

MAHATMA GANDHI UNIVERSITY
PRIYADARSINI HILLS
KOTTAYAM
KERALA



SYLLABUS FOR UNDER GRADUATE PROGRAMME IN
BOTANY
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

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B Sc BOTANY PROGRAMME – MODEL I

PROGRAMME DESIGN

The UG programme in Botany (Model - I) must include (a) Common courses*, (b) Core courses (c) Complementary Courses (d) Open courses (e) Choice based courses and (f) Project work. 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 12 compulsory core courses, 1 open course, 1 choice based elective course from the frontier area of the core courses, 6 core practical courses, 1 project work, 8 complementary courses and 2 complementary practical courses. There should be 10 common courses, or otherwise specified, which includes the first and second language of study.

PROGRAMME STRUCTURE: SUMMARY OF COURSES AND CREDITS

Sl. No.	Course type	No. of courses	Total credits
1	Common course I - English	6	22
2	Common course II – Additional language	4	16
3	Core + Practical	12 + 6	46
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	2
Total		43	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.

B Sc BOTANY PROGRAMME – MODEL I

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 3	5	4
Common course – English 2	4	3	Common course – English 4	4	3
Common course – Additional language course 1	4	4	Common course – Additional language course 2	4	4
Core course 1 + Practical	4	3	Core course 2 + Practical	4	3
st 1 Complementary course – Zoology course 1 + Practical	4	3	st 1 Complementary course – Zoology course 2 + Practical	4	3
nd 2 Complementary course – Chemistry/Biochemistry course 1 + Practical	4	3	nd 2 Complementary course - Chemistry/Biochemistry course 2 + Practical	4	3
Total	25	20	Total	25	20
SEMESTER III			SEMESTER IV		
Common course – English 5	5	4	Common course – English 6	5	4
Common course – Additional language course 3	5	4	Common course – Additional language course 4	5	4
Core course 3 + Practical	5	4	Core course 4 + Practical	5	4
st 1 Complementary course – Zoology course 3 + Practical	5	4	st 1 Complementary course – Zoology course 4 + Practical	5	4
nd 2 Complementary course – Chemistry/Biochemistry course 3 + Practical	5	4	nd 2 Complementary course – Chemistry/Biochemistry course 4 + Practical	5	4
Total	25	20	Total	25	20
SEMESTER V			SEMESTER VI		
Core course 5 + Practical	5	4	Core course 9 + Practical	5.5	4
Core course 6 + Practical	5.5	4	Core course 10 + Practical	5	4
Core course 7 + Practical	5.5	4	Core course 11 + Practical	6.5	4
Core course 8 + Practical.	5	4	Core course 12 + Practical	5	4
Open course	4	3	Programme elective - Choice based core course	3	3
Total	25	19	Project work	--	2
			Total	25	21

B Sc BOTANY PROGRAMME – MODEL I

COMBINATION OF CORE AND COMPLEMENTARY COURSES AND SEMESTER-WISE DISTRIBUTION

Sem.	Course category	Course code	Course title	Instr. hrs.*		Credits
				Th.	Pr.	
I	Core	BO1CRT01	Methodology of Science and an Introduction to Botany	36	36	2 + 1
II	Core	BO2CRT02	Microbiology, Mycology and Plant Pathology	36	36	2 + 1
III	Core	BO3CRT03	Phycology and Bryology	54	36	3 + 1
IV	Core	BO4CRT04	Pteridology, Gymnosperms and Paleobotany	54	36	3 + 1
V	Core	BO5CRT05	Anatomy, Reproductive Botany, Microtechnique	54	36	3 + 1
	Core	BO5CRT06	Research methodology, Biophysics and Biostatistics	54	45	3 + 1
	Core	BO5CRT07	Plant Physiology and Biochemistry	54	45	3 + 1
	Core	BO5CRT08	Environmental sciences and Human Rights	54	36	3 + 1
	Open	BO5OPT01	1. Agri-based microenterprises	72	--	3
	Open	BO5OPT02	2. Horticulture and Nursery management	72	--	3
	Open	BO5OPT03	3. Ecotourism	72	--	3
VI	Core	BO6CRT09	Genetics, Plant Breeding and Horticulture	54	45	3 + 1
	Core	BO6CRT10	Cell and Molecular Biology	54	36	3 + 1
	Core	BO6CRT11	Angiosperm morphology, Taxonomy and Economic Botany	72	45	3 + 1
	Core	BO6CRT12	Biotechnology and Bioinformatics	54	36	3 + 1
	Elective	BO6PET01	1. Agribusiness	54	--	3
	Elective	BO6PET02	2. Plant Genetic Resources Management	54	--	3
	Elective	BO6PET03	3. Phytochemistry and Pharmacognosy	54	--	3
	Project	BO6PRT01	Investigatory project work done individually or in groups	--	--	2
I	Compl. 1	BO1CMT01	Cryptogams, Gymnosperms and Plant Pathology	36	36	2 + 1
II	Compl. 2	BO2CMT02	Plant Physiology	36	36	2 + 1
III	Compl. 3	BO3CMT03	Angiosperm Taxonomy and Economic Botany	54	36	3 + 1
IV	Compl. 4	BO4CMT04	Anatomy and Applied Botany	54	36	3 + 1

* 18 instructional hours is equal to one teaching hour per week

*** UG Botany Course offered by DEPARTMENT OF BOTANY, GOVERNMENT COLLEGE KOTTAYAM, includes the highlighted parts of M.G. University syllabus along with common course English, Additional language - Malayalam or Hindi, and complementary courses - Chemistry and Zoology.

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 - Carnoy’s fluid, Farmer’s fluid, FAA; herbarium (brief study only). Whole mounts and sections – hand sectioning – TS, TLS, RLS. Staining plant tissues: purpose; stains - safranin, 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

1. Carl R Woese, O Kandler, M L Wheelis, 1990. "Towards a natural system of organisms: proposal for the domains Archaea, Bacteria, and Eucarya". Proceedings of the National Academy of Sciences of the United States of America, 87 (12): 4576–4579.
2. Kenneth A Mason, Jonathan B Losos, Susan R Siger, 2013. Biology (IX Edn). McGraw Hill.
3. James B Reece, Lisa A Urry, Michael L Cain, Steven A Wasserman, Peter V Minorsky, Robert B Jackson, 2011. Biology (IX Edn). Pearson.
4. Peter H Raven, George B Johnson, Jonathan B Losos, Susan R Siger, 2005. Biology (VII Edn). McGraw Hill.
5. Scott Freeman, 2005. Biological Science. Pearson education international.
6. Teresa Audesirk, Gerald Audesirk, Bruce E Byer, 2005. Biology: Life on earth. Pearson.
7. Sylvia S Mader, 1990. Biology (III Edn). Wm Crown publishers.
8. Paul B Weisz. The Science of Biology. McGraw Hill.
9. James H Otto, Albert Towle. Modern Biology. Holt, Reinhart and Winston Publishers.
10. D J Taylor, N P O Green, G W Stout, 1997. Biological Science (III Edn). Cambridge.
11. William S Beck, Karel F Liem, George Gaylord Simpson, 1991. LIFE: An Introduction to Biology (III Edn). Harper Collins Publishers.
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.
15. Prasad M K, Krishna Prasad M, 1986. Outlines of microtechnique. Emkay Publishers, New Delhi.
16. Varantha Pallabhi, Gautham N, 2005. *Biophysics*. Narosa Publishing House, New Delhi.

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, virioids 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, wine, 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 - wine, 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

1. Ahamadjian Vernon, Hale M E (eds), 1973. *The Lichens*. Academic press, New Delhi.
2. Ainsworth G C, Sparrow K F, Sussman A S (eds), 1973. *The Fungi: an advanced Treatise*, Vol. 4a & 4b, a Taxonomic review with keys. Academic press, New York.
3. Alexopoulos C J, Mims C W C, Blackwell M, 1996. *Introductory Mycology*. John Willy and sons, Inc. New York.
4. Campbell R, 1987. *Plant Microbiology*. ELBS Edward Arnold, London.
5. Gupta V K, Paul T S, 2004. *Fungi & Plant diseases*. Kalyani publishers, New Delhi
6. Hale M E, 1983. *The Biology of Lichen* (III Edn). Edward Arnold, London.
7. Jim Deacon, 2007. *Fungal Biology* (IV Edn). Blackwell Publishing, Ane Books Pvt. Ltd.
8. Krishnamurthy K V, 2004. *An Advanced Text Book on Biodiversity Principles and practice*. Oxford and IBH Publishing Co. Pvt. Ltd.
9. Kirk P M, Cannon P F, Minter D W, Stalpers J A, 2008. *Dictionary of the Fungi* (X Edn). Wallingford, UK: CAB International.
10. Mamatha Rao, 2009. *Microbes and Non flowering plants - impact and application*. Ane Books Pvt. Ltd.
11. Misra A, Agrawal P R, 1978. *Lichens*. Oxford and IBH, NewDelhi.
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.

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 N₂ 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

1. Anand N, 1989. Culturing and cultivation of BGA. Handbook of Blue Green Algae.
2. Fritsch F E, 1935. The structure and reproduction of the algae, Vol. 1 and II. Uni. Press. Cambridge.
3. Morris I, 1967. An Introduction to the Algae. Hutchinson and Co. London.
4. Robert Edward Lee, 2008. Phycology. Cambridge University Press,
5. Singh V, Pandey P C, Jain D K. A text book of botany.
6. Vashishta B R. Text Book of Algae. New Delhi.
7. Gangulee Das and Dutta. College Botany Vol. I. Central Book Depot. Calcutta.
8. Ganguly, Kar A K. College Botany Vol. II. New Central Book Agency, Calcutta.
9. Khan M, 1983. Fundamentals of Phycology. Bishen Singh Mahendra Pal Singh, Dehradun.
10. Campbell H D, 1940. The Evolution of land plants (Embryophyta). Univ. Press, Stanford.
11. Chopra R N, P K Kumar, 1988. Biology of Bryophytes. Wiley Eastern Ltd. New Delhi.
12. Parihar N S, 1965. An Introduction to Bryophyta. Central Book Depot, Allhabad.
13. Shaw J A, Goffinet B, 2000. Bryophyte Biology. Cambridge University Press.
14. Smith G M, 1938. Cryptogramic Botany Vol. II. Bryophytes and pteridophytes. McGraw Hill Book Company, London.
15. Sporne K R, 1967. The Morphology of Bryophytes. Hutchinson University Library, London.
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.

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 al.*, 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*. Stellar 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.

REFERENCES

1. Chamberlain C J, 1935. Gymnosperms: Structure and Evolution. Chicago University Press.
2. Coutler J M, C J Chamberlain, 1958. Morphology of Gymnosperms. Central book depot. Allahabd.
3. Sporne K R, 1967. The Morphology of Gymnosperms. Hutchinson and Co. Ltd. London.
4. Sreevastava H N, 1980. A Text Book of Gymnosperms. S Chand and Co. Ltd., New Delhi.
5. Vasishta P C, 1980. Gymnosperms. S Chand and Co., Ltd., New Delhi.
6. Maarten J M, Christenhusz, James L Reveal, Aljos Farjon, Martin F Gardner, Robert R Mill, Mark W Chase, 2011. A new classification and linear sequence of extant gymnosperms. *Phytotaxa*, 19: 55 – 70.
8. Campbell H D, 1940. The Evolution of land plants (Embryophyta). Univ. Press, Stanford.
9. Bower F O, 1935. Primitive Land Plants. Cambridge, London.
10. Chandra S, Srivastava M, 2003. Pteridology in New Millennium. Kluwer Academic Publishers.
11. Eames A J, 1979. Morphology of vascular plants, lower group. Wiley International edition, New Delhi.
12. Parihar N S, 1977. Biology and Morphology of Pteridophytes. Central Book Depot, Allhabad.
13. Rashid A, 1976. An Introduction to Pteridopyta. Vikas publ. Co., New Delhi.
14. Ranker T A, Haufler C H (eds), 2008. *Biology and Evolution of Fern sand Lycophytes*. Cambridge University Press.
15. Mehlreter K, Walker L R, Sharpe J M (eds), 2010. *Fern Ecology*. Cambridge University Press.
16. Smith A R, Pryer K M, Schuettpelz E, Korall P, Schnelder H, Wolf P G, 2006. A Classification for extant Ferns. *Taxon* 53: 705731.
17. Smith A R, Pryer K M, Schuettpelz E, 2008. Fern classification. In: T.A.Ranker and C.H. Haufler (eds.). *Biology and Evolution of Ferns and Lycophytes*. Cambridge University press, UK.
18. Smith G M, 1938. Cryptogamic Botany Vol. II, Bryophytes and Pteridophytes. McGraw Hill Book Company, London.
19. Sporne K R, 1967. Morphology of Pteridophytes. Hutchi University Library, London.
20. Sreevastava H N. A text book of Pteridophyta. S Chand and Co., New Delhi.
22. Vasishta B R, 1993. Pteridophyta. S Chand and Co., New Delhi.
23. Maarten J M, Christenhusz, Xian-Chun Zhang, Harald Schneider. A linear sequence of extant families and genera of lycophytes and ferns. *Phytotaxa* 19: 7– 54 (2011) 15
24. Andrews H N, 1961. Studies in Paleobotany. John Wiley and Sons Inc., New York.
25. Arnold C A, 1947. Introduction to Paleobotany. Tata McGraw Hill, New Delhi.
26. Shukla A C, S P Misra, 1975. Essential of Paleobotany. Vikas Publishing House Pvt. Ltd., Delhi.
27. Sreevastava H N, 1998. Paleobotany. Pradeep Publishing Company, Jalandhar.
28. Sewart W N, 1983. Paleobotany and the Evolution of Plants. Cambridge Uni. Press, London.
29. Taylor T N. Paleobotany: An Introduction to Fossil Plant Biology. Mc Graw Hill, New York.
30. Watson J. An introduction to study of fossil plants. Adams and Charles Black Ltd. London.

SEMESTER V

Core course 5

Code: BO5CRT05

ANATOMY, REPRODUCTIVE BOTANY AND MICROTÉCHNIQUE

(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-carpus 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 embryo sac, types of embryo sacs - 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 - monothealous, dithealous.
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).

REFERENCES

1. Bhojwani S S, Bhatnagar S P, 2011. The Embryology of Angiosperms (V Edn). Vikas Publishing House, Delhi.
2. Coulter E G, 1969. *Plant Anatomy - Part I: Cells and Tissues*. Edward Arnold, London.
3. Dickinson W C, 2000. Integrative Plant Anatomy. Har cort Academic Press, USA.
4. Easu K, 1977. *Anatomy of seed plants* (II Edn). Wiley Eastern, New York.
5. Fahn A, 1982. *Plant Anatomy* (III Edn). Pergamon Press, Oxford.
6. Johnson D A, 1940. *Plant Microtechnique*, McGraw Hill Co., New York.
7. Johri B M, 1984. Embryology of Angiosperms. Springer-Verlag.

8. Khasim S M, 2002. Botanical Microtechnique: Principles and Practice. Capital Publishing Company, New Delhi.
9. Maheshwari P, 1971. *An introduction to the Embryology of Angiosperms*. Tata McGraw Hill Publishing Company Ltd., New Delhi.
10. Pandey B P, 2015. Plant Anatomy. S Chand Publ., New Delhi.
11. Patki L R, B L Bhalchandra, I H Jeevaji, 1983. An Introduction to microtechnique. S Chand & Co.
12. Prasad M K, Krishna Prasad M, 1986. Outlines of microtechnique. Emkay Publishers, New Delhi.
13. Raghavan V, 2000. Developmental biology of flowering plants. Springer, Netherlands.
14. Shivanna K R, 2003. Pollen Biology and Biotechnology. Oxford and IBH, Delhi.
15. Vashista P C, 1984. *Plant Anatomy*. Pradeep publication, Jalandhar.

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.

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.

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-square 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.

REFERENCES

1. Anita Goel. Computer Fundamentals. Dorling Kindersley (India) Pvt. Ltd.
2. Agarwal S K, 2008. *Foundation course in Biology*. Ane Books Pvt. Ltd., New Delhi.
3. Day R A, 1998. *How to Write and Publish a Scientific Paper*. University Press Cambridge.
4. Sunder Rao P S S, Richard J, 2012. *Introduction to Biostatistics and Research methods*. PHI Learning, New Delhi.
5. Bajpai P K. *Biological instrumentation and methodology*. S Chand & co Ltd.
6. Cotteril R, 2002. *Biophysics an Introduction*. John Wiley and Sons.
7. Debajyoti Das. *Biophysics and Biophysical Chemistry*. Academic publishers, Kolkatta.
8. Dwivedi J N, R B Singh, 1990. *Essentials of Plant Techniques*. Scientific Publishers, Jodhpur.
9. *Experimental Design for the Life sciences*. University press, Oxford.
10. Gini Courter, Annette Marquis. Ms-Office 2007: BPB Publications.

- 141 GW Stout, D J Taylor, 2008. *Biological Sciences*. NPO Green, University Press, Cambridge.
12. Holmes D, Moody P, D Dine, 2006. *Research methods for the biosciences*. Oxford University Press.
13. Jeffrey A Lee, 2009. *The Scientific Endeavour: Methodology and perspectives of sciences*. Pearson.
14. Narayanan P. *Essentials of Biophysics*. New Age International Publishers.
15. Norman T, J Bailey, 2008. *Statistical Methods in Biology*. Cambridge.
16. Patrick Blattner, Louie Utrich, Ken Cook, Timothy Dyck. Special Edition Ms Excel 2007: Prentice Hall India Pvt. Ltd.
17. Prasad S, 2003. *Elements of Biostatistics*. Rastogi Publications, Meerut.
18. Varantha Pallabhi, Gautham N, 2005. *Biophysics*. Norosa Publishing House New Delhi.
19. Ranjit Kumar, 2014. *Research Methodology: A Step-by-Step Guide for Beginners*. SAGE Publications India Pvt Ltd, New Delhi.

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, Krebs'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 CO₂ in photosynthesis.
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 - Molisch's test, Benedict'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.

REFERENCES

1. Dayananda B, 1999. Experiments in Plant Physiology. Narosa Publishing House, New Delhi.
2. Hopkins W G, Norman P A Huner, 2008. Introduction to plant physiology. John Wiley and sons. New York.
3. Jain J L, Sanjay Jain, Nitin Jain, 2005. Fundamentals of Biochemistry. S Chand, New Delhi.
4. Lehninger A L, 1961. Biochemistry. Lalyan publishers, Ludhiana.
5. Nelson D L, Cox M M, 1993. Principles of Biochemistry. MacMillan Publications.
6. Pandey S N, Sinha B K, 2006. Plant Physiology. Vikas Publishing House Pvt. Ltd.
7. Plummer D T, 1988. An introduction to practical biochemistry. Tata McGraw-Hill publishing Company, New Delhi.
8. Sadasivam S, Manickan A, 1996. Biochemical Methods. New Age International Ltd. New Delhi.
9. Salisbury F B, Ross C W, 1992. Plant Physiology. CBS Publishers and Distributers, Delhi.
10. Srivastava H S, 2005. Plant Physiology. Rastogi publications, Meerut.
11. Verma V, 2007. Textbook of Plant Physiology. Ane Books India, New Delhi.
12. Taiz L, Zeiger E, 2003. Plant Physiology (III Edn). Panima publishing Corporation, New Delhi.

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, protooperation, 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 N₂.

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 (15th 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 CO₂, 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 quadrat 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, Quadrat).
6. Ecological adaptations in xerophytes, hydrophytes, epiphytes, halophytes and mangroves.

REFERENCES

1. Ahmedullah M, Nayar M P, 1987. Endemic plants of the Indian region. Botanical survey of India, Calcutta.
2. A K Bhattacharya, 2005. Ecotourism and Livelihoods. Concept Publishing Co. New Delhi.
3. AmalRaj S. Introduction to environmental science and technology. Laxmi Publications Pvt. Ltd., New Delhi.
4. Asthana D K, Meera Asthana, 2006. A text book of environmental studies. S Chand.
5. Basha S C, 1991. Indian forester. 117: 439-448. The distribution of mangroves in Kerala.
6. Bharucha, Erach, 2003. The Biodiversity of India. Mapin Publishing Co., New Delhi.
7. Ceballos-Lascurian, Hector, 1996. Tourism, Ecotourism and Protected areas. IUCN, Cambridge UK.
8. Champion H G, 1986. A preliminary survey of forests of India and Burma. Ind. For. Rec. 1: 1-236.
9. Champion H G, Seth S K, 1968. A revised survey of the forest types of India. Govt. of India press, Delhi.
10. Chandrasekharan C, 1962. A General note on the vegetation of Kerala state; Ind. For.88: 440-441.
11. Chandrasekharan C, 1962. Ecological Study of the Forests of Kerala State; Ind. For.88: 473-480.
12. Chandrasekharan C, 1962. Forest Types of Kerala State. Ind. For. 88: 660-847.
13. Garg M R, Bansal V K, Tiwana N S, 2007. Environmental Pollution and Protection. Deep and Deep Publishers, New Delhi.
14. H D Kumar, 2000. Modern Concepts of Ecology. Vikas Publishing House, New Delhi.
15. H Kaur. Environmental studies. Pragathi Prakashan, Meerut.
16. IUCN, 2000. The IUCN Red list categorie. IUCN. Gland.
17. IUCN, 2007. The 2000 IUCN Red list of Threatened Species. IUCN. Gland.
18. Jain S K, Sastry A R K, 1984. The Indian plant red data book. Botanical survey of India, Calcutta.
19. Khopkar S M, 1995. Environmental Pollution Analysis. New Age International (P) Ltd.
20. Kreg Lindberg, Deonal E Hawkins, 1999. Ecotourism: A guide for planners and managers. Natraj Publishers, Dehradun.
21. Kumar D, 2006. Ecology for Humanity Eco Tourism. Intellectual Book Bureau, Bhopal.
22. Kumar U, M Asija, 2006. Biodiversity: Principles and conservation. Agrobios India.
23. Mani M S, 1974. Ecology and Biogeography in India. W Junk B V Publishers, Netherlands.
24. Misra D D, 2008. Fundamental concepts in Environmental Studies. S. Chand & Co. Ltd., New Delhi.
25. Myers N, 1988. The Environmentalist 8: 187-208.
26. Nayar M P, Giri G S, 1988. Keywords to the Floristics of India. Vol. 1. Botanic Survey of India. Calcutta.
27. Nayar M P, Sastry A R K, 1987, 1988, 1990. Red Data Book of Indian Plants, Vols. I - III. Botanical Survey of India, Calcutta.
28. Nayar M P, 1996. Hot Spots of Endemic Plants of India, Nepal and Bhutan. Tropical Botanic Garden and Research Institute, Trivandrum.

29. Nayar M P, 1997. Biodiversity challenges in Kerala and science of conservation biology. In: P. Pushpangadan, K S S Nair (Eds), Biodiversity of tropical forests the Kerala scenario. STEC, Kerala.
30. Odum E P, 1971. Fundamentals of Ecology. WB Saunders.
31. Oza G M, 1992. The Earth Summit. Ind. For. 5: 338.
32. Panday S N, S P Misra, 2011. Environment and Ecology. Ane Books Pvt.Ltd. New Delhi
33. Ravindranath N H, Sudha P, 2004. Joint Forest Management: Spread performance and Impact. Universities Press.
34. Richard Wright, 2009. Environmental Science towards a Sustainable Future. Pearson Education.
35. Santhra S C, 2004. Environmental Science. New Central Book Agency.
36. Sulekha, Chendel. Plant Ecology and Soil. S Chand & Co. Ltd. New Delhi.
37. Waxena H M, 2006. Environmental Studies. Rawat Publications, New Delhi.
38. Wood, Ronald, 1974. The Geography of the Flowering Plants. Longman Group Ltd., London.
39. Amartya Sen, 2009. The Idea Justice. Penguin Books, New Delhi.
40. Chatrath, K J S (ed.), 1998. Education for human rights and democracy (Shimla: Indian Institute of Advanced Studies)
41. Law Relating to Human Rights, Asia Law House, 2001.
42. Shireesh Pal Singh, Human Rights Education in 21st Century. Discovery Publishing House Pvt. Ltd. New Delhi.
43. S K Khanna, 1998, 2011. Children and the human rights. Commonwealth publishers.
44. Sudhir Kapoor, 2001. Human Rights in 21st Century. Mangal Deep Publications, Jaipur.
45. United Nations Development Programme, Human Development Report 2004. Cultural liberty in today's diverse world. Oxford University Press, New Delhi.

