GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

REVISED MINUTES

of the 2nd Meeting of the

X ACADEMIC COUNCIL

Day & Date

18th & 19th January, 2021

Time

10.30 a.m.

Venue
Conference Hall
Administrative Block

Minutes of the Second Meeting of the X Academic Council

Date: 18.01.2021 and 19.01.2021

Time: 10.30 a.m.

Venue: Conference Hall, Goa University, Taleigao Plateau, Goa.

A list of members who attended the meeting of Academic Council and those who sought leave of absence is appended.

The Chairperson (Vice-Chancellor) welcomed the members to the Second meeting of the X Academic Council, especially the external members of the House and informed that this was the first meeting of the X Academic Council that was being held offline.

He further informed that Shri M. Shreedhara, Joint Registrar, Administration who was appointed as the Officiating Registrar during the absence of Officiating Registrar, Prof. Radhika S. Nayak was requested to be the Member Secretary for the meeting.

Thereafter, the agenda was taken up for discussion.

D	**DISCCUSSION ITEMS**
D 1	**CONFIRMATION**
D 1.1	**To confirm the minutes of the First meeting of the X Academic Council held on 22.10.2020 and 27.10.2020.** The House noted that no observations were received from the members. The request of a member to circulate the format for submission of information for the Annual Performance Appraisal Report to the Colleges and also make them available on the Goa University website was accepted. Thereafter, the minutes of the First meeting of the X Academic Council held on 22.10.2020 and 27.10.2020 were confirmed. **(Action: Assistant Registrar Academic - General)**
D 1.2	**To confirm the minutes of the First meeting of the Standing Committee of the X Academic Council held on 04.12.2020.** As no observations were received from the members, the minutes of the First meeting of the Standing Committee of the X Academic Council held on 04.12.2020 were confirmed. **(Action: Assistant Registrar Academic –General)**
D 2	**FOLLOW UP ACTION**
D 2.1	**Follow up action on the minutes of the First meeting of the X Academic Council held on 22.10.2020 and 27.10.2020.** The Academic Council noted the action taken/initiated on the various decisions taken in its meeting held on 22.10.2020 and 27.10.2020. **(Action: Concerned AR's)**

D 3.8	**Minutes of the meeting of the Board of Studies in Botany held on 08.01.2021.** The Academic Council approved the minutes of the meeting of the Board of Studies in Botany held on 08.01.2021. The House decided to refer back to the Board of Studies only regarding the syllabus of one Optional paper i.e. Intellectual Property Rights, instead of one credit, it could be made as two credits. **(Action: Assistant Registrar Academic -PG)**
D 3.9	**Minutes of the meeting of the Board of Studies in Physical Education held on 11.01.2021.(Item withdrawn)** The item was withdrawn. **(Action: Assistant Registrar Academic -PG)**
D 3.10	**Minutes of the meeting of the Board of Studies in Civil Engineering held on 06.01.2021.** The Academic Council approved the minutes of the meeting of the Board of Studies in Civil Engineering held on 06.01.2021. The Academic Council approved the list of online courses (Swayam/NPTEL) to be taken up by IV Semester Civil Engineering students during the academic year 2020-21. The Note given below the proposed NPTEL Courses to be dropped. The House reiterated that all courses are required to be recommended by the Board of Studies and approved by the Academic Council. The proposed question paper format for the subject CV350: COMPUTER-AIDED BUILDING PLANNING AND DESIGN (ONLINE EXAM) RC 2019-20 was also approved. **(Action: Assistant Registrar Academic -PG)**
D 3.11	**Minutes of the meeting of the meeting of the Board of Studies in Electrical & Electronics Engineering held on 09.01.2021 and 11.01.2021.** The Academic Council approved the minutes of the meeting of the Board of studies in Electrical & Electronics Engineering held on 09.01.2021 and 11.01.2021. The Academic Council approved the list of online courses (Swayam/NPTEL) to be taken up by IV Semester Electrical and Electronics Engineering students during the academic year 2020-21. **(Action: Assistant Registrar Academic -PG)**
D 3.12	**Minutes of the meeting of the Board of Studies in Computer Engineering held on 05.12.2020.** The Academic Council approved the minutes of the meeting of the Board of Studies in Computer Engineering held on 05.12.2020. The House also approved the syllabus in the subjects in V to VIII Semester (i.e. Third Year and Fourth Year) in B. E. (Computer Engineering) for the Revised Scheme RC 2019-20. **(Action: Assistant Registrar Academic -PG)**

X AC- 2
18 & 19-01-2021

GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

U P D A T E D F I N A L A G E N D A

For the 2nd Meeting of the

X ACADEMIC COUNCIL

Day & Date

18th & 19th January, 2021

Time

10.30 a.m.

Venue
Conference hall
Administrative Block

iii) May be recommended for approval of Academic Council.
iv) Special remarks if any.

Date: 12th January 2021 Sd/-
Place Goa University Signature of the Dean

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D 3.8 **Minutes of the meeting of the Board of Studies in Botany held on 08.01.2021.**

Part A

(i) Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level**:**

(a) Objectives and learning outcome for all the papers of first and second year B.Sc. have been prepared.

(b) The following Swayam course was recommended by the BoS at undergraduate level:

Sr. No.	Title of the Course	Credit Equivalent
1	Fundamentals of Bioinformatics	3

(ii) Recommendations regarding courses of study in the subject or group of subjects at the post-graduate level :

(a) The following Swayam course was recommended by the BoS at postgraduate level:

Sr. No.	Title of the Course	Credit Equivalent
1	Biomass Characterization	4

(b) Syllabus for following Optional papers were discussed and approved

- BOO- 454: Intellectual property rights : 1 Credit
- BOO-455: Bioinformatics: 2 Credit
- BOO-456: Lab in Bioinformatics : 1 Credit

Part B

(i) Scheme of examinations at the under-graduate level: **Nil**
(ii) Panel of examiners for different examinations at the under-graduate level: **Nil**
(iii) Scheme of examinations at the post-graduate level: **Nil**
(iv) Panels of Examiners for different examinations at post-graduate level: **Nil**

Part C

(i) Recommendations regarding preparation and publication of selection of reading material in any subject or group of subject or group of subjects and names of persons recommended for appointment to make the selection.: **Nil**

Part D

(i) Recommendations regarding general academic requirements in the Departments of University or affiliated Colleges: **Nil**

Part E

(i) Recommendations of text books for the courses of study at the under-graduate Level:
Additional reference books for some of the B. Sc papers were added in the syllabus.

(ii) Recommendations of text books for the courses of study at Post-Graduate Level : **Nil**

Part F

(i) The important points/recommendations of BoS that require consideration/approval of Academic Council (points to be highlighted) as mentioned below**.**

- **Objectives and learning outcome for all papers of first year and second year B. Sc is submitted for approval (Annexure I refer page no 200)**
- **Syllabus of Swayam courses for postgraduate and undergraduate is submitted for approval (Annexure II refer page no 251)**
- **Syllabus of M.Sc. Optional papers is submitted for approval (Annexure III refer page no 257)**

(ii) The declaration by the Chairman, that the minutes were read out by the Chairman at the meeting itself.

Date: 8.01.2021 Sd/-
Place: Goa University Signature of the Chairperson

Part G. The Remarks of the Dean of the Faculty

i) The minutes are in order
ii) The minutes may be placed before the Academic Council with remarks if any.
iii) May be recommended for approval of Academic Council.
iv) Special remarks if any.

Date: 8.01.2021 Sd/-
Place: Goa Signature of the Dean

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D 3.9 **Minutes of the meeting of the Board of Studies in Physical Education held on 11.01.2021. (Item Withdrawn)**

Part A.

i. Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level:
It was recommended to implement Health Education as an optional subject at undergraduate level.

ii. Recommendations regarding courses of study in the subject or group of subjects at the postgraduate level: **NIL**

D 3.8 Minutes of the meeting of the Board of Studies in Botany held on 08.01.2021.

Annexure I

Syllabus for B.Sc. Botany
(Choice Based Credit System)

PROGRAM STRUCTURE (CBCS)

CODES	COURSE TITLES	CREDITS
DISCIPLINE SPECIFIC CORE COURSES (DSC)		
BOC 101 (Sem. I)	Biodiversity I (Microbes, Algae, Fungi and Bryophytes)	4T + 2P = 6
BOC 102 (Sem. II)	Biodiversity II (Vascular Plants)	4T + 2P = 6
BOC 103 (Sem. III)	Plant Anatomy and Embryology	4T + 2P = 6
BOC 104 (Sem. IV)	Plant Physiology	4T + 2P = 6
BOC 105 (Sem. V)	Classical Taxonomy and Phylogeny	4T + 2P = 6
BOC 106 (Sem. V)	Cell Biology and Plant Biochemistry	4T + 2P = 6
BOC 107 (Sem. V)	Microbiology and Plant Pathology	4T + 2P = 6
BOC 108 (Sem. VI)	Cytogenetics and Plant Breeding	4T + 2P = 6
BOC 109 (Sem. VI)	Molecular Biology and Genetic Engineering	4T + 2P = 6
BOC 110 (Sem. VI)	Plant Ecology and Phytogeography	4T + 2P = 6
GENERAL ELECTIVE COURSES (GE)		
BOG 101 (Sem. I)	Environmental Biotechnology	4T
BOG 102 (Sem. II)	Coastal and Mangrove Ecology	4T
SKILL ENHANCEMENT COURSES (SEC)		
BOS 101 (Sem. III)	Floriculture	3T + 1P = 4
BOS 102 (Sem. IV)	Herbal Technology	3T + 1P = 4
DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)		
BOD 101 (Sem. V)	Plant Tissue Culture	3T + 1P = 4
BOD 102 (Sem. V)	Research Methodology, Bioinformatics and Biostatistics	3T + 1P = 4
BOD 103 (Sem. V)	Economic and Medicinal Botany	3T + 1P = 4
BOD 104 (Sem. VI)	Biofertilizers	3T + 1P = 4
BOD 105 (Sem. VI)	Nursery and Gardening	3T + 1P = 4
BOD 106 (Sem. VI)	Horticulture and Postharvest Technology	3T + 1P = 4
BOP 101 (Sem. VI)	PROJECT	4

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PROGRAM SPECIFIC OUTCOME

A Graduate in Botany will be able to acquire competency in the subject and its allied branches so as to identify major groups of plants and compare their characteristics; understand plant developmental processes and their metabolic activities; understand concepts in plant breeding, molecular biology, genetic engineering and plant tissue culture; understand the ecology of plants and their economic and medicinal value; understand various concepts in microbiology and how to prevent and manage plant diseases; have in-depth knowledge of gardening, floriculture and horticulture; develop and use bio-fertilizers; gain insights into various aspects of the environment and its conservation; study plants in their natural habitat through field visits as well as acquire skills to handle scientific instruments and plan and perform laboratory experiments.

The curriculum will thus provide in-depth subject knowledge of fundamental concepts as well as advanced and emerging areas of Botany and its applied aspects along with necessary skills for critical thinking and problem solving capabilities to integrate with academia and industry.

BOTANY
Semester I & Semester II

CODES	**COURSE TITLES**	**CREDITS**
Semester I		
Discipline Specific Core Course (DSC)		
BOC 101	Biodiversity I (Microbes, Algae, Fungi and Bryophytes)	4T + 2P = 6
General Elective Course (GE)		
BOG 101	Environmental Biotechnology	4T
Semester II		
Discipline Specific Core Course (DSC)		
BOC 102	Biodiversity II (Vascular Plants)	4T + 2P = 6
General Elective Course (GE)		
BOG 102	Coastal and Mangrove Ecology	4T

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Semester I - DSC:
BOC 101: BIODIVERSITY I (Microbes, Algae, Fungi and Bryophytes)
Credits: 4 (Theory) + 2 (Practical)

Course Objectives:
Biodiversity of the plant kingdom includes lower organisms, non-vascular plants and vascular plants. Knowledge of organisms under these groups is very essential to lay a strong foundation for Botany.
Biodiversity I is designed to give basic knowledge of microorganisms and lower groups of plants such as viruses, bacteria, fungi, algae and bryophytes with regards to their morphological and anatomical features, reproductive structures and their ecological and economic importance. Laboratory exercises are designed to give hands on experience in culturing of microbes, handling various plant specimens and their conservation.

THEORY: Total Lectures: 60

Unit 1: Microbes **(15 Lectures)**
Viruses – Discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance; Bacteria – Discovery, General characteristics and cell structure; Types - archaebacteria, eubacteria and mycoplasma. Reproduction – vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance.

Unit 2: Algae **(15 Lectures)**
General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Smith's classification of algae; Morphology and life-cycles of the following: *Nostoc*, *Spirogyra*, *Sargassum* and *Polysiphonia*. Economic importance of algae with special reference to food, biofertilizers and medicine.

Unit 3: Fungi **(15 Lectures)**
Introduction - General characteristics, ecology and significance, range of thallus organization, cell wall composition, nutrition, reproduction, Ainsworth's classification and economic importance with special reference to medicine; Life cycle of *Rhizopus* (Zygomycota), *Penicillium* (Ascomycota) and *Agaricus* (Basidiomycota); Symbiotic Associations - Lichens: General account, reproduction and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance.

Unit 4: Bryophytes **(15 Lectures)**
General characteristics, range of thallus organization. Smith's classification (up to family), morphology, anatomy and reproduction of *Riccia*, *Anthoceros* and *Funaria* (developmental details not to be included). Ecology and economic importance of bryophytes with special mention of *Sphagnum*.

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PRACTICAL: Total Practical: 30P = 30 x 2 hours

1. EMs/models of viruses – T-Phage and TMV, line drawing/photograph of lytic and lysogenic cycle. **(2P)**
2. Types of bacteria from temporary/permanent slides/photographs; EM bacterium; binary fission; conjugation. **(2P)**
3. Monochrome and Gram staining. **(2P)**
4. Study of vegetative and reproductive structures of *Nostoc*, *Spirogyra*, *Sargassum* and *Polysiphonia* through temporary preparations and permanent slides. **(4P)**
5. *Rhizopus* and *Penicillium*: Asexual stage from temporary mounts and sexual structures through permanent slides. **(2P)**
6. *Agaricus*: Specimens of button stage and full grown mushroom; sectioning of gills of *Agaricus*. **(1P)**
7. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose). **(1P)**
8. Mycorrhiza: Ectomycorrhiza and endomycorrhiza – (slide preparation/photographs). **(2P)**
9. *Riccia*: Morphology and T.S. of thallus, W.M. of rhizoids and scales, L.S. of sporophyte (fresh materials/ permanent slides). **(1P)**
10. *Anthoceros*: Morphology and T.S. of thallus and sporophyte (permanent slides). **(1P)**
11. *Funaria*: Morphology, W.M. of leaf, rhizoids, sporophyte (permanent slides); permanent slides showing antheridial and archegonial heads, L.S. of capsule and protonema. **(2P)**
12. Preparation of jelly, pudding and custard using agar-agar. **(2P)**
13. Herbarium preparation of algae. **(2P)**
14. Conservation of at least one species of alga and bryophyte in the botanical garden (*Ex-situ* conservation/preparation of a conservatory). **(2P)**
15. Preparation of spawn for oyster mushroom cultivation. **(2P)**
16. Culturing of *Mucor* and *Aspergillus.* **(2P)**

Learning Outcomes:

- Gain basic knowledge of microbes with respect to their discovery, structure, reproduction and economic importance.
- Understand morphological and anatomical features and reproductive structures of lower groups of plants such as algae, fungi and bryophytes.
- Appreciate plant diversity and their economic and ecological importance.
- Develop basic skills in handling and sectioning of plant specimens.
- Develop specific skills in handling and culturing of microbes.
- Use practical knowledge for preparation of value-added edible plant products.

SUGGESTED READINGS:

1. Kumar, H.D. 1999. *Introductory Phycology*. 2nd edition. Affiliated East-West Press Pvt. Ltd., Delhi.
2. Tortora, G.J., Funke, B.R. and Case, C.L. 2010. *Microbiology: An Introduction*. 10th edition. Pearson Benjamin Cummings, U.S.A.
3. Sethi, I.K. and Walia, S.K. 2011. *Text Book of Fungi & Their Allies*. MacMillan Publishers Pvt. Ltd., Delhi.

4. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 1996. *Introductory Mycology*. 4th edition. John Wiley and Sons (Asia), Singapore.
5. Raven, P.H., Johnson, G.B., Losos, J.B. and Singer, S.R. 2005. *Biology*. Tata McGraw Hill, Delhi.
6. Smith, G.M. 1955. *Cryptogamic Botany. Vol. I. Algae and Fungi*. 2nd edition. McGraw-Hill, New York.
7. Smith, G.M. 1955. *Cryptogamic Botany. Vol. II. Bryophytes and Pteridophytes*. 2nd edition. McGraw-Hill, New York.
8. Vashishta, B.R. and Sinha, A.K. 2011. *Botany for Degree Students: Bryophyta*. S. Chand & Company Pvt. Ltd., New Delhi.
9. Vashishta, B.R. and Sinha, A.K. 2014. *Botany for Degree Students: Fungi*. S. Chand & Company Pvt. Ltd., New Delhi.

Semester I - GE:

BOG 101: ENVIRONMENTAL BIOTECHNOLOGY

Credits: 4 (Theory)

Course Objectives:

This course is designed to give students a basic understanding of environmental problems and their impact and the approaches for management through legislations, policies and public participation for sustainable development.

THEORY: Total Lectures: 60

Unit 1: Environment **(4 Lectures)**

Basic concepts and issues, global environmental problems - ozone depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, their impact and biotechnological approaches for management.

Unit 2: Environmental problems **(6 Lectures)** Environmental pollution - types of pollution, sources of pollution, measurement of pollution, methods of measurement of pollution, fate of pollutants in the environment, bio-concentration, bio/geo-magnification.

Unit 3: Microbiology of waste water treatment **(8 Lectures)** Aerobic process - activated sludge, oxidation ponds, trickling filter, towers, rotating discs, rotating drums, oxidation ditch. Anaerobic process - anaerobic digestion, anaerobic filters, upflow anaerobic sludge blanket reactors. Treatment schemes for waste water of dairy, distillery, tannery, sugar and antibiotic industries.

Unit 4: Xenobiotic compounds **(10 Lectures)**

Organic (chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants) and inorganic (metals, radionuclides, phosphates, nitrates). Bioremediation of xenobiotics in environment - ecological consideration, decay behaviour and degradative plasmids, molecular techniques in bioremediation.

Unit 5: Role of immobilized cells/enzymes in treatment of toxic compounds (6 Lectures) Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control.

Unit 6: Sustainable development (8 Lectures) Economics and Environment: Economic growth, Gross National Productivity and the quality of life, Tragedy of Commons, Economics of Pollution control, Cost-benefit and cost-effectiveness analysis, WTO and Environment, Corporate Social Responsibility, Environmental awareness and Education; Environmental Ethics.

