Chappel and ManselHaeney, ELBS/Blackwell Scientific Publications
5. Introduction to Immunology – John W, Kimball Maxwell, Mac Millan International Edition.
6. Text book of Microbiology – R. Ananthanarayanan and C K Jayaram Panicker. Orient Longman.

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SEMESTER IV

Semester IV Core course BO 4 Code: BO4CRT04
PTERIDOLOGY, GYMNOSPERMS AND PALEOBOTANY
(See model I syllabus)
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Semester IV Core course BT 7 Code: BOBT4CRT07
ANIMAL BIOTECHNOLOGY AND NANO-BIOTECHNOLOGY
(Theory 54 Hours; Practical 36 Hours; Credits 3 + 1)

Objectives:

- To acquire basic knowledge of current developments in different areas of animal biotechnology.
- To understand and develop skills involved in the production of nanoparticles and their application in life sciences

ANIMAL BIOTECHNOLOGY (34 hrs)

Module 1: Animal cells (10 hrs)

Structure of animal cell: History of animal cell culture: Cell culture media and reagents, different type of cell culture media, growth supplements, serum free media, balanced salt solution, other cell culture reagents, culture of different tissues and its application. Infrastructure requirements, conditions required for culturing animal cells, Behavior of cells in culture conditions, division, their growth pattern, estimation of cell number. Culture of mammalian cells, tissues and organs, primary, culture, secondary culture, continuous cell lines, suspension cultures. Development of cell lines, characterization and maintenance of cell lines, stem cells, cryopreservation. Common cell culture contaminants. Commercial scale production of animal cells. Application of animal cell culture for *in vitro* testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.

Module 2: Immune system (5 hrs)

Introduction to immune system, cellular and humeral immune response, Vaccines, history of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, hybridoma technology. Antigen-antibody based diagnostic assays including radioimmunoassays and enzyme immunoassays, immunoblotting, commercial scale production of diagnostic antigens and antisera.

Module 3: *in vitro* techniques of animal breeding (14 hrs)

Structure of sperms and ovum, cryopreservation of sperms and ova of livestock, artificial insemination, super ovulation, *in vitro* fertilization, culture of embryos, cryopreservation of embryos, embryo transfer, embryo-splitting, embryo sexing, i*n utero* testing of foetus for genetic defects.

Animal cloning basic concept, cloning from embryonic cells and adult cells, cloning of different animals, cloning for conservation of endangered species. Ethical, social and moral issues related to cloning.

Transgenic manipulation of animal embryos, animal viral vectors, different applications of transgenic animal technology. Transgenic animal production and application in expression of therapeutic proteins, biopharming.ene knock out technology and animal models for human genetic disorders

Gene therapy, somatic cell therapy, germline therapy, gene augmentation therapy, gene replacement therapy: Candidate diseases for gene therapy: Methods of gene transfer, vectors used: Initial trials and observations: Current status of gene therapy

NANO-BIOTECHNOLOGY (20 hrs)

Module 4: (5 hrs)

Introduction to Biomacromolecules: The modern concepts to describe the conformation and dynamics of biological macromolecules: scattering techniques, micromanipulation techniques, drug delivery applications.

Module 5: (5 hrs)

Cellular engineering: signal transduction in biological systems, feedback, control signaling pathways, cell-cell interactions etc. Effects of physical, chemical and electrical stimuli on cell function and gene regulation.

Module 6: (6 hrs)

Chemical, physical and biological properties of biomaterials and bioresponse, Biosynthesis, and properties of natural materials (proteins, DNA, and polysaccharides), structure-property relationships in polymeric materials (synthetic polymers and structural proteins); Aerosol, properties, application and dynamics Statistical Mechanics in Biological Systems

Module 7: (4 hrs)

Characteristics of nanoparticles: Preparation and characterization of nanoparticles, biosynthesis of nanoparticles, Nanoparticular carrier systems, Micro- and Nano-fluidics, Drug and gene delivery system, Microfabrication, Biosensors, Chip technologies, Nano-imaging, Metabolic engineering and Gene therapy.