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.

REFERENCES

1. Purohit S S, 2005. Plant Tissue Culture. Student Edition.
2. Rema L P, 2006. Applied Biotechnology. MJP Publishers.
3. Adams M R, M O Moss, 1995. Food Microbiology. Panima Publishing.
4. Casida L E (Jr.), 2005. Industrial Microbiology. New Age International.
5. Chandha.K L, 2003. Handbook of Horticulture. ICAR. New Delhi.
6. Frazier, Westhoff, 1988. Food Microbiology. Tata McGraw Hill.
7. George Acquichah, 2004. Horticulture: Principles and Practices (II Edn). Prentice Hall. India.
8. George J Banwant, 2004. Basic Food Microbiology. CBS Publishers and Distributors.
9. Gopal Chandha De, 2002. Fundamentals of Agronomy. Oxford and IBH Publishing House.
10. Hudson T, Hartmann, Dale E Kester, 2001. Plant Propagation, Principles and Practices (VI Edn). Prentice Hall, India.
11. James M Jay, 2005. Modern Food Microbiology. CBS Publishers and Distributors.
12. Kalyan Kumar De, 1996. Plant Tissue Culture. New Central Book Agency (P) Ltd.

13. Kaul T N, 2002. Biology and Conservation of Mushroom. Oxford and IBH Publishing Co.
14. Kunte, Kawthalkar, Yawalker, 1997. Principles of Horticulture and Fruit Growing. Agri – Horticulture Co.
15. Neshamani S, 2003. Pazhanganal, Pazhavibhavanganal (Malayalam). Kerala Bhasha Institute.
16. Pandey R K, S K Ghosh, 1996. A Hand Book on Mushroom Cultivation. Emkey Publications.
17. Prem Singh Arya, 2004). Vegetable Seed Production Principles. Kalyani Publishers.
18. Prince Alex, Rajani A Nair, 2003. Ayurveda Avshodha Nirmanam – Sidhanthavum Prayogavum (Malayalam). Kerala Bhasha Institute.
19. Razdan M K, 1995. Introduction to Plant Tissue Culture (II Edn). Oxford and IBH Publishing Co.
20. Sharma R R, 2005. Propagation of Horticultural Crops. Kalyani Publishers.
21. Singh B D, 1996. Biotechnology. Kalyani Publishers.

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 (Amaranthus), 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, arboretum.

ON HAND TRAINING (18 hrs)

1. Preparation of potting mixture of known combination and potting in earthen 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.

REFERENCES

1. Adams C R, Early M P, 2004. *Principles of Horticulture*. Elsevier, N. Delhi.
2. Barton West R, 1999. *Practical Gardening in India*. Discovery Pub. House, New Delhi.
3. Edmond J B, Senn T L, Andrews F S, Halfacre P G, 1975. *Fundamentals of Horticulture* (IV Edn). TMH, New Delhi.
4. John Weathers, 1993. *Encyclopaedia of Horticulture*. Discovery Pub. House. New Delhi
5. Jules Janick, 1979. *Horticultural Science*. Surjeet publications, Delhi
6. Kumar N, 1994. *Introduction to Horticulture*. Rajalakshmi Pub. Nagarcoil
7. Manibhushan Rao K, 1991. *Text Book of Horticulture*. Macmillan India Ltd.

8. Randhawa G S, Mukhopadhyay A, 1986. *Floriculture in India*. Allied Publishers Pvt. Ltd. Ahamedabad.
9. Sadhu M K, 1996. *Plant Propagation*. New age International publishers, N. Delhi
10. Schilletter J C, Richey H W, 1999. *Text Book of General Horticulture*. Biotech Books, New Delhi
11. Mazundar B C, P M Mukhopadhyay, 2006. *Principles & Practices of Herbal Garden*. Daya Publishing House, Delhi.
12. Vishnu Swarup, 1997. *Ornamental Horticulture*. MacMillan India Ltd.
13. Linda William, 2005. *Ornamental Science Demystified*. Tata Mc Graw hill Co.
14. Percy Lancasher, 2004. *Gardening in India*. Oxford IBH Publishing Co. Pvt. Ltd.

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

1. A K Bhattacharya, 2005. *Ecotourism and Livelihoods*. Concept Publ. company, New Delhi.
2. Kreg Lindberg, Deonal E. Hawkins, 1999. *Ecotourism: A guide for planners and managers*. Natraj Publishers, Dehradun.
3. Batta A., 2000. *Tourism and environment*. Indus Publishing Co., New Delhi.
4. Cater E, 1994. *Ecotourism in the third world: Probolems and prospects for sustainability*. In: E. Cater and G. Lowman (Ed.) *Ecotourism: a sustainable option*, Wiley, Chichester.
5. Croall J, 1995. *Preserve or Destroy: Tourism and Environemnt*. Calouste Gulbenkian Foundation, London.

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 experiment e.g. eye colour in *Drosophila*, 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.

REFERENCES

1. Adams C R, Bamford K M, Early M P, 2004. *Principles of Horticulture* (V Edn). Elsevier, Linacre House, Jordan Hill, Oxford OX2 8DP, UK.
2. Edmond J B, Senn T L, Andrews F S, Halfacre P G, 1975. *Fundamentals of Horticulture* (IV Edn). TMHN, Delhi.
3. Jules Janick, 1979. *Horticultural Science*. Surjeet publications, New Delhi.
4. Kumar N, 1994. *Introduction to Horticulture*. Rajalakshmi Pub. Nagarcoil.
5. Manibhushan Rao K, 2005. *Text Book of Horticulture* (II Edn). Macmillan India Ltd.
6. Randhawa G S, Mukhopadhyay A, 1986. *Floriculture in India*. Allied Publishers Pvt. Ltd. Ahmedabad.
7. Sadhu M K, 1989. *Plant propagation*. New age international publishers, N. Delhi.
8. Schilleter J C, Richey H W, 2005. *Text Book of General Horticulture*. Biotech Books, New Delhi.
9. Shukla R S, Chandel P S, 2004. *Cytogenetics Evolution and Plant breeding*. S. Chand & Co. Ltd. New Delhi.
10. Singh B D, 2015. *Plant breeding* (X Edn). Kalyani publishers, New Delhi.
11. West R, 1999. *Practical Gardening in India*. Discovery Pub. House, New Delhi.
12. Sinnot E W, Dunn L C, Dodzhansky T, 1958. Principles of genetics.
13. Swanson C P, 1957. Cytology and Genetics. Englewood cliffs, New York.
14. Raven P H, Johnson G B, Losos J B, Singer S R, 2005. *Biology* (VII Edn). Tata McGraw-Hill, New Delhi.
15. William Hexter, Henry T Yost Jr., 1977. The science of Genetics.
16. Laura Livingston Mays, 1981. Genetics: A Molecular approach. Macmillan publishing company.
17. Benjamin A P, 2005. *Genetics: a conceptual approach* (II Edn). W H Freeman and Company, New York.
18. Snustad D P, Simmons M J, 2012. *Principles of genetics* (VI Edn). John Willey and sons, USA.

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)**Module 1: 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, inducible 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.

REFERENCES

1. Aggarwal S K, 2009. Foundation Course in Biology (II Edn). Ane Books Pvt. Ltd.
2. Avinash, Kakoli Upadhyay, 2005. *Basic Molecular Biology*. Himalaya Publishing House, Mumbai.
3. Cohn N S, 1964. Elements of Cytology. Brace and World Inc., New Delhi.
4. Darlington C D, 1965. Cytology. Churchill, London.

5. Darnel J, Lodish, Hand Baltimore D, 1991. Cell and molecular biology. Lea and Fibiger, Washington.
6. De Robertis E D P, Robertis E M P, 1991. Cell and molecular biology. Scientific American books.
7. Dobzhansky B, 1961. Genetics and origin of species. Columbia University Press, New York.
8. Gardner E J, Snustad D P, 1984. Principles of Genetics. John wiley, NewYork.
9. Gerald Karp, 2006. Cell Biology. McGraw Hill company.
10. Gupta P K. Genetics. Rastogi Publications.
11. Lewin B, 1999. Genes. Oxford University Press, NewYork.
12. Lewis W H, 1980. Polyploidy. Plenum Press, NewYork.
13. Roy S C, Kalayan Kumar De, 1997. Cell biology. New central Boos, Calcutta.
14. Sandhya Mitra, 1998. Elements of Molecular biology. Macmillan, India Ltd.
15. Sharma A K, Sharma A, 1980. Chromosome technique: Theory and practice. Aditya Books, NewYork.
16. Veer Bala Rastogi, 2008. Fundamentals of Molecular Biology. Ane Books Pvt. Ltd.
17. Wayne M Becker, Lewis J Kleinsmith, Jeff Hardin, 2004. The World of Cell. Pearson Education.
18. Waseem Ahammede (faridi), 2013. Genetics and Genomics. Pearson.

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 - scorpid and helicoid, dichasial and polychasial; special type - cyathium, hypanthodium, verticillaster, thyrus and panicle. Fruits: simple - fleshy, dry - dehiscent, schizocarpic, indehiscent, aggregate, multiple (sorsis 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. Interdisciplinary 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, Caesalpinaceae 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, hesperidium. 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.

REFERENCES

1. Ashok Bendra and Ashok Kumar, 1980. Economic botany, Rastogi publications, Meerut.
2. Cornquist A, 1968. The evolution and Classification of Flowering Plants.

3. Davis P H and Heywood V H, 1967. Principles of Angiosperm Taxonomy. Oliver and Boyd, Edinburgh.
4. Eames A J, 1961. Morphology of Angiosperms. Mc Graw Hill, New York.
5. Foaster A S, Giffad E M, 1962. Comparative morphology of vascular plants. Allied Pacific Pvt. Ltd. Bombay.
6. Henry and Chandra Bose, 2001. An aid to the International Code of Botanical Nomenclature. Botanical Survey of India, Coimbatore.
7. Heywood V H, 1967. Plant Taxonomy. Edward Arnold, London.
8. Hill A F, 1982. Economic Botany. Mc Graw Hill, New York.
9. Jain S K, 1981. Glimpses of Indian Ethnobotany. Oxford and IBH, New Delhi.
10. Jain S K, 1987. A Manual of Ethnobotany. Scientific Publishers, Jodhpur.
11. Jain S K, Rao R R, 1976. A hand book of field and herbarium technique. Today and tomorrow's Publishers, New Delhi.
12. Jeffery C, 1968. An Introduction to Plant Taxonomy. J and A Churchill, London.
13. Lawrence G H M, 1951. Taxonomy of Vascular Plants. Macmillan, New York.
14. Maheshwari P and Umamo Singh, 1965. Dictionary of Economic Plants in India. ICAR, New Delhi.
15. Naik V N, 1984. Taxonomy of angiosperms. Tata Mc Graw- Hill Publishing Company, New Delhi.
16. Pandey S N, Misra S P, 2008. Taxonomy of Angiosperms. Ane Books India, New Delhi.
17. Rendle A B, 1979. Classification of flowering plants, Vols. I & II. Vikas Publishing House, U.P.
18. Sambamurthy A, 2005. Taxonomy of Angiosperms. i.K. International Pvt. Ltd, New Delhi.
19. Sharma O P, 1996. Plant Taxonomy. Tata McGraw Hill, New Delhi.
20. Sreemali J L, 1979. Economic Botany. Kitab Mahal, Allahabad.
21. Singh V and Jain D K, 1989. Taxonomy of Angiosperms. Rastogi Publication, Meerut.
22. Swain T, 1963. Chemical Plant Taxonomy. Academic Press, New York.
23. Sivarajan V V, 1991. Introduction to the Principles of Plant taxonomy. Oxford IBH Publishing Co. Pvt. Ltd., New Delhi.

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 electrophoresis 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).

REFERENCES

1. R Keshavachandran and K V Peter. Plant Biotechnology: Methods in Tissue Culture and Gene Transfer. Orient Blackswan.
2. G Smita Rastogi and Neelam Pathak. Genetic Engineering. Oxford Higher Education.
3. Jean-Michel Claverie, Cedric Notredame. Bioinformatics: A beginner's Guide. Wiley India.
4. David W Mount. Bioinformatics: sequence and genome analysis. CBS Publishers.
5. Cynthia Gibas and Per Jambeck. Developing Bioinformatics and Computer Skills. O'Reilly.
6. T A Brown, 2002. Genomes. Wiley-Liss.
6. C R Cantor, C L Smith. Genomics: The Science and Technology behind the Human Genome Project. John Wiley and Sons.
7. Orpita Bosu, Simminder Kaurthukral. Bioinformatics, databases: tools and algorithms.
8. S Ignasimuthu, 2009. Basic Bioinformatics. Narosa Publications.
9. K Vijayakumar, V S Sugunan, S S Vinod Chandra, K Shiny Sreedhar. Informatics, Bioinformatics. Academica, Thiruvananthapuram.

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.

REFERENCES

1. Adams M R, M O Moss, 1995. Food Microbiology. Panima Publishing.
2. Casida L E (Jr.), 2005. Industrial Microbiology. New Age International.
3. Chandha K L, 2003. Handbook of Horticulture. ICAR. New Delhi.
4. Frazier, Westhoff, 1988. Food Microbiology. Tata McGraw Hill.

5. George Acquichah, 2004. Horticulture: Principles and Practices (II Edn). Prentice Hall. India.
6. George J Banwant, 2004. Basic Food Microbiology. CBS Publishers and Distributors.
7. Gopal Chandha De, 2002. Fundamentals of Agronomy. Oxford and IBH Publishing House.
8. Hudson T, Hartmann, Dale E Kester, 2001. Plant Propagation: Principles and Practices (VI Edn). Prentice Hall. India.
9. James M. Jay, 2005. Modern Food Microbiology. CBS Publishers and Distributors.
10. Kalian Kumar De, 1996. Plant Tissue Culture. New Central Book Agency (P) Ltd.
11. Kaul T N, 2002. Biology and Conservation of Mushroom, Oxford and IBH Publishing Co.
12. Kunte, Kawthalkar, Yawalker, 1997. Principles of Horticulture and Fruit Growing. Agri-Horticulture Co.
13. Neshamani S, 2000. Pazhangal, Pazhavibhavangal (Malayalam). Kerala Bhasha Institute.
14. Pandey R.K, S K Ghosh, 1996. A Hand Book on Mushroom Cultivation. Emkey Publications.
15. Prem Singh Arya, 2004. Vegetable Seed Production Principles. Kalyani Publishers.
16. Prince Alex, Rajani A Nair, 2003. Ayurveda Avshodha Nirmanam – Sidhanthavum Prayogavum Malayalam. Kerala Bhasha Institute.
17. Purohit S S, 2005. Plant Tissue Culture. Student Edition.
18. Razdan M K, 1995. Introduction to Plant Tissue Culture (II Edn). Oxford and IBH Publishing Co.
19. Rema L P, 2006. Applied Biotechnology. MJP Publishers.
20. Sharma R R, 2005. Propagation of Horticultural Crops. Kalyani Publishers.
21. Singh B D, 1996. Biotechnology. Kalyani Publishers.

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 gladiata* (Sword bean, Valpayar), *Psophocarpus tetragonolobus* (Winged bean, Chathurapayar), (Sessile joyweed), *Sauropus androgynus* (Velicheera, Chikurmanis, Sauropus), *Ipomoea turbinata* (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)

REFERENCES

1. Arora R K, E R Nayar, 1984. *Wild Relatives of Crop Plants in India*. NBPGR, New Delhi.
2. Chang S T, Miles P G, 1979. *Edible Mushrooms and their Cultivation*. Boca Raton; CRC Press.
3. FAO (1989) *Plant Genetic Resources: their Conservation for Human use*, Rome Italy.
4. Frankel O H, E Bennet, 1970. *Genetic Resources of Plants: their Exploration and Conservation*, Oxford, Blackwell.
5. Harlan J R, 1975. *Crops and Man. Wisconsin: American Society of Agronomy*.
6. ICAR ,1969. *Handbook of Agriculture*, New Delhi.
7. Purseglove J W, 1974. *Tropical Crops Dicotyledons*, Longerman Group Ltd., London.
8. Purseglove J W, 1975. *Tropical Crops Monocotyledons*, Longerman Group Ltd., London.
9. Sambamurthy AV S S, N S Subramanyam, 1989. *A text book of Economic Botany*. Wiley Eastern Ltd. New Delhi.
10. Simmonds N W, 1976. *Evolution of Crop Plants*, Longman Group Ltd. , London.
11. Zeven A C, P M Zhukovasky, 1975. *Dictionary of Cultivated Plants and their centers of Diversity*, Centre for Agricultural Publishing and Documentation Washington.
12. Nair M.C. (ed) 1990. *Mushrooms Tech. Bulletin 17*, Kerala Agri. Univ. Pub. Mannuthy. Thrissur.
13. Paroda R.S. and R.K. Arora 1991. *Plant Genetic Resources Conservation and Management*, NBPGR, New Delhi.
14. Kirtikar K R, B D Basu, 1991. *Indian Medicinal Plants*. Dehra Dun.
15. Rana R.S., R.K.Saxena, R.K Tyagi, S. Saxena and V. Mitter 1994 *ex-situ conservation of Plant Genetic Resources*, NBPGR. New Delhi.

16. Guarino, RamanathaRao & Reid (eds) 1995. *Collecting Plant Genetic Diversity: Technical Guidelines*; CAB International.
17. Singh B.B., Neeta Singh and KalyaniSrinivasan (eds) 1996. *Principles and Procedures in Germplasm Conservation*, NBPGR. New Delhi
18. Patel D.P. V.D. Verma, T.R. Loknathan, M.N. Koppa and K.P.S. Chandel (eds) 1997. *Crop Improvement through Plant Genetic Resources (Evaluation, maintenance and documentation)*, NBPGR. New Delhi.
19. Erich Hoyt 1998. *Conserving Wild Relatives of Crops*, IPGRI, Rome.
20. Sivarajan V.V. and Indira Balachandran 1998. *Ayurvedic Drugs and their Plant Sources*, Oxford and IBH, New Delhi.
21. Singh B.P. & Umesh Srivastava 2004. *Plant Genetic Resources in Indian Perspective- Theory and Practice*, Directorate of Information and Publications of Agriculture, ICAR. New Delhi.
22. Amal Kumar Mondal 2005. *Advanced Plant Taxonomy-chapter xi. Remote sensing Technology and Vegetation Classification* pp.391-406, New Central Book Agency. Kolkata.
23. Varaprasad K.S., Z. Abraham, S.R. Pandravada et al 2006. *Medicinal Plants Germplasm of Peninsular India*, NBPGR New Delhi..
24. Peter K.V. & Z. Abraham 2007. *Biodiversity in Horticultural Crops Vol.1*, Daya Publishing House. New Delhi.
25. Panda B.C. 2008. *Remote Sensing- Principles and Applications*, Viva Books, New Delhi.

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 characterisation 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, naphthoquinones, 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*, *Syzygium aromaticum*, *Santalum album*, *Eucalyptus*, *Ocimum bacilicum*, *Rosa*, *Mentha piperita*, *Cymopogon*, *Cananga*, *Pelargonium*.

PHARMACOGNOSY**Module 6: Pharmacognosy (4 hrs)**

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

Module 7: Ethnomedicine (4 hrs)

Traditional 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 ethnopharmacological 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.

REFERENCES

1. Ashutosh Kar, 2006, *Pharmacognosy and Pharmacobiotechnology*, New Age International, New Delhi
2. Atal.C K, Kapur B M, 1982. *Cultivation and Utilization of Medicinal Plants*.
3. Bhattacharjee S K, 2003, *Hand Book of Medicinal Plants*, Pointer Publishers, Jaipur
4. Daniel M, 1991. *Methods in plant chemistry and Economic Botany*. Kalyani publishers, New Delhi.
5. Glossary of *Indian Medicinal Plants with Active Principles* Part I & II, 1980. CSIR, New Delhi.
6. *Indian Medicinal Plants* (5Vols) 1994. Arya Vaidya Sala Kottackal, Orient longoman New Delhi.
7. Irfan Ali Khan, 2008. *Medicinal and Aromatic plants of India*, Ukaaz Publishers, Hyderabad
8. Jain S K 2004. *A Manual of Ethnobotany*, Scientific Publishers, India
9. Khory R N 1999. *Materia Medica of India and their Therapeutics*, Komal Prakashan, Delhi
10. Krishnaswamy N R 2003. *Chemistry of Natural Products*, Universities press, Hyderabad
11. Pushpangaden P Nyman ULF George V. *Glimpses of of Indian Ethno Pharmacology*. The Royal Danish School of Pharmacy Copenhagen, Denmark.
12. Trease, Evans, 2002. *Pharmacognosy*, W.B. Saunder's Co., Ltd.
13. Trivedi P C, 2007. *Medicinal Plants Utilisation and Conservation*, Avishkar Publishers, Jaipur
14. Upadhyaya R C, 2008. *The treatise on Aromatic plants*, Anmol Publications, New Delhi
15. Wallis T E, 1997. *Text Book of Pharmacognosy*. CBS Publication & Distribution.
16. Wealth of India, (XI Vols) 1985. CSIR.

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.

REFERENCES

1. Ahamdijan, Vernon, Mason H E, 1973. The Lichens. Academic press, New York.
2. Alexopoulos C J, Mims C W, 1983. Introductory Mycology. Wiley Eastern, New York.
3. Bhatia K N, 1975. A treatise on Algae. S Chand and Co.
4. Bilgrami K S, Dube H C, 1976. Text Book of Modern Plant pathology. Vikas Publishing House Pvt. Ltd. New Delhi.
5. Chaube H S, Ramji S, 2001. Introductory Plant Pathology. International Book Distributing Co. Lucknow.
6. Chopra R N, Kumra P K, 1988. Biology of Bryophytes. Wiley Eastern Ltd. New Delhi.
7. Fritsch F E, 1945. Structure and Reproduction of Algae Vol. I & II. Cambridge University Press.
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.
11. Pandey S N, Trivedi P S, 1994. A Text book of College Botany Vol. I.
12. Pandey S N, Trivedi P S, 1998. A Text book of College Botany Vol. II.
13. Pandey B P, 2007. College Botany Vol. I. S.Chand and Company.
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.

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. Demonstration 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.

REFERENCES

1. Hopkins W G, Norman P A, Huner, 2008. Introduction to Plant Physiology. John Wiley & Sons, New York.
2. Jain V K, 2008. Fundamentals of Plant Physiology. S Chand and Co.
3. Kochhar P L, Krishnamoorthy H N. Plant Physiology. Atmaram and sons, Delhi.
4. Kumar and Purohit. Plant Physiology: Fundamentals and Applications. Agrobotanical Publishers.
5. Malik C P, 2002. Plant Physiology. Kalyani publishers.
6. Mukherjee S, Ghosh AK, 2005. Plant Physiology. New Central Book Agency, Calcutta.
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.

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 scorpioid; 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. Aggregate. 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 -

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*. Macmillan 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.

SEMESTER IV

Complementary course 4 Code: BO4CMT04
ANATOMY AND APPLIED BOTANY
(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)

Objectives:

- Understand different types of plant tissues.
- Understand the internal structure of different plant organs with reference to their functions.
- Understand the process of normal and anomalous secondary thickening in plants.
- Know the morphological and anatomical adaptations of plants growing in different habitats.
- Understand how botanical knowledge could be applied for crop improvement.

PLANT ANATOMY (27 hrs)

Module 1: Cells and tissues (9 hrs)

Gross structure of primary and secondary cell walls; structure and function of plasmodesmata; non-living inclusions - cystolith, raphides; Tissues – meristematic and permanent, types of meristems; simple and complex tissues, secretory tissues (nectaries, hydathodes, mucilage ducts and lactiferous tissue).