Unit 7: International and national legislations, policies for pollution management (10Lectures)

Stockholm Conference-1972 and its declaration, Ramsar Convention-1971, Kyoto Protocol- 1997, Salient features of Wild Life Protection Act-1972, Water Pollution (Prevention and Control) Act-1974, Forest Conservation Act-1980, Air Pollution (Prevention and Control) Act-1981, National Environmental Policy-2006, Central and State Pollution Control Boards: Constitution and Power.

Unit 8: Public participation for environmental protection (8 Lectures)

Environmental movement and people's participation with special references to Gandhamardan, Chilika and Narmada Bachao Andolan, Chipko and Silent Valley Movement; Women and Environmental Protection, Role of NGO in bringing environmental awareness and education in the society.

Learning Outcomes:

- Develop an understanding of the global environmental problems and their impact.
- Have an insight into the microbiology of waste water treatment.
- Enhance the understanding of xenobiotic compounds and their bioremediation.
- Understand the role of bio-techniques for management of environmental pollution.
- Understand the approaches for pollution management through legislations, policies and public participation.
- Develop a deeper understanding of economics and environment with reference to sustainable development.

SUGGESTED READINGS:

1. Metcalf and Eddy Inc. 1991. *Waste Water Engineering - Treatment, Disposal and Reuse*. Tata McGraw Hill, New Delhi.
2. De, A.K. 1994. *Environmental Chemistry*. Wiley Eastern Ltd., New Delhi.
3. Allsopp, D. and Seal, K.J. 2004. *Introduction to Biodeterioration*. ELBS / Edward Arnold.
4. Baaker, K.H. and Herson, D.S. 1994. *Bioremediation*. McGraw Hill Inc., New York.
5. Ahmed, N., Qureshi, E.M. and Khan, O.Y. 2006. *Industrial and Environmental Biotechnology*. Horizon Press.
6. Paul, A.R. 2001. *Environmental Molecular Biology*. Horizon Press.

7. Jadhav, H.V. and Bhosale, V.M. 1997. *Environmental Protection and Laws*. Himalaya Publication House.
8. Trivedi, P.C. 2006. *Biodiversity Assessment and Conservation*. Agrobios, India.
9. Thukral, A.K. and Virk, G.S. 2000. *Environmental Protection*. Scientific Publiushers (India).

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Semester II - DSC:
BOC 102: BIODIVERSITY II (Vascular Plants)
Credits: 4 (Theory) + 2 (Practical)

Course Objectives:
This course is an extension of Biodiversity I and is designed to give basic knowledge of vascular plants namely pteridophytes, gymnosperms and angiosperms with regards to their morphological and anatomical features, reproductive structures and their ecological and economic importance. The theoretical and practical components of this course will provide the basics of plant taxonomy such as identification, classification and modern techniques in plant taxonomy.

THEORY: Total Lectures: 60

Unit 1: Pteridophytes (12 Lectures)
General characteristics, classification; early land plants (*Cooksonia* and *Rhynia*). Classification (up to family), morphology, anatomy and reproduction of *Psilotum*, *Selaginella*, *Equisetum* and *Pteris* (developmental details not to be included). Heterospory and seed habit, stellar evolution. Ecological and economical importance of Pteridophytes.

Unit 2: Gymnosperms (10 Lectures)
General characteristics, classification (Coulter & Chamberlain), morphology, anatomy and reproduction of *Cycas*, *Pinus* and *Gnetum* (developmental details not to be included). Ecological and economical importance.

Unit 3: Documentation and identification (8 Lectures)
Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access.

Unit 4: Taxonomic hierarchy (2 Lectures) Ranks, categories and taxonomic groups.

Unit 5: Botanical nomenclature (6 Lectures)
Principles and rules (IUCN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

Unit 6: Classification to plant taxonomy (18Lectures)
Classification and nomenclature. Types of classification - artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (upto order); Taxonomic evidences from palynology, cytology, phytochemistry and molecular data. Study of families: Asteraceae, Solanaceae, Lamiaceae, Liliaceae and Poaceae.

Unit 7: Biometrics, numerical taxonomy and cladistics (4 Lectures)
Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).

PRACTICAL: Total Practical: 30P = 30 x 2 hours

1. *Psilotum* – morphology, T.S. of synangium, T.S. of stem. **(2P)**
2. *Selaginella* - morphology, W.M. of leaf with ligule, T.S. of stem, W.M. of strobilus, W.M. of microsporophyll and megasporophyll (temporary slides), L.S. of strobilus (permanent slide). **(2P)**
3. *Equisetum* - morphology, T.S. of internode, L.S. of strobilus, W.M. of sporangiophore, W.M. of spores; T.S. of rhizome (permanent slides). **(2P)**
4. *Pteris* - morphology, T.S. of rachis, V.S. of sporophyll, W.M. of sporangium, W.M. of spores (temporary slides), T.S. of rhizome, W.M. of prothallus with sex organs and young sporophyte (permanent slide). **(2P)**
5. *Cycas* - morphology (coralloid roots, bulbil, leaf), T.S. of coralloid root, T.S. of rachis (permanent slide), V.S. of leaflet, V.S. of microsporophyll, W.M. of spores (temporary slides), L.S. of ovule, T.S. of root (permanent slide). **(2P)**
6. *Pinus* - morphology (long and dwarf shoots, male and female), T.S. of needle, T.S. of stem (permanent slide), L.S./T.S. of male cone, W.M. of microsporophyll, W.M. of microspores (temporary slides), L.S. of female cone (permanent slide). **(2P)**
7. *Gnetum* - morphology, T.S. of leaf, T.S. of stem (permanent slide), L.S. of male and female cone (permanent slide). **(1P)**
8. Study of vegetative and floral characters of the following families (description, V.S. of flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification): Asteraceae, Solanaceae, Lamiaceae, Liliaceae and Poaceae (any two locally available plants per family). **(10P)**
9. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book). **(2P)**
10. Field Botany. **(5P)**

Learning Outcomes:

- Gain knowledge of different members of pteridophytes, gymnosperms and angiosperms.
- Understand the morphological and anatomical features of pteridophytes and gymnosperms.
- Identify and classify plants belonging to different angiosperm families.
- Appreciate the economic and ecological importance of the above mentioned plant groups.

SUGGESTED READINGS:

1. Vashishta, P.C., Sinha, A.K. and Kumar, A. 2010. *Pteridophyta*. S. Chand, Delhi, India.
2. Bhatnagar, S.P. and Moitra, A. 1996. *Gymnosperms*. New Age International (P) Ltd., New Delhi, India.
3. Parihar, N.S. 1991. *An Introduction to Embryophyta. Vol. I. Bryophyta*. Central Book Depot, Allahabad.
4. Simpson, M.G. 2006. *Plant Systematics*. Elsevier Academic Press, San Diego, CA, U.S.A.
5. Singh, G. 2012. *Plant Systematics: Theory and Practice*. 3rd edition. Oxford & IBH Pvt. Ltd., New Delhi.
6. Vashishta, B.R., Sinha, A.K. and Kumar, A. 1971. *Botany for Degree Students: Pteridophyta*. S. Chand & Company Pvt. Ltd., New Delhi.

Semester II - GE:
BOG 102: COASTAL AND MANGROVE ECOLOGY
Credits: 4 (Theory)

Course Objectives:
This course is designed to provide basic as well as advanced understanding of the principles of coastal ecology in relation to sand dune and mangrove biodiversity. It will also create an awareness of the various threat factors causing damage to mangroves and the various conservation and management strategies that can be employed for their restoration.

THEORY: Total Lectures: 60

Unit 1: Principles of coastal ecology **(6 Lectures)**
Sand dunes with emphasis on vegetation and ecological importance, mangrove biodiversity - Inter-relationships between ecosystems - Methods of assessing biodiversity - Importance of assessing species diversity and status - IUCN conservation species status - Status book.

Unit 2: Distribution of mangroves **(3 Lectures)** Global distribution, Extent of mangroves in various countries - Past and present extent of distribution, damage and reclamation caused in the recent past.

Unit 3: Biology of mangroves **(15 Lectures)**
Taxonomy and genetics - Temporal and regional variations - Morphology and anatomy - temporal and regional variations; Physiology and biochemistry - Factors affecting various growth parameters. Pollination biology - Types of reproduction, seed propagation, dispersal and establishment. Ecological and environmental conditions that affect mangrove ecosystems.

Unit 4: Flora and fauna of mangroves and associated environments **(8 Lectures)** Bacteria, fungi and actinomycetes, microalgae, sea-grasses, salt-marsh and other flora - Collection, preservation and identification techniques - Factors affecting biodiversity - Comparison of flora of mangroves and associated environments; general account of mangrove fauna.

Unit 5: Ecological roles of mangroves **(8 Lectures)**
Litter production and decomposition and nutrient enrichment; biomass, food web and energy fluxes; interaction of mangroves with other halophytes and agro-ecosystems; Importance - Damages caused - Need for conservation.

Unit 6: Threat factors affecting mangrove systems **(8 Lectures)**

Water quality parameters, Anthropogenic pressure, Types of pollutants causing damage to mangroves - Sewage, industrial, and other organic and inorganic man-made pollutants, Extent of damage, Possible remedial measures.

Unit 7: Conservation and management strategies restoration technology (8 Lectures) Species selection, propagation and plantation techniques; Conservation strategies.

Unit 8: Study visit to mangrove ecosystem/ NIO (Report to be submitted) (4 Lectures)

Learning Outcomes:

- Understand the role of coastal ecology in relation to sand dune vegetation and mangrove diversity.
- Learn about the diverse flora and fauna of mangrove ecosystem.
- Understand the various threats to mangrove ecosystem and strategies for their conservation, restoration and management.

SUGGESTED READINGS:

1. Chapman, V.J. and Chapman, D. J. 1975. *The Algae*. 2nd edition. MacMillan Publications Inc., New York.
2. Lembi, C.A. and Waaland, J. R. 1988. *Algae and Human Affairs*. Press Syndicate of the University of Cambridge.
3. Lobban, C.S., Harrison, P. J. and Duncan, M. J. 1985. *The Physiological Ecology of Seaweeds*. Cambridge University Press, New York.
4. Roy, P.M. and Helfferich, C. 1997. *Seagrass Ecosystems*. Maxel Dekker II, New York.
5. Borse, D.G. and Bhat, D. J. 2012. *Marine Fungi of India*. BBC Publishers.
6. Websites of NIO and Mangrove Society of India.

BOTANY

Semester III & Semester IV

CODES	COURSE TITLES	CREDITS
Semester III		
Discipline Specific Core Course (DSC)		
BOC 103	Plant Anatomy and Embryology	4T + 2P = 6
Skill Enhancement Course (SEC)		
BOS 101	Floriculture	3T + 1P = 4
Semester IV		
Discipline Specific Core Course (DSC)		
BOC 104	Plant Physiology	4T + 2P = 6

Skill Enhancement Course (SEC)		
BOS 102	Herbal Technology	3T + 1P = 4

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Semester III - DSC:
BOC 103: PLANT ANATOMY AND EMBRYOLOGY
Credits: 4 (Theory) + 2 (Practical)

Course Objectives:
This course is designed to give a basic understanding of the fundamental concepts of plant anatomy and embryology. The theoretical and practical components of this course will provide detailed knowledge of the internal structure of plants, adaptations and mechanisms for reproduction and embryogenesis resulting in development of seed.

THEORY: Total Lectures: 60

Unit 1: Meristematic and permanent tissues (4 Lectures)
Root and shoot apical meristems; simple and complex tissues.

Unit 2: Primary structure of organs (4 Lectures)
Structure of dicot and monocot root, stem and leaf.

Unit 3: Secondary growth (10 Lectures)
Activity of vascular cambium, Anomalous secondary growth in stems of *Boerhaavia*, *Bignonia* and *Dracaena*; Wood Anatomy - Wood elements, heartwood and sapwood, Tension Wood; Economic importance of wood and wood elements. Periderm and Rhytidome: Structure and functions.

Unit 4: Adaptive and protective systems (8 Lectures)
Epidermis, cutin, cuticle and other types of coverings, epidermal appendages, stomatal types, adaptations in Hydrophytes, Xerophytes and Halophytes.

Unit 5: Structural organization of flower (15 Lectures)
Flower as modified reproductive shoot; structure of anther and pollen; development of male gametophyte; structure and types of ovules; development of female gametophyte; ultrastructure of mature embryo sac; types of embryo sacs: monosporic - *Polygonum* type, bisporic - *Allium* type, tetrasporic - *Peperomia* type.

Unit 6: Pollination and fertilization (5 Lectures)
Pollination mechanisms and adaptations; insect pollination as an evolved mechanism, Double fertilization.

Unit 7: Embryo and endosperm, seed structure **(10 Lectures)**

Structure of dicot and monocot embryo; Endosperm types and functions, structure of mature seed, Endospermous seeds. Fruit and seed dispersal mechanisms and adaptations.

Unit 8: Apomixis and polyembryony **(4 Lectures)**

Concepts, types and practical applications.

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PRACTICAL: Total Practical: 30P = 30 x 2 hours

1. Study of meristems (permanent slides/photographs). **(1P)**

2. Study of simple tissues - parenchyma, chlorenchyma, collenchyma and sclerenchyma (fresh specimens/permanent slides). **(1P)**

3. Primary structure: **(5P)**
   - Stems of *Helianthus annus* / *Eupatorium odorum* and *Oryza sativa* / *Zea mays.*
   - Roots of *Helianthus annus* / *Eupatorium odorum* and *Oryza sativa* / *Zea mays.*
   - Leaves of *Helianthus annus* / *Eupatorium odorum* or any other suitable dicot plant.
   - Leaves of *Oryza sativa* or *Zea mays.*

4. Maceration of wood, structure of xylem & phloem (permanent slides, photographs). **(2P)**

5. Structure of periderm (permanent slide). **(1P)**

6. T.S. of stems of *Boerhaavia*, *Bignonia* and *Dracaena* showing anomalous secondary growth (fresh or preserved specimens). **(3P)**

7. Epidermal appendages and stomatal types (fresh/permanent slides). **(2P)**

8. Anatomical adaptations: Xerophyte (*Opuntia*); Hydrophyte (any hydrophyte – anatomy of stem/root/leaf)), Halophyte (leaf and pneumatophore of *Avicennia)*, Epiphyte (aerial root of any epiphyte). **(4P)**

9. Structure of anther (young and mature); tapetum - amoeboid and secretory (permanent slides/pictures/photographs). **(2P)**

10. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/campylotropous. (permanent slides/pictures/photographs). **(2P)**

11. Female gametophyte: *Polygonum* (monosporic), *Allium* (bisporic) and *Fritillaria* or *Peperomia* (tetrasporic) types of embryo sac development (permanent slides/ photographs). **(3P)**

12. Pollination types and dispersal mechanisms of fruits/seeds (any 4 types - live/preserved/ photographs and/specimens). **(3P)**

13. Demonstration of polyembryony using *Citrus* seeds. **(1P)**

Learning Outcomes:

- Gain knowledge of plant cellular organization into tissues and their specific functions.
- Understand the primary structure of root, stem and leaf as also secondary growth in plants.
- Analyze the anatomical adaptations and protective systems in plants.
- Understand the structural organization of flower and functions of reproductive whorls.
- Evaluate mechanisms and adaptations for pollination and fertilization.
- Understand the structure of embryo, endosperm and seed.
- Analyze mechanisms and adaptations for fruit and seed dispersal.
- Develop basic skills in sectioning of plant specimens to study anatomical adaptations and analyze various embryological features.

SUGGESTED READINGS:

1. Esau, K. 2006. *Anatomy of Seed Plants*. 2nd edition. Wiley Eastern Private Ltd., New Delhi.
2. Arthur, J.E. and Mac Daniels, L.H. 1977. *An Introduction to Plant Anatomy*. 2nd edition. Tata McGraw-Hill Publishing Company Ltd., New Delhi.
3. Bhojwani, S.S. and Bhatnagar, S.P. 2011. *Embryology of Angiosperms*. 5th edition. Vikas Publication House Pvt. Ltd., New Delhi.
4. Fahn, A. 1990. *Plant Anatomy*. 4th edition. Pergamon Press.
5. Pandey, S.N. and Chadha, A. 1993. *A Textbook of Botany: Plant Anatomy and Economic Botany*. *Vol. III.* Vikas Publishing House Pvt. Ltd., New Delhi.
6. Bhojwani, S.S., Bhatnagar, S.P. and Dantu, P.K. 2015. *The Embryology of Angiosperms*. 6th edition. Vikas Publishing House Pvt. Ltd., Noida.
7. Pandey, B.P. 2014. *Plant Anatomy*. S. Chand & Company Pvt. Ltd., New Delhi.

Semester III - SEC:
BOS 101: FLORICULTURE
Credits: 3 (Theory) + 1 (Practical)

Course Objectives:

Floriculture, a branch of horticulture, deals with the cultivation of flowers and ornamental plants from the time of planting to the time of harvesting. The theoretical and practical components of this course will provide detailed knowledge of nursery bed preparation, use of various methods of plant propagation, cultivation, care, harvesting and marketing of flowers and designing floral arrangements.

THEORY: Total Lectures: 45

Unit 1: Introduction **(3 Lectures)**

History, concept and scope of floriculture; Floriculture industry - Importance, global trend, trend in India and Goa – present scenario and future prospects.

Unit 2: Study of commercial plants **(7 Lectures)**

Flowering plants - Marigold, *Gladiolus*, *Anthurium*, Gerbera, Orchids and Jasmine; Cut green plants - Ferns, *Thuja*, Palm and *Asparagus*; Cacti; Water plants - *Hydrilla*, *Pistia* and *Nymphaea*.

Unit 3: Flower arrangement (9 Lectures)

Importance, principle; styles and types of flower arrangements; preparation of floral bouquets, floral rangoli, garlands, crown, wreaths, baskets and dry flower arrangements; study of vertical garden and bonsai: types and techniques (with respect to flower plants). Topiary - a green sculpture.

Unit 4: Nursery management and routine garden operations (8 Lectures)

Techniques: Preparation of beds, sowing of seeds, soil sterilization, planting and transplanting; Pricking, pinching, defoliation and mulching; Propagation: Types of grafting, layering, cutting and budding.

Unit 5: Role of plant growth regulators and fertilizers (3 Lectures)

Auxins, Gibberellins, Cytokinins and ABA; Fertilizers and Manures.

Unit 6: Commercial floriculture (8 Lectures)

Factors affecting flower production; Post-harvest technology - Harvesting, conditioning, storing, packing and prolonging shelf life of flowers; dehydration technique for drying of flowers; Irrigation: Advanced irrigation system (drip, sprinklers and micro tubes); fragrance and flavour industry; bio-colour.

Unit 7: Pathology (2 Lectures)

Identification of pests and diseases, symptoms and control (viral, fungal, mycoplasmic, bacterial and insects.