PRACTICAL (36 hrs)

1. Sterilization techniques for cell culture
2. Preparation of reagents and media for cell culture.
3. Cultivation of continuous cell lines.
4. Sub culturing: Trypsinization
5. Cell Counting
6. Nuclear staining

REFERENCES

1. Gordon I. 2005. Reproductive Techniques in Farm Animals. CABI.
2. Levine MM, Kaper JB, Rappuoli R, Liu MA, Good MF. 2004. New Generation Vaccines. 3rd Ed. Informa Healthcare.
3. Lincoln P J & Thomson J. 1998. *Forensic DNA Profiling Protocols*. Humana Press.
4. Portner R. 2007. *Animal Cell Biotechnology*. Humana Press.
5. Nalwa H S. 2005. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology. American Scientific Publ.
6. Niemeyer CM & Mirkin CA. 2005. *Nanobiotechnology*. Wiley

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Semester IV Core course BT 8 Code: BOBT4CRT08

PLANT BIOTECHNOLOGY

(Theory 54 Hours; Practical 36 Hours; Credits 3 + 1)

Objectives:

- To familiarize with the tools and techniques of plant biotechnology
- Aware of the life forms and activities that can be exploited for human advancement.
- To impart an introductory knowledge about the potential of plant transgenics
- To discuss about various aspects of biosafety regulations, IPR and bioethic concerns arising from the commercialization of biotech products

Module 1: Introduction to plant tissue culture (10 hrs)

Introduction – The concept of biotechnology, landmarks in biotechnology: Plant tissue culture – Principles and techniques. Cellular totipotency, *in vitro* differentiation; dedifferentiation and redifferentiation, callus induction organogenesis and somatic embryogenesis. Tissue culture medium – Basic components in tissue culture medium – Solid and liquid medium – suspension culture – Murashige and Skoog medium – composition and preparation, Aseptic techniques in tissue culture – sterilization – different methods – sterilization of instruments and glass wares, medium, explants. Working principle of laminar air flow and autoclave; preparation of explants – surface sterilization, inoculation and incubation, sub culturing, Establishment of axenic explants, callus initiation and multiplication, production of suspension culture, cell.

Module 2: Micropropagation (10 hrs)

Micropropagation - advantages and disadvantages, different methods – axillary bud proliferation, direct and indirect organogenesis and somatic embryogenesis, different phases of micropropagation – hardening, transplantation and field evaluation. Applications of tissue culture: Micropropagation of elite plants, Synthetic seed production, Meristem culture for virus free plants, Somaclonal variation and *in vitro* mutagenesis, Embryo rescue – embryo culture, Protoplast isolation culture and regeneration, Somatic cell hybridization, I*n vitro* secondary metabolite production — cell immobilization, bio reactors, hairy root culture, *In vitro* production of haploids – anther and pollen culture, Cryopreservation, *in vitro* fertilization

Module 3: Plant transformation (20 hrs)

Methods of plant transformation; Gene cloning, genetic engineering: vectors and methods of transformation – electroporation, particle bombardment, *Agrobacterium* mediated, different types of Agrobacterium based vectors; Vectors for plant transformation; Target traits and transgenic crops; Genetic and molecular analyses of transgenics; Role of molecular markers in characterization of transgenic crops, fingerprinting of cultivars, Achievements, problems and future thrusts in horticultural biotechnology.

Biotechnology and floriculture, molecular approaches to control ethylene response, improving shelf life, improving resistance for environmental stress, approaches to improve flower development, pigment production. Achievements of bio-technology in flower crops: Extraction of biocolours, uses in food and textile industries. Examples of transgenic plants produced successfully, Bt crops, golden rice, Flavr Savr Tomato, virus and herbicide resistant crops, edible vaccines. Biosafety issues, regulatory procedures for commercial approval.

Module 3: Concerns over modern plant biotechnology (14 hrs)

Biosafety and risk assessment issues; Regulatory framework; National biosafety policies and law, The Cartagena protocol on biosafety, WTO and other international agreements related to biosafety, Cross border movement of germplasm; Risk management issues - containment.

General principles for the laboratory and environmental biosafety; Health aspects; toxicology, allergenicity, antibiotic resistance, Sources of gene escape, tolerance of target organisms, creation of superweeds/superviruses, etc.

Ecological aspects of GMOs and impact on biodiversity; Monitoring strategies, Radiation safety and nonradio isotopic procedures; Benefits of transgenics to human health, society and the environment.