Module 2: Anatomy of plant organs (12 hrs)

Primary structure of stem and root in dicots and monocots; anatomy of monocot and dicot leaf. Secondary thickening in dicot stem and dicot root, heart wood and sap wood; tyloses; hard wood and soft wood; growth rings, dendrochronology. Anomalous secondary thickening in *Bignonia*.

Module 3: Ecological anatomy (6 hrs)

Study of the morphological and anatomical adaptations of the following groups: Hydrophytes – *Nymphaea*, *Hydrilla*; Xerophytes – *Nerium*; Epiphytes - *Vanda*.

APPLIED BOTANY: Plant breeding, Horticulture and Micropropagation (27 hrs)

Module 4: Plant breeding (12 hrs)

Objectives of plant breeding, methods of plant improvement - plant introduction, acclimatization, plant quarantine; selection - mass selection, pureline selection and clonal selection; hybridization - intervarietal, interspecific and intergeneric; procedure of hybridization.

Module 5: Artificial vegetative propagation methods (5 hrs)

Propagation of plants through cutting, layering - air layering; budding T and patch budding; grafting - tongue and splice grafting. Role of cambium in budding and grafting.

Module 6: Plant tissue culture (10 hrs)

Principles of tissue culture, micropropagation - different steps - selection of explants, culture media – general composition and preparation; sterilization of media and explants; callus. Regeneration of plants: organogenesis, somatic embryogenesis; artificial seeds. Applications of plant tissue culture.

PRACTICAL (36 hrs)

1. Primary structure of stem and root of dicots and monocots; Dicot stem - *Centella*; Monocot stem – Bamboo, grass, asparagus; Dicot root - *Tinospora*; Monocot root - *Colocasia*, *Musa*.
2. Structure of dicot stem and dicot root after secondary thickening; Stem - *Vernonia*, *Eupatorium*; Root - *Tinospora*, *Papaya*.

3. Anomalous secondary thickening in *Bignonia*.
4. Anatomical adaptations of Hydrophytes - *Nymphaea* petiole, *Hydrilla* stem; Xerophytes - *Nerium* Leaf; Epiphytes - Velamen root of *Vanda*.
5. Emasculation of pea or *Caesalpinia* flower.
6. Demonstrate T and patch budding.
7. Demonstration of tissue culture techniques: culture media, surface sterilization and inoculation of explants.
8. Identification of non living inclusions - cystolith, raphides.

REFERENCES

1. Christopher E P, 1958. *Introductory Horticulture*. McGraw – Hill, New York.
2. Esau K, 1965. *Plant Anatomy*. Wiley, New York.
3. Fahn A, 1985. *Plant Anatomy*. Pergamon Press, Oxford.
4. Hartman H T, D E Kester, 1991. *Plant Propagation: Principles and Practices*. Prentice Hall of India, New Delhi.
5. Kumar N, 1994. *Introduction to Horticulture*. Rajalakshmi Publications, Nagercoil.
6. Pandey B P, 1984. *Plant Anatomy*. S Chand and Company, New Delhi.
7. Vasishta V C, 1978. *Plant Anatomy*. S Nagin and Company, Jalandhar.

B Sc BOTANY PROGRAMME - MODEL II (VOCATIONAL)

PROGRAMME DESIGN

The UG Programme in Botany (Model II Vocational) must include (a) Common courses, (b) Core courses, (c) Complementary courses, (d) Vocational courses, (e) Open course, (f) Choice based core course (Elective course), (g) Project work and (h) Hands-on training (HOT). No paper shall carry more than 4 credits. The student shall select choice based core course offered by the department that enables the students to familiarize the advanced area of core course. Students can opt for any one of the Open course offered by different departments of the college in V semester.

PROGRAMME STRUCTURE: SUMMARY OF COURSES AND CREDITS

Sl. No.	Course type	No. of courses	Total credits
1	Common course I - English	4	16
2	Common course II – Additional language	2	8
3	Core + Practical	12 + 6	46
4	Vocational + Practical	8 + 3	26
5	Complementary + Practical	4 + 2	14
6	Open course	1	3
7	Programme elective (Choice based core course)	1	3
8	Project work	1	2
9	HOT	1	2
Total		45	120
Total credits		120	
Programme Duration		6 Semesters	
Minimum attendance required		75%	

B Sc BOTANY PROGRAMME - MODEL II (VOCATIONAL)

SEMESTERWISE DISTRIBUTION OF COURSES

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
Common course – Additional language course 1	5	4	Common course – Additional language course 2	5	4
Core course 1 + Practical	4	3	Core course 2 + Practical	4	3
Complementary course 1 + Practical	5	3	Complementary course 2 + Practical	5	3
Vocational course 1	2	2	Vocational course 3	2	2
Vocational course 2 + Practical	4	3	Vocational course 4 + Practical	4	3
Total	25	19	Total	25	19
SEMESTER III			SEMESTER IV		
Common course – English 3	5	4	Common course – English 4	5	4
Core course 3 + Practical	5	4	Core course 4 + Practical	5	4
Complementary course 3 + Practical	5	4	Complementary course 4 + Practical	5	4
Vocational course 5 + Practical	5	4	Vocational course 7 + Practical	5	4
Vocational course 6 + Practical	5	4	Vocational course 8 + Practical	5	4
Total	25	20	Total	25	20
SEMESTER V			SEMESTER VI		
Core course 5 + Practical	5	4	Core course 9 + Practical	5.5	4
Core course 6 + Practical	5.5	4	Core course 10 + Practical	5	4
Core course 7 + Practical	5.5	4	Core course 11 + Practical	6.5	4
Core course 8 + Practical.	5	4	Core course 12 + Practical	5	4
Open course	4	3	Programme elective - Choice based core course	3	3
Total	25	19	Project work	--	2
			Hands-on training	--	2
			Total	25	23

**B Sc BOTANY PROGRAMME - MODEL II (VOCATIONAL)
COMBINATION AND SEMESTER-WISE DISTRIBUTION OF VOCATIONAL
COURSES**

1. Environmental monitoring and Management						
Sem.	Course category	Course code	Course title	Instr. hrs.*		Credits
				Th.	Pr.	
I	Vocational	BO1VO1T01	Environmental Biology Part-I	36	--	2
	Vocational	BO1VO1T02	Environmental Biology Part-II	36	36	2 + 1
II	Vocational	BO2VO1T03	Environmental Microbiology	36	--	2
	Vocational	BO2VO1T04	Environmental hygiene and Human health	36	36	2 + 1
III	Vocational	BO3VO1T05	Environmental Monitoring Part-I	54	36	3 + 1
	Vocational	BO3VO1T06	Environmental Conservation and Management Part-I	54	36	3 + 1
IV	Vocational	BO4VO1T07	Environmental Monitoring Part-II	54	36	3 + 1
	Vocational	BO4VO1T08	Environmental Conservation and Management Part-II	54	36	3 + 1
2. Food Microbiology						
I	Vocational	BO1VO2T01	Microbial world Part-I	36	--	2
	Vocational	BO1VO2T02	Microbial world Part-II	36	36	2 + 1
II	Vocational	BO2VO2T03	Applied Microbiology Part-I	36	--	2
	Vocational	BO2VO2T04	Applied Microbiology Part-II	36	36	2 + 1
III	Vocational	BO3VO2T05	Principles of Food Microbiology	54	36	3 + 1
	Vocational	BO3VO2T06	Contamination, spoilage and Preservation of Food Part-I	54	36	3 + 1
IV	Vocational	BO4VO2T07	Contamination, spoilage and Preservation of Food Part-II	54	36	3 + 1
	Vocational	BO4VO2T08	Food fermentations, Food infection and Food borne diseases	54	36	3 + 1
3. Horticulture and Nursery management						
I	Vocational	BO1VO3T01	Fundamentals of Horticulture	36	--	2
	Vocational	BO1VO3T02	Plant Propagation	36	36	2 + 1
II	Vocational	BO2VO3T03	Ornamental Horticulture and Landscaping	36	--	2
	Vocational	BO2VO3T04	Plant protection and Nursery management	36	36	2 + 1
III	Vocational	BO3VO3T05	Floriculture	54	36	3 + 1
	Vocational	BO3VO3T06	Olericulture	54	36	3 + 1
IV	Vocational	BO4VO3T07	Pomology, Food technology and Post-harvest management of Horticultural crops	54	36	3 + 1
		BO4VO3T08	Cultivation of Medicinal and aromatic plants, spices and Plantation crops	54	36	3 + 1
4. Plant Biotechnology						
I	Vocational	BO1VO4T01	Introduction to Biotechnology	36	--	2
	Vocational	BO1VO4T02	Microbiology	36	36	2 + 1
II	Vocational	BO2VO4T03	Molecular Biology	36	--	2
	Vocational	BO2VO4T04	Fundamentals of Enzymology and Radiobiology	36	36	2 + 1
III	Vocational	BO3VO4T05	Biotechniques and Instrumentation	54	36	3 + 1
	Vocational	BO3VO4T06	Basics of Molecular cloning techniques	54	36	3 + 1
IV	Vocational	BO4VO4T07	Genetic Engineering	54	36	3 + 1
	Vocational	BO4VO4T08	Plant Tissue culture	54	36	3 + 1

* 18 instructional hours is equal to one teaching hour per week

ENVIRONMENTAL MONITORING AND MANAGEMENT

SEMESTER I

Vocational course 1 Code: BO1VO1T01
ENVIRONMENTAL BIOLOGY PART - I
(Theory 36 hrs; Credits 2)

Objectives:

To enable students to;

- Create awareness on aspects of the ecosystem and interactions within the system.
- Have an idea on diverse group of plants, their survival and their interactions in different environments.
- Understand the flow of energy and route of elements through the ecosystem.

Module 1: Environment and Ecology (4 hrs)

Definition, principles and scope of environmental science, history of ecology, subdivisions of ecology - autoecology and synecology. Fundamental ecological variables - matter, light, time, space and diversity.

Module 2: Ecosystems (14 hrs)

Definition, components, structure, function and size of ecosystems. Types of ecosystems - freshwater ecosystems, marine ecosystem, terrestrial ecosystems. Structure, function and characteristics of: forest ecosystem - temperate and tropical forests, arctic and alpine forests, tundra's. Deserts ecosystem - arid and semi-arid. Grassland ecosystems - savannas. Coastal and marine ecosystem - coral reefs. wetlands - lakes, rivers, estuaries. Mangroves.

Module 3: Ecosystem processes (8 hrs)

Nutrient cycles, energy flow, homeostasis in the ecosystem. Biogeochemical cycles (gaseous - C, N, O; sedimentary cycles – S, P). Trophic relations, food chain, food-web and ecological pyramids, concept and measurement of productivity.

Module 4: Biodiversity (10 hrs)

Introduction, definition, types of biodiversity - species, genetic and ecosystem diversity. Composition and levels of biodiversity, ecological foot prints, endemic species, endangered species - flora and fauna. Red data book, key stone species, flag ship species, values and distribution pattern of biodiversity - biodiversity hotspots, biodiversity depletion-causes and consequences. Plant and animal interactions.

REFERENCES

1. Abbasi S A, 1998. Environmental pollution and its control. Cogent International, Pondicherry.
2. Abbasi S A, 1998. Water Quality: Sampling and Analysis. Discovery publishing house, New Delhi.
3. Abbasi S A, Ramasami E, 1999. Biotechnological methods of pollution control. Universities Press, Hyderabad.
4. Agarwal K C, 1996. Biodiversity. Agrobotanical Publishers, Bikaner.
5. Agarwal K C, 1993. Environmental Biology (II Edn). Agrobotanical Publishers, Bikaner.
6. Apha, 1998. Standard methods for the examination of water and wastewater. Moduleed Book Press, Inc., Baltimore, Maryland, USA.
7. Baird C, 1999. Environmental chemistry. W H Freeman & Co., New York.

8. Barry R G, Chorley R J, 1998. Atmosphere, Weather and Climate (VII Edn). Routledge, London.
9. Bennet N H, 2001. Soil conservation for sustainable development. Agrobotanical Publishers, Bikaner.
10. Brady N C, 1996. Nature and Properties of Soil. Prentice Hall of India Pvt. Ltd. New Delhi.

Vocational course 2 **Code: BO1VO1T02**
ENVIRONMENTAL BIOLOGY PART-II
(Theory 36 hrs; Practical 36 hrs; Credits 2 + 1)

Objectives:

To enable students to;

- Assess the inter-relationship between organisms at population and community level
- Create awareness on importance of biological resources
- Study types and process of succession

Module 1: Population Ecology (6 hrs)

Definition, structure and measurements - density, growth, natality, mortality. population dispersal and distribution, population growth. Factors affecting population, carrying capacity, population regulation.

Module 2: Community Ecology (12 hrs)

Concepts of community, structure, community gradients - ecotone, edge effect, continuum concept, ecological niche, ecological equivalents, ecotypes. Characters of community: qualitative characters - floristic composition, stratification and periodicity. Quantitative characters - density, abundance and species diversity. Analysis - quadrat and transect method.

Module 3: Ecological Succession (12 hrs)

Definition, classification, processes - nivation, invasion or migration, competition, climax - concept of climax, theories and significance, Kinds of succession - hydrosere and xerosere. Interactions between species: competition, predation, mutualism commensalism, parasitism and allelopathy.

Module 4: Biological resources (6 hrs)

Plant and animal resources, mangrove and wet land resources, agricultural resources, forest products and biomass, microbial resources and their ecological significance.

PRACTICAL (36 hours)

1. Vegetation analysis - association, diversity, frequency, density, productivity (primary) indirect estimation of standing crop.
2. Aquatic ecosystems - survey, mapping, preservation, identification and abundance estimation of macrophytes, biomass and primary productivity; dissolved oxygen and pH.
3. Visits to mangrove and inland water ecosystems.
4. Demonstration of ecosystems and succession patterns: familiarization of forest products, plants and animal resources.

REFERENCES

1. Chakrabarti N K, 1994. Environmental Protection and Law. Abilash Publishing House, New Delhi.
2. Chapman J L, Reiss M J, 1992. Ecology: Principles and Applications. Cambridge University Press.
3. Claus W G, 1989. Understanding Microbes: A laboratory text book for Microbiology. W H Freeman and Co., New York.

4. Dash M C, 2001. Fundamentals of Ecology (II Edn). Tata McGraw-Hill, New Delhi.
5. De A K, 2003. Environmental Chemistry. New Age International Publishing, New Delhi.
6. Emiliani C, 1997. Planet Earth: Cosmology, Geology.
7. Freedman B (Ed), 1995. Environmental Ecology: The ecological aspects of pollution, disturbance and other stresses. Academic Press.
8. Gabriel Bitton, 1994. Water and Waste water Microbiology. John Wiley & sons, N. York.
9. Goel P K, Sharma K P, 1996. Environmental Guidelines and Standards in India. Techno Science Publications, Jaipur.

SEMESTER II

Vocational course 3 **Code: BO2VO1T03**
ENVIRONMENTAL MICROBIOLOGY
(Theory 36 hrs; Credits 2)

Objectives:

To enable students to;

- Understand the world of microbes & evaluate their role in the environmental segments.
- Evaluate the application of microbiology in different fields.
- Study the aspects of food spoilage and importance of preservation of food.

Module 1: Microorganisms in the Environment (12 hrs)

Introduction to Microbiology. Bacteria: Morphology and ultra structure of bacteria, classification, nutrition - autotrophy and heterotrophy, reproduction. Fungi: morphology and structure of fungal hyphae and mycelium, classification, reproduction and life cycle. Protozoa: structure, symbiotic and parasitic protozoans, reproduction and life cycle. Viruses: structure, types, multiplication and life cycle. Bacteriophages - lytic and lysogenic cycle.

Module 2: Microorganisms and the Environment (12 hrs)

Role of microbes in the environment, microbes in biogeochemical cycles, microbial transformation of metals, biological nitrogen fixation and microbial antibiotics, microorganisms in extreme environments. Distribution of microorganisms in soil, water and air. Soil Microbiology - soil microorganisms association with plants - the rhizosphere, mycorrhizae, actinorrhizae, tripartite association, fungal and bacterial endophytes of plants, Agrobacterium, soil microorganisms interactions with the atmosphere.

Module 3: Food microbiology (4 hrs)

General properties of food spoilage, chemical changes caused by microorganisms, microbial toxins, fermentation products, preservation of food.

Module 4: Diseases connected with food and water (8 hrs)

Food poisoning, food allergy. Microorganisms and water pollution: significance of bio-indicators - faecal bacteria and pathogenic microorganisms, microbial interaction with other organisms - competition, parasitism and mutualism. Microbial analysis of water quality.

REFERENCES

1. Hans F Linskens, John F Jackson, Peter J S Bain, 1999. Analysis of plant waste material. Springer, Berlin.

- Holmes A, 1965. Principles of Physical Geology, ELBS.
- Jackson M L, 1973. Soil Chemical Analysis. Prentice Hall Pvt. Ltd, New Delhi.
- Khan A, 2002. Sustainable Development Watershed Management for Sustainable Development. Agro botanical Publishers, Bikaner.
- Khopkar S M, 2004. Environmental Pollution: Monitoring and Control. New Age International, New Delhi.
- Schlegel H G, 1973. General microbiology, Cambridge University Press.
- Scragg A, 1999. Environmental Biotechnology. Addison Wesley Longmann, Singapore.
- Sharma P D, 2005. Environmental Microbiology. Narosa Publishing House, New Delhi.

Vocational course 4 **Code: BO2VO1T04**
ENVIRONMENTAL HYGEINE AND HUMAN HEALTH
(Theory 36 hrs; Practical 36 hrs; Credits 2 + 1)

Objectives:

To enable students to;

- Understand the environmental factors that relate to human health and diseases.
- Study the importance of sanitation and hygiene in preserving the environment and maintaining good health.
- Make awareness on industrial hazards.

Module 1: Environmental factors in health (7 hrs)

Health and Diseases: physical, chemical and biological factors that affect health. Common water borne diseases and their control, home environment, Sanitation and hygiene, basic needs and relationships of sanitation to health. Epidemiological diseases due to pollution problems with special reference to Kerala. Role of sex education; sexually transmitted diseases – AIDS.

Module 2: Occupational hazards and safety (10 hrs)

Environmental and occupational safety - definitions, concept and scope. Occupational hazards and diseases - physical hazards - noise, radiation. Chemical hazards - dust of silica, cement, paper, cotton, jute, pesticides, particulate matter. Biological hazards - psychological and physiological fatigue. Control of toxic materials and safety measures.

Module 3: Toxicology (9 hrs)

Definition, poison, toxin, dose, exposure, xenobiotics and hazards. Physical toxicity - particulates, gaseous, solvent and vapour. Chemical toxicity - halogens, hydrocarbons, pesticides and heavy metals. Physiological toxicants - irritants, anaesthetics, narcotics, asphyxiants and systemic poisons.

Module 4: Mode of action of toxicants (10 hrs)

Transport processes of toxicants, biotransformations, bioaccumulation and bioconcentration. Factors affecting toxicity, dose effect and dose response relationship, dose effect and dose response curves. Toxic effect due to combination of chemicals - additive, potentiation, antagonism and synergism.

PRACTICAL (36 hours)

- Microbial techniques: sterilization – flame sterilization, hot-air oven, boiling water bath, autoclaving, chemical sterilization, plating, isolation, streaking and identification.
- Mounting and staining: (a) gram stain, (b) acid fast: aerobic and anaerobic microbes, identification: milk, food and soil microbes. Identification of pathogenic microbes in water.
- Toxicity studies - application of LC₅₀ in fishes, spot test for plant.

4. Pollution indicators: phytoplankton and zooplankton counts, biotic index, palmer's algal pollution index.
5. Field visits (regions of environmental problems).

REFERENCES

1. Kumar U, 2002. Air Pollution: Effects, Causes, Control and Analysis. Agro botanical Publishers, Bikaner
2. Kumar A, Lalan H S, 2000. Advanced Ecology. Daya Books.
3. Levy B S, Wagman D H (Ed), 1995. Occupational health: recognizing and preventing work related disease. Little Brown & Co.
4. Majumdar, Singh, 2002. Analysis of Soil Physical Properties. Agro botanical Publishers, Bikaner.
5. Marquita K Hill, 1997. Understanding Environmental Pollution. Cambridge University Press.

SEMESTER III

Vocational course 5 **Code: BO3VO1T05**
ENVIRONMENTAL MONITORING – PART I
(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)

Objectives:

- Study about pollutants that adversely affect air environment
- Familiarize techniques involved in monitoring and controlling of air pollutants
- To study the causes & effects of soil pollution
- To highlight the adverse effects of quarrying, deforestation & unscientific farming practices
- To create awareness on different land use practices, involved in preserving our soil resource
- Study the methods involved in analysis of the soil pollutants

Module 1: Air pollution (15 hrs)

Structure and constituents; sources , nature and types of pollutants, particulate matter, aerosols, fly ash, sulphur, halogen, carbon and nitrogen compounds, primary and secondary air pollutants, Photochemical smog, Ozone depletion, Acid rain, Green house effect, Inversions, Biopollutants: effect of air pollution on health, plants, climate and materials. Radioactive pollutants: origin of radionuclides - natural and artificial- their path and effects on the ecosystem.

Module 2: Air pollution monitoring and control (14 hrs)

Pollution control by particulate removal, settling chamber, air scrubbers, water spraying, filters and electro static preceptors. Removal of gaseous pollutants and treatment of air pollutants - in chemical industries, refineries, thermal power plants, cement industries, automobile exhausts. Air quality standards and principles of air monitoring devices.

Module 3: Environmental chemistry of soil (7 hrs)

Introduction, weathering and pedogenesis; factors of soil formation, development of soil profile, structure of soil, organic and inorganic components of soil, physico-chemical characteristics of soil, ion-exchange and adsorption processes in the soil. Classification of soil types of soil (Reference to India and Kerala).

Module 4: Soil pollution (4 hrs)

Sources, nature and types of soil pollutants - fertilizer residues, solid wastes, radio active substances, hospital wastes, pesticide pollution, field run off and sewage effluents.

Module 5: Adverse effects of soil pollution (14 hrs)

Various aspects of soil erosion, soil degradation, water logging, sand and clay mining, desertification, quarrying, land conversion for agriculture, deforestation and farming, urban housing, road development and over grazing. Soil plant interactions, adverse effects of land use practices in Kerala. Soil pollution monitoring and control; methods and principles of analysis for the soil pollutants.

PRACTICAL (36 hrs)

1. Sampling techniques of soil.
2. Physical parameters: Soil type, soil profile and texture.
3. Preparation of soil extract.
4. Determination of pH, acidity, total organic content, potassium and calcium.
5. Familiarize the equipments used in soil analysis.
6. Determination of soil texture - triangular diagram.

REFERENCES

1. Brady N C, 1996. Nature and Properties of Soil. Prentice Hall of India Pvt. Ltd. New Delhi.
2. Mido Y, S A Iqbal, 1995. Chemistry of air and air pollution. Discovery publishing house, New Delhi.
3. Marquita K Hill, 1997. Understanding Environmental Pollution. Cambridge University Press.
4. Kumar U, 2002. Air Pollution: Effects, Causes, Control and Analysis. Agrobotanical Publishers, Bikaner.
5. Khopkar S M, 2004. Environmental Pollution: Monitoring and Control. New Age International, New Delhi.
6. Jackson M L, 1973. Soil Chemical Analysis. Prentice Hall Pvt. Ltd, New Delhi.
7. Abbasi S A, 1998. Environmental Pollution and its control. Cogent International, Pondicherry.
8. Subramanyam N S, Sambamurthy A V S S, 2006. Ecology. Narosa Publishing house, New Delhi.
9. Pandey S N, Mishra S P, 2011. Environment and Ecology. Ane Books Pvt Ltd. New Delhi.

Vocational course 6**Code: BO3VO1T06****ENVIRONMENTAL CONSERVATION AND MANAGEMENT – PART I****(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)****Objectives:**

- Familiarize different aspects of habitat management
- Highlight strategies and planning involved in land use management for sustainable development
- Create awareness on importance of solid waste and water resource management
- Study various aspects of ecotourism
- Evaluate the importance of environmental education in preserving our resources

Module 1: Habitat management (15 hrs)

Conservation of forests, wild life, air, water, soil and environments. Threats/depletion of biodiversity, conservation of biodiversity - ex-situ and in-situ; national parks, wildlife sanctuaries, biosphere reserves, sacred groves. International conservation strategies - CBD, CITES, global biodiversity strategy, GEF Initiatives, national biodiversity action plans, biodiversity registries, biodiversity with

special reference to Kerala, cause of extinction of species, endangered species, management of mangrove vegetation.