Unit 8: Garden implements (2 Lectures)

Different garden tools and their operations; Green house and Polyhouse.

Unit 9: Scope (3 Lectures)

Floriculture as an industry; current status, government initiatives (SCHEMES) and constraint of commercial floriculture in India; marketing and export.

PRACTICAL: Total Practical: 15P = 15 x 2 hours

1. Soil preparation and sterilization of nursery beds and pots. **(2P)**
2. Garden implements and their operations. **(1P)**
3. Methods of vegetative propagation: Grafting, Layering, Cutting and Budding. **(2P)**
4. Handling and propagation of seeds, bulbs and corms. **(1P)**
5. Identification of plant diseases and pest. **(1P)**

6. Identification and description of plants: **(2P)**
   Flowers (any 5); Cut greens (any 5); Cacti (any 2); Water plants (any 2); Lawns (any 2).

7. Styles of flower arrangements: **(3P)**
   Garlands (any 2); Bouquets (any 2); Crown (any 1); Wreath (any 1); Baskets (any 1); Dry flower arrangement (any 1).

8. Harvesting, packing and prolonging shelf life of flowers. **(1P)**

9. Mulching, Pricking, Topping, Trimming and Pinching. **(1P)**

10. Cultivation of Orchids and *Anthuriums*. **(1P)**

Learning Outcomes:

- Understand the concept of floriculture and cultivation of commercial ornamental plants.
- Develop basic skills in techniques and different styles flower arrangement.
- Learn routine nursery management practices, garden operations and plant propagation techniques.
- Understand the concept of plant growth, practical problems and plant care.
- Have knowledge of use of phytohormones & postharvest technology for ornamental plants.
- Have an insight to various government schemes in floriculture industry.
- Be able to establish start-ups in floriculture business.

SUGGESTED READINGS:

1. Hall, A.D. 2002. *Fertilizers and Manures*. Biotech Books, Delhi.
2. Gorer, R. 1978. *The Growth of Gardens*. Faber and Faber, London.
3. Hartman, H.T. and Kester, D.E. 1976. *Plant Propagation: Principles and Practices*. Prentice & Hall of India, New Delhi.
4. *Publications of Directorate of Agriculture*. Govt. of Goa and ICAR, Old Goa.
5. Swarup, V. 1997. *Ornamental Horticulture*. MacMillan India Ltd.
6. Randhawa, G.S. and Mukhopadhyay, A. 1986. *Floriculture in India*. Allied Publishers.

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Semester IV - DSC:

BOC 104: PLANT PHYSIOLOGY
Credits: 4 (Theory) + 2 (Practical)

Course Objectives:
This course deals with physical, chemical and biological functioning of plants. It is designed to survey current aspects of plant processes, biochemistry and functions with emphasis on recent research progress in related fields.

THEORY: Total Lectures: 60

Unit 1: Plant-water relations (8 Lectures)
Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation.

Unit 2: Mineral nutrition (8 Lectures)
Essential elements, macronutrients and micronutrients; Criteria of essentiality of elements; Role of essential elements; Transport of ions across cell membrane, active and passive transport carriers, channels and pumps.

Unit 3: Translocation in phloem (6 Lectures)
Composition of phloem sap, girdling experiment; Pressure flow model; Phloem loading and unloading.

Unit 4: Enzymes (4 Lectures)
Structure and properties; Mechanism of enzyme catalysis and enzyme inhibition.

Unit 5: Photosynthesis (12 Lectures)
Photosynthetic pigments (Chl. a, Chl. b, xanthophylls, carotenes, phycobillins); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C_3, C_4 and CAM pathways of carbon fixation; Photorespiration.

Unit 6: Respiration (6 Lectures)
Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate, Oxidative Pentose Phosphate Pathway.

Unit 7: Nitrogen metabolism **(4 Lectures)**

Biological nitrogen fixation; Nitrate and ammonia assimilation.

Unit 8: Plant growth regulators **(6 Lectures)**

Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA and ethylene.

Unit 9: Plant response to light and temperature **(6 Lectures)**

Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure), red and far-red light responses on photomorphogenesis; Vernalization.

PRACTICAL: Total Practical: 30P = 30 x 2 hours

1. Determination of osmotic potential of plant cell sap by plasmolytic method. **(1P)**
2. To study the effect of two environmental factors (light and wind) on transpiration by excised twig. **(2P)**
3. Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte. **(5P)**
4. Demonstration of Hill's reaction. **(1P)**
5. Demonstration of deficiency symptoms of any two macronutrients and micronutrients. **(1P)**
6. Role of light on germination of photoblastic seeds. **(1P)**
7. Demonstration of the activity of catalase to study the effect of pH and enzyme concentration. **(2P)**
8. To study the effect of light intensity and bicarbonate concentration on O_2 evolution in photosynthesis. **(2P)**
9. Comparison of the rate of respiration in any two parts of a plant. **(2P)**
10. Separation of amino acids by paper chromatography. **(1P)**
11. Anatomical features of C_3 and C_4 plants. **(1P)**
12. Measurement of pH of different plant extracts (C_3, C_4 and CAM plants). **(1P)**
13. Determination of chlorophyll a and total chlorophyll in shade and sun plants. **(1P)**
14. Photo-oxidation of photosynthetic pigments. **(2P)**
15. Effect of pH and substrate concentration on the activity of enzyme amylase. **(2P)**

16. Determination of Q_{10} from germinating seeds. **(1P)**

17. Demonstration experiments (any four). **(4P)**
    a) Bolting.
    b) Effect of auxins on rooting.
    c) Suction due to transpiration.
    d) R.Q.
    e) Respiration in roots.

Learning Outcomes:

- Understand plant-water relation with respect to various physiological processes.
- Examine the role of macronutrients and micronutrients in plant growth.
- Understand the process of photosynthesis, respiration and biological nitrogen fixation in plants.
- Analyze the role of enzymes, plant growth regulators, light and temperature in plant growth and development.

SUGGESTED READINGS:

1. Taiz, L. and Zeiger, E. 2010. *Plant Physiology*. 5th edition. Sinauer Associates Inc., U.S.A.
2. Hopkins, W.G. and Huner, N.P. 2009. *Introduction to Plant Physiology*. 4th edition. John Wiley & Sons, U.S.A.
3. Bajracharya, D. 1999. *Experiments in Plant Physiology - A Laboratory Manual*. Narosa Publishing House, New Delhi.
4. Nagar, S. and Adhav, M. 2009. *Practical Biotechnology and Plant Tissue Culture.* S. Chand & Company Pvt. Ltd., New Delhi.

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Semester IV - SEC:
BOS 102: HERBAL TECHNOLOGY
Credits: 3 (Theory) + 1 (Practical)
Course Objectives:

Natural plant products are the most commonly used complementary and alternative therapies for a healthy lifestyle. This course deals with basic phytopharmacognosy, providing information on medicinal, tonic and culinary uses of plants. It also involves the use of technology in the manufacturing of value-added plant products like herbal cosmetics, nutraceuticals and herbal drugs. This course also involves hands-on training in preparation of herbal soap, mouthwash and formulations.

THEORY: Total Lectures: 45

Unit 1: Herbal medicines (7 Lectures)

Importance of medicinal plants; use of medicinal plants in indigenous / traditional systems of medicine - Siddha, Unani, Ayurveda and Homeopathy. Herbal remedies for holistic health. Collection and processing (harvesting, drying, garbling, packing, storage) of crude drugs and their marketing.

Unit 2: Pharmacognosy (12 Lectures)

Plant morphology and organoleptic characters, biological source, chemical constituents and medicinal uses of the following herbs: Aloe (*Aloe vera*), Jungli pyaz (*Urginea indica*), Kirayat (*Andrographis paniculata*), Lemon grass (*Cymbopogon citratus*), Mint (*Mentha piperita*), Coriander (*Coriandrum sativum*), Garlic (*Allium sativum*), Tulsi (*Ocimum sanctum*), Ginger (*Zingiber officinale*), Turmeric (*Curcuma longa*), Sarpagandha (*Rauwolfia serpentina*) and Periwinkle (*Catharanthus roseus*).

Unit 3: Phytochemical analysis (11 Lectures)

General methods of preparation of crude herbal extracts – decoction, maceration, infusion, hot continuous extraction, distillation and supercritical fluid extraction. Histochemical tests for screening of phytoconstituents in natural drugs – alkaloids, flavonoids, steroids, terpenoids, tannins, glycosides and volatile oils. Drug adulteration – deliberate and indeliberate adulteration; types of adulterants. Need for quality control of herbal drugs; microscopic evaluation for quality control.

Unit 4: Herbal cosmetics and nutraceuticals **(8 Lectures)** Herbal plants used in cosmetic formulations for skin care (cream, lotion and sunscreen), hair care (oil, shampoo, conditioner and dye) and oral care (toothpaste and mouthwash). Advantages of herbal formulations over synthetic cosmetics. Study of various oils used in aromatherapy with special reference to its applications in inhalation, local application and bath. Herbal nutraceuticals and their health benefits; culinary uses of herbs.

Unit 5: Conservation of medicinal plants **(7 Lectures)**

Conservation and sustainable use of medicinal plants; in-situ and ex-situ conservation methods. Centres for conservation of medicinal plants – CIMAP and FRLHT; TKDL. Plant tissue culture as a source of phytopharmaceuticals.

PRACTICAL: Total Practical: 15P = 15 x 2 hours

1. Study of biological source, organoleptic characters, chemical constituents and medicinal uses of the following herbs: *Andrographis paniculata*, *Mentha piperita*, *Allium sativum*, *Ocimum sanctum*, *Rauwolfia serpentina* and *Catharanthus roseus*. **(2P)**

2. Study of organoleptic and microscopic characters, chemical constituents and medicinal uses of the following herbs: *Aloe vera* (leaf), *Zingiber officinale* (rhizome), *Curcuma longa* (rhizome), *Urginea indica* (bulb scale), *Cymbopogon citratus* (leaf) and *Coriandrum sativum* (fruit). **(3P)**

3. Detection of alkaloids (*Datura* / Sadafuli / Tirphal), flavonoids (Green Tea / Onion) and saponins (Karando / Godekashtha) or from other suitable plant materials. **(1P)**

4. Microscopic evaluation and chemical tests (Metanil yellow test and chalk powder test) to detect adulteration of turmeric powder. **(1P)**

5. Preparation of herbal mouthwash (demonstration). **(1P)**

6. Preparation of herbal soap (demonstration). **(1P)**

7. Preparation of herbal formulation for common cold (demonstration). **(1P)**

8. Preparation of lemon grass medicinal tea (demonstration). **(1P)**

9. Preparation of coriander chutney or any other herbal dish (demonstration). **(1P)**

10. Oral presentation and submission of one herbal plant grown by the student (to be evaluated during regular practical - 3 marks). **(3P)**

Learning Outcomes:

- Gain knowledge of the importance of herbal medicines, their collection, processing and marketing.

- Learn about various herbs, their botanical names, chemical constituents and medicinal uses.
- Develop skills in preparation of crude herbal extracts, cosmetic formulations and detect drug adulteration.
- Understand the importance of herbal nutraceuticals for a healthy lifestyle.
- Learn about medicinal plant conservation methods.

SUGGESTED READINGS:

1. Kokate, C.K., Purohit, A.P. and Gokhale, S.B. 2010. *Pharmacognosy*. 45th edition. Nirali Prakashan, Pune.
2. Anonymous. 1999. *The Ayurvedic Pharmacopoeia of India*. *Vol. I & II.* Ministry of Health and Family Welfare, Govt. of India, New Delhi.
3. Jackson, B.P. and Snowdon, D.W. 1992. *Atlas of Microscopy of Medicinal Plants, Culinary Herbs and Spices*. CBS Publishers, New Delhi.
4. Sivarajan, V.V. and Balachandran, I. 1994. *Ayurvedic Drugs and Their Plant Sources*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
5. Rosaline, A. 2011. *Pharmacognosy*. MJP Publishers, Chennai.
6. Trease and Evans. 2009. *Pharmacognosy*. 16th edition. W.B. Saunders Co. Ltd., London.
7. Kar, A. 2003. *Pharmacognosy & Pharmacobiotechnology*. New Age International (P.) Ltd.
8. Fuller, K.W. and Gallon, J.A. 1998. *Plant Products and New Technology*. Clarendon Press, New York.
9. Sachs, M. 2014. *Ayurvedic Beauty Care: Ageless Techniques to Invoke Natural Beauty.* ISBN: 9788120818804.
10. Miller, L. and Miller, B. 1998. *Ayurveda and Aromatherapy: The Earth Essential Guide to Ancient Wisdom and Modern Healing*. Lotus Press, United States.
11. Akerele, O.O., Heywood, V. and Singe, H. 1991. *Conservation of Medicinal Plants*. Cambridge University Press, U.K.
12. Harborne, J.B. 1984. *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*. 2nd edition. Chapman and Hall, New York.
13. Khandelwal, K.R. 2002. *Practical Pharmacognosy: Techniques and Experiments*. 9th edition. Nirali Prakashan, Pune.
14. Bakhru, H.K. 2010. *Foods That Heal: The Natural Way to Good Health*. Orient Paperbacks, New Delhi.
15. Mendonsa, G. 2010. *The Best of Goan Cooking*. UBS Publishers & Distributors Pvt. Ltd.
16. Kapoor, S. 2000. *Khana Khazana*. Popular Prakashan Pvt. Ltd., Mumbai.

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BOTANY

Semester V & Semester VI

CODES	COURSE TITLES	CREDITS
Semester V		
Discipline Specific Core Courses (DSC)		
BOC 105	Classical Taxonomy and Phylogeny	4T + 2P = 6
BOC 106	Cell Biology and Plant Biochemistry	4T + 2P = 6
BOC 107	Microbiology and Plant Pathology	4T + 2P = 6
Discipline Specific Elective Courses (DSE)		
BOD 101	Plant Tissue Culture	3T + 1P = 4
BOD 102	Research Methodology, Bioinformatics and Biostatistics	3T + 1P = 4
BOD 103	Economic and Medicinal Botany	3T + 1P = 4
Semester VI		
Discipline Specific Core Courses (DSC)		
BOC 108	Cytogenetics and Plant Breeding	4T + 2P = 6
BOC 109	Molecular Biology and Genetic Engineering	4T + 2P = 6
BOC 110	Plant Ecology and Phytogeography	4T + 2P = 6
Discipline Specific Elective Courses (DSE)		
BOD 104	Biofertilizers	3T + 1P = 4
BOD 105	Nursery and Gardening	3T + 1P = 4
BOD 106	Horticulture and Postharvest Technology	3T + 1P = 4
BOP 101	Project	4

Semester V - DSC:
BOC 105: CLASSICAL TAXONOMY AND PHYLOGENY
Credits: 4 (Theory) + 2 (Practical)

Course objectives:
Plant taxonomy involves collection, identification, description, classification and naming of plants. This course is designed to give knowledge of morphological characters of vegetative and reproductive structures of different plants belonging to different families and their origin and evolutionary relationship.

THEORY: Total Lectures: 60

Unit 1: Morphology of angiosperms (25 **Lectures**)
Definition, Characteristics and functions; different types and modifications of following: Roots- Tap, fibrous and adventitious, etc; Stem- Aerial and underground; Leaf- phyllotaxy and its significance, forms/shapes of leaves, leaf incision/types, leaf margins, leaf apex, leaf surface, leaf texture, leaf venation, types of leaves, associated outgrowths, modification of stipules; leaf modifications, vernation; buds; Inflorescence types; Flower- parts, symmetries, characters, types, functions of different parts of the flower, aestivation types; Fruit - types: Simple, Aggregate, Multiple; Seeds - different types.

Unit 2: Systematic position (Bentham and Hooker's classification), diagnostic features and important ornamental/economical/medicinal species of the following families:
(21 **Lectures**)
Annonaceae, Capparidaceae, Brassicaceae, Tiliaceae, Rutaceae, Myrtaceae, Leguminosae (Caesalpiniaceae, Papilionaceae, Mimosaceae), Cucurbitaceae, Rubiaceae, Apocynaceae, Asclepiadaceae, Verbenaceae, Amarantaceae, Moraceae, Orchidaceae, Araceae, Arecaceae, Musaceae, Commelinaceae.

Unit 3: Origin and evolution of angiosperms (7 **Lectures**)
A general account with special reference to Bennettitalean, Gnetalean, Caytonialean and Herbaceous origin theories; primitive living angiosperms; evolution of flower; co-evolution of flowers and insects.

Unit 4: Phylogeny of angiosperms (7 **Lectures**) Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, paraphyly, polyphyly and clades). Methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).

PRACTICAL: Total Practical: 30P = 30 x 2 hours

1. To study different types of root. (1P)
2. To study different types of stem. (1P)
3. To study different characters of leaves with respect to:
   a) Vernation, phyllotaxy, leaf incision, leaf surface, venation types. (2P)
   b) Shapes, margins and apex types. (2P)
   c) Associated outgrowths. (1P)
   d) Modification of stipules and modification of leaves. (1P)
4. To study various kinds of buds, parts of the flower and types of inflorescences. (2P)
5. To study types of fruits, seed types. (2P)
6. To study the classification, distinguishing characters, diagnostic characters, L.S. of flower, T.S. of ovary, floral formula and any 5 economically important plants each of families mentioned in theory. (16P)
7. Field visit to study morphological characters of plants. (2P)

** Preferably fresh specimens to be shown or to be studied with preserved specimen, herbarium, photographs, etc. mentioned in theory.*

Learning Outcomes:

- Understand various morphological terms and apply the same to describe plants.
- Generalize characters of families to identify common and economically important plants according to Bentham & Hooker's system of classification.
- Describe the floral structure and infer the floral formula.
- Gain knowledge about the origin and phylogeny of angiosperms.

SUGGESTED READINGS:

1. Davis, P.H. and Heywood, V.H. 1963. *Principles of Angiosperm Taxonomy*. Oliver & Boyd, London.
2. Heywood, V.H. and Moore, D.M. 1984. *Current Concepts in Plant Taxonomy*. Academic Press, London.
3. Jones, Jr. S.B. and Luchsinger, A.E. 1986. *Plant Systematics*. 2nd edition. McGraw-Hill Book Co., New York.
4. Lawrence, G.H.M. 1951. *Taxonomy of Vascular Plants*. MacMillan, New York.
5. Naik, V.N. 1984. *Taxonomy of Angiosperms*. Tata McGraw Hill, New Delhi.
6. Radford, A.E. and Caddell, G.M. 1986. *Fundamentals of Plant Systematics*. Harper & Row, New York.
7. Singh, G. 2012. *Plant Systematics: Theory and Practice*. 3rd edition. Oxford & IBH Pvt. Ltd., New Delhi.
8. Jeffrey, C. 1982. *An Introduction to Plant Taxonomy*. 2nd edition. Cambridge University Press, Cambridge, London.
9. Stace, C.A. 1989. *Plant Taxonomy and Biosystematics*. 2nd edition. Hodder Arnold, London.
10. Woodland, D.W. 1991. *Contemporary Plant Systematics*. Prentice Hall, New Jersey.
11. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. and Donoghue, M.J. 2002. *Plant Systematics - A Phylogenetic Approach*. 2nd edition. Sinauer Associates Inc., Cary, NC.
12. Maheshwari, J.K. 1963. *Flora of Delhi*. CSIR, New Delhi.