Intellectual properties, copyrights, trademarks, trade secrets, patents, geographical indications, etc; Protection of plant variety and farmers right act; Indian patent act and amendments, patent filing; Convention on biological diversity; Implications of intellectual property rights on the commercialization of biotechnology products.

PRACTICAL (36 hrs)

1. Preparation of nutrient medium – Murashige and Skoog medium, sterilization, preparation of explants, inoculation.
2. Establishment callus culture, shoot and suspension
3. Immobilization of whole cells or tissues in sodium alginate.
4. Establishment of the suspension culture of one medicinal plant
5. Production of somatic embryos from one plant
6. Transformation of leaf discs using *Agrobacterium* and selection of transmormed leaf discs
7. Induction of hairy root culture in any one plant
8. Visit a well equipped biotechnology lab and submit a report along with the practical record.

REFERENCES

1. Keshavachandran R & Peter KV. 2008. Plant Biotechnology: Methods in Tissue Culture and Gene Transfer. Orient & Longman (Universal Press)
2. Debnath M. 2005. Tools and Techniques of Biotechnology. Pointer Publ.
3. Brown T A. 2001. Gene Cloning and DNA Analysis and Introduction. Blackwell Publ.
4. Chadha K L, Ravindran PN & Sahijram L. (Eds.). 2000. Biotechnology of Horticulture and Plantation Crops. Malhotra Publ. House.
5. Singh BD. 2007. Biotechnology: Expanding Horizon. Kalyani.

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SEMESTER V

Semester V Core course BO 5 Code: BO5CRT05

ANATOMY, REPRODUCTIVE BOTANY AND MICROTECHNIQUE

(See model I syllabus)

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Semester V Core course BO 6 Code: BO5CRT07

PLANT PHYSIOLOGY AND BIOCHEMISTRY

(See model I syllabus)

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Semester V Core course BO 7 Code: BO5CRT08

ENVIRONMENTAL SCIENCE AND HUMAN RIGHTS

(See model I syllabus)

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Semester V Core course BT 9 Code: BOBT5CRT09

RECOMBINANT DNA TECHNOLOGY

(Theory 54 Hours; Practical 45 Hours; Credits 3 + 1)

Objectives:

- To understand advances in field of genetic engineering and their applications.
- To familiarize with the various tools and techniques in genetic engineering

Module 1: Isolation of DNA and RNA (10 hrs)

Introduction to gene cloning. DNA isolation; DNA isolation solutions, isolation buffer pH, concentration and ionic strength, DNase inhibitors, detergents used for isolation, methods for breaking the cells Removal of proteins from cell homogenate; using organic solvents, Kirby method and Marmur method, using CTAB: Removal of RNA; using RNase A, RNase T1: Concentrating the isolated DNA; precipitating with alcohols, salts added along with alcohol: Determination of the concentration and purity of DNA; using UV spectrophotometry: Storage of DNA samples: Commercially available kits for genomic and plasmid DNA isolation: Preparation of genomic DNA from animal cells, plant cells and bacterial cells; protocol for small scale and large scale preparations: Isolation of plasmid DNA; protocol for small scale and large scale preparations: Isolation and purification of RNA; purification of total RNA, RNase inhibitors, preparation of cell material, preparation of glass wares, guanidinium hot phenol method, high salt lithium chloride method, isolation of poly A RNA

Module 2: (15 hrs)

Agarose Gel electrophoresis of DNA and RNA; principles of electrophoresis, buffers used for electrophoresis of nucleic acids, gel concentration, sample concentration, sample loading solutions, gel staining, determination of molecular weight using molecular weight markers, special precautions and treatments required for electrophoresis of RNA, elution of DNA from agarose gels; electroelution, using low-melting point agarose.

Nucleic acid transfer and hybridization; Southern blot transfer, dot-blot transfer, plaque and colony transfer, Southern blot hybridization, Northern blot transfer and hybridization, in situ hybridization

Preparation of probes for hybridization, radioactive labeling, digoxigenin labeling, nick translation, preparation of primer using PCR, RNA probes.