Module 2: Land use management for sustainable development (10 hrs)

Strategies and planning for soil pollution control, changes in agricultural practices, solid waste management, vermicomposting, bacterial composting. Precautions in the use of radioactive substances. Occupational health hazards with relation to solid waste disposal.

Module 3: Water resources management (6 hrs)

Socio-economic factors involved in managing water resources. Conventional and non-conventional sources of water supply management, rain water harvesting.

Module 4: Ecotourism (15 hrs)

From an environmental management perceptive rather than tourism as an industry. Ecotourism and responsible tourism. Identification of nature based ecotourism opportunities in Kerala - dam sites, HEP, waterfalls, mangroves, bird sanctuaries, pilgrim tourism, forest area, parks, sacred groves, beaches, wildlife sanctuaries, national parks. Strategies to maintain these areas in an ecological sustainable way. Coastal management activities in India and Kerala.

Module 5: Environmental education (8 hrs)

Education to inculcate environmental consciousness among learners. Non-formal and formal education (business, union, community and other organizations): methodologies (posters, banners, audio-visual aids, street plays, padayatras, corner meetings).

PRACTICAL (36 hrs)

1. Analysis of chemical parameters - acidity, alkalinity and hardness of water sample.
2. Analysis of biological parameters: Identification, counting of zooplanktons and phytoplanktons, estimation of productivity using algae.
3. Study different agricultural practices and its significance.
4. Familiarize the equipments and the steps involved in estimating soil water content.
5. Identification of endangered animal and plant species of Kerala from photographs.

REFERENCES

1. Nagore A P, 1996. Biological diversity and international Environmental law. ABH Publishing Corp. New Delhi.
2. Nayar, M P, 1996. Hotspots of Endemic Plants of India, Nepal and Bhutan. TBGRI, Trivandrum.
3. Odum E P, 1971. Fundamentals of Ecology. W B Saunders Company. Philadelphia.
4. Prescott L M, Harley J P, Klein D A, 1993. Microbiology. WCB Publishers.
5. Purohit S S, 1992. The World of Microbes, Agrobios (India) Jodhpur.
6. Purohit S S, 2002. Microbiology: Fundamentals and Applications (VI Edn). Agrobios (India), Jodhpur.
7. Ramada F (Ed), 1997. Ecotoxicology. John Wiley & Sons.

SEMESTER IV

Vocational course 7**Code: BO4VO1T07****ENVIRONMENTAL MONITORING - PART II****(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)****Objectives:**

- Create awareness on importance of water as a resource
- Know about pollutants that adversely affect aquatic environment
- Familiarize techniques involved to analysis of water pollutants
- Study the causes & effects of water pollution.
- Highlight the adverse effects various industries that contribute to aquatic pollution
- Study methods involved in water pollution monitoring and control
- Perform analysis to assess soil & water quality

Module 1: Hydrosphere (15 hrs)

Nature and composition of natural waters, hydrological cycle, trace level substances in water, redox equilibria in natural waters. Physical and chemical properties of water in relation to living organisms. Biological importance of water, hydrological cycle, ground water, types of water, origin, movement, storage and factors affecting ground water. Ground water – replenishment, potable water qualities. Quality and productivity of fresh water, estuarine and marine water.

Module 2: Water analysis (10 hrs)

Sampling techniques - sample preservation and their importance. Water quality monitoring devices - principles. Physical and chemical tests of water related to water pollution. Principles and methods of water analysis.

Module 3: Water pollution (10 hrs)

Sources, types and nature of pollutants. Nature and effects of water pollutants - acids, alkalis, thermal, radioactive, heavy metals, pesticides, waxes, soaps, fertilizers, farm wastes, sewage and industrial effluents, synthetic detergents. Effects of water pollutants on human beings, plants and animals. Quality of water - eutrophication, bloom formation, COD, BOD, turbidity, salinity and colour.

Module 4: Water pollution monitoring and control (12 hrs)

Water and waste water treatment. Preliminary, primary, secondary and tertiary treatments. Treatment of industrial waste water - chemical, fertilizer, paper pulp, tannery, sugar distillery and oil refineries; recycling of industrial and domestic waste waters. Water quality criteria and standards (Indian and International).

Module 5: Biomonitoring (7 hrs)

Bioassessment - bioassays, 5 R's of biomonitoring – eutrophication monitoring. Biotic index. Bioindicators - uses of biomonitoring.

PRACTICAL (36 hrs)

1. Analysis of physical parameters - temperature, colour, pH, turbidity, conductivity, and total solids, total dissolved solids and total suspended solids of water sample.
2. Analysis of chemical parameters – CO₂, salinity, dissolved oxygen, COD, productivity and BOD of water sample.
3. Analysis of biological parameters: Identification counting of zooplanktons and phytoplanktons, estimation of productivity using algae.
4. Familiarize instruments and chemicals used in water quality analysis.

REFERENCES

1. Michael P, 1990. Ecological methods for Laboratory and Field investigations. Tata McGraw Hill Publishing Company Ltd. New Delhi.
2. Mido Y, S A Iqbal, 1995. Chemistry of Air and air pollution. Discovery Publishing House, New Delhi.
3. Mishra P C, 1995. Advances in Ecology and Environmental Sciences. APH Publishing.
4. Munn R E (Ed), 1979. Environmental Impact Assessment: Principles and procedures. John Wiley & sons, New York.

Vocational course 8**Code: BO4VO1T08****ENVIRONMENTAL CONSERVATION AND MANAGEMENT – PART II****(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)****Objectives:**

- Create awareness on the present laws associated with environmental protection
- Know about role of various international & national organizations that help in preserving our environment & resources
- Study the principles and tools evolved for development on sustainable basis
- Attain the acquired ability to impart knowledge to local public as a means to preserve environment and resources at grass root level
- Get an idea on aspects of disaster management and its effect on development

Module 1: Environmental legislation (10 hrs)

Fundamental principles of environmental laws, General structure of environmental laws in India and constitutional responsibilities, The Water (Prevention and Control of Pollution) Act 1974, The Air (Prevention and Control of Pollution) Act 1981, The environment (Protection) act 1986, wild life protection act 1972, Forest Conservation Act 1980. Laws for the waste disposal – solid waste and hazardous waste, biomedical waste.

Module 2: Environmental conventions and summits (6 hrs)

Stockholm Convention 1972, Montreal Protocol 1987, Ramsar Convention, Rio declaration 1992 and Agenda 21, Earth Summit, Kyoto Protocol.

Module 3: National and international organizations on environment (9 hrs)

UNEP, UNDP, WWF, IUCN, Earth watch, Green Peace; Information networks - ENVIS centres, National bureau for plant genetic resources (NBPGR), conservation of gene reserve, global environmental management, non-conventional energy use.

Module 4: Tools in sustainable development (10 hrs)

Principles and tools in sustainable development; careful identification of the causes and consequences (short term and long term) of a broad range of problems in developing and industrial countries. Environmental impact assessment, environmental auditing, remote sensing, geographic information systems, biofarming, environmental planning.

Module 5: Environmental policy (7 hrs)

Role of social movements - peoples Participation and various movements for environmental protection, formal organizations, national organizations, institutions (Parliament and Cabinet), mass media, the educational systems and scientists, role of NGOs in the implementation of environmental policies.

Module 6: Disaster management and Development (12 hrs)

Characterization of natural disasters and its management - earthquake, draught, flood and landslide.
Link between disasters and development.

PRACTICAL (36 hours)

1. Analysis of chemical parameters - acidity, alkalinity of water sample.
2. Illustrate the steps involved in management of organic waste / control of soil pollution.
3. Study of different types of disasters and enumerate its environmental effects.

REFERENCES

1. Sabbins F F, 1994. Practical guide to environmental impact assessment. Academic Press Inc. San Diego, California.
2. Sadasivam S, A Manickam, 1996. Biochemical methods (II Edn). New Age International publications.
3. Schlegel H G, 1973. General microbiology. Cambridge University Press.
4. Scragg A, 1999. Environmental Biotechnology. Addison Wesley Longman, Singapore.
5. Sharma P D, 2005. Environmental Microbiology. Narosa Publishing House, New Delhi.
6. Sivashanmugam P, 2007. Basics of Environmental Science and Engineering.
7. Tomar Mamta, 1999. Quality assessment of water and wastewater. CRC Press, New Delhi.
8. Trivedi R K, Goel P K, 1986. Chemical and biological methods for water pollution studies. Karad Environmental Publications.
9. Trivedy P R, 1996. International Environmental Laws. ABH Publishing Corporation, New Delhi.
10. Verma P S, Agarwal V K, 1998. Concepts of Ecology. S Chand & Co.
11. Williard H H, Merritt L L, Deen J A, Settle F A, 1986. Instrumental methods of analysis. CBS Publishers and distributors, New Delhi.

FOOD MICROBIOLOGY

SEMESTER I

Vocational Course 1

Code: BO1VO2T01

MICROBIAL WORLD - PART I

(Theory 36 hrs; Credits 2)

Module 1: History and scope of microbiology (6 hrs)

History and scope of Microbiology; theory of spontaneous generation, theory of biogenesis. Contributions of early microbiologists - Anton van Leeuwenhoek, Robert Koch, Edward Jenner, Louis Pasteur, Paul Ehrlich, Alexander Fleming.

Module 2: Cell structure of prokaryotes and eukaryotes (10 hrs)

Prokaryotic cell - structure and function; size, shape and arrangement; cell organisation, membrane system, nucleoid; wall structure - peptidoglycan, gram positive and gram negative cell walls; components external to cell wall - capsule, slime layers, pili and fimbriae, flagella, endospore, cysts. General characters of Archaeobacteria – classification.

Eukaryotic cell - structure and function, nucleus, cell inclusions - living and non living, external cell coverings, cilia and flagella.

Module 3: General characters of other microorganisms (10 hrs)

Viruses - Structure of viruses, virion size, nucleic acids, capsids, cultivation of viruses - structure of TMV and HIV. Bacteriophages - discovery, structure of bacteriophages, methods of replication - lytic and lysogenic cycle. Viroids and prions. General characters of fungi, yeast, protozoa.

Module 4: Microscopy (10 hrs)

Introduction to microscopy - resolution - limit of resolution - magnification - optics, principle and working of bright field microscopy, dark field microscopy, fluorescence microscopy, phase contrast microscopy - electron microscopy - TEM and SEM.

REFERENCES

1. Joanne M Willey, Linda M Sherwood, Christopher J Woolverton, 2011. *Prescott's Microbiology* (VIII Edn). McGraw-Hill International Edition, New York.
2. Pelczar, Chan, Krieg. *Microbiology*. Tata Mc-Graw Hill Publishers, New York.
3. George Plopper, David Sharp Eric Sikorski, 2015. *Lewin's CELLS* (III Edn). Jones and Barlett India pvt. Ltd., Dryaganj, New Delhi.
4. S C Rastogi, 2006. *Cell Biology* (III Edn). New Age International Publishers Limited, Daryaganj, New Delhi.
5. C B Powar, H F Daginawala. *General Microbiology*, Vol. I. Himalaya Publishing House.
6. R C Dubey, D K Maheswari. *A Text Book of Microbiology*. S. Chand & Company Ltd., Ram Nagar, New Delhi.
7. Ananthanarayanan, C K Jayaram Panikar, 2006. *Ananthanarayan & Paniker's Textbook of Microbiology* (VII Edn). Orient Longaman.
8. Purohit S S, 2005. *Microbiology: Fundamentals and Applications*. Student Edition Publishers, Jodhpur.
9. Salle A J, 2001. *Fundamentals & Principles of Bacteriology* (VII Edn). Tata McGraw-Hill, New York.
10. Davis, Delbecco, Eisen, Ginsburg, 1990. *Microbiology* (V Edn). Harper & Raw, New York.
11. Gerhardt, Murray, Wood and Kreig, 1994. *Methods for General and Molecular Bacteriology*, ASM Press, Washington.
12. Alexopoulos C J, C W Mims, 1993. *Introductory Mycology* (III Edn). Wiley Eastern Ltd., New Delhi.
13. Elizabeth Moore-Landecker, 1996. *Fundamentals of the Fungi* (IV Edn). Prentice Hall International Inc., London.
14. Conrat H F, Kimball P C, Levy J A, 1988. *Virology* (II Edn). Prentice Hall, Englewood Cliff, New Jersey.
15. P V Ramana Rao, 2005. *Essentials of Microbiology*. CBS Publishers and Distributors, New Delhi.
16. Ronald M Atlas, 2015. *Principles of Microbiology* (II Edn). McGraw Hill Education (India) Private Limited, Green Park extension, New Delhi.
17. Jacquelyn G Black, 2005. *Microbiology: Principles and Explorations* (VI Edn). John Wiley & Sons, Inc., USA.
18. A Krishnan, 2000. *Agro's Dictionary of Microbiology* (II Edn). Agrobios (India), Jodhpur.
19. I Edward Alcamo. *Schaum's Outline of Theory and problems of Microbiology*. Tata McGraw Hill Companies Inc., New York.
20. Mark Wheelis, 2010. *Principles of Modern Microbiology*. Jones and Bartlett India Pvt. Ltd., Daryaganj, New Delhi.

22. Ajit K R, Banerjee, Nirmalya Banerjee, 2012. *Fundamentals of Microbiology and Immunology*. New central Book Agency (P) Ltd., Sankrail, Howrah.
23. D R Arora, B Arora, 2008. *Text Book of Microbiology* (III Edn). CBS Publishers & Distributors, New Delhi.
24. Aneja K R, Jain P, Aneja R, 2008. *A textbook of Basic and Applied Microbiology*. New age International Pvt. Ltd., New Delhi, India.
25. Kathleen Talaro, Arthur Talaro, 1996. *Microbiology* (II Edn). Wm C. Brown Publishers.

Vocational Course 2 **Code: BO1VO2T02**
MICROBIAL WORLD - PART II
(Theory 36 hrs; Practical 36 hrs; Credits 2 + 1)

Module 1: Systematic Bacteriology (6 hrs)

Bergey's manual of systematic bacteriology: history, classification into 4 volumes – study of major groups - Spirochaetes, Enterobacteriaceae, Nitrogen Fixers, Rickettsiae, Chlamydiae, Mycoplasma, Endospore forming bacteria.

Module 2: Bacterial Growth (8 hrs)

Bacterial multiplication – bacterial growth curve - generation time - batch culture - continuous culture - synchronous culture - quantitative measurement of growth.

Module 3: Bacterial Physiology (12 hrs)

Nutritional requirements of microorganisms - nutritional types of Bacteria - physical conditions required for growth - Bacterial metabolism - respiration, fermentation, photosynthesis.

Module 4: Bacterial Genetics (10 hrs)

Mutation - types of mutation - bacterial recombination - transformation, conjugation, transduction. Genetic mapping in Bacteria. Plasmids – general features, use in recombinant DNA Technology.

PRACTICAL (36 hrs)

1. Laboratory techniques in Microbiology: Microscopy - use of bright field microscope, study of parts and functions; Use of equipment and glass wares - inoculating loop, needle, petri dishes, flasks, culture tubes, pipettes, pasteur pipettes, hot air oven, autoclave, incubator, water bath, colony counter, filters, UV lamp, pH meter, centrifuge, colorimeter, laminar air flow system.
2. Micrometry: measurement of size of fungal spores/yeast cells/ bacteria.
3. Bacterial motility - Hanging drop technique.
4. Cleaning glass wares, drying, plugging tubes and flasks, wrapping Petri dishes.

REFERENCES

1. Albert G. Moat and John W. Foster. *Microbial Physiology*. John Wiley & Sons Inc, Pub. David Frifelder, *Microbial Genetics*.
2. R C Dubey, D K Maheswari. *A text book of microbiology*. S.Chand & Company Ltd., New Delhi
3. Caldwell D R, 1995. *Microbial Physiology and Metabolism*. Brown Publishers.
4. Laurence A. Moran, H. Robert Horton, K. Gray Scrimgeour, Marc D. Perry. (2012). *Principles of Biochemistry* (V Edn). Pearson, USA
5. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton, 2011. *Prescott's Microbiology*. Eighth Edition. McGraw-Hill International Edition, New York
6. Pelczar, Chan, Krieg. *Microbiology*. Tata Mc-Graw Hill Publishers, New York

7. C.B. Powar and H.F. Dagainawala. *General Microbiology*, Volume I. Himalaya Publishing House.
8. R.C. Dubey and D.K. Maheswari. *A Text Book of Microbiology*. S. Chand & Company Ltd.
9. Purohit S S, 2005. *Microbiology: Fundamentals and Applications*. Student Edition Publishers, Jodhpur.
10. Salle A J, 2001. *Fundamentals & Principles of Bacteriology* (VII Edn). Tata McGraw-Hill, New York.
11. Davis, Delbecco, Eisen & Ginsburg (1990) *Microbiology*. 5th Edition. Harper & Raw, New York
12. Gerhardt, Murray, Wood and Kreig (1994). *Methods for General and Molecular Bacteriology*, ASM Press, Washington.
13. P V Ramana Rao, 2005. *Essentials of Microbiology*. CBS Publishers and Distributors, New Delhi.
14. Ronald M. Atlas. (2015). *Principles of Microbiology*. Second Edition. McGraw Hill Education (India) Private Limited, Green Park extension, New Delhi
15. Jacquelyn G Black, 2005. *Microbiology: Principles and Explorations* (VI Edn). John Wiley & Sons, Inc.
16. I. Edward Alcamo. *Schaum's Outline of Theory and Problems of Microbiology*. Tata McGraw Hill Companies Inc., New York.
17. Mark Wheelis. (2010). *Principles of Modern Microbiology*. Jones and Bartlett India Pvt. Ltd., Daryaganj, New Delhi.
18. Ajit Kr. Banerjee, Nirmalya Banerjee. (2012). *Fundamentals of Microbiology and Immunology*. New central Book Agency (P) Ltd., Sankrail, Howrah.
19. D R Arora and B. Arora. (2008). *Text Book of Microbiology*. 3rd Edition. CBS Publishers & Distributors, New Delhi.
20. Aneja K. R., Jain P., Aneja R. (2008). A textbook of Basic and Applied Microbiology. Published by Newage International Pvt. Ltd., New Delhi, India.
21. James G. Cappuccino, Natalie, Sherman. *Microbiology- A Laboratory Manual*.
22. Kanika Sharma. *Manual of Microbiology: Tools and Techniques*
23. K. R. Aneja. *Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Production Technology*. New Age International (P) Limited Publishers, Bangalore.
24. Kanakam Elizabeth Thomas. (2011). *Laboratory Manual of Microbiology for Biotechnology Students*. Ane Books Pvt. Ltd., New Delhi.
25. N Kannan. *Laboratory manual in general microbiology*. Panima Publishing Corporation, New Delhi.
26. P Gunasekaran, 1996. *Laboratory Manual in Microbiology*. New Age International Publishers Limited, Daryaganj, New Delhi.

SEMESTER II

Vocational Course 3

Code: BO2VO2T03

APPLIED MICROBIOLOGY- PART I

(Theory 36 hrs; Credits 2)

Module 1: Sterilization Techniques (10 hrs)

Principles of sterilization - Control of microorganism by physical agents: dry heat, moist heat, filtration, radiation - Control of microorganism by chemical agents: phenolic compounds, alcohol, halogens, aldehydes and gaseous agents

Module 2: Staining Techniques (8 hrs)

Stains - wet mount and hanging drop techniques - smear preparation – heat fixation. Staining methods - simple staining - differential staining: gram staining, acid fast staining; special staining: spore staining, capsular staining.

Module 3: Cultivation of Microorganisms (6 hrs)

Media and media components: peptone, beef extract, yeast extract, agar agar, blood/serum – Sterilization of media - Types of media: crude and synthetic media, selective and differential media - composition and preparation of nutrient broth, nutrient agar, PDA, Czapek-dox agar.

Isolation of microbes - serial dilution, pure culture techniques: pour plate, spread plate and streak plate methods

Module 4: Antimicrobial Chemotherapy (12 hrs)

Chemotherapeutic agents - antibiotics and their classification based on mode of action- antifungal agents - antiviral agents - Determination of antimicrobial activity - Tube dilution and disk diffusion techniques - MIC and MBC.

REFERENCES

1. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton. (2011). *Prescott's Microbiology*. Eighth Edition. McGraw-Hill International Edition, New York
2. Pelczar, Chan, Krieg. *Microbiology*. Tata Mc-Graw Hill Publishers, New York
3. C.B. Powar and H.F. Dagainawala. *General Microbiology*, Volume I. Himalaya Publishing House.
4. R C Dubey, D K Maheswari. *A Text Book of Microbiology*. S. Chand & Company Ltd., Ram Nagar, New Delhi
5. Ananthanarayanan and C.K. Jayaram Paniker (2006) *Ananthanarayan & Paniker's Textbook of Microbiology*. Orient Longaman. 7th ed.
6. Purohit S S (2005). *Microbiology - Fundamentals and Applications*. Student Edition Publishers, Jodhpur.
7. Salle AJ (2001). *Fundamentals & Principles of Bacteriology*. 7th Edition. Tata McGraw-Hill, New York.
8. Aneja K. R., Jain P., Aneja R. (2008). *A textbook of Basic and Applied Microbiology* 1st Edition. Published by Newage International Pvt. Ltd., New Delhi, India.
9. Davis, Delbecco, Eisen & Ginsburg (1990) *Microbiology*. 5th Edition. Harper & Raw, New York
10. Gerhardt, Murray, Wood and Kreig 1994. *Methods for General and Molecular Bacteriology*, ASM Press, Washington.
11. P V Ramana Rao, (2005). *Essentials of Microbiology*. CBS Publishers and Distributors, New Delhi
12. Ronald M. Atlas. (2015). *Principles of Microbiology* (II Edn). McGraw Hill Education. (India) Private Limited, Green Park extension, New Delhi
13. Jacquelyn G. Black. (2005). *Microbiology – Principles and Explorations*. 6th Edition. . John Wiley & Sons, Inc.,
14. A. Krishnan. (2000). *Agro's Dictionary of Microbiology*. Second enlarged Edition. Agrobios (India), Jodhpur.
15. Mark Wheelis. (2010). *Principles of Modern Microbiology*. Jones and Bartlett India Pvt. Ltd., Daryaganj, New Delhi
16. Ajit Kr. Banerjee, Nirmalya Banerjee. (2012). *Fundamentals of Microbiology and Immunology*. New central Book Agency (P) Ltd., Sankrail, Howrah
17. D R Arora and B. Arora. (2008). *Text Book of Microbiology*. 3rd Edition. CBS Publishers & Distributors, New Delhi
18. Robert F Boyd. (1984). *General Microbiology*. Times Mirror/ Mosby College Publishers.

Vocational Course 4**Code: BO2VO2T04****APPLIED MICROBIOLOGY – PART II****(Theory 36 hrs; Practical 36 hrs; Credits 2 + 1)****Module 1: Environmental Microbiology (10 hrs)**

Role of microbes in bio-geochemical cycling : Carbon, Sulphur and Nitrogen cycles - biological nitrogen fixation – Biofertilizers – Biocompost – Biodeterioration of leather, textile, jute, paper, rubber, paints - Role of microbes in organic decomposition of cellulose, hemicelluloses, lignin, pectin, starch, proteins

Module 2: Microbiology of Water (6 hrs)

Microorganisms and water pollution - Significance of bio-indicators - Faecal bacteria and pathogenic microorganisms - Detection of coliforms by MPN - Waste water treatment

Module 3: Clinical microbiology (12 hrs)

Fundamentals of Immunology - Immunity : innate and acquired immunity - Antigens Epitopes - Haptens - Factors influencing immunogenicity - Immunoglobulins - basic and fine structure, 5 classes of immunoglobulins – B cells and T cells - MHC restriction - Immune response : antibody mediated and cell mediated immune responses – vaccines – toxins and toxoids - interferons

Module 4: Microbial Diseases (8 hrs)

Bacterial diseases - diphtheria, tuberculosis, whooping cough, leprosy, syphilis, tetanus and cholera
Viral diseases - chicken pox and shingles, measles, mumps, rabies, serum hepatitis, AIDS

PRACTICAL (36 hrs)

1. Study of bacteria: Preparation and fixation of bacteria for staining; Simple staining- methylene blue/ crystal violet/ carbol fuchsin / safranin; Differential staining- Gram staining, acid fast staining, spore staining.
2. Preparation of culture media: Sterilisation - media, glass wares; moist heating - Autoclaving, Tyndallization, Boiling in water, Steaming; Dry heating - Heating in hot air oven and flaming. Preparation of media - Nutrient agar, Nutrient broth, PDA, Czapek-Dox agar; Preparation of agar slant, agar plate, broth tube and flasks.