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Semester V - DSC:
BOC 106: CELL BIOLOGY AND PLANT BIOCHEMISTRY
Credits: 4 (Theory) + 2 (Practical)

Course Objectives:
This course is designed to provide an overview of how cellular structure and function arise as a result of the properties of cellular macromolecules. The practical component of the study deals with experiments supporting cell structure and functioning principles as well as applications of bio-analytical techniques.

THEORY: Total Lectures: 60
Cell Biology:

Unit 1: Techniques in cell biology (6 Lectures)
Principle, working and applications of the following techniques: Phase contrast microscopy; Fluorescence microscopy; Electron microscopy (SEM and TEM); Micrometry and Photomicrography.

Unit 2: Cell and its components (20 Lectures)
Cell - Cell theory; structure of prokaryotic and eukaryotic cells.
Cell wall - chemical composition, ultrastructure and functions.
Cell Membrane - chemical composition, structure (Fluid Mosaic Model) and functions; fluidity of membrane.
Nucleus - structure of nuclear envelope, nucleoplasm, chromatin (euchromatin and heterochromatin) and nucleolus.
Plastids - types of plastids; morphology, ultrastructure and function of Chloroplast. Mitochondria - origin, morphology, ultrastructure and function.
Ribosomes - structure of prokaryotic and eukaryotic ribosomes and their functions. Cytoskeleton - structure and function of microtubules, microfilaments and intermediate filaments.
Other cell organelles - structure and functions of Endoplasmic Reticulum, Golgi apparatus, Lysosomes, Peroxisomes and Glyoxisomes.

Unit 3: Cell Division (4 Lectures)
Overview of cell cycle; cell division (mitosis and meiosis) and its significance.

Plant Biochemistry:

Unit 4: Biomolecules

Carbohydrates: **(5 Lectures)**

Classification and biological role of carbohydrates; structure and properties of monosaccharides (glucose and fructose), oligosaccharides (sucrose and maltose) and polysaccharides (starch and cellulose); synthesis and degradation of starch in plants.

Amino acids and proteins: **(10 Lectures)**

Amino acids - classification, structure, properties and biological role of amino acids; essential and non-essential amino acids; transamination.

Proteins - classification, structure (primary, secondary, tertiary and quaternary), properties and biological role of proteins; protein synthesis (transcription and translation); post- translational changes.

Lipids: **(4 Lectures)**

Classification, structure, properties and biological role of fatty acids and lipids; synthesis and breakdown of triglycerides; β-oxidation.

Nucleic acids: **(4 Lectures)**

Structure of nucleic acids (nitrogen bases, nucleosides and nucleotides); structure of B-DNA; alternate forms of DNA (A, C, D and Z); RNA and its types.

Vitamins: **(4 Lectures)**

Broad classification of vitamins; properties, occurrence, functions and deficiency symptoms of vitamins A, B complex, C, D, E and K.

Unit 5: Secondary metabolites **(3 Lectures)**

Broad classification of secondary metabolites; properties and functions of terpenoids, alkaloids and phenolics.

PRACTICAL: Total Practical: 30P = 30 x 2 hours

1. Measurement of plant cell dimensions (length and breadth) using micrometry. **(2P)**
2. Study of cell organelles using electron micrographs. **(1P)**
3. Micro-chemical detection of reducing sugars in floral nectar using Benedict's reagent. **(1P)**
4. Study of starch grains of wheat, potato and rice using I_2KI reagent. **(1P)**
5. Localization of carbohydrates using Periodic Acid Schiff's reagent. **(1P)**
6. Localization of lipids using Sudan III reagent. **(1P)**
7. Histochemical tests for detection of cellulose, lignin, cutin & suberin in plant sections. **(2P)**
8. Qualitative tests for biomolecules (carbohydrates, proteins and lipids). **(2P)**
9. Extraction and estimation of total sugars using phenol sulphuric acid. **(2P)**
10. Extraction and estimation of reducing sugars by Nelson-Somogyi method. **(2P)**
11. Extraction and estimation of amino acids using ninhydrin reagent. **(2P)**
12. Extraction and estimation of proteins by Lowry's method. **(2P)**
13. Extraction and estimation of ascorbic acid by titrimetric method. **(2P)**
14. Isolation and comparison of casein content of different milk samples using sodium acetate buffer. **(2P)**

15. Determination and comparison of acid value of fresh and rancid fat samples by titrimetric method. **(2P)**
16. Separation of lipids by thin layer chromatography. **(2P)**
17. Extraction and separation of chlorophyll pigments by paper chromatography. **(2P)**
18. Study of structure of DNA and RNA with the help of models. **(1P)**

Learning Outcomes:

- Gain knowledge about the various cell organelles and their role in cell functioning.
- Understand the chemical structure and properties of biomolecules and their role in living organisms.
- Develop skills in various techniques used in cell biology studies.
- Be proficient in handling various instruments used in biochemistry related experiments.

SUGGESTED READINGS:

1. Kleinsmith, L.J. and Kish, V.M. 1995. *Principles of Cell and Molecular Biology*. 2nd edition. Harper Collins College Publishers, New York.
2. Gupta, P.K. 1999. *A Text Book of Cell and Molecular Biology*. Rastogi Publications, Meerut, UP.
3. Karp, G. 2010. *Cell and Molecular Biology: Concepts and Experiments*. 6th edition. John Wiley & Sons Inc.
4. Avers, C.J. 1986. *Molecular Cell Biology*. Addison-Wesley Publishing Co., Boston.
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8. Jain, J.L., Jain, S. and Jain, N. 2007. *Elementary Biochemistry*. 3rd edition. S. Chand and Company Ltd., New Delhi.
9. Mathur, R. and Mehta, M. 2002. *Biochemistry*. 1st edition. Anmol Publications Pvt. Ltd., New Delhi.
10. Berg, J.M., Tymoczko, J.L. and Stryer, L. 2011. *Biochemistry*. W.H. Freeman and Company, New York.
11. Nelson, D.L. and Cox, M.M. 2008. *Lehninger Principles of Biochemistry*. 5th edition. W. H. Freeman and Company, New York.
12. Stryer, L. 1995. *Biochemistry*. W.H. Freeman and Co., New York.
13. Campbell, M.K. 1999. *Biochemistry*. Saunders College Publishing, Philadelphia.
14. Verma, S.K. and Verma, M. 2007. *A Textbook of Plant Physiology, Biochemistry and Biotechnology*. 6th edition. S. Chand and Company Ltd., New Delhi.
15. Sadasivam, S. and Manickam, A. 1996. *Biochemical Methods*. New Age International Publishers.
16. Boyer, R. 2001. *Modern Experimental Biochemistry*. 3rd edition. Pearson Education, Singapore.
17. Wilson, K. and Goulding, K.H. 1986. *A Biologists Guide to Principles and Techniques of Practical Biochemistry*. Edward Arnold, London.
18. Rao, B.R. and Deshpande, S. 2005. *Experimental Biochemistry*. I.K. International Pvt. Ltd., New Delhi.
19. Nigam, A. and Ayyagari. 2007. *Lab Manual in Biochemistry, Immunology and Biotechnology*. Tata McGraw-Hill Publishing Company Limited, New Delhi.

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Semester V - DSC:
BOC 107: MICROBIOLOGY AND PLANT PATHOLOGY
Credits: 4 (Theory) + 2 (Practical)

Course Objectives:
This course deals with basic and advanced concepts of microbiology and plant pathology. It aims to create awareness of the occurrence and economic value of various microbes; their interactions with the environment and impact on living organisms. The laboratory exercises provide training in basic skills in isolation and handling of microorganisms and its relevant applications.

THEORY: Total Lectures: 60

Microbiology:

Unit 1: Introduction to microbiology (5 Lectures)
Terms and definitions; aseptic technique and concept of sterilization; physical and chemical methods of sterilization; biosafety levels and biohazards in the laboratory; disposal of laboratory wastes and cultures.

Unit 2: Methods in microbiology (6 Lectures)
Types and preparation of culture media; methods of obtaining pure cultures of microorganisms (streak plate, spread plate and pour plate); enumeration of microorganisms (direct and indirect methods); bacterial motility; bacterial growth curve.

Unit 3: Preservation and maintenance of microbial cultures (3 Lectures)
Methods of preservation (periodic transfer, lyophilisation, use of mineral oil and liquid nitrogen); culture collection centres (culture banks) and their importance.

Unit 4: Microbiology of air, soil and water (7 Lectures)
Occurrence of microorganisms in air. Microorganisms in soil; role of microorganisms in decomposition of plant residues. Microorganisms in water; microorganisms as indicators of water pollution; bacteriological determination of potability of water (standard multiple tube fermentation and membrane filtration technique); methods of purification of water.

Unit 5: Applications of microorganisms (9 Lectures)
Role of microorganisms in typical fermentation processes - fermented food and dairy products (bread, yoghurt and cheese); organic acids (citric acid and vinegar); alcoholic beverages made from fruit juices (grape and cashew apple); antibiotics (penicillin and streptomycin). Role of microorganisms in bioremediation; biodegradable plastics; production of biogas.

Plant Pathology:

Unit 6: Introduction to plant pathology: Terms and concepts; classification of plant diseases; disease symptoms caused by bacterial, fungal and viral plant pathogens; identification of plant disease – Koch's postulates. **(5 Lectures)**

Unit 7: Pathogen attack and defense mechanisms (5 Lectures)
Stages of disease establishment – the disease cycle; structural and biochemical defense mechanisms in plants (pre-existing and induced).

Unit 8: Plant disease epidemiology **(4 Lectures)**
Transmission and spread of plant pathogens; development of disease in plants - the disease triangle; plant disease epidemics (monocyclic and polycyclic).

Unit 9: Plant disease management **(9 Lectures)** Physical, cultural, chemical, biological and IPM systems; development of transgenics for disease management; biopesticides; plant disease clinics.

Unit 10: Genetics of pathogenicity **(3 Lectures)**
Genes for virulence and avirulence and their role in susceptibility and resistance; molecular diagnosis - identification of genes and specific molecules in disease development (DNA and protein based diagnostic kits).

Unit 11: Application of modern technologies in plant pathology **(4 Lectures)** Computer simulation of epidemics and disease forecasting; use of remote sensing and image analysis in plant pathology.

PRACTICAL: Total Practical: 30P = 30 x 2 hours

1. Working and handling of equipment used in microbiology laboratory. **(1P)**
2. Determination of microbial (yeast) population size using serial dilution technique and total count using haemocytometer; relationship between dilution and cell count. **(2P)**
3. Preparation of liquid and solid (plates and slants) culture media – Nutrient Broth, Nutrient Agar and Potato Dextrose Agar. **(2P)**
4. Study of bacterial motility by hanging drop method. **(2P)**
5. Isolation of microorganisms from air; study of colony characteristics of bacteria and fungi; preparation of pure culture of bacteria by streak plate method to obtain isolated colonies; streaking on slants. **(2P)**
6. Evaluation of effectiveness of different agents on hand washing (sanitizer, handwash, dettol and alcohol). **(2P)**
7. Screening for amylase producing microorganisms in soil using starch agar by serial dilution spread plate method. **(2P)**
8. Analysis of water sample to determine its potability (presumptive test, confirmed test and completed test). **(3P)**
9. Demonstration of fermentation by yeast for preparation of idli and *sanna*. **(2P)**
10. Testing quality of milk by methylene blue dye reduction test. **(2P)**
11. Screening for antimicrobial activity of plant extracts by agar well/disc diffusion method (extracts of neem, garlic and lemon grass; positive and negative control). **(2P)**
12. Study of causal organism, symptoms, disease cycle and control measures of plant diseases (viral, bacterial and fungal – one each). **(2P)**
13. Anatomy/mounting of spores of fungus infected specimens (rust, blight and rot). **(2P)**
14. Demonstration of Koch's postulates for a bacterial/fungal pathogen. **3P)**
15. Image analysis of infected field. **(1P)**

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Learning Outcomes:

- Gain knowledge of sterilization methods, biohazards and biosafety measures.
- Gain knowledge of methods for cultivation, preservation and maintenance of microbial cultures.
- Understand the role and relevance of beneficial microorganisms and their applications in day to day life.
- Understand the fundamental basis of plant-microbe interaction that leads to plant diseases and measures to be adopted for plant health management.
- Acquire skills in isolation and handling of microbes.

SUGGESTED READINGS:

1. Dubey, R.C. and Maheshwari, D.K. 1999. *A Text Book of Microbiology*. S. Chand and Company Ltd., New Delhi.
2. Sullia, S.B. 2001. *General Microbiology*. Oxford Publishers, New Delhi.
3. Sharma, K. 2011. *Text Book of Microbiology*. Anne Books Pvt. Ltd., New Delhi.
4. Kalaichelvan, P.T. and Pandi, A. 2007. *Bioprocess Technology*. MJP Publishers, Chennai.
5. Moshrafuddin, A. and Basumatany, S.K. 2006. *Applied Microbiology*. MJP Publishers, Chennai.
6. Meyneil, E. and Meynell, G.G. 1970. *Theory and Practice in Experimental Bacteriology*. Cambridge University Press, Cambridge.
7. Agrios, G.N. 1997. *Plant Pathology*. Academic Press, London.
8. Mehrotra, R.S. 1995. *Plant Pathology*. Tata McGraw-Hill Publishing Company Limited, New Delhi.
9. Sambamurty, A.V.S.S. 2006. *Text Book of Plant Pathology*. I.K. International Publishing House, New Delhi.
10. Albajes, R., Gullino, M.L., van Lenteren, J.C. and Elad, Y. 2000. *Integrated Pest and Disease Management in Greenhouse Crops*. Kluwer Academic Publishers.
11. Persley, G.J. 1996. *Biotechnologies and Integrated Pest Management*. CAB International, UK.
12. Bridge, P.D., Couteaudier, Y. and Clarkson, J.M. 1998. *Molecular Variability of Fungal Pathogens*. CAB International, UK.
13. Skerritt, J.H. and Apples, R. 1995. *New Diagnostics in Crop Sciences*. CAB International, UK.
14. Bridge, P.D., Arora, D., Reddy, C.A. and Elander, R.P. 1999. *Applications of PCR in Mycology*. CAB International, UK.
15. Bridge, P.D., Jeffries, P., Morse, D.R., Scott, P.R. and Boland, G.J. 1998. *Information Technology, Plant Pathology and Biodiversity*. CAB International, UK.
16. Eklund, C. and Lankford, C.E. 1967. *Laboratory Manual for General Microbiology*. Prentice-Hall, Inc., London.
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18. Pawsey, R.K. 1974. *Techniques with Bacteria - A Guidebook for Teachers*. Hutchinson Educational.
19. Pelczar, M.J. and Chan, E.C.S. 1972. *Laboratory Exercises in Microbiology*. McGraw Hill Book Co.
20. Wistreich, G.A. and Lechtman, M.D. 1973. *Laboratory Exercises in Microbiology*. Macmillan Publishers, London.
21. Dubey, R.C. and Maheshwari, D.K. 2002. *Practical Microbiology.* S. Chand & Company Ltd., New Delhi.
22. Kale, V. and Bhusari, K. 2001. *Practical Microbiology: Principles & Techniques.*, Himalaya Publishing House, Mumbai.
23. Garg, N., Garg, K.L. and Mukerji, K.G. 2010. *Laboratory Manual of Food Microbiology*. I.K. International Publishing House Pvt. Ltd., New Delhi.

24. Aneja, K.R. 1993. *Experiments in Microbiology, Plant Pathology and Tissue Culture*. Wishwa Publication, New Delhi.
25. Mahadevan, A. and Sridhar, R. 1986. *Methods in Physiological Plant Pathology*. Sivakami Publication, Chennai.
26. Schaad, N.W. 1988. *Plant Pathogenic Bacteria: Laboratory Guide for Identification of Plant Pathogenic Bacteria*. Academic Press.
27. Sivakumar, P.K., Joe, M.M. and Sukesh, K. 2010. *An Introduction to Industrial Microbiology*. S. Chand & Company Pvt. Ltd., New Delhi.
28. Pandey, B.P. 2014. *Plant Pathology: Pathogen and Plant Disease*. S. Chand & Company Pvt. Ltd., New Delhi.

Journals / Series:

1. Methods in Microbiology; Methods in Enzymology; Methods in Biochemistry.
2. Indian Journal of Mycology & Plant Pathology, Jodhpur.
3. Mycorrhiza News Letter, TERI, New Delhi.
4. Indian Journal of Microbiology.

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Semester V - DSE:
BOD 101: PLANT TISSUE CULTURE
Credits: 3 (Theory) + 1 (Practical)

Course Objectives: This course is designed to provide an overview of the concept of plant tissue culture and the laboratory setup needed for culturing plant tissues. It provides hands-on training in the basic protocols of preparation of culture media, plant tissue culture, micro-propagation, regeneration of plantlets from tissues and acclimatization in greenhouse/ polyhouse.

THEORY: Total Lectures: 45

Unit 1: Introduction to plant tissue culture (5 Lectures)

Concept and history of plant tissue culture; pioneering work and significant achievements of Indian scientists. Plant tissue culture laboratory design; basic requirements and sterilization practices.

Unit 2: Plant tissue culture technique (6 Lectures)

Washing, packing and sterilization of glassware; composition, types, preparation and sterilization of culture media; selection, isolation, surface sterilization and inoculation of explants; establishment of *invitro* cultures, ideal conditions for incubation of cultures, maintenance of cultures and subculture; regeneration of plantlets; acclimatization of tissue cultured plantlets in greenhouse/polyhouse.

Unit 3: Cellular totipotency and differentiation (7 Lectures)

Concept of cellular totipotency and differentiation (dedifferentiation and redifferentiation); role of plant growth regulators in tissue culture; role of meristems in tissue culture; characteristics of callus tissue; somaclonal variation; organogenesis and somatic embryogenesis. Preparation of synthetic seeds.

Unit 4: Types of cultures (13 Lectures)

Principle, protocol and applications of the following types of culture: callus culture, meristem culture, embryo culture, root culture, anther and pollen culture; micro-propagation. Cell Suspension Culture - methods for isolation of single cells, testing viability of cells, protocol for cell suspension culture, types of suspension cultures (batch and continuous), growth pattern of cells in batch culture, methods for measurement of growth of cells in suspension and applications of cell suspension cultures.

Unit 5: Somatic hybridization (9 Lectures)

Introduction to somatic hybridization; role of enzymes in protoplast isolation, mechanical and enzymatic isolation of plant protoplasts, testing viability of isolated protoplasts, spontaneous and induced fusion of protoplasts, selection of hybrid protoplasts, culture of hybrid protoplasts and applications of somatic hybridization. Cybrids and their applications.