Module 3: Principles of gene cloning (15 hrs)

Cloning vectors; essential features of a cloning vector, plasmid derived vectors, bacteriophage derived vectors, hybrid vectors, high capacity cloning vectors; BACs, PACs and YACs, *Agrobacterium* based vectors, shuttle vectors, expression vectors

Enzymes used in recombinant DNA technology; type II restriction endonucleases, ligases, S1 nuclease, alkaline phosphatase, terminal transferase, DNA polymerase I, reverse transcriptase, exonuclease III, bacteriophages λ exonuclease,

Finding gene of interest; shot gun cloning followed by screening, construction and use of genomic DNA library and cDNA library, screening DNA libraries, chromosome walking, *in silico* gene discovery, cloning of the gene of interest, altering the gene of interest through site directed mutagenesis,

Preparation of recombinant DNA molecule, blunt ends and sticky ends, using tailing method, using polylinkers. Methods to transfer the recombinant DNA molecule into the cloning host; transformation, transfection, transduction, electroporation, microinjection, microprojectiles and DNA gun, *Agrobacterium* mediated transfer. Methods to select the recombinants; antibiotic markers, insertional inactivation, replica plating, blue-white selection, use of reporter genes; GUS, luciferase and GFP genes

Module 4: GMOs (14 hrs)

Transgenesis; introduction to transgenic organisms and their applications. Mechanism of gene transfer into eukaryotic cells, transfection methods; using polyethelene glycol, chemical transfection using lithium acetate, calcium phosphate, and DEAE-dextran, lipofection, electroporation, microinjection, DNA gun, fate of DNA transferred to eukaryotic cells, random integration transgenesis – gain of function effects and loss of function effects, gene targeting. Examples of transgenic crop plants and animals. Antisense and RNAi technology. Production of knock out models and their use. Applications of recombinant DNA technology. Ethical, Social and legal issues associated with recombinant DNA technology.

PRACTICAL (18 hrs)

1. Primer Designing
2. PCR assay for gene amplification
3. Isolation of plasmid DNA and Restriction Digestion
4. Agarose gel electrophoresis of the isolated plasmid DNA, its visualization and photography
5. Preparation of competent E.coli cells
6. Preparation of recombinant plasmids, transformation of *E.coli* and selection of transformants

REFERENCES

1. Recombinant DNA, JD Watson, 1992, Scientific American Books
2. Recombinant DNA: genes and genomes; a short course. J D Watson *et al*., 2006, W H Freeman & Co.
3. Recombinant DNA technology and applications, Alex Prokop et al., 1997, McGraw Hil
4. Principles of Gene Manipulation: An Introduction to Genetic Engineering, by R.W. Old and S B Primrose 2000, Blackwell Scientific
5. Molecular Cloning: a Laboratory Manual. Sambrook J, Russel D W & Maniatis T. 2001, Cold Spring Harbour Laboratory Press.

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SEMESTER VI

Semester VI Core course BO 8 Code: BO6CRT09

GENETICS, PLANT BREEDING AND HORTICULTURE

(See model I syllabus)

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Semester VI Core course BO 9 Code: BO6CRT11

ANGIOSPERM MORPHOLOGY, TAXONOMY AND ECONOMIC BOTANY

(See model I syllabus)

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Semester VI Core course BO 10 Code: BO6CRT13

BIOSTATISTICS

(Theory 54 Hours; Practical 36 Hours; Credits 3 + 1)

Module 1: Introduction (10 hrs)

Introduction to statistics - application of statistics in biosciences with examples. Statistical data – various types of data: Primary data, secondary data, quantitative and qualitative data, collection and classification of data, frequency distribution. Diagrammatic representation of data – significance and utility, types of diagrams-bar diagrams, pie diagram, histograms, frequency polygon, frequency curve. Population and sampling techniques- significance and utility, random sampling, stratified sampling, systematic sampling, multistage sampling.

Module 2I: Descriptive statistics (8 hrs)

Measures of central tendency- introduction, definition, Advantages and limitations. Mean, median and mode - computation in grouped and ungrouped data. Comparison: Measures of dispersion- introduction, definition and objectives. Range, Mean deviation, standard deviation, standard error - computation in grouped and ungrouped data; comparison: Skewness and Kurtosis- definition, types, graphical representation with examples.