REFERENCES

2. Joseph. C. Daniel. (1996). *Environmental Aspects of Microbiology*. 1st Edition, Bright Sun Publications, Chennai.
3. Mitcheli Reed. (1992). *Environmental Microbiology*. John Wiley and Sons, New York.
4. Robert F Boyd. (1984). *General Microbiology*. Times Mirror/ Mosby College Publishers.
5. Stapler, D.G. (1973). *An Introduction to Microbiology* Macmillan , London
6. Abul K. Abbas, Andrew H. Lichtman and Jordan S. *Cellular and Molecular Immunology*
7. Ian R. Tizard. *Immunology: An Introduction*
8. William E. Paul. *Fundamentals of Immunology*. Raven Press
9. Roitt IM & Delves PJ (2001) *Roitt's essential Immunology*. Blackwell Science, Oxford. 10th ed.
10. Atlas RM & Bartha R (1998) *Microbial Ecology : Fundamentals and Applications* (Benjamin/Cummings, Menlo Park, Calif. ; Harlow) 4th ed.
11. Campbell RE (1983) *Microbial Ecology*. 2nd Edition Blackwell Scientific Publications, Oxford, Boston.
12. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton. (2011). *Prescott's Microbiology*. Eighth Edition. McGraw-Hill International Edition, New York.
13. Pelczar, Chan, Krieg. *Microbiology*. Tata Mc-Graw Hill Publishers, New York

14. C.B. Powar and H.F. Dagainawala. *General Microbiology*, Volume I. Himalaya Publishing House.
15. R.C. Dubey and D.K. Maheswari. *A Textbook of Microbiology*. S. Chand & Company Ltd., Ram Nagar, New Delhi
16. Ananthanarayanan and C.K. Jayaram Panikar (2006) *Ananthanarayan & Paniker's Textbook of Microbiology*. Orient Longman. 7th ed.
17. Purohit SS (2005). *Microbiology - Fundamentals and Applications*. Student Edition Publishers, Jodhpur.
18. Davis, Delbecco, Eisen & Ginsburg (1990) *Microbiology*. 5th Edition. Harper & Raw, New York.
19. P. V. Ramana Rao. (2005). *Essentials of Microbiology*. CBS Publishers and Distributors, New Delhi.
20. Ronald M. Atlas. (2015). *Principles of Microbiology*. Second Edition. McGraw Hill Education (India) Private Limited, Green Park extension, New Delhi.
21. Jacquelyn G. Black. (2005). *Microbiology – Principles and Explorations*. 6th Edition. . John Wiley & Sons, Inc., USA.
22. Mark Wheelis. (2010). *Principles of Modern Microbiology*. Jones and Bartlett India Pvt. Ltd., Daryaganj, New Delhi
23. Ajit Kr. Banerjee, Nirmalya Banerjee. (2012). *Fundamentals of Microbiology and Immunology*. New central Book Agency (P) Ltd., Sankrail, Howrah
24. D.R. Arora and B. Arora. (2008). *Text Book of Microbiology*. 3rd Edition. CBS Publishers & Distributors, New Delhi
25. Martin Alexander. (1961). *Introduction to Soil Microbiology*. John Wiley & Sons Inc., New York
26. D. Clarson. (2004). *Biofertilizers for Ecofriendly Agriculture*. First Edition. Agro Clinic and research Centre, Kottayam, Kerala
27. V. K. Ahluwalia and Sunita Malhotra. (2006). *Environmental Science*. Ane Books Pvt. Ltd., New Delhi.
28. David Greenwood, Mike Barer, Richard Slack, Will Irving. (2012). *Medical Microbiology*. 18th Edition. Churchill Livingstone Elsevier.
29. Murray, Rosenthal, Pfaller. (2013). *Medical Microbiology*. Seventh Edition. Elsevier Inc., Philadelphia.
30. James G. Cappuccino, Natalie, Sherman. *Microbiology- A Laboratory Manual*.
31. Kanika Sharma. *Manual of Microbiology: Tools and Techniques*
32. K. R. Aneja. *Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Production Technology*. New Age International (P) Limited Publishers, Bangalore.
33. Kanakam Elizabeth Thomas. (2011). *Laboratory Manual of Microbiology for Biotechnology Students*. Ane Books Pvt. Ltd., New Delhi.
34. N. Kannan. *Laboratory Manual in General Microbiology*. Panima Publishing Corporation, New Delhi.
35. Arti Nigam, Archana Ayyagari. (2008). *Lab Manual in Biochemistry, Immunology and Biotechnology*. Tata McGraw-Hill Publishing Company Limited, New Delhi
36. P. Gunasekaran. (1996). *Laboratory Manual in Microbiology*. New Age International Publishers Limited, Daryaganj, New Delhi
37. Sean R. Gallagher, Emily A. Wiley. (2008). *Current Protocols Essential Laboratory Techniques*. John Wiley & Sons inc., Hoboken, New Jersey
38. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton. (2011). *Prescott's Microbiology*. Eighth Edition. McGraw-Hill International Edition, New York
39. Pelczar, Chan, Krieg. *Microbiology*. Tata Mc-Graw Hill Publishers, New York
40. C.B. Powar and H.F. Dagainawala. *General Microbiology*, Volume I. Himalaya Publishing House.

41. R.C. Dubey and D.K. Maheswari. A Textbook of Microbiology. S. Chand & Company Ltd., Ram Nagar, New Delhi
42. Ananthanarayanan and C.K. Jayaram Panikar (2006) Ananthanarayan & Paniker's Textbook of Microbiology. Orient Longman. 7th ed.
43. Purohit SS (2005). Microbiology - Fundamentals and Applications. Student Edition Publishers, Jodhpur.
44. Davis Delbecco, Eisen, Ginsburg, 1990. Microbiology (V Edn). Harper & Raw, New York.

SEMESTER III

Vocational Course 5

Code: BO3VO2T05

PRINCIPLES OF FOOD MICROBIOLOGY

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

Module 1: Industrial importance of microorganisms (10 hrs)

Fungi - *Penicillium*, *Mucor*, *Cladosporium*, *Aspergillus*, *Fusarium*, *Thamnidium*, *Neurospora*, *Geotrichum*, *Trichothecium*;

Yeasts - *Saccharomyces*, *Schizosaccharomyces*, *Zygosaccharomyces*, *Pichia*, *Candida*, *Rhodotorula*;

Bacteria - *Acetobacter*, *Bacillus*, *Clostridium Desulfotomaculum*, *Escherichia*, *Erwinia*, *Flavobacterium*, *Halobacterium*, *Lactobacillus*, *Leuconostoc*, *Micrococcus*, *Propionibacterium*, *Pseudomonas*, *Samonella*, *Staphylococcus*, *Streptococcus*, *Streptomyces*, *Yersinia*, *Vibrio*

Module 2: Food as a Substrate for Microorganisms (8 hrs)

Factors affecting growth of microorganisms in food - intrinsic factors: pH, moisture, concept of water activity, oxidation-reduction potential, nutrient content, inhibitors and biological structure - extrinsic factors : temperature, relative humidity, concentration of gases

Module 3: Principles of Food Preservation (18 hrs)

General principles of food preservation - Methods and principles of : Asepsis – Removal of microorganisms - Maintenance of anaerobic conditions - Preservation using high temperature : heat resistance, heat penetration, thermal processes canning - Preservation using low temperature : cellar storage, chilling, freezing - Preservation by drying – Use of chemical preservatives : additives, added inorganic and organic preservatives, developed preservatives - Preservation by radiation : UV rays, ionizing radiations

Module 4: Microorganism as Food (18 hrs)

Single Cell Proteins - Vitamins: vitamin B₁₂, vitamin B₂ - Enzymes: amylase, invertase, pectolytic enzymes, proteolytic enzymes, glucose oxidase - Acids: citric acid, lactic acid - Gums: dextran, xanthan - Fats - Probiotics: basic concepts, advantages of taking probiotics - Probiotic preparations: yogurt, kefir.

PRACTICAL (36 hrs)

1. Identification of important fungi associated with post harvest rot of cereals and vegetables - *Mucor*, *Rhizopus*, *Fusarium*, *Aspergillus*, *Penicillium*.
2. Isolation of fungi: From infected cereals and pulses; from spoiled fruits and vegetables; From foodstuffs including pickle, jam, dried fruits etc.
3. Culturing of fungi for morphological studies: Agar plate method, Slide culture method
4. Glass slide technique for observing fungal spore germination

REFERENCES

1. Lee B.H. (1996), *Fundamental of Food Biotechnology*, VCH Publishers.
2. Goldberg I. and Williams R. (1991), *Biotechnology and Food Ingredients*, Van Nostrand., Reinhold, New York.
3. Hui Y.H. (1995), *Food Biotechnology: Micro-organism*, VCH Publisher.
4. Doyle M.P. (1997), *Food Microbiology: Fundamentals and Frontiers*, ASM Press Washington.
5. Joshi V.K. and Pandey A. (1999), *Biotechnology: Food Fermentation Vol. 1 & 2*, Education Publisher and Distributer, New Delhi.
6. Marwaha S.S. and Arora, J.K. (2000), *Food Processing: Biotechnological Applications*, Asia tech Publishers Inc., New Delhi.
7. Frazier W. C. and Westhoff D.C. (1995). *Food Microbiology*. Fourth Edition. Tata McGraw Hill Publishing Company Limited, New Delhi.
8. Nair M. C. and Balakrishnan S. (1986). *Beneficial Fungi and their Utilization*, Scientific Publishers, Jodhpur.
9. Shakuntala Manay N. and M. Shadaksharaswamy.2001. *Foods-Facts and Principles*. New Age International (P) Ltd, Publishers, New Delhi.
10. Swaminathan, N. (1987). *Food Science and Experimental Foods*. Ganesh Publications, Madras.
11. Meyer L.M. (1969). *Food Chemistry*. Van Nousttrand Reinhold Co., New York.
12. James M Jay, 2004. Modern Food Microbiology (IV Edn). CBS Publishers and Distributors, New Delhi.
13. Norman N. Potter (1987). *Food Science (III Edn)*. New Delhi: CBS Publ. and Distributors.
14. Patel AH. (2005). *Industrial Microbiology*. Published by Macmillan India Ltd., New Delhi
15. Balakrishnan Iyer. (2011). *Introductory Food Microbiology*. BIO-GREEN BOOKS, Chawla offset Printers, New Delhi
16. Jhari Sahoo, Manish Kumar Chatli . (2015). *Textbook on Meat, Poultry and Fish Technology*. Daya Publishing House, Astral international Pvt. Ltd., Burari, New Delhi
17. Dr. T. K. Govindan. (1985). *Fish Processing Technology*. Oxford and IBH Publishing Co., 65 Janpath, New Delhi
18. M. R. Adams and M. O. Moss. (1995). *Food Microbiology*. New Age International (P) Limited, Publishers, Daryaganj, New Delhi
19. Aneja K R, Jain P, Aneja R, 2008. *A Textbook of Basic and Applied Microbiology* 1st Edition. Published by New age International Pvt. Ltd., New Delhi.
20. Ronald M. Atlas. (2015). *Principles of Microbiology*. Second Edition. McGraw Hill Education (India) Private Limited, Green Park extension, New Delhi
21. Jacquelyn G. Black. (2005). *Microbiology – Principles and Explorations*. 6th Edition. John Wiley & Sons, Inc., USA
22. R.C. Dubey and D.K. Maheswari. *A Text Book of Microbiology*. S. Chand & Company Ltd., Ram Nagar, New Delhi
23. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton. (2011). *Prescott's Microbiology*. Eighth Edition. McGraw-Hill International Edition, New York
24. Ramesh Chand. (2011). *Fruit and Vegetable Preservation*. Educational Publishers and Distributors, New Delhi.
25. Rajaratnam S. and Ramteke RS. (2011). *Advances in Preservation and Processing Technologies of Fruits and Vegetables*. New India Publishing Agency, New Delhi.
26. James G. Cappuccino, Natalie, Sherman. *Microbiology- A Laboratory Manual*.
27. Kanika Sharma. *Manual of Microbiology: Tools and Techniques*
28. K. R. Aneja. Experiments in Microbiology, *Plant Pathology, Tissue Culture and Mushroom Production Technology*. New Age International (P) Limited Publishers, Bangalore.

Vocational Course 6**Code: BO3VO2T06****CONTAMINATION, SPOILAGE AND PRESERVATION OF FOOD - PART I****(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)****Module 1: Sources of food contamination (12 hrs)**

Contamination of food from natural sources - pre-harvest and post harvest contamination: sources of pre-harvest contamination – green plants and fruits, animals, sewage, soil, water, and air; sources of post-harvest contamination: during transport, handling and processing - processing equipments or machineries – workers.

Module 2: Principles of food spoilage (12 hrs)

Criteria for fitness of food - causes of spoilage - general principles underlying spoilage - classification of food based on spoilage - chemical changes due to microbial spoilage: nitrogenous organic compound and non-nitrogenous organic compounds

Module 3: Cereals and sugars (20 hrs)

Cereals and cereal products: Contamination, preservation and spoilage of grains, flours, bread and cake. Sugar and sugar products: contamination, preservation and spoilage of cane sugar, jaggery, molasses and syrups, honey, candy.

Module 4: Vegetables and fruits (10 hrs)

Contamination, preservation and spoilage of raw vegetables and fruits, spoilage of fruit and vegetable juices.

PRACTICAL (36 hrs)

1. Serial dilution method for dilution of concentrated samples.
2. Isolation of bacteria by streak plate method: Continuous streak, Quadrant streak, Radial streak.
3. Bacteriological examination of water by multiple tube fermentation test or multiple tube test: Presumptive test, Confirmed test, Completed test.

REFERENCES

1. Lee B.H. (1996) *Fundamental of Food Biotechnology*. VCH Publishers.
2. Goldberg I. and Williams R. (1991). *Biotechnology and Food Ingredients*. Van Nostrand., Reinhold, New York.
3. Hui Y.H. (1995). *Food Biotechnology: Micro-organism* VCH Publisher.
4. Doyle M.P. (1997) *Food Microbiology: Fundamentals and Frontiers*. ASM Press Washington.
5. Joshi V.K. and Pandey A. (1999). *Biotechnology: Food Fermentation* Vol. 1 & 2, Education Publisher and Distributer, New Delhi.
6. Marwaha S.S. and Arora, J.K. (2000) *Food Processing: Biotechnological Applications*. Asia tech Publishers Inc., New Delhi.
7. Frazier W. C. and Westhoff D.C. (1995). *Food Microbiology*. Fourth Edition. Tata McGraw Hill Publishing Company Limited, New Delhi.
8. Nair M. C. and Balakrishnan S. (1986). *Beneficial Fungi and their Utilization*, Scientific Publishers, Jodhpur.
9. Shakuntala Manay N. and M. Shadaksharaswamy. (2001). *Foods-Facts and Principles*. New Age International (P) Ltd, Publishers, New Delhi.
10. Vijaya Ramesh, K. (2007). *Food Microbiology*. MJP Publishers, Chennai.
11. Swaminathan, N. (1987). *Food Science and Experimental Foods*. Ganesh Publications, Madras.
12. Meyer L.M. (1969). *Food Chemistry*. Van Nustrand Reinhold Co., New York.

13. James M Jay, 2004. *Modern Food Microbiology* (IV Edn). CBS Publishers and Distributors, New Delhi.
14. Joy J M, 1970. *Modern Food Microbiology*. Van Nostrand Reinhold Co., New York.
15. Norman N. Potter (1987). *Food Science* (III Edn). CBS Publ. and Distributors, New Delhi.
16. Patel A H, 2005. *Industrial Microbiology*. Macmillan India Ltd., New Delhi.
17. Ramesh Chand. (2011). *Fruit and Vegetable Preservation*. Educational Publishers and Distributors, New Delhi.
18. Rajaratnam S. and Ramteke RS. (2011). *Advances in Preservation and Processing Technologies of Fruits and Vegetables*. New India Publishing Agency, New Delhi.
19. Balakrishnan Iyer. (2011). *Introductory Food Microbiology*. BIO-GREEN BOOKS, Chawla offset Printers, New Delhi
20. M. R. Adams and M. O. Moss. (1995). *Food Microbiology*. New Age International (P) Limited, Publishers, Daryaganj, New Delhi
21. Aneja K. R., Jain P., Aneja R. (2008). *A Textbook of Basic and Applied Microbiology* 1st Edition. Published by Newage International Pvt. Ltd., New Delhi, India.
22. R.C. Dubey and D.K. Maheswari. *A Text Book of Microbiology*. S. Chand & Company Ltd., Ram Nagar, New Delhi
23. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton. (2011). *Prescott's Microbiology*. Eighth Edition. McGraw-Hill International Edition, New York.
24. James G. Cappuccino, Natalie, Sherman. *Microbiology- A Laboratory Manual*.
25. Kanika Sharma. *Manual of Microbiology: Tools and Techniques*
26. K. R. Aneja. Experiments in Microbiology, *Plant Pathology, Tissue Culture and Mushroom Production Technology*. New Age International (P) Limited Publishers, Bangalore.

SEMESTER IV

Vocational Course 7

Code: BO4VO2T07

CONTAMINATION, SPOILAGE AND PRESERVATION OF FOOD - PART II

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

Module 1: Meat and sea foods (18 hrs)

Meat and meat products - contamination - preservation: heat, cold, drying, preservatives - spoilage: general principles, types of spoilage

Fish and other sea foods – contamination - preservation: heat, cold, drying - spoilage: factors influencing spoilage, causative organisms - spoilage of special kind of fish and seafood.

Module 2: Poultry and eggs (12 hrs)

Poultry: contamination - preservation: removal, heat, cold, drying, preservatives – spoilage. Eggs – Contamination - preservation: removal, heat, cold, drying, preservatives - spoilage: defects and changes, bacterial rots, fungal rots.

Module 3: Milk and milk products (12 hrs)

Milk and milk products – contamination - preservation: asepsis, removal, heat, cold, drying, preservatives – spoilage of milk and cream, condensed and dry milk, frozen desserts, butter.

Module 4: Heated canned foods (12 hrs)

Heated canned foods: cause of spoilage - grouping on pH - types of spoilage - spoilage of canned meat and fish.

PRACTICAL (36 hrs)

1. Quantitative estimation of microorganism: (i) Viable count: soil/milk/fish/meat/vegetables/cereals - Spread plate method; Pour plate method; Drop technique (ii) Total count- Haemocytometer method.
2. Bacteriological analysis of milk by MBRT

REFERENCES

1. Lee B.H. (1996), *Fundamental of Food Biotechnology*, VCH Publishers.
2. Goldberg I. and Williams R. (1991), *Biotechnology and Food Ingredients*, Van Nostrand., Reinhold, New York.
3. Hui Y.H. (1995), *Food Biotechnology: Micro-organism*, VCH Publisher.
4. Doyle M.P. (1997), *Food Microbiology: Fundamentals and Frontiers*, ASM Press Washington.
5. Joshi V.K. and Pandey A. (1999), *Biotechnology: Food Fermentation* Vol. 1 & 2, Education Publisher and Distributer, New Delhi.
6. Marwaha S.S. and Arora, J.K. (2000), *Food Processing: Biotechnological Applications*, Asia tech Publishers Inc., New Delhi.
7. Frazier W. C. and Westhoff D.C. (1995). *Food Microbiology*. Fourth Edition. Tata McGraw Hill Publishing Company Limited, New Delhi.
8. Nair M. C. and Balakrishnan S. (1986). *Beneficial Fungi and their Utilization*, Scientific Publishers, Jodhpur.
9. Shakuntala Manay N. and M. Shadaksharaswamy.2001. *Foods-Facts and Principles*. New Age International (P) Ltd, Publishers, New Delhi.
10. Vijaya Ramesh, K.(2007). *Food Microbiology*,MJP Publishers, Chennai
11. Swaminathan, N. (1987). *Food Science and Experimental Foods*. Ganesh Publications, Madras.
12. Meyer L.M. (1969). *Food Chemistry*. Van Nousttrand Reinhold Co., New York.
13. James M Jay.2004. *Modern Food Microbiology*.4th Edition, CBS Publishers and Distributors, New Delhi.
14. Joy J M, 1970. *Modern Food Microbiology*, New York: Van Nostrand Reinhold Co.
15. Norman N. Potter (1987). *Food Science* (3rd ed), New Delhi: CBS Publ. and Distributors.
16. Patel AH. (2005). *Industrial Microbiology*. Published by Macmillan India Ltd., New Delhi
17. Balakrishnan Iyer. (2011). *Introductory Food Microbiology*. BIO-GREEN BOOKS, Chawla offset Printers, New Delhi
18. Jhari Sahoo, Manish Kumar Chatli . (2015). *Textbook on Meat, Poultry and Fish Technology*. Daya Publishing House, Astral international Pvt. Ltd., Burari, New Delhi
19. Dr. T. K. Govindan. (1985). *Fish Processing Technology*. Oxford and IBH Publishing Co., 65 Janpath, New Delhi
20. M. R. Adams and M. O. Moss. (1995). *Food Microbiology*. New Age International (P) Limited, Publishers, Daryaganj, New Delhi
21. Aneja K. R., Jain P., Aneja R. (2008). *A textbook of Basic and Applied Microbiology* 1st Edition. Published by Newage International Pvt. Ltd., New Delhi, India.
22. Ronald M. Atlas. (2015). *Principles of Microbiology*. Second Edition. McGraw Hill Education (India) Private Limited, Green Park extension, New Delhi
23. Jacquelyn G. Black. (2005). *Microbiology – Principles and Explorations*. 6th Edition. John Wiley & Sons, Inc., USA
24. R.C. Dubey and D.K. Maheswari. *A Text Book of Microbiology*. S. Chand & Company Ltd., Ram Nagar, New Delhi
25. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton. (2011). *Prescott's Microbiology*. Eighth Edition. McGraw-Hill International Edition, New York

26. James G. Cappuccino, Natalie, Sherman. *Microbiology- A Laboratory Manual*.
27. Kanika Sharma. *Manual of Microbiology: Tools and Techniques*
28. K. R. Aneja. Experiments in Microbiology, *Plant Pathology, Tissue Culture and Mushroom Production Technology*. New Age International (P) Limited Publishers, Bangalore.

Vocational Course 8**Code: BO4VO2T08****FOOD FERMENTATIONS, FOOD INFECTION AND FOOD BORNE DISEASES****(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)****Module 1: Microbes in fermented foods (20 hrs)**

Production of cultures for food fermentation - Culture maintenance and preparation - Bacterial, fungal and yeast cultures for food fermentation - Leavening agents: chemical leavening, biological leavening - Preparation of fermented foods: Bread - Malt beverages, wine and distilled liquors – Vinegar - Sauerkraut - Oriental fermented foods: tempeh, soya sauce, idli, appam, processing of tea, coffee, cocoa and vanilla.

Module 2: Food poisoning (12 hrs)

Foodborne illness or food poisoning - food infections and food intoxications - Bacterial food infection: *Clostridium prefringens* poisoning, Salmonellosis - Bacterial food intoxication: aflatoxicosis, *Staphylococcus* poisoning, botulism - Mycotoxins and mycotoxicosis - Aflatoxicosis

Module 3: Food and water borne diseases (12 hrs)

Viral: gastroenteritis, infectious hepatitis, poliomyelitis - Bacterial: cholera, typhoid fever, *Campylobacter* gastroenteritis - Protozoan: Amoebiasis (special reference of field investigation, laboratory testing and preventive measures)

Module 4: Food sanitation (10 hrs)

Cleaning and sanitation: Detergents and wetting agents - CIP and COP – Physical agents as sanitizers: Hot water, flowing steam or steam under pressure - Chemical sanitizers: Halogens such as chlorine and iodine based compounds - quaternary ammonium compounds - Acid-anionic sanitizers, Peroxides - HACCP principles; ISO 22000, FSSAI, AGMARK (in brief).