Unit 6: Applications of plant tissue culture (5 Lectures)

Role of plant tissue culture for crop improvement in agriculture, forestry and horticulture; production of secondary metabolites in culture (callus culture and cell suspension culture); cryopreservation and germplasm conservation (*in-situ* and *ex-situ* methods).

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PRACTICAL: Total Practical: 15P = 15 x 2 hours

1. Familiarization with working and handling of laboratory instruments and equipment; washing, packing and sterilization of glassware. **(2P)**
2. Preparation of plant tissue culture medium (MS) and its sterilization. **(2P)**
3. Surface sterilization and *in vitro* seed germination of *Brasasica* sps. / suitable seeds. **(1P)**
4. Induction of callus from *Daucus carota* cambium & hypocotyl segments as explants. **(2P)**
5. Morphological and microscopic study of callus. **(1P)**
6. Enzymatic isolation of plant protoplasts. **(2P)**
7. Encapsulation of somatic/true embryos to prepare synthetic seeds. **(1P)**
8. Embryo culture of *Zea mays*. **(2P)**
9. Regeneration of shoot and root from callus. **(2P)**

Learning Outcomes:

- Gain knowledge of the basic techniques involved in plant tissue culture.
- Understand the concept of cellular totipotency and differentiation as well as the role of plant growth regulators in plant tissue culture.
- Gain proficiency in techniques of plant regeneration.
- Have an insight of the applications of plant tissue culture in crop improvement.

SUGGESTED READINGS:

1. Collins, H.A. and Edwards, S. 1998. *Plant Cell Culture.* Bios Scientific Publishers, Oxford.
2. Misra, S.P. 2009. *Plant Tissue Culture*. Ane Books Pvt. Ltd., New Delhi.
3. Singh, S.K. and Srivastava, S. 2006. *Plant Tissue Culture*. Campus Books International, New Delhi.
4. Bhojwani, S.S. 1990. *Plant Tissue Culture: Applications and Limitations*. Elsevier Science Publishers, New York, NY.

5. Vasil, I.K. and Thorpe, T.A. 1994. *Plant Cell and Tissue Culture.* Kluwer Academic Publishers, The Netherlands.
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7. Razdan, M.K. 2003. *An Introduction to Plant Tissue Culture*. Oxford & IBH Publishing Co., New Delhi.
8. Chawla, H.S. 2000. *Introduction to Plant Biotechnology*. Oxford and IBH Publishers, New Delhi.
9. De, K.K. 1992. *Plant Tissue Culture*. New Central Book Agency (P) Ltd., Calcutta.
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11. Ramawat, K.G. 2004. *Plant Biotechnology*. S. Chand & Company Ltd., New Delhi.
12. Prakash, M. and Arora, C.K. 2005. *Cell and Tissue Culture*. Anmol Publications Pvt. Ltd., New Delhi.
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14. Narayanswamy, S. 1994. *Plant Cell and Tissue Culture*. Tata McGraw-Hill Publishing Company Ltd., New Delhi.
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16. Kumar, H.D. 2005. *Agricultural Biotechnology.* Daya Publishing House, New Delhi.
17. Gautam, H. 2006. *Agricultural and Industrial Applications of Bio-technology*. Rajat Publications, New Delhi.
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19. Raghavan, V. 1986. *Embryogenesis in Angiosperms: A Developmental and Experimental Study*. Cambridge University Press, New York.
20. Chawla, H.S. 2003. *Plant Biotechnology: A Practical Approach*. Oxford & IBH Publishers, New Delhi.
21. Kumar, U. 2011. *Methods in Plant Tissue Culture*. Agro-Bios.
22. Nair, L.N. 2010. *Methods in Microbial and Plant Biotechnology*. New Central Book Agency (P.) Ltd., Kolkata.

Semester V - DSE:
BOD 102: RESEARCH METHODOLOGY, BIOINFORMATICS & BIOSTATISTICS
Credits: 3 (Theory) + 1 (Practical)

Course Objectives:
This course is designed to give an exposure to basic concepts of research and general laboratory practices for collecting, handling, analyzing and interpreting data. It will also give an understanding of the use of biostatistics and bioinformatics tools for research.

THEORY: Total Lectures: 45

Unit 1: Basic concepts of research and general laboratory practices (8 Lectures)
Research – definition and types of research (library, field and laboratory). Research methods; Literature - review and its consolidation. Access to laboratory; laboratory practices and cleanliness; laboratory hazards (chemical, fire, electrical, noise, radiation), safety measures.

Unit 2: Data collection and documentation of observations (3 Lectures)
Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars, Importance of photography.

Unit 3: Scientific writing and presentation (5 Lectures)
Numbers, units, abbreviations and nomenclature used in scientific writing. Reference writing. Scientific presentation, writing and ethics; introduction to copyright - academic misconduct/plagiarism.

Unit 4: Bioinformatics; databases and their sequencing (12 Lectures)
Introduction, aim, scope and research areas of Bioinformatics; Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System. National Center for Biotechnology Information (NCBI): Tools and Databases, Database Sequence Submission to NCBI, Basic Local Alignment Search Tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database. Protein Information Resource (PIR): Introduction of PIR, Resources, Swiss Prot: Introduction and salient features.

Unit 5: Applications of bioinformatics (6 Lectures)
Structural bioinformatics in drug discovery, Quantitative structure-activity relationship (QSAR) techniques in drug design, Microbial genome applications, Crop improvement.

Unit 6: Introduction to biostatistics (5 Lectures)
Statistical methods - basic principles, sampling methods (random and stratified sampling); Collection of primary and secondary data, its tabulation and presentation.

Unit 7: Measures of central tendency (6 Lectures)
Mean, median, mode, standard deviation, standard error, correlation, regression, chi square analysis, Students' 't' test; merits and demerits of measures of central tendency.

PRACTICAL: Total Practical: 15P = 15 x 2 hours

1. Study of technique of microphotography and field photography. **(2P)**
2. Preparation of poster on defined topic. **(1P)**
3. Analysis of data for mean, mode, median, standard deviation and standard error using suitable plant material. **(1P)**
4. Determination of correlation and regression using suitable plant material. **(3P)**
5. Chi square analysis. **(1P)**
6. Analysis of Students' 't' test using suitable example. **(1P)**
7. Study of nucleic acid and protein databases. **(2P)**
8. Study of sequence retrieval from nucleic acid and protein databases. **(1P)**
9. Study of unknown DNA and protein sequences using sequence alignment tool from NCBI/BLAST. **(2P)**
10. Study of species affinity based on given phylogenetic tree. **(1P)**

Learning Outcomes:

- Understand the basic tenets of research, laboratory safety measures, importance of maintaining records and writing of research ideas.
- Use bioinformatics tools (BLAST and PIR) for research.
- Acquire skills in microphotography and field photography.

- Apply basic statistical techniques to research data for a valid scientific conclusion.

SUGGESTED READINGS:

1. Danniel, W.W. 1987. *Biostatistic*s. John Wiley Sons, New York, NY.
2. Campbell, A.M. and Heyer, L.J. 2006. *Discovering Genomics, Proteomics and Bioinformatics*. 2nd edition. Cold Spring Harbor Laboratory Press and Benjamin Cummings.
3. Campbell, R.C. 1974. *Statistics for Biologists*. Cambridge University Press.
4. Dawson, C. 2002. *Practical Research Methods.* UBS Publishers, New Delhi.
5. Freedman, P. 1949. *The Principles of Scientific Research*. Macdonald and Company Limited, Washington DC.
6. Ghosh, Z. and Bibekanand, M. 2008. *Bioinformatics: Principles and Applications*. Oxford University Press.
7. Gurumani, N. 2006. *Research Methodology for Biological Sciences*. MJP Publishers, Chennai, TN.
8. Pevsner, J. 2009. *Bioinformatics and Functional Genomics*. 2nd edition. Wiley Blackwell.
9. Ruzin, S.E. 1999. *Plant Micro Technique and Microscopy*. Oxford University Press, New York, NY.
10. Selvin, S. 1991. *Statistical Analysis of Epidemiological Data*. New York University Press, New York, NY.
11. Stapleton, P., Yondeowei, A., Mukanyange, J. and Houten, H. 1995. *Scientific Writing for Agricultural Research Scientists - A Training Resource Manual*. West Africa Rice Development Association, Hong Kong.
12. Sundarrao, P.S.S. and Richards, J. 2012. *An Introduction to Biostatistics and Research Methods*. 5th edition. PHI Learning Pvt. Ltd., New Delhi.

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Semester V - DSE:
BOD 103: ECONOMIC AND MEDICINAL BOTANY
Credits: 3 (Theory) + 1 (Practical)

Course Objectives: This course is designed to give an overview of how plants are indispensable to humans. It gives a broad exposure of the various aspects of plants such as their origin, plant resource utilization, conservation and ethnobotany.

THEORY: Total Lectures: 45

Unit 1: Origin of plants **(1 Lecture)**

Vavilov's concept of centre of origin; wild relatives of cultivated plants.

Unit 2: General account of economically important plants

Identification, brief botanical description, cultivation practices and utilization of the following plants and/or plant parts:

a. Cereals and millets - Rice, wheat, maize and ragi. **(4 Lectures)**

b. Pulses - Red gram, black gram and green gram. **(2 Lectures)**

c. Spices and condiments - Chillies, black pepper, cinnamon, ginger, turmeric and cardamom. **(4 Lectures)**

d. Beverages - Tea and coffee (including processing). (**2 Lectures)**

e. Vegetable oil sources - Sesame, groundnut, soybean, coconut and mustard (including extraction) **(4 Lectures)**

f. Fibre yielding plants - Cotton, coir, jute and agave (including types of fibres and extraction). **(3 Lectures)**

g. Fruit crops - Mango, jackfruit, banana, cashew, pineapple and papaya **(4 Lectures)**

h. Vegetable crops - Red amaranth, radish, knol-khol and okhra **(3 Lectures)**

i. Sugar and starch crops - Sugarcane (including processing, products and by-products of sugarcane industry), potato and yam. **(3 Lectures)**

j. Rubber yielding plants - *Hevea brasiliensis* (including tapping and processing). **(1 Lecture)**

k. Timber plants - Matti, Sailo, Shisham and Bamboo (including wood properties) **(3 Lectures)**

l. Miscellaneous - Dye (*Bixa orellana)*, Essential oil (*Eucalyptus)*, Insecticidal (Neem) **(2 Lectures)**

Unit 3: Popular medicinal plants and plant drugs (5 Lectures)

A brief account of the chief chemical constituents and uses of the following plant drugs used in indigenous and allopathic systems of medicine: *Hemidesmus indicus*, *Garcinia indica*, *Boerhaavia diffusa*, *Alstonia scholaris*, *Datura metel*, *Holarrhena antidysenterica*, *Piper longum*, *Syzygium cumini*, *Strychnos nux-vomica*, *Terminalia bellerica*, *Adathoda vasica* and *Tinospora cordifolia*.

Unit 4: Crop research organisations (4 Lectures)

Brief account of research organisations involved in improvement of different crops in India: ICAR (Indian Council of Agricultural Research); ICRISAT (International Crops Research Institute for the Semi-Arid Tropics); CRRI (Central Rice Research Institute) and SBRI (Sugarcane Breeding Research Institute).

PRACTICAL: Total Practical: 15P = 15 x 2 hours

1. Identification (botanical name and family), description and utilization of plants and/or plant parts studied in theory under each group. **(6P)**
2. Chemical tests for sesame and groundnut oil and study of oil glands in T.S. of *Eucalyptus* leaf. **(1P)**
3. Study of properties and measurement of diameter of plant fibres: cotton, jute and coir. **(2P)**
4. Study of plants used as sources of drugs as in theory. **(3P)**
5. Preparation of *Holi* colours using natural ingredients. **(1P)**
6. Identification and medicinal value of locally available plants (field visit). **(2P)**

Learning Outcomes:

- Gain knowledge of various economically and medicinally important plant species.
- Utilize the knowledge of cultivation and uses of plants in day to day life.
- Have an insight on crop research organizations involved in improvement of different economically important crops.

SUGGESTED READINGS:

1. Kochhar, S.L. 2012. *Economic Botany in the Tropics*. MacMillan India Ltd., New Delhi.
2. Wickens, G.E. 2001. *Economic Botany: Principles & Practices*. Kluwer Academic Publishers, The Netherlands.
3. Chrispeels, M.J. and Sadava, D.E. 1994. *Plants, Genes and Agriculture*. Jones & Bartlett Publishers.
4. Sambamurty, A.V.S.S. and Subramanyam, N.S. 1989. *A Textbook of Economic Botany*. Wiley Eastern Ltd., New Delhi.
5. Trivedi, P.C. 2006. *Medicinal Plants: Ethnobotanical Approach*. Agrobios, India.
6. Purohit, S.S. and Vyas, S.P. 2008. *Medicinal Plant Cultivation: A Scientific Approach*. Agrobios, India.
7. Fuller, K.W. and Gallon, J.A. 1985. *Plant Products and New Technology*. Clarendon Press, Oxford, New York.
8. Hill, A.F. 1952. *Economic Botany: A Textbook of Useful Plants and Plant Products*. McGraw Hill Publishing Company Ltd., New Delhi.
9. Sen, S. 2009. *Economic Botany*. NCBA Publishers, New Delhi.
10. Sharma, O.P. 1996. *Hill's Economic Botany*. Tata McGraw Hill Publishing Company Ltd., New Delhi.
11. Simpson, B.B. and Conner-Ogorzaly, M. 1986. *Economic Botany - Plants in Our World*. McGraw Hill, New York.
12. Singh, V., Pande, P.C. and Jain, D.K. 2009. *A Text Book of Economic Botany*. Rastogi Publications.

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Semester VI - DSC:
BOC 108: CYTOGENETICS AND PLANT BREEDING
Credits: 4 (Theory) + 2 (Practical)

Course Objectives:

This course deals with basic and advanced concepts in cytogenetics and plant breeding along with their applications. Laboratory exercises provide training in understanding genetics through problem solving and skills of plant breeding such as emasculation and artificial pollination and its relevant applications in crop improvement.

THEORY: Total Lectures: 60

Unit 1: Cell cycle **(2 Lectures)**

Mitosis, Meiosis; Significance.

Unit 2: Mendelian genetics and its extension **(9 Lectures)**

Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Backcross and test cross; Incomplete dominance, co-dominance and lethal alleles; Gene interactions (Epistasis) – Dominant, Recessive, Complementary, Supplementary, Duplicate; Multiple alleles (blood groups in humans, self-incompatibility in plants), Pleiotropy, Penetrance and Expressivity.

Unit 3: Extrachromosomal inheritance **(4 Lectures)**

Characteristics of extrachromosomal inheritance; Cytoplasmic inheritance in *Mirabilis jalapa*; Kappa particles in *Paramecium*; Mitochondria in yeast; Maternal effects in snail (shell coiling).

Unit 4: Linkage, crossing over and chromosome mapping (6 Lectures)
Linkage, crossing over types and significance; Cytological basis of crossing over; Recombination frequency, two-point and three-point test crosses and their significance in chromosome mapping; Interference and coincidence.

Unit 5: Autosomes and sex chromosomes (4 Lectures)
Mechanisms of sex determination; Balance concept of sex determination in *Drosophila*; Sex-linked inheritance; Sex-limited characters.

Unit 6: Alteration in chromosome number and structure (8 Lectures)
Deletion, Duplication, Inversion, Translocation, meiosis in structural heterozygote; Position effect; Euploidy and Aneuploidy.

Unit 7: Gene mutations (6 Lectures)
Types of mutations; Mutagens - physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Molecular basis of Mutations; Detection of mutations: ClB method.

Unit 8: Introduction to plant breeding (3 Lectures)
Introduction and objectives; important achievements and undesirable consequences of plant breeding. Centres of origin and domestication of crop plants.

Unit 9: Methods of crop improvement (11 Lectures)
Introduction and acclimatization; Selection methods for self-pollinated, cross-pollinated and vegetatively propagated plants; Hybridization: For self- and cross-pollinated plants – Procedure, advantages and limitations. Role of mutation, polyploidy; Distant hybridization in crop improvement.

Unit 10: Quantitative inheritance (4 Lectures)
Concept, mechanism, Monogenic v/s Polygenic Inheritance. Examples - Inheritance of kernel colour in wheat, ear length in maize.

Unit 11: Inbreeding depression and heterosis (3 Lectures)
Inbreeding depression, Heterosis; Applications.

PRACTICAL: Total Practical: 30P = 30 x 2 hours

1. Mendel's laws through seed ratios. **(2P)**
2. Problems on monohybrid, dihybrid cross and modified dihybrid ratios. **(4P)**
3. Preparation of chromosome map using three-point test cross data. **(4P)**
4. Study of stages in mitosis using *Allium cepa* root tips. **(3P)**
5. Study of stages in meiosis using *Allium cepa* /*Rheo bicolor* flower buds. **(3P)**
6. Preparation of karyotype from dividing *Allium cepa* root tip cells. **(2P)**
7. Photo/Permanent slides showing translocation ring, laggards and inversion bridge. **(2P)**
8. Emasculation and bagging of flowers of Brassicaceae and Malvaceae, pollinating them manually, estimating fruit and seed set. **(3P)**

9. Estimation of pollen fertility in any 2 locally grown crop plants (e.g. Chilly, Brinjal). **(2P)**

10. Estimation of pollen-ovule ratio and its bearing on pollination system. **(2P)**

11. Colchicine induced polyploidy. **(1P)**
12. Colchicine induced mutation (root / shoot / germination / chromosomes). **(2P)**

Learning Outcomes:

- Learn about basic and advanced concepts in cytogenetics.
- Understand Mendelian genetics through problem solving exercises.
- Apply the knowledge of cytogenetics in plant breeding.
- Understand the molecular basis of mutation and its phenotypic effect on the organism.
- Learn about the various methods of crop improvement.
- Develop skills in plant breeding such as emasculation, artificial pollination and induction of polyploidy.

SUGGESTED READINGS:

1. Acquaah, G. 2007. *Principles of Plant Genetics & Breeding*. Blackwell Publishing.
2. Chaudhari, H.K. 1984. *Elementary Principles of Plant Breeding*. 2nd edition. Oxford-IBH.
3. Gardner, E.J., Simmons, M.J. and Snustad, D.P. 1991. *Principles of Genetics*. 8th edition. John Wiley & Sons, India.
4. Griffiths, A.J.F., Wessler, S.R., Carroll, S. B. and Doebley, J. 2010. *Introduction to Genetic Analysis*. 10th edition. W. H. Freeman & Co., U.S.A.
5. Goswami, H.K. and Goswami, R. 1993. *Practical Cytology, Applied Genetics and Biostatistics*. 2nd revised edition. Himalaya Publishing House, Mumbai.
6. Klug, W.S., Cummings, M.R. and Spencer, C.A. 2009. *Concepts of Genetics*. 9th edition. Benjamin Cummings, U.S.A.
7. Singh, B.D. 2005. *Plant Breeding: Principles and Methods*. 7th edition. Kalyani Publishers, Ludhiana.
8. Snustad, D.P. and Simmons, M.J. 2010. *Principles of Genetics*. 5th edition. John Wiley & Sons Inc., India.
9. Verma, P.S. and Agarwal, V.K. 2009. *Genetics*. 9th revised edition. S. Chand & Co., New Delhi.
10. Shukla, R.S. and Chandel, P.S. 2013. *Cytogenetis, Evolution, Biostatistics and Plant Breeeding*. 5th edition. S. Chand & Company Pvt. Ltd., New Delhi.