Module 3: Probability (9 hrs)

Probability - introduction, classical definition, theorems of probability - addition theorem and multiplication theorem, conditional probability. Applications. Standard probability distributions - introduction and applications. Binomial distribution - definition, assumption with respect to a biological example. Poisson distribution - definition, forms of poisson distribution, assumption with respect to a biological example. Normal distribution - definition, properties, standard normal curve, assumption with respect to a biological example.

Module 4: Inferential statistics (12 hrs)

Testing of hypothesis - Hypothesis - definition, hypothesis testing, procedure of hypothesis testing, errors in hypothesis testing – type I and type II errors, two tailed and one tailed test of hypothesis. Chi square test and estimation of linkages, student t-test and F test: Experimental designs – introduction, principles, replication and randomisation. CRD, RBD, Latin square design, factorial design: Interpolation and extrapolation - introduction, definitions, significance and utility, assumptions, graphic methods. Computer analysis of data – application of computer in statistical data

processing, statistical programmes, preparation of charts and graphs, formula application with respect to M Stat.

Module 5: Analysis of variants (8 hrs)

ANOVA - introduction, Assumptions, technique of analyzing variance, one way and two-way ANOVA followed by t-test: Multivariate analysis of variants and its application in biological sciences.

Module 6: Correlation and regression (7 hrs)

Correlation - introduction, definition and utility. Types of correlation, positive and negative correlation, scatter diagram and correlation graph, coefficient of correlation calculation. Regression - introduction, utility, regression coefficient, comparison of correlation and regression,

PRACTICAL (36 hrs)

1. Classify a given data using frequency distribution and represent it graphically.
2. Analyse a data for mean, median and mode.
3. Analyse a data for mean deviation, standard deviation and standard error
4. Application of addition and multiplication theorem of probability.
5. Test the significance of the given data using chi-square test, t test and f test.
6. Analyse a set of data for correlation and regression
7. Analyse a given data in CRD, RBD and LSD.
8. Analyse the given data using M stat.
9. Prepare graphs with the help of MS excel or M stat.

REFERENCES

1. Bernard Rosner, 2005. Fundamentals of Biostatistics. Duxbury Press.
2. Marcello Pagano, Kimberlee Gauvreau. 2000. Principles of Biostatistics. Duxbury Press
3. Panse, V.G. and Sukathme, P.V. 1995. Statistical methods for agricultural workers. ICAR, New Delhi.
4. Pranab Kumar Banerjee, 2004. Introduction to Biostatistics. S. Chand and company Limited.
5. Roland Ennos, 2006. Statistical and Data Handling Skills in Biology, 2nd Edition. Pearson Education.

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Semester VI Core course BT 10 Code: BOBT6CRT10

BIOINFORMATICS

(Theory 54 Hours; Practical 36 Hours; Credits 3 + 1)

Objectives:

- To acquire detailed information about ourselves and other species
- To understand the role of computer science in biological investigations.
- To access data and techniques through the World Wide Web and utilize them for analysis.
- To use computers with confidence and handle biological databases, information retrieval and make him/her able to extend these skills by self-directed 'field work' on the Web.
- To apply principles of bioinformatics in molecular biology, clinical medicine, pharmacology, biotechnology, agriculture, forensic science, anthropology and other disciplines
- To develop a sense of optimism that the data and methods of bioinformatics will create profound advances in our understanding of life, and improvements in the health of humans and other living things.

Module 1: An Introduction to bioinformatics (5 hrs)

Scope and relevance of bioinformatics: Genomics: Definition: Sequencing genes to sequencing genomes. Sequence assembly: Major findings of the following genome projects: Human, *Arabidopsis thaliana, Drosophila melanogaster, Caenorhabditis elegans*

Module 2: Biological Data bases (20 hrs)

Detailed study of the following Biological Data bases: Bibliographic databases Finding Scientific Articles PubMed: Genome sequence databases: Entrez Genome: TIGR database

Nucleic acid sequence databases: GenBank

Protein sequence databases: GenBank, SWISS-PROT: Protein structure database: Protein Data Bank.