PRACTICAL (36 hrs)

1. Demonstration of enzyme action using a yeast fermentation system.
2. Demonstration of the effect of temperature on yeast fermentation.
3. Effect of environment on microbial growth: effect of temperature, effect of osmotic pressure, effect of oxygen, ionic effect.
4. Biochemical activities of microorganisms: IMViC tests, Catalase test.

REFERENCES

1. Lee B.H. (1996) *Fundamental of Food Biotechnology*. VCH Publishers.
2. Goldberg I. and Williams R. (1991) *Biotechnology and Food Ingredients*. Van Nostrand., Reinhold, New York.
3. Hui Y.H. (1995) *Food Biotechnology: Micro-organism*, VCH Publisher.
4. Doyle M.P. (1997) *Food Microbiology: Fundamentals and Frontiers*. ASM Press Washington.
5. Joshi V.K. and Pandey A. (1999) *Biotechnology: Food Fermentation* Vol. 1 & 2, Education Publisher and Distributer, New Delhi.

6. Marwaha S.S. and Arora, J.K. (2000) *Food Processing: Biotechnological Applications*. Asia tech Publishers Inc., New Delhi.
7. Frazier W. C. and Westhoff D.C. (1995) *Food Microbiology*. Fourth Edition. Tata McGraw Hill Publishing Company Limited, New Delhi.
8. Nair M. C. and Balakrishnan S. (1986). *Beneficial Fungi and their Utilization*, Scientific Publishers, Jodhpur.
9. Shakuntala Manay N. and M. Shadaksharaswamy .(2001). *Foods-Facts and Principles*. New Age International (P) Ltd, Publishers, New Delhi.
10. Vijaya Ramesh, K.(2007). *Food Microbiology*,MJP Publishers, Chennai.
11. Swaminathan, N. (1987). *Food Science and Experimental Foods*. Ganesh Publications, Madras.
12. Meyer L.M. (1969). *Food Chemistry*. Van Nousttrand Reinhold Co., New York.
13. James M Jay.2004. *Modern Food Microbiology* .4th Edition, CBS Publishers and Distributors, New Delhi.
14. Joy J M, 1970. *Modern Food Microbiology*. New York: Van Nostrand Reinhold Co.
15. Norman N Potter, 1987. *Food Science* (III Edn). CBS Publ. and Distributors, New Delhi.
16. Patel AH. (2005). *Industrial Microbiology*. Published by Macmillan India Ltd., New Delhi
17. Balakrishnan Iyer. (2011). *Introductory Food Microbiology*. BIO-GREEN BOOKS, Chawla offset Printers, New Delhi
18. Jhari Sahoo, Manish Kumar Chatli. (2015). *Textbook on Meat, Poultry and Fish Technology*. Daya Publishing House, Astral international Pvt. Ltd., Burari, New Delhi
19. Dr. T. K. Govindan. (1985). *Fish Processing Technology*. Oxford and IBH Publishing Co., 65 Janpath, New Delhi
20. L. E. Cassida JR. (2001). *Industrial Microbiology*. New Age International (P) Limited, Publishers, Daryaganj, New Delhi
21. O.P. Sharma. (2003). *Text book of Fungi*. Tata McGraw-Hill Publishing Company limited, New Delhi
22. M. R. Adams and M. O. Moss. (1995). *Food Microbiology*. New Age International (P) Limited, Publishers, Daryaganj, New Delhi
23. Aneja K. R., Jain P., Aneja R. (2008). *A textbook of Basic and Applied Microbiology* 1st Edition. Published by Newage International Pvt. Ltd., New Delhi, India.
24. Ronald M. Atlas. (2015). *Principles of Microbiology*. Second Edition. McGraw Hill Education (India) Private Limited, Green Park extension, New Delhi
25. Jacquelyn G. Black. (2005). *Microbiology – Principles and Explorations*. 6th Edition. . John Wiley & Sons, Inc., USA
26. R.C. Dubey and D.K. Maheswari. *A Text Book of Microbiology*. S. Chand & Company Ltd., Ram Nagar, New Delhi
27. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton. (2011). *Prescott's Microbiology*. Eighth Edition. McGraw-Hill International Edition, New York
28. David Greenwood, Mike Barer, Richard Slack, Will Irving. (2012). *Medical Microbiology*. 18th Edition. Churchill Livingstone Elsevier.
29. Murray, Rosenthal, Pfaller. (2013). *Medical Microbiology*. Seventh Edition. Elsevier Inc., Philadelphia.
30. James G. Cappuccino, Natalie, Sherman. *Microbiology- A Laboratory Manual*.
31. Kanika Sharma. *Manual of Microbiology: Tools and Techniques*
32. K. R. Aneja. *Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Production Technology*. New Age International (P) Limited Publishers, Bangalore.

HORTICULTURE AND NURSERY MANAGEMENT

SEMESTER I

Vocational course 1

Code: BO1VO3T01

FUNDAMENTALS OF HORTICULTURE

(Theory 36 hrs; Credits 2)

Module 1: Introduction (2 hrs)

Introduction, definition, history, importance, development and division of horticulture.

Module 2: Soil (16 hrs)

Soil: origin, properties and types - formation of soil, weathering (physical, chemical and biological pedogenesis). Components of soil - soil air, soil water, soil microbes, field capacity, permanent wilting percentage, pH, organic and inorganic components of soil (types and its importance). Classification of soil - basis of classification - soil profile- soil types - red soil, black soil, alluvial soil, laterite soil, coastal soil, sandy soil, serpentine soil, sodic soil, problematic soil, acidic and alkaline - properties and reclamation. Soil preparation - soil treatment, selection of site for crops, role of microorganisms and humus.

Module 3: Irrigation and manuring (9 hrs)

Principles and methods of irrigation - dry and wet land water management – methods of irrigation- surface irrigation, subsoil irrigation and overhead irrigation system - micro irrigation for mist chambers, .Fertilizers and Manures- organic manure –farmyard manure, leaf mould, bone meal, oil cakes compost making - green manuring; methods of manuring- broadcast, seed treatment, foliar application.

Module 4: Garden and related structures (9 hrs)

Garden Tools and Implements, Plant growth regulators in horticulture, uses of growth regulators - natural and synthetic regulators, growth regulators used for inducing rooting, flowering, breaking seed and bud dormancy, induction of parthenocarpy, preparation and methods of application, Plant propagating structures –green house, glass house, hot bed, lath house, net house, and mist chamber.

REFERENCES

1. Christopher E P, 1958. Introductory Horticulture. McGraw Hill, New Delhi.
2. Denixon R I, 1979. Principles of Horticulture. Mac Millan, New York.
3. Edmond J B, Sen T D, Andrews T S, Halfacre R G, 1977. Fundamentals of olericulture. Tata McGraw Hill, New Delhi.
4. Halfacre R G, Barden J A, 1979. Horticulture. McGraw Hill, New Delhi.
5. Janick J, 1963. Horticultural Science. W H Freeman, Sanfrancisco.
6. Kumar N, 1990. Introduction to Horticulture. Rajalekshmi Publication, Nagercoil.

Vocational course 2**Code: BO1VO3T02****PLANT PROPAGATION****(Theory 36 hrs; Practical 36 hrs; Credits 2 + 1)****Module 1: Introduction (2hrs)**

Introduction to plant propagation, definition, different methods of propagation, needs of plant propagation, Different methods (introduction)

Module 2: Plant propagation - natural (7 hrs)

Natural methods of plant propagation. Sexual method of propagation: characteristics of good seeds, types of pure seeds, seed treatment, seed dormancy, methods of breaking seed dormancy, care of seedlings. Advantages and disadvantages of seed propagation. Vegetative Propagation: natural - suckers, offsets, rhizome, stolon etc.

Module 3: Plant propagation – artificial (18 hrs)

Artificial methods of plant propagation. Cuttings: stem, root and leaf cuttings, factors affecting rooting of cuttings, advantages and disadvantages. Layering - advantages and disadvantages, types of layering ground layering, air layering, different types. Grafting: advantages and disadvantages, stock-scion relationships, incompatibility, different types. Budding: shield (T & I) and patch budding, green budding, chip budding - advantages and disadvantages.

Module 4: Plant tissue culture (9 hrs)

Basic principles of tissue culture. Regeneration of plants, micropropagation of horticulture plants - methods, advantages and disadvantages.

PRACTICAL (36 hrs)

1. Collection and identification of different types of soil from the locality.
2. Estimation of soil pH using pH meter.
3. Determination of water content of different types of soils.
4. Identification and uses of various garden tools and implements .Work experience based on these tools.
5. Preparation of potting mixtures of known combinations.
6. Practice different types of grafting(approach, whip or tongue, saddle, cleft and crown grafting)
7. Practice different type of budding - shield (T&I) and patch.
8. Collect and identify some natural vegetative propagules.
9. Familiarize common plant growing structures.
10. Familiarize common plant growth regulators.
11. Document the nutrient contents of different chemical fertilizers.

REFERENCES

1. C R Adams. Early principles of horticulture (IV Edn). Elsevier (Butterworth-Heinemann)
2. Bose T K, Mitra S K, Sadhu K, 1986. Propagation of tropical and Subtropical horticultural crops. Nayaprakash, Calcutta.
3. Halfacre R G, Barden J A, 1979. Horticulture. McGraw Hill, New Delhi.
4. Hartmann H T, Kester D E, 1986. Plant propagation: Principles and practices. Prentice-Hall, New Delhi.
5. Janick J, 1963. Horticultural Science. W H Freeman, Sanfrancisco.
6. Kumar N, 1990. Introduction to Horticulture. Rajalekshmi Publication, Nagercoil.
7. Leopold A C, Kriedeman P E, 1975. Plant Growth and Development. Tata McGraw Hill Publishing Co. Ltd., New Delhi.
8. Thorpe T A, 1981. Plant Tissue Culture: Methods and Application in Agriculture. Academic Press, New York.

SEMESTER II

Vocational course 3 **Code: BO2VO3T03**
ORNAMENTAL HORTICULTURE AND LANDSCAPING
(Theory 36 hrs; Credits 2)

ORNAMENTAL HORTICULTURE (32 hrs)**Module 1: (18 hrs)**

Commercial flower production; Scope and importance; Global Scenario in cut flower production and trade, Special characteristics and requirements; cut flower, loose flowers, dry flowers and floral oil trade. Major ornamental crops research stations in India- IIHR, IARI, NBRI. Types of gardens-characteristics and components of English, Mughal, Japanese, Persian, French and Italian gardens-designing a garden: budgeting and layout garden components (brief account only). Gardening: layout of the garden: for small, medium, and large gardens. Different types: indoor garden, water garden, rockery; garden components - lawns, shrubs and shrubberies, flower beds, carpet beds, borders, hedges, roads, walks and paths in the garden - Garden ornaments. Hydroponics, Bonsai.

Cultivation of plants in pots; different type of pots and containers-Earthen and plastic pots, par affined paper or styloform cups, polythene bags, basket container-plants suitable for pot culture, soil mixtures, their constituents of different type of pot plants-Annuals, Bulbs and tubers, Roses, Crotons, Palms, Ferns, Begonias, Anthurium, Succulents , cacti, and fruit plants. Orchard planning, lay out, preparation of nursery beds.

Training and pruning: principle, purpose and methods - right season for training and pruning-precautions in pruning operations-top dressing, staking, disbudding, defruiting, shaping and topiary - pruning fruit trees, root pruning - ringing or girdling - wintering.

Module 2: (9 hrs)

Brief study including taxonomy and methods of cultivation of the following groups of ornamental plants with suitable examples:

1. Shrubs: flowering shrubs, ornamental foliage shrubs
2. Climbers and creepers
3. Annuals, Biennials and herbaceous perennials
4. Bulbs, tubers and corms
5. Ferns and Selaginellas
6. Succulents and cacti
7. Ornamental grasses/bamboos
8. Palm, cycads and conifers.

Module 3: (5 hrs)

Indoor gardening: designing - selection of garden ornaments. Identification and selection of indoor plants-care and maintenance of indoor plants-care of water garden - fountain and suitable. Adornments. Conservatory: green house and fern house (fernery) – components - care and management.

LANDSCAPE ARCHITECTURE (4 hrs)**Module 4: (4 hrs)**

Commercial landscape gardening- History, Plant identification and ecology, Landscape gardening and Arboriculture: Importance and value of trees selection, planting, maintenance and care of trees-role of trees in landscaping Importance of landscaping, types of Landscaping - Contemporary landscaping,

Environmental landscaping, Industrial and institutional landscaping, Public and private garden making, playground landscaping.

REFERENCES

1. Bhandari, K. and Prakash, J. 1994. Floriculture: Technology Trades, Trends. Oxford & IBH Publishing Company, New Delhi.
2. Bose, T.K and Yadav, L.P. ed. 2003. Commercial Flowers. Naya Prakash, Calcutta, India.
3. Bose, T.K., Maiti, R.G., Dhua, R.S. and Das, P. ed. 1999. Floriculture and Landscaping. NayaPrakash, Culcutta, India.
4. Carpenter, P.L., Walker, T.D and Lanphear, F.O. 1975. Plants in the Landscape. W.H.Feeman and Co., San Francisco.
5. Chadha, K.L. 2001. Hand Book of Horticulture. ICAR, New Delhi.
6. Chadha, K.L. and Chowdhury, B, 1992. Ornamental Horticulture in India. ICAR New Delhi
7. Nambisan, K.M.P. 1991. Design elements of Landscape Gardening. Oxford & IBH Publishers Pvt. Ltd Calcutta
8. Pal, B.P. 1972. The Rose in India. Indian Council of Agricultural Research, New Delhi.
9. Rajeevan, P.K. Singh, K.P. and Valsalakumari P.K. 2003 ed. Bulbous Flowers. Indian Society of Ornamental Horticulture Division of Floriculture & Landscaping, IARI, New Delhi.
10. Rajeevan, P.K., Sobhana, A., JyothiBhasker, Swapna,S. and S.K. Bhattacharjee. 2003.Orchids. Technical Bulletin. ICAR.
11. Rajeevan, P.K., Valsalakumari, P.K. and Geetha, C.K. 1999. Pookrishi:, Sastravum Prayogavum. (Malayalam) Kerala Agricultural University, Mannuthy, Trichur
12. Rajeevan P K, Valsalakumari P K, Geetha C K, Leena Ravidas, S K Bhattacharjee, 2002. Anthurium. Technical Bulletin, ICAR.
13. Randhawa, G.S. and Mukhopadhyay, A. 1986. Floriculture in India. Allied publishers, New Delhi.
14. Swarup, V. 1993. Indoor Gardening. ICAR.
15. Trivedi, P.P. 1983. Home Gardening. ICAR.

Vocational course 4 **Code: BO2VO3T04**
PLANT PROTECTION AND NURSERY MANAGEMENT
(Theory 36 hrs; Practical 36 hrs; Credits 2 + 1)

PLANT PROTECTION (18 hrs)

Module 1: Plant protection (18 hrs)

Weeds definition and their control; Pests: insect and non-insect pests. Pest control: physical, chemical and biological Control; Diseases: common diseases of horticultural crops- symptoms, casual organisms, mode of spreading and control measures; Commonly used agricultural chemicals: Insecticides: eg. BHC, Carbary (sevin), Carbofuran (Furadon) Malathion, Phorate (thimet), Quanalphos (Ekalux) Fungicides: Captan, Bavistin, antibiotics, Dithane M 45, organo-mercurial compounds, sulphur dust, Zineb (Dithane Z- 78, Hexathane) Rodenticides - Anticoagulants (Ratafin), zinc phosphide (Retox) Herbicides - 2,4-D Sodium salt, 2,4-D amine salt (Weeder 96).

NURSERY MANAGEMENT (18 hrs)

Module 2: Nursery management (18 hrs)

Importance of nursery, types of nurseries-small scale and large scale, planning, budgeting and lay out-irrigation and plant protection devices in nurseries.

Maintenance and management of nurseries: personals involved, technicians and casual laborers-customer relations-assessment of customer needs-export potential of horticultural products-loans and subsidies from banks and other agencies. Planting and transplanting: seasons for planting and transplanting, transplanting failures- Transplanting trees and shrubs, annuals, corms, bulbs and tubers.

PRACTICAL (36 hrs)

1. Prepare potting mixtures for different type of pot plants, viz, roses, begonia, Palms, Ferns, Anthurium and cacti etc.
2. Collect and identify common diseases of horticultural crops. Identify and comment on plant protection chemicals.
3. Visit a garden and identify the components, plants, and prepare a report. Collect, familiarize and identify ornamental plant group.

REFERENCES

1. Verma L R, Verma A K, Goutham D C, 2004. Pest Management in Horticulture Crops: Principles and Practices. Asiatech Publ., New Delhi.
2. Plant protection I Pests, Diseases and Weeds, 4th edition, rootrot Press 22 Lynch Street, Hughes, Canberra, ACT, Australia (e-book available)
3. Methods of Control, 4th edition, rootrot Press 22 Lynch Street, Hughes, Canberra, ACT, Australia (e-book available)
4. Selected Ornamentals, Fruit and Vegetables, 4th edition, rootrot Press 22 Lynch Street, Hughes, Canberra, ACT, Australia (e-book available)
5. How to Diagnose Plant Problems 4th edition, root rot Press 22 Lynch Street, Hughes, Canberra, ACT, Australia (e-book available).

SEMESTER III

Vocational course 5 **Code: BO3VO3T05**
FLORICULTURE
(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)

Module 1: (18 hrs)

Floriculture: importance, scope and significance, components of floriculture: ornamental gardening, commercial floriculture, landscape gardening, arboriculture; Commercial floriculture: importance, scope and significance - perfume industry, flower pigments - flower trading - cut flowers post-harvest treatment and packaging of cut flowers.

Module 2: (27 hrs)

Detailed study of the cultivation (species, propagation, planting and after care, pruning, nutrition, plant protection, harvesting) and marketing of flowers of the following flowering plants:
Long stem cut flowers: perennials - Rose, Gladiolus, Carnation, Gerbera, Chrysanthemums, Jasmine, Orchids, Anthuriums, Tuberose, Dahlia, Heliconia. Annuals - Aster, marigold, Celosia, (Cockscomb) Gomphrena. Cut greens - Asparagus, Cycad, Thuja, Palms, Dracaena.

Module 3: (9 hrs)

Landscape gardening and Arboriculture. Importance and value of trees selection, planting, maintenance and care of trees-role of trees in landscaping.

Bonsai: basic styles - identification of plants suitable for Bonsai - Bonsai containers - Operation required: pruning, nipping and wiring.

Module 4: (18 hrs)

Flower arrangement: principles, different styles: Fresh, dry and artificial: practical hints for flower arrangement-flower carpet-preparation of bouquets, wreaths and garlands. Techniques to prolong the vase life of flowers - practical application of flower arrangement - vegetable carving and decorations. Floriculture promotion and extension: Role of agri-horticultural societies, Krishi bhavans, flower shows and exhibition.

PRACTICAL (36 hrs)

1. Identification of basic styles of bonsai and list out the plants suitable for bonsai.
2. Identification of the garden plants mentioned in the syllabus - their botanical name and family
3. Post-harvest treatment and packaging of cut flowers
4. Different styles of flower arrangement, bouquet, wreath and garland
5. Identification and collection of locally available plant materials for dry/artificial flower arrangement
6. Each student should familiarize with cultivation of ornamental plants in the syllabus
7. Visit and prepare a report on flower shows organized by agri-horticulture societies/any other agencies

REFERENCES

1. Bhandari, K. and Prakash, J. 1994. Floriculture: Technology Trades, Trends. Oxford & IBH Publishing Company, New Delhi.
2. Bland, J. and Davidson, W. 2004. Houseplant – Survival Manual. Quantum Books Ltd., London.
3. Bose, T.K and Yadav, L.P. ed. 2003. Commercial Flowers. Naya Prakash, Calcutta, India.
4. Bose, T.K., Maiti, R.G., Dhua, R.S. and Das, P. ed. 1999. Floriculture and Landscaping. Naya Prokash, Culcutta, India.
5. Carpenter, P.L., Walker, T.D and Lanphear, F.O. 1975. Plants in the Landscape. W.H. Feeman and Co., San Francisco.
6. Chadha, K.L. 2001. Hand Book of Horticulture. ICAR, New Delhi.
7. Chadha, K.L. and Chowdhury, B, 1992. Ornamental Horticulture in India. ICAR New Delhi
8. Desai, B.L. 1979. Planning and Planting of Home Gardens. ICAR, New Delhi.
9. Joiner, J.N. 1981. Foliage Plant Production. Prentice Hall Inc. London
10. Nambisan, K.M.P. 1991. Design elements of Landscape Gardening. Oxford & IBH Publishers Pvt. Ltd Calcutta
11. Pal, B.P. 1972. The Rose in India. ICAR, New Delhi.
12. Rajeevan, P.K. Singh, K.P. and Valsalakumari P.K. 2003 ed. Bulbous Flowers. Indian. Society of Ornamental Horticulture Division of Floriculture & Landscaping, IARI, New Delhi.
13. Rajeevan, P.K., Sobhana, A., Jyothi Bhasker, Swapna, S. and S.K. Bhattacharjee. 2003. Orchids. Technical Bulletin. ICAR.
14. Rajeevan, P.K., Valsalakumari, P.K. and Geetha, C.K. 1999. Pookrishi:, Sastravum Prayogavum. (Malayalam) Kerala Agricultural University, Mannuthy, Trichur
15. Rajeevan, P.K., Valsalakumari, P.K. and Geetha, C.K., Leena Ravidas and S.K. Bhattacharjee. 2002. Anthurium. Technical Bulletin. ICAR.
16. Randhawa, G.S. and Mukhopadhyay, A. 1986. Floriculture in India. Allied publishers New Delhi.

Vocational course 6**Code: BO3VO3T06****OLERICULTURE****(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)****Module 1: (9 hrs)**

Vegetables: Introduction, classification-botanical, cultural, thermo classification, food value of common vegetables grown in Kerala, role of vegetable growing in Indian economy.

Types of vegetable farming - kitchen, garden, terrace garden, market garden, truck garden, vegetable garden for processing, vegetable forcing, garden for seed production, organic farming and its significance.

Module 2: (18 hrs)

Cultivation-planting season, preparation of soil, seed selection, seeding, transplanting- thinning, mulching. Irrigation, manuring, plant protection methods-special care (if any). Harvesting and post harvesting operations of the following corps.

Warm season vegetables: brinjal, chilli, cucumber, bitter guard, pumpkin, snake guard, yam, tapioca, colocasia, ginger, lady's finger, cow pea, cephalandra, ash guard, amaranth, coleus, musa.

Module 3: (18 hrs)

Cool season vegetables: cabbage, carrot, beet, onion, peas and beans. Pre and post-harvest changes in vegetables: role of growth regulators and stimulants in vegetable production: changes during cooking and processing-spoilage of vegetables-factors influencing spoilage-microbial spoilage-problems and prospects of vegetable cultivation in Kerala

Module 4: (9 hrs)

Mushroom as a vegetable: cultivation of edible mushrooms; button, paddy straw and oyster mushroom. Spawn production, utilization of paddy straw and other agro wastes in cultivation, farm design, pest and disease control.