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Semester VI - DSC:
BOC 109: MOLECULAR BIOLOGY AND GENETIC ENGINEERING
Credits: 4 (Theory) + 2 (Practical)

Course Objectives:
This course is designed to have a basic understanding of the fundamental concepts of molecular biology such as structure of DNA, its synthesis and regulation of gene expression and to apply the knowledge in recombinant DNA technology. The theoretical and practical components of this course will provide a deeper understanding of various techniques in obtaining recombinant DNA and the varied applications of genetic engineering.

THEORY: Total Lectures: 60

Unit 1: Nucleic acids - Carriers of genetic information (2 Lectures)
Historical perspective; DNA/RNA as genetic material (Griffith's; Hershey & Chase; Avery, McLeod & McCarty; Fraenkel-Conrat's experiment).

Unit 2: The Structures of DNA and RNA/genetic material (5 Lectures)
DNA Structure: Salient features of double helix (Watson and Crick), Types of DNA, Types of RNA, denaturation and renaturation, cot curves; Organization of DNA - Prokaryotes, Viruses, Eukaryotes. Structure of nuclear DNA v/s Organelle DNA.

Unit 3: The replication of DNA (7 Lectures)
Genetic code; Central and revised dogma of molecular biology; General principles - Modes of replication, bidirectional replication. Models of DNA replication (Rolling circle, Theta replication and semi-discontinuous replication). Replication of linear dsDNA, Enzymes involved in DNA replication.

Unit 4: Transcription (4 Lectures)
Enzymes in transcription; Basic features of transcription - initiation, elongation and termination, promoters and enhancers.

Unit 5: Translation (4 Lectures)
Enzymes in translation; Basic features of translation - initiation, elongation and termination, Post-translational processing and modification.

Unit 6: Gene structure, regulation and modification of RNA (10 Lectures)

Gene organization in prokaryotes and eukaryotes; gene regulation in prokaryotes and eukaryotes. Split genes - concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, alternative splicing; Eukaryotic mRNA processing and stability (5' cap, 3' poly A tail); Ribozymes; RNA silencing.

Unit 7: Recombinant DNA technology (10 Lectures)

Definition of gene and recombinant DNA, steps in genetic engineering. Enzymes used in recombinant DNA technology (Restriction enzymes, DNA ligases, DNA modifying enzymes); Cloning Vectors: pBR322, Ti plasmid, YAC; λ phage, M13 phage, Cosmid; DNA isolation and sequencing (Sanger & Coulson, Maxam & Gilbert).

Unit 8: Methods of gene transfer (5 Lectures)

Gene transfer (*Agrobacterium* - mediated and gene gun); Selection of transformants; selectable marker (antibiotic resistant markers, herbicide resistant markers) and reporter genes (Luciferase, GUS, GFP). Hairy root culture.

Unit 9: Gene cloning (7 Lectures)

Construction of genomic and cDNA libraries, screening of DNA libraries; complementation, colony hybridization; Southern, Northern and Western blotting; Polymerase Chain Reaction. Techniques of DNA fingerprinting (RFLP, RAPD, AFLP).

Unit 10: Applications of genetic engineering (6 Lectures)

Pest resistant (Bt-cotton); herbicide resistant plants (Round Up Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Protease, Lipase); Genetically Engineered Products – Human Growth Hormone; Humulin; Superweeds; Bioethics and Biosafety concerns.

PRACTICAL: Total Practical: 30P = 30 x 2 hours

1. General laboratory methods and safety procedures. **(2P)**
2. Extraction of DNA from cauliflower. **(2P)**
3. Estimation of DNA by diphenylamine method. **(1P)**
4. Demonstration of separation of DNA by gel electrophoresis **(2P)**
5. Extraction of RNA from plant material. **(2P)**
6. Estimation of RNA by Orcinol reagent. **(1P)**
7. Study of DNA replication mechanisms through models/photographs (Rolling circle, Theta replication and semi-discontinuous replication). **(2P)**
8. Study of structures of pBR322, Ti plasmid, YAC, λ phage through models/photographs. **(2P)**
9. Culture of plasmid and maintenance of culture. **(2P)**
10. Isolation of plasmid DNA. **(2P)**

11. Photographs establishing nucleic acid as genetic material (Avery et. al., Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments). **(2P)**

12. Study of spliceosome machinery and alternative splicing mechanism through photographs. **(1P)**

13. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, microprojectile bombardment (gene gun). **(1P)**

14. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato and humulin production through photographs. **(2P)**

15. Deciphering DNA sequence from a sequencing gel photograph by Maxam and Gilbert's method. **(2P)**

16. Deciphering DNA sequence from a sequencing gel photograph by Sanger and Coulson's method. **(2P)**

17. Working of restriction enzyme & calculating the size of the fragments by use of maps. **(2P)**

Learning Outcomes:

- Gain knowledge of the concepts of molecular biology such as structure of nucleic acids, replication, transcription and translation.
- Understand gene structure, regulation and modification of RNA.
- Understand the concepts of recombinant DNA technology and gene cloning and its various applications.

SUGGESTED READINGS:

1. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. 2007. *Molecular Biology of the Gene*. 6th edition. CSHL Press, New York, NY.
2. Snustad, D.P. and Simmons, M.J. 2010. *Principles of Genetics*. 5th edition. John Wiley and Sons Inc., U.S.A.
3. Klug, W.S., Cummings, M.R. and Spencer, C.A. 2009. *Concepts of Genetics*. 9th edition. Benjamin Cummings, U.S.A.
4. Russell, P.J. 2010. *i-Genetics - A Molecular Approach*. 3rd edition. Benjamin Cummings, U.S.A.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B. and Doebley, J. 2010. *Introduction to Genetic Analysis*. 10th edition. W. H. Freeman and Co., U.S.A.
6. Glick, B.R. and Pasternak, J.J. 2003. *Molecular Biotechnology - Principles and Applications of Recombinant DNA*. ASM Press, Washington D.C.
7. Stewart, C.N. Jr. 2008. *Plant Biotechnology & Genetics: Principles, Techniques and Applications*. John Wiley & Sons Inc., U.S.A.
8. Dubey, R.C. 1993. *A Textbook of Biotechnology*. S. Chand & Company Pvt. Ltd., New Delhi.
9. Verma, P.S. and Agarwal, V.K. 2009. *Molecular Biology*. S. Chand & Company Ltd., New Delhi.
10. Purohit, S.S. 2008. *Biotechnology: Fundamentals and Applications*. Agrobios, Jodhpur.
11. Nagar, S. and Adhav, M. 2009. *Practical Biotechnology and Plant Tissue Culture*. S. Chand & Company Ltd., New Delhi.

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Semester VI - DSC:
BOC 110: PLANT ECOLOGY AND PHYTOGEOGRAPHY
Credits: 4 (Theory) + 2 (Practical)

Course Objectives:
Knowledge of ecology is essential for understanding plants and their interaction with other components of the ecosystem. This course is designed to provide knowledge of the basic concepts of ecosystems and the interaction amongst its biotic and abiotic components. It will also impart knowledge of the different ecosystems of Goa and their functional aspects. The practical component will help in developing skills in measurement of various ecological parameters.

THEORY: Total Lectures: 60

Unit 1: Introduction (3 Lectures)
Concept of Ecosystem, components and organization, structure and function, trophic organization.

Unit 2: Soil (8 Lectures)
Importance; Origin; Formation; Composition: Physical, chemical and biological components. Soil profile: type of soil; its effect on vegetation.

Unit 3: Water (4 Lectures)
Importance; States of water in the environment: Water in soil, Water table; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological cycle.

Unit 4: Ecological factors (3 Lectures)
Atmospheric humidity and precipitation in relation to plants.

Unit 5: Biotic interaction (5 Lectures)
Basic source of energy, autotrophy, heterotrophy, symbiosis, commensalism, parasitism; food chain; ecological pyramids; biomass; standing crop.

Unit 6: Plant communities (8 Lectures)
Definition, analytic, quantitative and synthetic characteristics; life forms; habitat and niche; Ecotone and edge effect; Dynamics; Succession - processes, types; climax concepts.

Unit 7: Ecosystems (9 Lectures)
Aquatic, terrestrial, manmade (agricultural). Ecosystems of west coast and Western Ghats with special reference to Goa: Wetlands, mangroves, coastal, sand dunes, plateaus and forests.

Unit 8: Functional aspects of ecosystem (8 Lectures) Principles and models of energy flow; production and productivity; Ecological efficiencies; Biogeochemical cycles; cycling of carbon, nitrogen and phosphorus.

Unit 9: Phytogeography (12 Lectures)

Principles: Continental drift; theory of tolerance; Endemism; Brief description of major terrestrial biomes (tropical, temperate and tundra); Phytogeographical division of India; Local vegetation – forest, agriculture.

PRACTICAL: Total Practical: 30P = 30 x 2 hours

1. Study of instruments used to measure microclimatic variables; Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter. **(2P)**
2. Determination of pH of various soil and water samples (pH meter, universal indicator/ lovibond comparator and pH paper). **(2P)**
3. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests. **(2P)**
4. Determination of organic matter of different soil samples by Walkley & Black rapid titration method. **(2P)**
5. Determination of soil conductivity & water holding capacity in soils of three habitats. **(2P)**
6. Study of dissolved oxygen of water samples from polluted and unpolluted sources. **(2P)**
7. a) Study of aquatic ecosystem of phytoplanktons and hydrophyte diversity. **(3P)**
   b) Study of morphological and anatomical adaptations of hydrophytes and xerophytes (two each). **(2P)**
   c) Study of biotic interaction of the following: Stem parasite (*Loranthus* & *Cuscuta*), Epiphytes (Orchids), Predation (Insectivorous plants – *Utricularia/Drosera*/Pitcher plant). **(3P)**
8. Determination of minimal quadrate size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed). **(2P)**
9. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution laws. **(2P)**
10. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus. **(2P)**
11. To prepare map of India with respect to (i) major climatic zones (ii) forest type (iii) biogeographical regions. **(2P)**
12. To prepare map of Goa to show its vegetation types as specified in theory. **(2P)**

Learning Outcomes:

- Learn fundamental aspects of ecology including abiotic and biotic components, their structure, interrelationship and function.
- Understand the different ecosystems.
- Gain knowledge of phytogeography with reference to continental drift, endemism and biomes.
- Develop skills in qualitative and quantitative measurement of various ecological parameters.

SUGGESTED READINGS:

1. Odum, E.P. 2005. *Fundamentals of Ecology*. 5th edition. Cengage Learning India Pvt. Ltd., New Delhi.
2. Singh, J.S., Singh, S.P. and Gupta, S. 2006. *Ecology, Environment and Resource Conservation*. Anamaya Publications, New Delhi, India.

3. Sharma, P.D. 2010. *Ecology and Environment*. 8th edition. Rastogi Publication, Meerut, India.
4. Wilkinson, D.M. 2007. *Fundamental Processes in Ecology: An Earth System Approach*. Oxford University Press., U.S.A.
5. Kormondy, E.J. 1996. *Concepts of Ecology*. 4th edition. PHI Learning Pvt. Ltd., Delhi, India.
6. Shukla, R.S. and Chandel P.S. 2014. *A Textbook of Plant Ecology Including Ethnobotany and Soil Science*. 12th edition. S. Chand and Company Limited, New Delhi.

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Semester VI - DSE:
BOD 104: BIOFERTILIZERS
Credits: 3 (Theory) + 1 (Practical)
Course Objectives:
This course is designed to give an exposure to various types of biofertilizers and the benefits of their use. The practical component of the course is designed to explore and handle various organisms used in biofertilizer formulations and to prepare biofertilizers from these isolates. These biofertilizers can be used for practicing organic agriculture for sustainable crop production.

THEORY: Total Lectures: 45

Unit 1: Introduction to biofertilizers (5 Lectures)
Concept of biofertilizers; various types of microbes used as biofertilizers; role of effective microorganisms and Plant Growth Promoting Rhizobacteria (PGPR) and their mode of action; benefits and limitations of usage of biofertilizers.

Unit 2: Symbiotic nitrogen fixing microbes (8 Lectures)
Rhizobium - root nodule symbiosis; identification, isolation, mass multiplication, production of carrier-based inoculants, techniques of field application and crop response to rhizobial inoculants; *Frankia* and actinorrhizal symbiosis; *Azolla-Anabaena* symbiosis; mass cultivation and field application of *Azolla* and its role as a green manure-cum-biofertilizer.

Unit 3: Free living nitrogen-fixing microbes (8 Lectures)
Cyanobacteria - diversity, identification, isolation, inoculum preparation, techniques of field application and crop response to cyanobacterial inoculants. *Azospirillum* and *Azotobacter* - identification, isolation, mass multiplication, production of carrier-based inoculants, techniques of field application and crop response. Algalization technology.

Unit 4: Phosphate solubilizing microbes (2 Lectures)
Occurrence, isolation, mass production, field application and crop response to phosphate solubilizing microoganisms.

Unit 5: Mycorrhizae as biofertilizers (7 Lectures)
Types of mycorrhizal association and their characteristics; ectomycorrhizae as biofertilizers; morphology and identification of AM fungal genera; isolation, mass production and field application of AM inoculum; role of mycorrhizae helper bacteria; significance of mycorrhizae in forestry and agriculture.

Unit 6: Organic farming (7 Lectures)

Principle, need and benefits of organic farming; crop rotation and its advantages; types of manure - green manure, farmyard manure and neem-coated urea. Recycling of biodegradable

municipal, agricultural and industrial wastes into biocompost; problems associated with presence of heavy metals and pathogens in biocompost. Method of vermicomposting, its advantages and disadvantages.

Unit 7: Quality control of biofertilizers (4 Lectures)

Standard parameters for quality control**;** quality management procedures; storage conditions and shelf life of biofertilizers; government support and programmes.

Unit 8: Future of biofertilizers (4 Lectures)

Biofertilizers for sustainable agriculture; farmers' acceptance and utilization of biofertilizers; selection of competitive and multi-functional biofertilizers – case study of *Piriformospora indica*.

PRACTICAL: Total Practical: 15P = 15 x 2 hours

1. Identification of any two cyanobacteria from rice fields. **(1P)**
2. Isolation of cyanobacteria using Fogg's medium and preparation of starter culture. **(2P)**
3. Mass culture of cyanobacterial inoculum by trough method. **(1P)**
4. Isolation of *Rhizobium* from root nodules using YEMA medium. **(2P)**
5. Preparation of carrier-based inoculum of *Rhizobium*. **(1P)**
6. Induction of root nodules in a leguminous plant using *Rhizobium* sps. (Demonstration). **(1P)**
7. Study of *Anabaena-Azolla* symbiosis in *Azolla* leaf sections. **(1P)**
8. Isolation of AM spores from soil by wet-sieving and decanting method. **(1P)**
9. Testing for ammonification by soil microbes using Nessler's reagent. **(2P)**
10. Determination of phosphate solubilising efficiency of soil microbes using Pikovskaya agar. **(2P)**
11. Preparation of compost (Demonstration). **(1P)**

Learning Outcomes:

- Develop an insight into the concept of biofertilizers.
- Develop an understanding of the types, formulation, method of field application and the benefits associated with use of biofertilizers.
- Acquire skills in preparation of compost and carrier based bio-inoculum.
- Develop an eco-friendly approach for management of agricultural land and crops in a cost-effective manner.

SUGGESTED READINGS:

1. Vyas, S.C., Vyas, S. and Modi, H.A. 1998. *Bio-fertilizers and Organic Farming*. Akta Prakashan, Nadiad.
2. NIIR Board. 2004. *The Complete Technology Book on Biofertilizer and Organic Farming*. 2nd revised edition.
3. Panda, H. 2011. *Manufacture of Biofertilizer and Organic Farming*. NIIR Board.
4. Sathe, T.V. 2004. *Vermiculture and Organic Farming*. Daya Publishers.
5. Subha Rao, N.S. 2000. *Soil Microbiology*. Oxford & IBH Publishers, New Delhi.
6. Dubey, R.C. 2005. *A Text Book of Biotechnology*. S. Chand & Company, New Delhi.

7. John Jothi Prakash, E. 2004. *Outlines of Plant Biotechnology*. Emkay Publication, New Delhi.
8. Kumaresan, V. 2005. *Biotechnology*. Saras Publications, New Delhi.
9. Rai, M.K. 2006. *Handbook of Microbial Biofertilizers*. Food Products Press, New York.
10. Gupta, P.K. 1999. *Soil, Plant, Water and Fertilizer Analysis*. Agro Botanica, Bikaner.
11. Bisen, P.S. 2014. *Laboratory Protocols in Applied Life Sciences*. CRC Press, Boca Raton.
12. Sharma, K. 2007. *Manual of Microbiology: Tools and Techniques*. 2nd edition. Ane Books Pvt. Ltd., New Delhi.
13. Dubey, R.C. and Maheshwari, D.K. 2002. *Practical Microbiology*. Revised edition. S. Chand & Company, New Delhi.

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Semester VI - DSE:

BOD 105: NURSERY AND GARDENING

Credits: 3 (Theory) + 1 (Practical)

Course Objectives:

This course is designed to give detailed knowledge of operation and management of nursery, greenhouse and gardens. The practical component of the course involves hands-on training in designing landscape and garden layouts, vegetative propagation techniques, and routine nursery and garden operations including kitchen gardening.

THEORY: Total Lectures: 45

Unit 1: Nursery **(7 Lectures)**

Definition, objectives and scope, nursery layout, building up of infrastructure for nursery, management of nursery - planning and seasonal activities - Planting - direct seeding and transplants, potting seedlings, manuring and irrigation, plant protection measures.

Unit 2: Seed **(6 Lectures)**

Structure and types - Seed dormancy, causes and methods of breaking dormancy; Seed storage: Seed banks, factors affecting seed viability, genetic erosion - Seed production and processing - seed testing and certification.

Unit 3: Vegetative propagation **(6 Lectures)**

Methods of vegetative propagation - Layering, grafting, budding, division, offset, suckers, runners, bulbs, corms, bulbils, cuttings. Hardening of plants. Green house, mist chamber, shed roof, shade house.