Searching Biological databases: Saving search results: FASTA format: ASN.1 format: Batch Entrez: PDB flat file format: mmCIF format: DNA micro array data bases

Gene expression Omnibus, NCBI: Stanford microarray database: 2D gel electrophoresis data bases: ExPASy SWISS-2DPAGE: Danish Centre for Human Genome Research database

Module 3: Sequence alignment (15 hrs)

Sequence comparison: Pair wise sequence alignment: Global alignment: Use of ALIGN: Local alignment: Use of BLAST, FASTA: Multiple sequence alignment: Use of ClustalW: Phylogenetic analysis: Use of: PHYLIP: Data mining: Use of PERL in bioinformatics

Module 4: Molecular visualization tools (14 hrs)

Structure visualization: Molecular structure viewers: RasMol: SWISS-PDB Viewer: Predicting protein structure and function from sequence: Protein modeling, Docking and drug discovery

PRACTICAL (36 hrs)

1. Familiarize with the various databases given in the syllabus
2. Practice retrieving data from the various databases
3. Learn how to store the retrieved data
5. 4. Practice the use of BLAST

Familiarize with the use of RasMol

REFERENCES

1. Bioinformatics: A Machine Learning Approach. P Baldi and S Brunak. MIT Press
2. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins
3. Developing Bioinformatics Computer Skills. Cynthia Gibas and Per Jambeck. O'Reilly Genomes. TA Brown. Wiley-Liss.
4. Genomics: The Science and Technology Behind the Human Genome Project. CR Cantor and CL Smith. John Wiley and Sons.

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Semester VI **Programme elective course** **Theory 54 hours; Credit 3**

(Any one of the following)

1. Code: BO6PET01 AGRIBUSINESS

2. Code: BO6PET02 PLANT GENETIC RESOURCES MANAGEMENT

3. Code: BO6PET03 PHYTOCHEMISTRY AND PHARMACOGNOSY

(See model I syllabus)

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Tapioca; Spices - Pepper, Cardamom; Beverages - Tea, Coffee; Oil yielding plants - Coconut, Groundnut; Fibre yielding plants - Cotton, Coir; Timber yielding plants - Teak, Rose wood; Latex yielding plants - Para rubber; Bio pesticides - Neem, Tobacco; Ornamental plants - Rose, Orchids, Anthurium.

Module 5: Medicinal plants (8 hrs)

Study of the following medicinal plants with special reference to their binomial, family, morphology of useful parts and uses: *Adhatoda, Aloe*, *Bacopa*, *Catharanthus*, *Eclipta*, Neem, *Ocimum*, *Phyllanthus amarus*, *Rauvolfia*, *Sida.*

PRACTICAL (36 hrs)

1. Students should be trained to identify the different types of inflorescence and fruits of typical plants belonging to the families prescribed in the syllabus.
2. Students should be trained to identify typical local plants belonging to the families prescribed in the syllabus.
3. Students should be trained to describe the floral parts in technical terms and draw the L.S. of flower, construct the floral diagrams and write the floral formula of at least one flower from each family.
4. Study of the groups of plants mentioned in the economic botany syllabus with special reference to their botanical name, family, morphology of useful part, economic products and uses.
5. Students should study the botanical name, family, morphology of the useful part and the uses of the medicinal plants listed in the syllabus.

REFERENCES

1. Eames A J, 1969. *Morphology of Angiosperms*. McGraw Hill, New York.
2. Hill A F, 1952. *Economic Botany: A Text book of Useful Plants and Plant Products*. Tata McGraw-Hill Publishing Company Limited, New Delhi.
3. Jain S K, 1987. A Manual of Ethnobotany. Scientific Publishers, Jodhpur.
4. Kochhar S L, 1981. *Economic Botany in the Tropics.* Macmillion India Limited, Delhi.
5. Lawrence G H M, 1951. *Taxonomy of Vascular Plants*. Oxford & IBH, New Delhi.
6. Naik V N, 1984. *Taxonomy of Angiosperms*. Tata McGraw Hill Publishing Co, New Delhi.
7. Pandey S N, S P Misra, 2008. Taxonomy of Angiosperms. Ane Books India, New Delhi.
8. Sharma O P, 1993. *Plant Taxonomy*. Tata McGraw Hill Publishing Co Ltd., New Delhi.
9. Simpson B S, M Conner – Ogorzaly, 1986. *Economic Botany: Plants in Our World.* McGraw Hill Book Company, New York.
10. Singh G, 1999. *Plant Systematics – Theory and Practice.* Oxford & IBH, New Delhi.

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