PRACTICAL (36 hrs)

1. Familiarization of different vegetable crops-through field visits and slide show, familiarization of seeds of vegetable corps, preparation of nursery bed, sowing and after care
2. Cultivate any five vegetable corps either in the pot or in the field. Equal representation should be given to plants like climbers, trailers, root tubers, underground stem crops etc.
3. Fertilizer application by different methods
4. Sterilization of paddy straw, inoculation, cultivation and harvesting of oyster/pleurotus sp. Using poly bag method
5. Field study: visit a market garden/truck garden to study the various cultivation practice

REFERENCES

1. Bose, T. K. and Som, M. G. 1990. Vegetable Crops in India. Naya Prokash, Calcutta.
2. Chadha, K. L. 2003. Handbook of Horticulture, ICAR, New Delhi.
3. Choudhury, B.1983. Vegetables. National Book Trust, New Delhi.
4. Das, P. C.1993. Vegetable Crops in India. Kalyani Publishers.
5. Gopalakrishnan, T. R. 2007. Vegetable Crops. New India Publishing Agency, New Delhi.
6. Hazra, P. and Som, M. G. 1999. Technology for Vegetable Production and Improvement. Naya Prokash, Calcutta.
7. Kallo, G. Tomato. Allied Publishers Pvt. Ltd.
8. Peter, K. V. 1998. Genetics and Breeding of Vegetables. ICAR, New Delhi.
9. Thamburaj, S. and Singh, N. 2005. Vegetables, Tuber Crops and Spices. ICAR, New Delhi.

SEMESTER IV

Vocational course 7

Code: BO4VO3T07

POMOLOGY, FOOD TECHNOLOGY AND POST-HARVEST MANAGEMENT OF HORTICULTURAL CROPS

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

POMOLOGY (36 hrs)

Module 1: (18 hrs)

Importance of fruits: classification-fruit cultivation in India-role of fruits in Indian economy. Cultivation of fruit trees/plants with special reference to Musa, Pineapple, Papaya, Mango, Sapota, Guava.

Selection of suitable sites-seasons for planting-preparation of land –selection of fruit plants and their varieties-planning, aftercare and pruning-disease and pest control

Module 2: (18 hrs)

Reasons for failure to fruit development; internal and external factors; causes and remedies; role of plant growth regulators in fruit yielding plants.

Harvesting, marketing and storage of fruits: Basic principles in harvesting and marketing; storage of fruits; physiological changes during storage, factors influencing storage and methods of storage

FOOD TECHNOLOGY AND POST-HARVEST MANAGEMENT OF HORTICULTURAL CROPS (18 hrs)

Module 3: (9 hrs)

Importance of post-harvest management of fruits and vegetables. Post-harvest losses of fruits, vegetables, physiology of maturity, ripening and senescence, storage of fruits and vegetables, ambient low temperature and controlled atmosphere storage systems.

Packaging of fresh and processed products: general principles and methods of preservation. Principles of preservation by dehydration, thermal processing, chemical preservatives, fermentation, ionizing, radiation, Preparation of jams, jellies, squashes, pickles, salads, syrups and beverages.

Module 4: (9 hrs)

Government policies, regulations and specifications for fresh and processed products, export promotion agencies and their role on export of fresh and processed products. General guidelines for establishment of a home scale processing unit,

PRACTICAL (36 hrs)

1. Identification of plant diseases of fruit trees
2. Preparation of Bordeaux mixture
3. Cultivate any one of the crops listed in syllabus
4. Identification and conservation of wild local varieties of Mangoes, Jack fruits, Musa etc.
5. Preparation of any one of the fruit products mentioned in the syllabus

REFERENCES

1. Amar Singh, 1986. Fruit Physiology and Production. Kalyani Publishers, New Delhi.
2. Bose T K, Mitra S K, Sanyal D, 2002. Fruits: Tropical and Subtropical, Vol. I & II, Nayaprakash publications, Calcutta.
3. Chadha K L, Reddy B M C, Sikhamony S D, 1998. Pineapple. ICAR, New Delhi.

4. Davies, F. S and Albrigo, L.G. 1994. Citrus. CAB International, UK.
5. Galletta, G.J. and Himelrick, D.G. 1989. Small Fruit Crop Management. Prentice Hall, New Jersey.
6. Hayes W B, 1957. Fruit Growing in India. Kitabitan, Allahabad.
7. Kumar, N. 1997 (6th Edition). Introduction to Horticulture. Rajhalakshmi Publications, Nagercoil
8. Mitra S K, Bose T K, Rathore D S, 1991. Temperate Fruits. Horticulture and Allied Publishers, Calcutta.
9. Naik K C, 1949. South Indian Fruits and their Culture. Varadachari Co., Madras.
10. Randhava, G.S and Srivastava, K.C. Citriculture in India. Hindustan Publishing Co., New Delhi.
11. Samson, J.A. 1980. Tropical Fruits. Longman group, London.
12. Shanmughavelu K G, Aravindakshan K, Satiamoorthy S, 1992. Banana. Metropolitan Book Co. Pvt. Ltd. New Delhi.
13. Singh, I.D. 1990. Papaya. Oxford & IBH Publishing Co. Ltd. , New Delhi.
14. Singh, L.B. 1960. The Mango. Leonard Hill (Books), London.
15. Singh, R., N. 1990. Mango. ICAR, New Delhi.
16. Singh, R. 1960. Fruits. National Book Trust, India.
17. Stover, R.H and Simmonds, N.W. 1987. Bananas. Longman scientific and Technical Publications, New York.
18. Veera Raghava Thataham, Jawaharlal M, Jeeva S, R Rabindran, 1996. Scientific Fruit Culture. Suri Associates, Coimbatore.
19. Westwood, M.N. 1978. Temperate zone Pomology. Freeman & Co., Sanfransisco.
20. Mitra, S. K. 1997. Postharvest Physiology and Storage of Tropical Fruits CAB International UK.
21. Panastico, B.M 1975. Postharvest Physiology, Handling and Utilization of Tropical and Sub-Tropical Fruits and Vegetables. The AVI Publishing Company,
22. Purseglove, J.W. et al 1981. Spices, Longman, New York (2 vols).
23. Roger, C Griffin, J.R and Stanley Sacharow 1972. Principles of Package Development. The AVI Publishing Company INC, Westport, USA.

Vocational course 8 **Code: BO4VO3T08**
CULTIVATION OF MEDICINAL AND AROMATIC PLANTS, SPICES, AND
PLANTATION CORPS
(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)

Module 1: (18 hrs)

Significance of medicinal and aromatic plants Indian system of medicine, Indigenous Traditional Knowledge. Taxonomy and uses of important medicinal and aromatic plants available in Kerala Cultivation of Sida, Adathoda, Ocimum, Rauvolfia, Vinca, Mentha, Pumbago, Kaempferia, Lemon grass, Vetiver, Turmeric.

Module 2: (18 hrs)

Introduction, importance of spice crops-historical account, present status, future prospects, botany and taxonomy, climatic and soil requirements, site selection, planting times and methods, treatment, nutritional and irrigation requirements, weed control, mulching, harvesting, post-harvest management and plant protection measures of following spices; Black pepper, Cardamom, Clove, Cinnamon, Nutmeg, Allspice Turmeric, Ginger, Coriander, Fenugreek, Cumin, Fennel, Tamarind, Garcinia and Vanilla

Module 3: (18 hrs)

Plantation crops-scope and importance of plantation crops, Role of plantation crops in national economy, export potential, Types of plantation crops. Cultivation of Coffee, Tea, Cashew, Cocoa, Rubber, Oil palm, Coconut and Arecanut

PRACTICAL (36 hours)

1. Collection and identification of important medicinal and aromatic plants
2. Extraction of the active principles of local medicinal, aromatic and spices (Any five types)
3. Collect and identify the natural propagules of common spices **FIELD WORK**
4. Visit any spice/plantation crop estate to familiarize with the cultivation and processing practices. Besides, a project work based on horticultural aspects is an essential requirement

REFERENCES

1. Chadha.K.L. and Rethinam.P (Eds.) 1994. Advances in Horticulture. Vol. 9 Plantation and Spice Crops. Malhotra Publishing House, N. Delhi, India.
2. Edison.S. Johnney.A.K. Nirmal Babu.K. and Ramadasan.A. 1991. Spice Varieties. Indian Institute of Spices Research (IISR), Calicut, India.
3. Nybe, E.V, Mini Raj,N and Peter, K.V.2007. Spices. New India Publishing Agency, NewDelhi.
4. Pruthi.J.S. 1993. Major Spices of India, Crop Management – Post Harvest Technology, ICAR, New Delhi.
5. Pruthi, J.S.2001 Minor Spices and Condiments-Crop Management and Post-Harvest Technology, ICAR, New Delhi, India.
6. Aiyar.N. and Kolammal.M 1962. Pharmacognosy of Ayurvedic Drugs of Kerala, Kerala University, Thiruvananthapuram.
7. Atal C K, Kapur B M, 1982. Cultivation and Utilization of Medicinal Plants. RRL, CSIR, Jammu.Tawi.
8. Atal C K, Kapur B M, 1982. Cultivation and Utilization of Aromatic plants. RRL, CSIR, Jammu.Tawi.
9. Cains J. F. 1986. Medicinal and Poisonous Plants of India. Scientific Publishers, Jodhpur.
10. Chadha. K.L. and Gupta. R. 1995. Advance in Horticulture Vol. 11 Medicinal & Aromatic Plants. Malhotra Pub. House., New Delhi.
11. CSIR. 1971. The Wealth of India. Vol. A-Z. CSIR, New Delhi.
12. Dastur J F, 1977. Medicinal plants of India and Pakistan. Taraporevala sons & Co. Pvt. Ltd., Bombay.
13. Farooqui, A.A., Khan, M.M. and Sreeramu, B.S. 1997. Cultivation of Medicinal and Aromatic Acrops in India. Naya Prakash, Kolkatta.
14. Jain S K, 1979. Medicinal Plants. National Book Trust of India, New Delhi.
15. Kaushik P, 1988. Indigenous Medicinal Plants Including Microbes and Fungi. Today and Tomorrow's Printers and Pub., New Delhi.54
16. Kirthikar K R, Basu B D, 1993. Indian Medicinal Plants, Vol. 1-4.
17. Lalit Mohan Basu, Allahabad Morton J P, 1971. Major medicinal plants: Botanic Culture and Uses.
18. Kurian, A and Sankar, M.A.2007. Medicinal Plants. New India Publishing Agency, New Delhi.
19. Nesamony.S. 1988 & 1999. Oushadha Sasyangal (Vol. 1 & 2). State Institute of Languages, Kerala, Thiruvananthapuram.
20. Sivarajan, V.V. and Balachandran, I. 1994. Ayurvedic drugs and their plant sources. Oxford & IBH Pub. Co. Pvt. Ltd., New Delhi.

21. Warriar.P.K. Nambiar, V.P.K. and Ramankutty.C. 1993 - 1996. Indian Medicinal Plants a Compendium. Vol. 1-5. Orient Longman Ltd., New Delhi.
22. Banerjee.B, 1993. Tea Production and Processing. Oxford & IBH Publishing Co. Pvt. Ltd.
23. Bhaskara Rao.E.V. Nambiar.K.K..N. Nambiar.M.C. and Nair.M.K. (Eds) 1979.Monograph on Plantation crops I. Cashew (*Anacardium occidentale*) CPCRI, Kasargod.
24. Chadha, K.L.2001. Hand Book of Horticulture, ICAR, New Delhi.
25. CPCRI, 2003. Coffee guide, Central Coffee Research Institute, Coffee Board, Chickamangalur, Karnataka.
26. Kumar.N, Abdul Khader.J.B.M. Rangaswami.P. and Irulappan., 1993. Introduction to spices – Plantation crops, Medicinal and Aromatic plants, Rajalekshmi Pub, Nagercoil.
27. Menon.K.P.V. and Pandalai.K.M. 1960. The coconut Palm – a monograph. Indian Central Coconut Committee, Ernakulam.
28. Nampoothiri,K. U. K and Singh, H. P. 2000 Trends in Coconut Research and Development in India, Coconut Development Board, Kochi.
29. Peter, K.V. 2002 Plantation Crops, National Book Trust, India
30. Purselglove. 1978. Tropical Crops. Monocots (Vol. I & II combined)
31. Thampan.P.K. 1976. The coconut palm and its products Green Villa Pub. House, Cochin.
32. Thampan.P.K. 1981. Handbook on coconut Palm, Oxford & IBH, New Delhi.

PLANT BIOTECHNOLOGY

SEMESTER I

Vocational course 1

Code: BO1VO4T01

INTRODUCTION TO BIOTECHNOLOGY

(Theory: 36 hrs; Credits: 2)

Module 1: Introduction to Biotechnology (4 hrs)

Introduction: concept of Biotechnology, Definition, landmarks in biotechnology; traditional and modern biotechnology; scope and relevance of Biotechnology.

Module 2: Application of Biotechnology in industry (10 hrs)

Basic principle of fermentation, Production of fermented food products - bread, wine, and fermented milk products – butter, cheese and yogurt. High value food products - single cell proteins and mycoproteins. Production of organic acids (citric acid and acetic acid) alcohol (ethanol) and enzymes (cellulase and amylase).

Module 3: Application of Biotechnology in agriculture (10 hrs)

Brief introduction to GM crops, transgenic plants and its applications. Biofertilizers and biopesticides. Tissue culture - scope and importance in crop improvement.

Module 4: Application of Biotechnology in environment (6 hrs)

Principle and applications of bioremediation. Bioenergy from waste - biogas, fuel alcohol from biomass and lignocellulose residues, biodiesel, advantages of biofuels.

Module 5: Application of Biotechnology in medicine (6 hrs)

Biotechnology in disease diagnosis and treatment - antenatal diagnosis, recombinant therapeutics, gene therapy. Production of monoclonal antibodies. Stem cell and organ culture and its importance.

REFERENCES

1. Pubohit S S, 2005. Biotechnology Fundamentals and Applications (IV Edn). Agrobious (India).
2. Singh B D, 1998. Biotechnology. Kalyani Publishers.
3. Brown C M, Campbell I, Priest F G, 2005. Introduction to Biotechnology. Panima Pub.
4. Satyanarayana U, 2013. Biotechnology. Books & Allied (P) Ltd.
5. Julius M Cruse, Robert Elwin. Atlas of Immunology (III Edn). CRC press.
6. M K Sateesh. Introduction to Biotechnology. New age International publishers.
7. William J Thieman, Michael A Palladino. Introduction to Biotechnology. Pearson.

Vocational course 2 **Code: BO1VO4T02**
MICROBIOLOGY
(Theory: 36 hrs; Practical: 36 hrs; Credits 2 + 1)

Module 1: Introduction to Microbiology (4 hrs)

Definition of microbiology. History of microbiology - important contributions of Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming, Edward Jenner, John Tyndall. Scope and applications of microbiology.

Module 2: Structure and reproduction of Viruses (4 hrs)

Viruses: General characteristics-structure and properties. Structure of bacteriophage. Replication of bacteriophage - Lytic and lysogenic cycle.

Module 3: Structure and reproduction of Bacteria (10 hrs)

Bacterial cells: Morphology, size, shape and arrangement. General principles of bacterial classification: - classification on the basis of carbon and energy source. Ultra structure of bacteria: structures and functions of capsule, flagella, pili, cell wall, plasma membrane, cytoplasm, ribosome, mesosomes, reserve food material, nuclear materials-nucleotides, plasmids. Reproduction of bacteria: - binary fission, budding, fragmentation, bacterial endospores. Recombination in bacteria - conjugation, transformation, transduction.

Module 4: Instruments used in microbiology labs (4 hrs)

Principle, working and applications of inoculation loops, haemocytometer, laminar air flow, hot air oven, autoclave, colony counter, incubator.

Module 5: Methods of microbial control (4 hrs)

Definition of sterilization, Antiseptics, disinfectants, antimicrobial agents and antibiotics. Dry and moist heat, pasteurization, tyndalization, radiation, filtration. Chemical methods of sterilization, Fumigation.

Module 6: Microbial growth and culture techniques (6 hrs)

Microbial growth: Definition, Phases of growth, Measurement of growth, growth curve. Factors affecting microbial growth: nutrients, pH, temperature, oxygen, osmotic pressure, light and moisture. Bacteriological media - Natural, synthetic, semi-synthetic, enriched, differential & selective. Media components. Pure culture techniques: serial dilution, pour plate, streak plate, spread plate.

Module 7: Staining and staining techniques (4 hrs)

Classification of stains-acidic, basic and neutral stains. Theories and procedure of different bacterial staining - simple staining, negative staining, capsule staining, endospore staining, gram staining, acid fast staining.

PRACTICAL (36 hrs)

1. Preparation of agar slants and broths
2. Streak plate technique for purification of bacteria.
3. Culture bacteria in artificial medium.
3. Grams staining
4. Negative staining
5. Viable count – enumeration of bacteria – pour plate technique
6. Isolation of Microorganisms from drinking water/ soil through serial dilution technique
7. Test for catalase
8. Test for amylase
9. Hanging drop experiment – demonstration
10. Demonstration - principle, working and application of Laminar air flow, Autoclave, Colony counter, Hot air oven, Incubator, Haemocytometer.

REFERENCES

1. A.J. Salle (1974) Fundamental Principles of Bacteriology (TMH Edition) Tata McGraw – Hill Publishing Co. Ltd, New Delhi – 110008.
2. H.G. Schlegel (1995) General Microbiology, Cambridge.
3. I E Alcamo. Fundamentals of Microbiology (IV Edn). The Benjamin cummings publishing co, Inc.
4. Michael J. Pelczar, Jr, E.C.S. Chan, Noel R. Krieg (1993) Microbiology (Fifth Edition), Tata Mcgraw – Hill Publishing Company Ltd, NewDelhi.
5. Roger Y. Stanier, John L. Ingraham, Mark L Wheelis, Page R. Painter (2003) General Microbiology (Fifth Edition), Mac Millan Press Ltd.
6. A.N. Glazes (1995) Microbial Biotechnology, New York: WH
7. N.Mukherjee, T Ghosh (1995). Agricultural Microbiology, (First Edition). Kalyani Publishers.
8. Powar & Daginawala (1997)General Microbiology (Vol II). Himalaya Publishing House
9. R.C. Dubey and D.K. Maheswari (2005) A Text Book of Microbiology. S Chand and Company Ltd, New Delhi.
10. S. R. Maloy (1994). Microbial Genetics. Jones and Bartlett Publishers.

SEMESTER II

Vocational course 3

Code: BO2VO4T03

MOLECULAR BIOLOGY

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

Module 1: DNA – Basic features, mutation and polymorphism (10 hrs)

DNA – types and Structure. DNA replication. Mutation - types. Physical and chemical mutagens. Role of mutation in creating genetic variability. Polymorphism in DNA - SNPs. Methods to analyse polymorphism – RAPD, RFLP, DNA fingerprinting.

Module 2: Basic concepts of gene, chromosome and genome (10 hrs)

Definition of gene, cistron. Structure of eukaryotic gene. Chromosome as physical carriers of gene. Organization of DNA into chromosomes: chromatin, nucleosome, 30nm fiber, 300nm fiber, coiled coil structure. Structural features of chromosome - centromere, telomere. Euchromatin and

heterochromatin. Chromosome as a linkage group. Genome: Definition, satellite DNA, minisatellites and microsatellites. Coding and non coding sequences.

Module 3: Gene expression (10 hrs)

Central dogma of molecular biology. Steps involved in gene expression. Steps of transcription and translation. Genetic code. Structure and role of mRNA, tRNA and rRNA. Regulation of gene expression - Operon concept with Lac operon and Trp operon as examples. Reverse transcription.

Module 4: Cancer (6 hrs)

Introduction, characteristic features of cancer cell. Molecular biology of cancer - Oncogenes, proto oncogenes and tumour suppressor genes. Heredity and cancer.

REFERENCES

1. Lewin's Gene X. Jocelyn E.Krebs, Elliot S. Goldstein, Stephen T. Kilpatrick
2. Daniel Hartl. Essential genetics: A genomic perspective (VI Edn).
3. Molecular Biotechnology-Principles and applications of rDNA. Bernard R.Glick, Jack J.Pasternak, Cheryl L.Patten
4. An introduction to Molecular Biotechnology-Concepts and Experiments. Gerald Karp
5. Human Genetics- Concepts and applications.Ricki Lewis
6. Molecular cell biology. Lodhish et.al
7. Principles of Genetics. Snustard, Simmons.

Vocational course 4 **Code: BO2VO4T04**
FUNDAMENTALS OF ENZYMOLOGY AND RADIOBIOLOGY
(Theory 36 hrs; Practical 36 hrs; Credits 2 + 1)

Module 1: Water, Solutions and pH (8 hrs)

Water as solvent in biological system: polarity, cohesiveness, physical properties, H-bonding. Solutions - Molarity, Molality and Normality. Acids and bases. pH and pH scale, measurement of pH - pH paper, pH meter: glass electrode and calomel electrode. Buffers - properties, buffer action, significance in biological systems and preparations.

Module 2: Chemical nature and general properties of enzymes (10 hrs).

Properties of Enzymes, Classes of enzymes- oxidoreductases (eg.alcoholdehydrogenase), transferases (Hexokinase), hydrolases (chymotrypsin), lyases (pyruvate decarboxylase), isomerases (alanine racemase) Structure of enzyme - Apoenzyme, coenzyme, cofactor, holoenzyme. Active site of an enzyme. Mechanism of enzyme action – lock & key hypothesis, induced fit hypothesis. Enzyme regulation - feedback, allosteric; enzyme inhibition. Factors affecting enzyme action.

Module 3: Enzyme kinetics (8 hrs)

Michaelis-Menten equation, Km value and its significance. Velocity of a reaction. Chemical equilibrium of enzymatic reaction, Reversible reaction. Isoenzymes. Significance of isoenzymes (eg: LDH)

Module 4: Radioisotopes and their applications in biology (10 hrs)

Half life period, tracer techniques; measurement of radioactivity – GM counter, solid scintillation counter, liquid scintillation counter, and autoradiography. Applications of C14, P32, S35 isotopes in biology.

PRACTICAL (36 hrs)

1. Preparation of buffers of various pH.
2. Preparation of molar solutions
3. Estimation of pH using pH paper and pH meter
4. Estimation of proteins by biuret method
5. Estimation of proteins by Lowry's method
6. Estimation of rate of enzyme catalyzed reaction
7. Effect Temperature on enzymatic reaction
8. Role of substrate concentration on enzyme catalyzed reaction

REFERENCES

1. Donald Voet, Judith G Voet. Biochemistry.
2. Lehninger. Principles of Biochemistry.
3. Lubert Stryer. Biochemistry.
4. David Wemmer, John Kurian, Boyana Konforti. The molecules of life: Physical and chemical principles.
5. Thomas M Devlin. Text book of Biochemistry with clinical correlations.
6. Nicholas C Price, Lewis Stevens. Fundamentals of Enzymology.
7. Trevor Palmer. Understanding Enzymes.

SEMESTER III

Vocational course 5 **Code: BO3VO4T05**
BIOTECHNIQUES & INSTRUMENTATION
(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)

Module 1: Microscopy (10 hrs)

Compound Microscope – parts of compound microscope, bright field microscopy, dark field microscopy. Phase contrast microscopy, fluorescent microscopy, Electron microscopy- TEM, SEM

Module 2: Centrifugation (10 hrs)

Principles and Applications, Types of centrifuges, parts of centrifuges. Velocity gradient centrifugation, Isopycnic centrifugation, Differential centrifugation.

Module 3: Electrophoresis (12 hrs)

Principles and Applications. Separation of macromolecules by Agarose gel Electrophoresis, Poly Acrylamide Gel Electrophoresis. SDS-PAGE, Pulse Field gel Electrophoresis, Isoelectric focusing, Two dimensional gel electrophoresis.

Module 4: Chromatography (12 hrs)

Principle, Mobile and stationary phases, Rf value. Types of chromatography- Paper chromatography, TLC, Ion-Exchange chromatography, Affinity chromatography, Gel filtration chromatography, HPLC, GLC. Applications of chromatography techniques

Module 5: Photometric analysis (10 hrs)

Electromagnetic spectrum. Beer-Lamberts Law. Colorimetry and Photometry. Colorimeter and spectrophotometer. UV spectroscopy, Infrared spectroscopy.

PRACTICAL (36 hrs)

1. Estimation of proteins by Lowry's method
2. Estimation of DNA by Diphenylamine method
3. Estimation of RNA
4. Thin layer chromatography
5. Paper chromatography
6. Demonstration – Principle and experimental set up of column chromatography, Poly acrylamide gel electrophoresis (PAGE), density gradient centrifugation, UV spectroscopy.