Unit 4: Gardening **(10 Lectures)**

Definition, objectives and scope - different types of gardens – landscape, avenue plantation and home gardening - parks and its components - plant materials and design - computer applications in landscaping; different features of a garden – fencing, steps, drives and paths, hedge, edging, arches, pergolas, lawns, carpet bedding, flower beds, shrubbery, borders, topiary, rock garden, water garden, garden adornments.

Unit 5: Routine garden operations (4 Lectures)

Preparation of soil, manuring, watering, pruning, staking, defoliation, pinching etc., management of pests and diseases and harvesting.

Unit 6: Indoor gardening (5 Lectures)

Selection and cultivation of house plants; gardening in tubs or urns, hanging baskets, window boxes; gardening in troughs, dishes, bowls and trays; vertical garden; jar, bottle and terrarium gardening; bonsai.

Unit 7: Kitchen garden (7 Lectures)

Kitchen garden layout; classification of vegetables, vegetables in different seasons; organic manures and substrates; preparation of beds; sowing/raising of seeds and seedlings; transplanting of seedlings; study of cultivation of different vegetables: local leafy vegetables (red amaranth and spinach), chillies, cluster beans, cabbage, brinjal, lady's finger, onion, turmeric, ginger, knol khol, sweet potatoes, cucurbits, tomatoes and carrots; storage and marketing procedures.

PRACTICAL: Total Practical: 15P = 15 x 2 hours

1. Different methods of vegetative propagation – Grafting, layering, cutting, budding, runners, suckers, corms, bulbs, bulbils, tubers. **(2P)**
2. Study of some nursery operations - raising seedlings in trays, preparation of potting mix, transplantation of seedlings in pots, care and maintenance of plants till flowering or fruiting. **(2P)**
3. Treatment of seeds (any two types) to break seed dormancy and to find germination percentage of treated seeds. **(2P)**
4. To prepare a garden in bowls, urns, tubs, troughs, hanging baskets, jars, bottles, terrarium gardening (any 3). **(1P)**
5. To prepare a sketch of kitchen garden layout / nursery layout plan. **(1P)**
6. To prepare a landscape design plan for a small home garden. **(1P)**
7. Cultivation of any five local vegetables. **(2P)**
8. Identification and description of avenue plants, hedge plants, flower beds (any 3), lawn (any 2), ornamental shrubs (any 3) and trees (any 3), rock garden plants (any 3), water garden plants (any 3), indoor plants (any 2 of each). **(2P)**
9. Field visit to a plant nursery / landscaped public place / kitchen garden / local vegetable cultivation. **(2P)**

Learning Outcomes:

- Understand the basic concepts of nursery layout and management practices like sowing, planting, potting, vegetative propagation, seed storage and plant protection.
- Understand different features of indoor gardening such as vertical garden, bonsai, terrarium and its routine operations.
- Develop skills in kitchen gardening for cultivation of different vegetables.
- Be able to establish start-ups in gardening/kitchen gardening or work as landscape designers.

SUGGESTED READINGS:

1. Bose, T.K. and Mukherjee, D. 1972. *Gardening in India*. Oxford & IBH Publishing Co., New Delhi.
2. Sandhu, M.K. 1989. *Plant Propagation*. Wiley Eastern Ltd., Bangalore.
3. Kumar, N. 1997. *Introduction to Horticulture*. Rajalakshmi Publications, Nagercoil.
4. Edmond, J.B., Musser, A.M. and Andrews, F.S. 1957. *Fundamentals of Horticulture*. McGraw Hill Book Co., New Delhi.
5. Agrawal, P.K. 1993. *Hand Book of Seed Technology*. Department of Agriculture and Cooperation, National Seed Corporation Ltd., New Delhi.
6. Janick, J. 1979. *Horticultural Science*. 3rd edition. W.H. Freeman & Co., San Francisco, USA.
7. Rao, K. M. 2005. *Textbook of Horticulture*. 2nd edition. Macmillan India Limited.
8. Randhawa, G.S. and Mukhopadhyay, A. 1986. *Floriculture in India*. Allied Publishers Limited.
9. Trivedi, P.P. 1987. *Home Gardening*. Indian Council of Agricultural Research, New Delhi.
10. Rao, P.S. 2016. *Vegetable Crops Production*. Sonali Publications, New Delhi.
11. Zingare, A.K. 2013. *A Manual of Gardening*. Satyam Publishers & Distributors, Jaipur.

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Semester VI - DSE:
BOD 106: HORTICULTURE AND POST-HARVEST TECHNOLOGY
Credits: 3 (Theory) + 1 (Practical)

Course Objectives:
This course deals with the science and techniques applied in cultivation of fruits, vegetables and ornamental plants which perform a vital role in the Indian economy by generating employment, providing raw material to various food processing industries and higher farm profitability. The theoretical and practical components of this course deal with basic horticultural techniques and simple technologies used in reducing post-harvest losses, increase processing levels and add value to horticultural products.

THEORY: Total Lectures: 45

Unit 1: Introduction (4 Lectures)
Scope and Importance, Branches of Horticulture, Role in Rural Economy and Employment Generation, Importance in food and nutritional security, Urban Horticulture and Ecotourism.

Unit 2: Horticultural techniques (6 Lectures)
Application of manure, fertilizers, biofertilizers and nutrients. Weed control, Biopesticides, Irrigation methods (drip irrigation, surface irrigation, furrow and border irrigation); Hydroponics; Propagation methods – vegetative (grafting, cutting, layering, budding) and seed propagation, scope and limitations.

Unit 3: Ornamental plants (4 Lectures)
Types - annuals, perennials, climbers and trees; salient features of some ornamental plants - Rose, Marigold, *Gladilolus,* Carnations, Orchids, Poppies, Gerberas, Tuberose, Cacti and succulents *(Opuntia*, *Agave*, *Kalanchoe)*, *Cassia fistula*, *Delonix regia*, *Nyctanthes arbor-tristis*, *Lawsonia inermis*, *Plumeria rubra*, *Saraca indica*, *Michelia champaca*.

Unit 4: Horticultural crops (fruits and vegetables) (6 Lectures)
Origin and distribution, identification of varieties and cultivars; distribution of some fruits and vegetable varieties (banana, mango, cashew, jackfruit, chillies, brinjal, cucurbits) and their economic products. Management and marketing of vegetable and fruit crops.

Unit 5: Conservation and management of horticultural crops (4 Lectures)
Documentation and conservation, Micropropagation and tissue culture techniques; IPR issues, Local conservation strategies.

Unit 6: Landscaping and garden design (5 Lectures)
Planning and layout of gardens (kitchen garden, rock garden, terrace garden, water garden, lawn making). Gardening traditions – Ancient Indian, European, Mughal and Japanese gardens.

Unit 7: Disease control and management (6 Lectures)

Field and post-harvest diseases; Identification of deficiency symptoms; remedial measures and nutritional management practices; crop sanitation; IPM strategies (genetic, biological and chemical methods for pest control); Quarantine practices; Identification of common diseases and pests of ornamentals, fruits and vegetables crops.

Unit 8: Post-harvest technology (10 Lectures)

Importance of PHT in horticultural crops, Evaluation of quality traits, harvesting and handling of fruits, vegetables; Methods of preservation and processing; minimizing losses during storage and transportation; Food irradiation – advantages and disadvantages; food safety.

PRACTICAL: Total Practical: 15P = 15 x 2 hours

1. Identification (botanical name and family), description, salient features of ornamental plants (based on unit 3). **(2P)**
2. Identification of horticultural crops (botanical name and family) varieties, cultivars and description and their economic products (based on Unit 4). **(2P)**
3. Identification and description (symptoms and remedial measures) of common diseases and pests of ornamentals, fruits and vegetables crops. **(2P)**
4. Demonstration of vegetative propagation. **(1P)**
5. Demonstration of hydroponics. **(1P)**
6. Study of preservation techniques. **(1P)**
7. Study of the preparation of traditional economic products of horticultural crops of Goa (1fruit-jam/squash; 1 vegetable - pickle). **(2P)**
8. Graphic layout of kitchen garden, terrace garden, water garden and list of plants used therein. **(2P)**
9. Field visit to ICAR/Kulagar/Garden/Nursery/Park. **(2 P)**

Learning Outcomes:

- Understand the basic concept of horticulture, its role in economy and various horticultural practices.
- Gain knowledge about different types of ornamental and horticultural crops; their conservation, management and marketing.
- Understand post-harvest practices like handling of fruits and vegetables, their storage and preservation.
- Acquire skills in different landscaping practices and garden design.

SUGGESTED READINGS:

1. Singh, D. and Mannivannan, S. 2009. *Genetic Resources of Horticultural Crops*. Ridhi International, Delhi, India.
2. Swaminathan, M.S. and Kochhar, S.L. 2007. *Grooves of Beauty and Plenty: An Atlas of Major Flowering Trees in India*. Macmillan Publishers, India.
3. NIIR Board. 2005. *Cultivation of Fruits, Vegetables and Floriculture*. National Institute of Industrial Research Board, Delhi.
4. Kader, A.A. 2002. *Post Harvest Technology of Horticultural Crops*. UCANR Publications, U.S.A.
5. Rao, K. M. 2005. *Textbook of Horticulture*. 2nd edition. Macmillan Publishers, India.

BOP 101: PROJECT (4 credits)

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Annexure II

Syllabus for the Swayam Courses

The following Swayam course was recommended by the BoS at postgraduate level

1. BIOMASS CHARACTERIZATION

By Prof.(Dr.) K. Arunkumar | Central University of Kerala

Objectives: There is an immense prospect in the biomass feed stocks to address the growing energy demands and minimize the use of fossil fuel that accelerate global warming. This course cover information on various biomass resources availability and its suitability for different energy conversion. In brief this course impart knowledge and techniques for converting various biomass feedstock into different energy forms by lectures and vitual lab moduless

Course Status :	Upcoming
Course Type :	Elective
Duration :	15 weeks
Start Date :	01 Jan 2021
End Date :	30 Apr 2021
Exam Date :	09 May 2021
Enrollment Ends :	28 Feb 2021
Category :	Biological Sciences & Bioengineering
Level :	Postgraduate

SYLLABUS: COURSE LAYOUT

Week 1

Day 1 : 1. Biomass as a Resource
Day 2 : 2. Advantages of biomass energy among alternative sources
Day 3 : Opportunities and Challenges
Day 4 : Interaction and discussion
Day 5 : Graded and non-graded assignment

Week 2

Day 1 : 4. Forms of biomass – Solid
Day 2 : 5. Forms of biomass –Liquid
Day 3 : 6. Forms of biomass – Gas
Day 4 : Interaction and discussion
Day 5 : Graded and non-graded assignment

Week 3

Day 1 : 7. Biomass Properties
Day 2 : 8. Biomass Recalcitrance
Day 3 : 9. Lignin Characterization
Day 4 : Interaction and discussion
Day 5 : Graded and non-graded assignment

Week 4
Day 1 : 10. Lignin Content in various Biomasses
Day 2 : 11. Non-ligno Cellulosic Biomass(Algae)
Day 3 : 12. Macroalgae (Seaweeds) Cultivation
Day 4 : Interaction and discussion
Day 5 : Graded and non-graded assignment

Week 5
Day 1 : 13. Algal Biomass Processing
Day 2 : 14. Algal Industrial Polymers
Day 3 : 15. Biomass Characterization (Techniques)- I
Day 4 : Interaction and discussion
Day 5 : Graded and non-graded assignment

Week 6
Day 1 : 16. Biomass Characterization (Techniques)- II
Day 2 : 17. Biomass Sample Preparation
Day 3 : 18. Proximate Analysis in Prepared Biomass
Day 4 : Interaction and discussion
Day 5 : Graded and non-graded assignment

Week 7
Day 1 : 19. Ultimate analysis in prepared biomass
Day 2 : 20. Spectroscopy Techniques for Biomass Characterization
Day 3 : 21. Microscopy and Particle Size Distribution (Rheological Properties) Analyses
Day 4 : Interaction and discussion
Day 5 : Graded and non-graded assignment

Week 8
Day 1 : 22. Extractive methods of processing the biomass
Day 2 : 23. Pretreatment methods of processing the biomass
Day 3 : 24. Thermochemical properties of digested/pre-treated biomass
Day 4 : Interaction and discussion
Day 5 : Graded and non-graded assignment

Week 9
Day 1 : 25. Biomass Hydrolysization
Day 2 : 26. Biomass-Combustion
Day 3 : 27. Gasification
Day 4 : Interaction and discussion
Day 5 : Graded and non-graded assignment

Week 10
Day 1 : 28. Pyrolysis and Liquefaction
Day 2 : 29. Fermentation(Principles and types) I
Day 3 : 30. Fermentation (Fermentors and Products)-II
Day 4 : Interaction and discussion

Day 5 : Graded and non-graded assignment

Week 11

Day 1 : 31. Biohydrogen generation
Day 2 : 32. Biomethane generation
Day 3 : 33. Electricity production from Biomass
Day 4 : Interaction and discussion
Day 5 : Graded and non-graded assignment

Week 12

Day 1 : 34. By-products utilization
Day 2 : 35. Biomass storage simulation
Day 3 : 36. Biomass experimental validation
Day 4 : Interaction and discussion
Day 5 : Graded and non-graded assignment

Week 13

Day 1 : 37. Biomass process optimization
Day 2 : 38. Industrial operation of ethanol production
Day 3 : Interaction and discussion
Day 4 : Interaction and discussion
Day 5 : Graded and non-graded assignment

Week 14

Day 1 : 39. Future directions on biomass energy by CC views
Day 2 : 39. Future directions on biomass energy by other modules presentors views.
Day 3 : Interaction and discussion
Day 4
Day 5 : Graded and non-graded assignment

Week 15

Day 1 : 40. Over all interaction with CC and other modules presenters.

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The following Swayam course was recommended by the BoS at undergraduate level

1. **FUNDAMENTALS OF BIOINFORMATICS**

By Dr. VIVEK P J | Sree Neelakanta Govt. Sanskrit College, Pattambi

Objectives: The proposed course is framed for UG students in the life science or biological sciences domain. Through this course, the students will be able to address some questions like, How do we find potentially harmful mutations in your genome? How can we reconstruct the evolutionary Tree of Life? How do we compare related genes from different species? These are just three of the major questions in modern biology that can only be answered using bioinformatics approaches. The course will delve into computational ideas used in biology as well as let students apply existing resources that are used in practice every day by bioinformatics professionals. The course offers an opportunity for students who possess a biological background to become more familiar with the biological process occurring within an organism at genetic level.

Course Status :	Upcoming
Course Type :	Core
Duration :	13 weeks
Start Date :	18 Jan 2021
End Date :	
Exam Date :	
Category :	
Level :	Undergraduate

SYLLABUS: COURSE LAYOUT

Week 1
Day1 Module 1: Origin, History, and Scope of Bioinformatics
Day2 Module 2: Importance and Use of Bioinformatics
Day3 Module 3: Applications of Bioinformatics
Day4 Interaction based on the three modules covered
Day5 Deadline for submitting assignments

Week 2
Day1 Module 4: IT in teaching, Learning and Research
Day2 Module 5: Open Access Bibliographic Resources
Day3 Module 6: Basic Concepts of Copyrights and Patents
Day4 Interaction based on the three modules covered
Day5 Deadline for submitting assignments

Week 3
Day1 Module 7: Central Dogma and Emergence of Omics Technologies
Day2 Module 8: Genomics and Transcriptomics
Day3 Module 9: Proteomics and Metabolomics

Day4 Interaction based on the three modules covered
Day5 Deadline for submitting assignments

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Week 4
Day1 Module 10: Introduction to Biological Databases
Day2 Module 11: Sequence and Structural Databases
Day3 Module 12: Functional and Other Databases
Day4 Interaction based on the three modules covered
Day5 Deadline for submitting assignments

Week 5
Day1 Module 13: Basic Concepts of Sequence Similarity and Identity
Day2 Module 14: File Formats for Sequences
Day3 Module 15: Sequence – Patterns and Profiles
Day4 Interaction based on the three modules covered
Day5 Deadline for submitting assignments

Week 6
Day1 Module 16: Scoring Matrices
Day2 Module 17: Sequence – Pairwise alignments
Day3 Module 18: Multiple Sequence Alignments
Day4 Interaction based on the three modules covered
Day5 Deadline for submitting assignments

Week 7 Day1 Module 19: GenBank
Day2 Module 20: BLAST
Day3 Module 21: Protein Data Bank (PDB)
Day4 Interaction based on the three modules covered
Day5 Deadline for submitting assignments

Week 8
Day1 Module 22: Taxonomy and Phylogeny
Day2 Module 23: Phylogenetics – Methods
Day3 Module 24: Phylogenetics – Tools
Day4 Interaction based on the three modules covered
Day5 Deadline for submitting assignments
Week 9
Day1 Module 25: Molecular Modelling
Day2 Module 26: Molecular visualization – Rasmol and Pymol
Day3 Module 27: Molecular docking
Day4 Interaction based on the three modules covered
Day5 Deadline for submitting assignments

Week 10
Day1 Module 28: Definition of Drugs and its Advances
Day2 Module 29: Pharmacophore Identification and Novel Drug Design
Day3 Module 30: Structure based drug design

Day4 Interaction based on the three modules covered
Day5 Deadline for submitting assignments

Week 11
Day1 Module 31: DNA sequencing – Basic methods
Day2 Module 32: Next Generation Sequencing (NGS)
Day3 Module 33: Human Genome Project
Day4 Interaction based on the three modules covered
Day5 Deadline for submitting assignments

Week 12
Day1 Module 34: Protein structure – Primary, Secondary, Tertiary and quaternary
Day2 Module 35: Protein Structure Prediction
Day3 Module 36: Protein Interaction analysis
Day4 Interaction based on the three modules covered
Day5 Deadline for submitting assignments

Week 13
Day1 Module 37: Gene Prediction
Day2 Module 38: Mapping populations
Day3 Interaction based on the two modules covered
Day4 Revision
Day5 End term assessment

BOOKS AND REFERENCES

- Introduction to Bioinformatics, 5th Edition – Arthur Lesk; Oxford University Press
- Bioinformatics-sequence and genome analysis, 2nd Edition – David W Mount; Cold Spring Harbor Laboratory Press
- Fundamentals of Bioinformatics – Harisha S; I K International Publishing House
- Introduction to Bioinformatics, 1st Edition – Attwood; Pearson Publications
- Essential Bioinformatics – Jin Xiong – Cambridge University Press

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Annexure III

Programme: M.Sc. (Botany)
Course code: BOO-454
Title of the Course: Intellectual Property Rights
Number of Credits: 1

Prerequisite for the Course:	Basic knowledge of intellectual property rights at UG level	
Objective:	Introduce students to basic knowledge on intellectual property rights, IPR policies and biopiracy with their use in Research and Product development.	
Content:	**1. Introduction to IPR**; Types of IP: Patents, Trademarks, Copyright, Traditional Knowledge, industrial design, Geographical Indications, History of GATT, WTO, WIPO and TRIPS; Protection of GMOs; International framework for the protection of IP; Farmers Rights Act and protection of new plant varieties (UPOV), concept of prior art; Patent Databases - country-wise patent searches (USPTO, EPO, India); Types of patents; Indian Patent Act 1970; Recent Amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications. **2. Procedure for filing a PCT application**: Patent Application-forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; role of a Country Patent Office; International Patenting- requirement, procedures and costs; Financial assistance for patenting-existing schemes; Publication of patents-Gazette of India, Status in Europe and US; Patent Infringement; Commercialization of patented innovations; Licensing -outright sale, licensing, royalty; 3. **IP in Research and Development**: Patenting by research laboratories, university/organizational rules in India and abroad, Collaborative research - backward and forward IP; benefit/credit sharing among parties/communities. Protection of environment and biodiversity – Biopiracy, Equity sharing.	4 h 4h 4h
Learning Outcomes:	On completion of this course students will understand the principles of IPR, different types of IPRs, patents and regulations (national and international), Indian IPR Policy. Students will be able to understand and apply intellectual property rights in general and protection of products derived from research.	

Pedagogy:	Lectures/Tutorials/Seminars/Assignment/Self study	
References/Readings:	1. Adukia S. R. (2012). Handbook On Intellectual Property Rights In India. 2. David C. (2009)The Role of Intellectual Property Rights in Biotechnology Innovation, Edward Elgar Publishing Limited, UK 3. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub. 4. Lionel B. and Brad S. (2008) Intellectual property law, Oxford University Press. 5. Sreenivasulu, N.S. and Raju C.B. (2008) Biotechnology and Patent laws: patenting living beings, Manupatra Publishers. 6. Trevor M. (2007) A User's Guide to Patents, Tottel Publishing. 7. International Union for the Protection of New Varieties of Plants. http://www.upov.int 8. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce GoI, National Portal of India. http://www.archive.india.gov.in 9. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/	

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Programme: M.Sc. (Botany)
Course code: BOO-455
Title of the Course: Bioinformatics
Number of Credits: 2

Prerequisite for the Course:	Knowledge of computers, Internet, Modern biology and biochemistry.	
Objective:	Course has focus on rapidly advancing fields of basics of bioinformatics (stress on genomics and proteomics), incorporating many hands on practice lessons with a wide range of public domain software tools, demos and mini projects assisting the students to pick up the minimum required skill sets demanded by bioknowledge based industries	
Content:	**1. Introduction to Bioinformatics**: Nature of biological data, Overview of available Bioinformatics resources on the web, NCBI/EBI/EXPASY; Biological Databases: Nucleic acid sequence databases, GenBank/EMBL/DDBJ Protein sequence databases, PDB, SwissProt, UniProtKB, Genome databases-OMIM, structural databases, NDB, CCSD, drived databases Prosite, BLOCKS, Pfam/Prodom, Database search engines, Entrez , SRS.	4 h
	2. Overview/concepts in sequence analysis: Pairwise sequence alignment algorithms, Scoring matrices for Nucleic acids and proteins, Database Similarity Searches – BLAST, FASTA Multiple sequence alignment, PRAS, CLUSTALW.	3h
	3. Structural biology and molecular modeling: Proteins - Primary, Secondary, Supersecondary, Tertiary and Quaternary structure, Nucleic acid - DNA and RNA, Carbohydrates, 3D Viral structures, Methods to study 3D structure, Analysis of 3D structures. Principles of protein folding and methods to study protein folding. Macromolecular interactions, Protein-Protein, Protein-Nucleic acids, Protein-carbohydrates. Introduction to Molecular modelling methods.	4h
	4. Phylogenetic analysis: Alignment, tree building and tree evaluation, Comparison and application of Unweighted Pair Group Method with Arithmetic Mean (UPGMA), Neighbour Joining (NJ), Maximum Parsimony (MP), Maximum Likelihood (ML) methods, Bootstrapping, Jackknife; Software for Phylogenetic analysis. DNA barcoding: Methods tools and databases for barcoding across all species, Applications and limitations of barcoding, Consortium for Barcode of Life (CBOL) recommendations, Barcode of Life Database (BOLD).	4h
	5. Analysis of DNA and Protein Microarrays: Designing of oligo probes; Image processing and normalization; Microarray data variability (measurement and quantification); Analysis of differentially expressed genes; Experimental designs.	4h
	6. Application in drug design: Chemical databases like NCI/PUBCHEM; Fundamentals of Receptor-ligand interactions; Structure-based drug design: Identification and Analysis of Binding sites and virtual	5h

	screening; Ligand based drug design: Structure Activity Relationship – QSARs & Pharmacophore; in silico predictions of drug activity and ADMET.	
Learning Outcomes:	Student will be able to: 1) Develop an understanding of basic theory of computational tools. 2) Gain working knowledge of these computational tools and methods. 3) Appreciate their relevance for investigating specific contemporary biological questions.	
Pedagogy:	Lectures/Tutorials/Seminars/Assignment/Self study	
References/Readings:	1. Andrew Leach. 2001. Molecular Modeling: Principles and Applications, Prentice Hall. 2. Attwood, T. K. and Parry-Smith, D. J. 2001. Introduction to Bioinformatics Delhi. Pearson Education (Singapore) Ptd. Ltd 3. Baxevanis, A. D. and Ouellettee, B. F. F. 2002. Bioinformatics: A Practical Guide to the analysis of Genes and Proteins. (2nd Ed.), New York, John Wiley & Sons, Inc. Publications 4. Baxevanis, A. D., Davison, D. B., Page, R. D. M. and Petsko, G. A. 2004.Current Protocols in Bioinformatics by, New York, John Wiley & Sons Inc. 5. Dov Stekel, (2003); Microarray Bioinformatics; Cambridge University Press 6. Fasman, G.D. 1989. Prediction of protein structure and the principles of protein conformation. New York. Plenum Press. 7. Friesner, R.A. Ed., Prigogine, L. Ed. and Rice, S.A. 2002. Computational methods for protein folding: advances in chemical physics vol. 120. New York. John wiley & sons, Inc. Publication. 8. Gimona, G. Cesareni and Yaffe, M. Sudol (EDS.). 2004. Modular protein domains, USA, Wiley-vch Verlag gmbh & co. 3-527-30813-X . 9. Gundertofte, K. and Jorgensen, F.S. 2000. Molecular modelling and prediction of bioactivity, New York. Kluwer Academic Publishers. 10. J. bajorath 2004. Chemoinformatics: Concepts, Methods, and Tools for Drug Discovery (Methods in Molecular Biology), Humana Press 11. Mount, David. 2004. Bioinformatics: Sequence and Genome Analysis. New York, Cold Spring Harbor Laboratory Press. 12. Philip E. Bourne and Helge Weissig. 2003. Structural Bioinformatics - Methods of biochemical Analysis V. 44. New Jersey. Wiley-Liss 13. Rastogi, S.C., Mediratta, N. and Rastogi. P. 2004. Bioinformatics, methods and applications, genomics, proteomics and drug discovery, Prentice hall of India, pvt. Ltd., New Delhi. 14. Stephen Misener and Stephen Krawetz. 2004. Bioinformatics, methods and protocols, methods in molecular biology, Volume 132, Humana Press, New Jersey, Third Indian reprint 15. Webster, D. M. Ed. 2000. Protein structure prediction: methods and protocols, Totowa Humana Press, 2000.	

	Public domain database/tools/resources DBGET-http://www.genome.jp/dbget/ LinkDB-http://www.genome.jp/dbget/linkdb.html Fgeneshttp://www.softberry.com/berry.phtml?topic=products GeneBuilder-http://www.itb.cnr.it/sun/webgene/ GeneSCAN-http://genes.mit.edu/GENSCAN.html GRAIL-http://compbio.ornl.gov/Grail-1.3/ CLC Free Workbench http://www.clcbio.com/index.php?id=28 BioEditor-http://bioeditor.sdsc.edu/ CN3D 4.1 - http://www.ncbi.nlm.nih.gov/Structure/CN3D/cn3d.shtml Protein Explorerhttp://www.umass.edu/microbio/chime/pe_beta/pe/protexpl/f rntdoor.htm Chimera-http://www.cgl.ucsf.edu/chimera/ Yasara-http://www.yasara.comhttp://www.yasara.com) Ribosome builder-http://rbuilder.sourceforge.net/ ArrayExpress-www.ebi.ac.uk/arrayexpress/ EPICLUST-http://ep.ebi.ac.uk/EP/	

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Programme: M.Sc. (Botany)
Course code: BOO-456
Title of the Course: Lab in Bioinformatics
Number of Credits: 1

Prerequisite for the Course:	Basic knowledge of biochemistry and molecular biology, computers and Internet, biodiversity and genomics.	
Objective:	Provide students with practical experience of use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts. To train the students in modern areas of biological analysis.	
Content:	1. Exploring NCBI database, PUBMED and GenBank databases, EBI server and searching the EMBL Nucleotide database, Entrez, SWISSPROT & UniProtKB 2. Use of scoring matrices, Pair-wise local alignments of protein and DNA sequences using Smith-Waterman algorithm and interpretation of results. 3. Homology searches using different versions of BLAST and FASTA and interpretation of the results to derive the biologically significant relationships of the query sequences (proteins/DNA) with the database sequences. 4. Multiple sequence alignments of sets of sequences using web based and stand-alone version of CLUSTAL. Interpretation of results to identify conserved and variable regions and correlate them with physico-chemical and structural properties. 5. Search and retrieval: genomic and OMIM data at NCBI server, Interpreting DNA and Protein microarray data. 6. Use of gene prediction methods (GRAIL/Genscan,/Glimmer), various	2h 1 h 1h 1h 1h 1h

	primer designing and restriction site prediction tools. 7. Use of different protein structure prediction databases (PDB, SCOP, CATH). 8. Exploring and using the derived databases: PROSITE, PRINTS, BLOCKS, Pfam and Prodom for pattern searching, domain searches, etc.) 9. Construction and study of protein structures using RASMOL/Deepview/PyMol. Homology modelling of proteins. Use of tools for mutation and analysis of protein structures. 10. Phylogenetic analysis of protein and nucleotide sequences, tree building, databases for barcoding.	1h 1h 1h 2h
Learning Outcomes:	Student will be able to: 1) Develop an understanding of basic theory of computational tools. 2) Gain working knowledge of these computational tools and methods. 3) Appreciate their relevance for investigating specific contemporary biological questions.	
Pedagogy:	Internet based tools, hands on and group exercises, mini projects, videos, moodle guided exercises, videos, expert lectures, industrial visits, seminars.	
References/Readings:	1. Andrew Leach. 2001. Molecular Modeling: Principles and Applications, Prentice Hall. 2. Attwood, T. K. and Parry-Smith, D. J. 2001. Introduction to Bioinformatics Delhi. Pearson Education (Singapore) Ptd. Ltd 3. Baxevanis, A. D. and Ouellettee, B. F. F. 2002. Bioinformatics: A Practical Guide to the analysis of Genes and Proteins. (2nd Ed.), New York, John Wiley & Sons, Inc. Publications 4. Baxevanis, A. D., Davison, D. B., Page, R. D. M. and Petsko, G. A. 2004.Current Protocols in Bioinformatics by, New York, John Wiley & Sons Inc. 5. Dov Stekel, (2003); Microarray Bioinformatics; Cambridge University Press 6. Fasman, G.D. 1989. Prediction of protein structure and the principles of protein conformation. New York. Plenum Press. 7. Friesner, R.A. Ed., Prigogine, L. Ed. and Rice, S.A. 2002. Computational methods for protein folding: advances in chemical physics vol. 120. New York. John wiley & sons, Inc. Publication. 8. Gimona, G. Cesareni and Yaffe, M. Sudol (EDS.). 2004. Modular protein domains, USA, Wiley-vch Verlag gmbh & co. 3-527-30813-X . 9. Gundertofte, K. and Jorgensen, F.S. 2000. Molecular modelling and prediction of bioactivity, New York. Kluwer Academic Publishers. 10. J. bajorath 2004. Chemoinformatics: Concepts, Methods, and Tools for Drug Discovery (Methods in Molecular Biology), Humana Press 11. Mount, David. 2004. Bioinformatics: Sequence and Genome Analysis. New York, Cold Spring Harbor Laboratory Press. 12. Philip E. Bourne and Helge Weissig. 2003. Structural Bioinformatics - Methods of biochemical Analysis V. 44. New Jersey. Wiley-Liss 13. Rastogi, S.C., Mediattta, N. and Rastogi. P. 2004. Bioinformatics,	

	methods and applications, genomics, proteomics and drug discovery, Prentice hall of India, pvt. Ltd., New Delhi. 14. Stephen Misener and Stephen Krawetz. 2004. Bioinformatics, methods and protocols, methods in molecular biology, Volume 132, Humana Press, New Jersey, Third Indian reprint 15. Webster, D. M. Ed. 2000. Protein structure prediction: methods and protocols, Totowa Humana Press, 2000. **Public domain database/tools/resources** DBGET-http://www.genome.jp/dbget/ LinkDB-http://www.genome.jp/dbget/linkdb.html Fgeneshttp://www.softberry.com/berry.phtml?topic=products GeneBuilder-http://www.itb.cnr.it/sun/webgene/ GeneSCAN-http://genes.mit.edu/GENSCAN.html GRAIL-http://compbio.ornl.gov/Grail-1.3/ CLC Free Workbench http://www.clcbio.com/index.php?id=28 BioEditor-http://bioeditor.sdsc.edu/ CN3D 4.1 - http://www.ncbi.nlm.nih.gov/Structure/CN3D/cn3d.shtml Protein Explorerhttp://www.umass.edu/microbio/chime/pe_beta/pe/protexpl/f rntdoor.htm Chimera-http://www.cgl.ucsf.edu/chimera/ Yasara-http://www.yasara.comhttp://www.yasara.com) Ribosome builder-http://rbuilder.sourceforge.net/ ArrayExpress-www.ebi.ac.uk/arrayexpress/ EPICLUST-http://ep.ebi.ac.uk/EP/	

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D 3.10 Minutes of the meeting of the Board of Studies in Civil Engineering held on 06.01.2021.

Annexure I

FOLLOWING NPTEL COURSES ARE SUGGESTED FOR FOURTH SEMESTER CIVIL ENGINEERING REVISED SCHEME (REVISED COURSE 19-20)

Sr.No	Course	Number of weeks	Credits
1	Electronic Waste Management - Issues and Challenges	4 weeks	1
2	Introduction to History of Architecture in India	4 weeks	1
3	Landscape Architecture and Site Planning - Basic Fundamentals	8 weeks	2
4	Plastic Waste Management	8 weeks	2
5	Architectural Conservation and Historic Preservation	8 weeks	2
6	Digital Land Surveying And Mapping (DLS&M)	8 weeks	2
7	Safety in Construction	8 weeks	2
8	Natural Hazards	8 weeks	2
9	Enhancing Soft Skills and Personality	8 weeks	2
10	Speaking Effectively	8 weeks	2
11	Soft Skill Development	8 weeks	2
12	Foundation Course in Managerial Economics	8 weeks	2
13	Engineering Mechanics - Statics and Dynamics	8 weeks	2
14	Engineering/Architectural Graphics - part I - Orthographic projection	8 weeks	2
15	Basic construction materials	12 weeks	3
16	Geotechnical Engineering - 1	12 weeks	3
17	Geology and Soil Mechanics	12 weeks	3
18	Hydraulic Engineering	12 weeks	3

Note: Students are also eligible to take other interdisciplinary courses which are not mentioned here but available on NPTEL/MOOOCS, at his /her his own capacity with due information to Department. The credits will be awarded based on the scheme proposed above. The student shall submit all the NPTEL/SWAYAM certificates to university through Heads of Department while applying for the degree.

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Annexure II

QUESTION PAPER PATTERN (ONLINE EXAM)

Approved by BOS Civil Engg.

[CV350: COMPUTER-AIDED BUILDING PLANNING AND DESIGN]

Syllabus will have 4units and it is as per latest revision accepted by Goa University.
Question paper shall be drawn as follows:

Question No	From Units	No. of Questions to be Set	No. of Questions to be Answered
1 (Part A)	2 OR 3 (Complete Floor Plan only)	1 x 20marks	1 x 20= 20 marks
2&3 (Part B)	2 OR 3 (Line Plan)	2x15 marks	1 x 15= 15 marks
4 & 5 (Part C)	4 &1 (Perspective drawing) ON 2 OR 3 or Theory	2 x 15 marks	1 x 15= 15 marks
Total		5–80 marks	3 - 50 marks

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SAMPLE QUESTION PAPER

SUBJECT: CV 350: COMPUTER-AIDED BUILDING PLANNING AND DESIGN

MARKS: 50 **MAXIMUM DURATION: 2 hours**

Instructions to the candidates:

1. Q. No. 1 is compulsory
2. Answer one question each from Part B and C

Part –A (One Question to be drawn from Unit 2or 3...complete floor plan only)

Answer the following question: 1 x 20= 20 Marks

Question-1: Plan a Residential or Public Buildings (give required details) 20 Marks

Part –B (One Question to be drawn from Unit 2 or 3)

Answer the following question: 1 x 15= 15 Marks

Question-2:Line Plan of a Public or Residential Building 15 Marks

Question-3: Draw Section **OR** Elevation of the building drawn in Q No: 1 above 15 Marks

Part –C (One Question to be drawn on perspective drawings set above in part A or B and One Question to be drawn from ANY UNIT with more stress on Unit 1 Theory)

Answer any **ONE** question from the following: 1 x 15= 15 Marks

Question-4: Perspective drawing on residential/public building in part A or Part B above 15 Marks

Question- 5: On theory..... 3 x 5= 15 Marks

a)

b)

c)

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D 3.11 Minutes of the meeting of the Board of Studies in Electrical & Electronics Engineering Held on 09.01.2021.

Annexure I

FOLLOWING NPTEL COURSES ARE SUGGESTED FOR FOURTH SEMESTER ELECTRICAL & ELECTRONICS ENGINEERING REVISED SCHEME (REVISED COURSE 19-20)

Sr.No	Course	Number of weeks	Credits
1	Modern Digital Communication Techniques	12 weeks	3
2	Power Management Integrated Circuits	13 weeks	3
3	Sensors and Actuators	12 weeks	3
4	Energy Resources, Economics and Environment	12 weeks	3
5	Biomass conversion and biorefinery	12 weeks	3
6	Conservation economics	12 weeks	3
7	Elements of solar energy conversion	12 weeks	3
8	Antennas	12 weeks	3
9	Electromagnetic waves in guided wireless media	8 week	2
10	Transmission Lines and Electromagnetic waves	12 weeks	3

Note: The credits will be awarded based on the scheme proposed above. The student shall submit all the NPTEL/SWAYAM certificates to university through Heads of Department while applying for the degree.

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