REFERENCES

1. Debajyoti Das. Biophysics and Biophysical Chemistry (III Edn). Academic Press, Calcutta.
2. Sharma B K, 2002. Spectroscopy. Goel Publishing House, Meerut.
3. T C Ford, Graham J M, 1991. An Introduction to Centrifugation. Bios.
4. Vasantha Pattabhi, N Gautham, 2004. Biophysics. Nirosa Publishing House.

Vocational course 6 **Code: BO3VO4T06**
BASICS OF MOLECULAR CLONING TECHNIQUES
(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)

Module 1: Enzymes used in genetic Engineering (10 hrs)

Restriction Endonucleases, Ligases, DNA polymerases, Reverse Transcriptase, Polynucleotide Kinase, Terminal Transferase, Alkaline Phosphatase.

Module 2: Cloning vectors (12 hrs)

Vectors from plasmids - Essential features common plasmid vectors - PBR322, PUC18, Vectors from Bacteriophages - construction of λ based vectors, M13, cosmids, Phagemids. Eukaryotic vectors YAC, BAC, and Shuttle Vectors. Expression vector

Module 3: Molecular probes (6 hrs)

Preparation of probes, nick translation, methods of labeling probes - radioactive and non radioactive labelling, GFP; applications of probes.

Module 4: Nucleic acid hybridization (8 hrs)

Principles and applications; Southern Blotting, Northern Blotting, Western Blotting, Dot - Blotting, colony hybridisation, Plaque hybridisation, *In-situ* hybridization.

Module 5: DNA amplification using PCR (6 hrs)

Polymerase Chain Reaction - methods, types and application.

Module 6: Sequencing of DNA (12 hrs)

Maxam and Gilbert chemical degradation method, Sanger and Coulson Enzymatic method, Direct DNA sequencing using PCR, Automated DNA sequencing methods.

PRACTICAL (36 hrs)

1. Isolation of plasmids
2. Preparation of competent cells for transformation
4. Demonstration – Principle and experimental set up of restriction digestion, transformation of competent cells, Southern blotting, PCR, Vector mediated gene transfer using pBR322, pUC18, YAC.

REFERENCES

1. B.D. Singh (1998.) Biotechnology (First Edition), Kalyani Publishers.

2. J Sambrook, E F Fritsch, Maniatis, 1989. Molecular Cloning: A Laboratory Manual, Cold Spring Harbour Laboratory Press.
3. M.S. Clark (1997). Plant Molecular Biology, A Laboratory Manual, Springer Verlag.
4. S S Pubohit, 2005. Biotechnology: Fundamentals and Applications (IV Edn). Agrobios (India).
5. T.A. Brown (1996). Gene Cloning – An introduction (Third Edition), Chapman and Hill.

SEMESTER IV

Vocational course 7 **Code: BO4VO4T07**
GENETIC ENGINEERING
(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)

Module 1: Gene cloning strategies (10 hrs)

Methods of isolation of foreign gene, Transformation and transfection. Screening of transformants- Marker genes and Reporter genes. Direct and Indirect selection of transformants.

Module 2: Genetic Transformation of plants (10 hrs)

Direct and Indirect gene transfer - vectors based on Ti plasmid, Ri plasmid of Agrobacterium, Agroinfection. Plant viral vectors - Caulimovirus vectors, Gemini virus vectors

Module 3: Genetically modified crops (10 hrs)

Application of transgenic plants in agriculture – herbicide resistance, modification of seed protein quality – golden rice, Flavr savr tomato. Molecular farming – production of edible vaccines, antibodies, biodegradable plastics.

Module 4: Gene Libraries (10 hrs)

Genomic libraries Vs cDNA libraries - construction, screening and applications. Mapping of DNA :Restriction mapping, Chromosome walking, Chromosome jumping, DNA footprinting, Transposon tagging.

Module 5: Basic Principles & applications of the following technologies (6 hrs)

DNA chip Technology and Micro arrays- Types of DNA chips and their production. Applications of micro arrays on DNA chips. Nanobiotechnology.

Module 6: Genomics (4 hrs)

Human genome Project – history, significance, major findings.

Module 7: Drawbacks of Recombinant DNA Technology (4 hrs)

Ethical, Legal, Social, Environmental and Practical problems of Recombinant DNA Technology- Biosafety, Biowar, Patenting and IPR issues.

PRACTICAL (36 hrs)

1. Isolation of plant cell DNA.
2. Agarose gel electrophoresis - fractionation and staining of DNA.
3. Demonstration – Principle and experimental set up of Southern blotting, methods of direct Gene transfer - Microinjection, Biolistic Transfer, Liposome mediated gene transfer, Electroporation, Chemical mediated gene transfer, Agrobacterium mediated gene transfer - Agroinfection, Production of genetically engineered plants.

REFERENCES

1. S.N. Jogdand (1997). Gene Biotechnology (First Edition). Himalaya Publishing House.

- Sandhya Mitra (1996). Genetic Engineering, MacMillan India Ltd.
- R W Old, S B Primrose, 1994. Principles of Gene Manipulation: An Introduction to Genetic Engineering (V Edn). Black well Scientific Publishers.
- P K Gupta, 2004. Biotechnology and Genomics. Rastogi Publishers, Shnagi Road, Meerut.
- H. K. Das (2005). Text Book of Biotechnology, Wiley Dream tech, India Pvt Ltd.
- R. C. Dubey (2002). Text book of Biotechnology. S. Chand and Company Ltd., New Delhi.

Vocational course 8 **Code: BO4VO4T08**
PLANT TISSUE CULTURE
(Theory 54 hrs; Practical 36 hrs; Credits 3 + 1)

Module 1: Introduction and history of plant tissue culture (2 hrs)

Definition, principle of tissue culture-cellular totipotency, de differentiation and redifferentiation.
Brief history of plant tissue culture

Module 2: General facilities for plant tissue culture (4 hrs)

Equipments, laboratory organization and green house

Module 3: Methods of sterilization (4 hrs)

Dry heat, Wet heat, Filter sterilization, Sterilization by chemicals and antibiotics of plant material.
Isolation of different types of explants: shoot tips, nodal segments, leaves, and anther.

Module 4: Plant tissue culture medium (4 hrs)

General components and their role. Plant growth regulators: Cytokinins, Auxins, Gibberellins, Abscissic acid, Ethylene. Method of preparation of stock solutions: MS medium.

Module 5: Method and importance of the following (2 hrs)

Inoculation, incubation, subculturing and hardening

Module 6: Importance, methodology and significance of the culture techniques (6 hrs)

Callus and suspension culture. Meristem culture, anther culture, pollen culture, ovary culture and embryo culture

Module 7: Organogenesis and Somatic Embryogenesis (8 hrs)

Organogenesis and factors affecting organogenesis. Cytodifferentiation and factors affecting cytodifferentiation. Somatic embryogenesis: Induction of somatic embryos – direct and indirect. Factors affecting somatic embryogenesis. Importance of somatic embryogenesis. Synthetic (artificial) seeds. Method of preparation and importance of artificial seeds.

Module 8: Protoplast culture and Somatic Hybridization (6 hrs)

Protoplast isolation (mechanical and enzymatic methods), culture and regeneration. Protoplast fusion - Somatic hybridization. Methods and applications of somatic hybridization. Cybrids-applications.

Module 9: Single cell culture and its importance (4 hrs)

Paper raft nurse technique, The petridish plating technique, The microchamber technique, Growth of single cell induced by nurse callus and microdroplet technique.

Module 10: Somaclonal variation (4 hrs)

Genetic basis and applications of somaclonal variations.

Module 11: Production of secondary metabolites (6 hrs)

Bioreactors – design. Types- batch, continuous, multistage bioreactors. Cell immobilization and immobilized cell bioreactors. Process scale up, biotransformation, elicitors and downstream processing. Hairy root culture.

Module 12: (4 hrs)

Applications of plant tissue culture.

PRACTICAL (36 hrs)

1. Preparation of stock solutions of MS medium
2. Preparation of MS medium
3. Surface sterilization and inoculation of explants (node, anther, leaf, cambium)
4. Subculturing of callus.
5. Production of synthetic seeds.
6. Set up an experiment for paper raft nurse technique.
7. Demonstration – Principle and experimental set up of suspension culture.

REFERENCES

1. S.N. Jogdand (1997). Gene Biotechnology (First Edition) Himalaya Publishing House
2. Sandhya Mitra (1996). Genetic Engineering, Macmillan India Ltd. R.W. Old and S.B. Primrose (1994)
3. Principles of Gene Manipulation -An Introduction to Genetic Engineering (Fifth Edition) Black well Scientific Publishers.
4. P. K. Gupta (2004). Biotechnology & Genomics (First Edition) Rastogi Publishers, Shnagi Road, Meerut.
5. H. K. Das (2005). Text Book of Biotechnology, Wiley Dream tech, India Pvt Ltd.
6. R. C. Dubey (2002). Text book of Biotechnology. S. Chand and Company Ltd., New Delhi.

COMPLEMENTARY COURSES FOR MODEL-II (VOCATIONAL) B Sc ZOOLOGY - AQUACULTURE

COMBINATION OF COURSES AND SEMESTER-WISE DISTRIBUTION

Sem.	Course category	Course code	Course title	Instr. hrs.*		Credits
				Th.	Pr.	
I	Compl.1	BO1CMVOT01	Plant Diversity and Plant Pathology	54	36	2 + 1
II	Compl.2	BO2CMVOT02	Plant Physiology	54	36	2 + 1
III	Compl.3	BO3CMVOT03	Angiosperm Taxonomy and Economic Botany	54	36	3 + 1
IV	Compl.4	BO4CMVOT04	Anatomy and Applied Botany	54	36	3 + 1

SEMESTER I

Complementary course 1 **Code: BO1CMVOT01**
PLANT DIVERSITY AND PLANT PATHOLOGY
For B. Sc. Zoology Model II - Vocational
(Theory 54 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 diversity of plants with respect to Algae, Fungi, Lichens, Bryophytes, Pteridophytes and Gymnosperms.

PLANT DIVERSITY (45 hrs)

Module 1: Diversity of plants (5 hrs)

Introduction to the origin of plant diversity in the existing forms of plants, evolutionary trends among plants; general classification of plants – Eichler's system.

Module 2: Algae (16 hrs)

General characters and classification of Algae up to classes (F E Fritsch); range of thallus variation. Reproduction and life history of the following groups with reference to the types quoted: Cyanophyceae – *Nostoc*; Chlorophyceae - *Oedogonium* (*Volvox*, *Spirogyra*, *Cladophora* –Vegetative features only); Phaeophyceae - *Ectocarpus* (*Vegetative only*), *Sargassum* (vegetative and reproductive features); Rhodophyceae – *Polysiphonia*. Economic importance of Algae: food, industry, medicine, biofertilizers; algal bloom. Role of algae in Aquaculture.

Module 3: Fungi (16 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 quoted: Zygomycotina – *Rhizopus*; Ascomycetes – *Xylaria*; Basidiomycetes – *Puccinia*; Deuteromycetes - General characters only. Economic importance of Fungi: as food, in industry, decomposition of

organic matter; fungal toxins and human health. Fungal diseases of fishes: Causative organism, symptoms and control measures of following diseases:

(a) Saprolegniasis (b) Branchiomycosis.

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

Module 4: Bryophytes (2 hrs)

General account; *Riccia* - morphology, anatomy, reproduction and life cycle.

Module 5: Pteridophytes (3 hrs)

General account; *Selaginella* - morphology, anatomy (stem), reproduction and life cycle.

Module 6: Gymnosperms (3 hrs)

General account; *Cycas* - morphology, anatomy (leaf let), reproduction and life cycle.

PLANT PATHOLOGY (9 hrs)

Module 7: Plant diseases and their control (9 hrs)

Classification of plant diseases based on causative organism and symptoms; different types of defence mechanisms in plants - morphological, anatomical and physiological; use of fungicides, pesticides and antibiotics for disease control. Study the following diseases with special emphasis on causative organism, symptoms and control measures:

Nut fall of Arecanut, Bacterial blight of Paddy, Leaf mosaic disease of Tapioca, Abnormal leaf fall of Rubber.

PRACTICAL (36 hrs)

1. Identification and micro preparation of the following:

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

Fungi: Vegetative and reproductive structure of *Rhizopus*, *Xylaria*, *Puccinia*.

Lichen: Morphology of *Usnea* thallus and Apothecium.

Bryophytes: *Riccia* thallus anatomy.

Pteridophyte: *Selaginella* – Anatomy of Stem and Morphology of Strobilus.

Gymnosperms: *Cycas* – Anatomy of leaflet, morphological features of megasporophyll, microsporophyll and ovule.

2. Identify plant diseases mentioned in the syllabus.

REFERENCES

1. Ahamdijan, Vernon, Mason H E, 1973. The Lichens. Academic press, New York.
2. Alexopoulos C J, Mims C W, 1983. Introductory Micology. Wiley Eastern, New York.
3. Bhatia K N, 1975. A treatise on Algae. S. Chand and co.
4. Bilgramie K S, Dube H C, 1976. Text Book of Modern Plant pathology. Vikas Publishing House Pvt. Ltd. New Delhi.
5. Chaube H S, Ramji S, 2001. Introductory Plant Pathology. International Book Distributing Co. Lucknow.
6. Chopra R N, Kumra P K, 1988. Biology of Bryophytes. Wiley Eastern Ltd. New Delhi.
7. Fritsch F E, 1945. Structure and Reproduction of Algae Vol. I & II. Cambridge University Press.
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.
11. Pandey S N, Trivedi P S, 1994. A Text book of College Botany Vol. I.

12. Pandey S N, Trivedi P S, 1998. A Text book of College Botany Vol. II.
13. Pandey B P, 2007. College Botany Vol. I. S.Chand and Company.
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.

SEMESTER II

Complementary course 2 Code: BO2CMVOT02
PLANT PHYSIOLOGY
For B. Sc. Zoology Model II - Vocational
(Theory 54 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 (15 hrs)

Introduction and unifying principles of plant physiology *(Reference 14). Plant water relations: physical aspects of water absorption - Diffusion, DP, DPD. Imbibition. Osmosis - OP, Exosmosis, Endosmosis, Plasmolysis. Water potential and its components.

Movement of water in soil towards root by bulk flow; 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.

Stress physiology: Water stress

Module 2: Mineral nutrition (8 hrs)

Major and minor elements - criteria for essentiality of mineral elements, hydroponics; Absorbable form, function and deficiency symptom of the following mineral nutrients – N, P, K, Mg, B, Fe, Zn.

Nitrogen metabolism: sources of nitrogen, biological nitrogen fixation, mechanism of nitrogen fixation in root nodule of legume; synthesis of aminoacids - reductive and transamination reactions.

Module 3: Photosynthesis (13 hrs)

Basic requirements of Photosynthesis: Light - PAR; organs and site of photosynthesis, chloroplast, Photosynthetic pigments, action spectrum, absorption spectrum; Photosynthetic unit; Red drop and Emerson's enhancement effect, two pigment systems,

Mechanism of photosynthesis: light dependent reaction - cyclic and non cyclic photo phosphorylation. Chemi osmotic theory of ATP formation. Light independent reaction (dark reactions) - C3 cycle; brief account on C4 and CAM Cycles. Factors affecting photosynthesis. Photorespiration (brief study only). Blackman's law of limiting factors.

Module 4: Translocation of organic solutes (6 hrs)

Substances translocated, path of translocation, direction of translocation; source-sink concept, mechanism of translocation (pressure flow hypothesis).

Module 5: Growth and Development (12 hrs)

Seed structure, seed dormancy, causes of seed dormancy, and methods of breaking dormancy. Germination of seeds: physiological changes; growth, growth regions, growth rate, phases of growth, sigmoid growth curve. Plant growth regulators: auxins, gibberellins, cytokinins, abscissic acid and ethylene and their physiological role (brief study only). Abscission, senescence. Photoperiodism: definition - short day plants, long day plants, day neutral plants. Vernalization. Role of phytochrome in photoperiodism.

PRACTICAL (36 hrs)**Core experiments**

1. Demonstration 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.

REFERENCES

1. Hopkins W G, Norman P A, Huner, 2008. Introduction to Plant Physiology. John Wiley & Sons, New York.
2. Jain V K, 2008. Fundamentals of Plant Physiology. S Chand and Co.
3. Kochhar P L, Krishnamoorthy H N. Plant Physiology. Atmaram and sons, Delhi.
4. Kumar and Purohit. Plant Physiology: Fundamentals and Applications. Agrobotanical Publishers.
5. Malik C P, 2002. Plant Physiology. Kalyani publishers.
6. Mukherjee S, Ghosh A K, 2005. Plant Physiology. New Central Book Agency, Calcutta.
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.
- *14. Lincoln Taiz, Eduardo Zeiger, 2015. Plant physiology and Development VI Edn). Sinauer Associates Inc.

SEMESTER III

Complementary course 3 **Code: BO3CMVOT03**
ANGIOSPERM TAXONOMY AND ECONOMIC BOTANY
For B. Sc. Zoology Model II - Vocational
(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 (38 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 scorpioid; 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. Aggregate. 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), its merits and demerits. Cytotaxonomy and chemotaxonomy (brief account only). Herbarium techniques; importance of herbarium.

Module 3: Angiosperm families (20 hrs)

Study of the following families of Bentham and Hooker's 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, Areaceae (Palmae), Poaceae (Gramineae).

ECONOMIC BOTANY (16 hrs)**Module 4: Classification (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, economically important products and uses: Cereals - Paddy, Wheat; Pulses - Green gram, Bengal gram; Tuber crops - 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 (6 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. Identify the different types of inflorescences and fruits of typical plants belonging to the families prescribed in the syllabus.
2. Identify typical local plants belonging to the families prescribed in the syllabus.
3. 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 the botanical name, family, morphology of the useful part and the uses of the medicinal plants listed in the syllabus. .
5. 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

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*. Macmillon 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.

SEMESTER IV

Complementary course 4

Code: BO4CMVOT04

**For B. Sc. Zoology Model II - Vocational
ANATOMY AND APPLIED BOTANY**

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

Objectives:

- Understand different types of plant tissues.
- Understand the internal structure of different plant organs with reference to their functions.
- Understand the process of normal and anomalous secondary thickening in plants.
- Know the morphological and anatomical adaptations of plants growing in different habitats.
- Understand the applications of botanical knowledge in the field of crop improvement for human prosperity.

PLANT ANATOMY (34 hrs)

Module 1: Cells and tissues (9 hrs)

Gross structure of primary and secondary cell walls; structure and function of plasmodesmata; non-living inclusions - cystolith, raphides; Tissues - meristematic and permanent, types of meristems;

simple and complex tissues, secretory tissues (nectaries, hydathodes, mucilage ducts and lactiferous tissue).

Module 2: Anatomy of plant organs (16 hrs)

Primary structure of stem and root in dicots and monocots; anatomy of monocot and dicot leaf. Secondary thickening in dicot stem and dicot root; growth rings, dendrochronology, heart wood and sap wood; tyloses; hard wood and soft wood. Anomalous secondary thickening in *Bignonia*.

Module 3: Ecological anatomy (9 hrs)

Study of the morphological and anatomical adaptations of the following groups: Hydrophytes – *Nymphaea*, *Hydrilla*; Xerophytes – *Nerium*; Epiphytes - *Vanda*.

APPLIED BOTANY (20 hrs)

Module 4: Plant breeding (10 hrs)

Objectives of plant breeding, methods of plant improvement - plant introduction, acclimatization, plant quarantine; selection - mass selection, pureline selection and clonal selection; hybridization - intervarietal, interspecific and intergeneric; procedure of hybridization.

Module 5: Artificial vegetative propagation methods (4 hrs)

Propagation of plants through cutting, layering - air layering; budding T and patch budding; grafting - tongue and splice grafting. Role of cambium in budding and grafting.

Module 6: Plant tissue culture (6 hrs)

Principles of tissue culture, micropropagation - different steps - selection of explants, culture media, sterilization (explants and culture media), callus. Regeneration of plants: organogenesis, somatic embryogenesis; artificial seeds; applications of plant tissue culture.

PRACTICAL (36 hrs)

1. Primary structure of stem and root of dicots and monocots; Dicot stem - *Centella*; Monocot stem – Bamboo, grass, asparagus; Dicot root - *Tinospora*; Monocot root - *Colocasia*, *Musa*.
2. Structure of dicot stem and dicot root after secondary thickening; Stem - *Vernonia*, *Eupatorium*; Root - *Tinospora*, *Papaya*.
3. Anomalous secondary thickening in *Bignonia*.
4. Anatomical adaptations of Hydrophytes - *Nymphaea* petiole, *Hydrilla* stem; Xerophytes - *Nerium* Leaf; Epiphytes - Velamen root of *Vanda*.
5. Emasculation of pea or *Caesalpinia* flower.
6. Demonstrate T and patch budding.
7. Demonstration of tissue culture techniques: culture media, surface sterilization and inoculation of explants.
8. Identification of non living inclusions - cystolith, raphides.

REFERENCES

1. Christopher E P, 1958. *Introductory Horticulture*. McGraw Hill, New York.
 2. Esau K, 1965. *Plant Anatomy*. Wiley, New York.
 3. Fahn A, 1985. *Plant Anatomy*. Pergamon Press, Oxford.
 4. Hartman H T, D E Kester, 1991. *Plant Propagation: Principles and Practices*. Prentice Hall of India, New Delhi.
 5. Kumar N, 1994. *Introduction to Horticulture*. Rajalakshmi Publications, Nagercoil.
 6. Pandey B P, 1984. *Plant Anatomy*. S Chand and Company, New Delhi.
 7. Vasishta V C, 1978. *Plant Anatomy*. S Nagin and Company, Jalandhar.
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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
I st Complementary - Biochemistry course 1	4	2 + 1	I st Complementary – Biochemistry course 2	4	2 + 1
II nd Complementary - Zoology course 1	4	2 + 1	II nd 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
I st Complementary - Biochemistry course 3	5	3 + 1	I st Complementary – Biochemistry course 4	5	3 + 1
II nd Complementary - Zoology course 3	5	3 + 1	II nd 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

Semester I Core course BO 1 Code: BO1CRT01
METHODOLOGY OF SCIENCE AND AN INTRODUCTION TO BOTANY
(See model I syllabus)

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), Hierarchical 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

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, Massachusetts.
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.

SEMESTER-II

Semester II **Core course BO 2** **Code: BO2CRT02**
MICROBIOLOGY, MYCOLOGY AND PLANT PATHOLOGY
(See model I syllabus)

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 Rydberg'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 emitting 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, capsaicin)
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.

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 Fraenkel-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 surveillance; 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 acetylation, 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.

SEMESTER III

Semester III

Core course BO 3

Code: BO3CRT03

PHYCOLOGY AND BRYOLOGY

(See model I syllabus)

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 manual, 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, CO₂ generating packet, CO₂ 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 BIOTECHNOLOGY (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 construction, 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.

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 immunosystem. 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. Agglutination 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-Immunodiffusion (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.

SEMESTER IV

Semester IV Core course BO 4 Code: BO4CRT04
PTERIDOLOGY, GYMNOSPERMS AND PALEOBOTANY
(See model I syllabus)

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, *in 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, Nanoparticulate 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

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, *In 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 transformed 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.

SEMESTER V

Semester V Core course BO 5 Code: BO5CRT05
ANATOMY, REPRODUCTIVE BOTANY AND MICROTECHNIQUE
(See model I syllabus)

Semester V Core course BO 6 Code: BO5CRT07
PLANT PHYSIOLOGY AND BIOCHEMISTRY
(See model I syllabus)

Semester V Core course BO 7 Code: BO5CRT08
ENVIRONMENTAL SCIENCE AND HUMAN RIGHTS
(See model I syllabus)

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 polyethylene 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.

SEMESTER VI

Semester VI **Core course BO 8** **Code: BO6CRT09**
GENETICS, PLANT BREEDING AND HORTICULTURE
(See model I syllabus)

Semester VI **Core course BO 9** **Code: BO6CRT11**
ANGIOSPERM MORPHOLOGY, TAXONOMY AND ECONOMIC BOTANY
(See model I syllabus)

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.

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.

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)
