FOUR YEARS UNDER GRADUATE (FYUG) PROGRAMME UNDER NEW EDUCATION POLICY, 2020

Syllabus for B.Sc. Botany
(Semesters 7th and 8th)
Date of approved by the Academic Council: 21/05/2025

7th Semester

Course Code	Course Title	Credits			Total contact hours
		Theory	Practical	Total	
BOT-400	Research Methodology and Proposal Writing (Major)	4	-	4	60
BOT-401	Industrial, Agricultural and Environmental Microbiology (Major)	3	1	4	75
BOT-402	Forestry and Agroforestry (Major)	3	1	4	75
BOT-403	Ecosystem Analysis (Major)	3	1	4	75
BOT-404	Fungi and Plant Pathology (Minor)	4	-	4	60
	Total	17	3	20	345

8th Semester

Course Code	Course Title		Credits			Total Contact Hours
			Theory	Practical	Total	
BOT-450	Tools and Techniques in Plant sciences (Major)		3	1	4	75
BOT-451	Physiology and Genetics of Plants (Minor)		4	-	4	60
BOT-452	Project/dissertation (Major course)		-	12	12	360
BOT-453	Statistical Analyses and Bioinformatics (Major)		-	4	4	120
BOT-454	Fundamentals of Genetic Engineering (Major)		-	4	4	120
BOT-455	Bioeconomy and Entrepreneurship (Major)		4	-	4	60
	Total	Honours	11	9	20	435
		Honours with Research	7	13	20	495

SUB-452 shall be a course for students choosing a 4-year UG degree (Honours with Research).
SUB-453 & SUB-454 shall be practical courses for subjects with practical components.
SUB-453, SUB-454 & SUB-455 shall be advanced courses for students choosing a 4-year UG degree (Honours).

7th SEMESTER

BOT-400 Research Methodology and Proposal Writing **Total Credits: 4**
(Contact Hours: 60)
Total Marks: 100

Course Objectives:

- The objective of the course is to provide a familiarization with research methodology and to induct the students into the overall research process and methodologies.

Learning Outcomes:

After the completion of the course, the students will learn:

- Collection and analysing of the data and survey of literature.
- Scientific research process and writing research proposals, publications and ethics.
- Presentation of the results and writing of manuscripts.

(Theory)

Unit 1 (1 Credit)

Basic concepts of research: Research-definition and types of research (descriptive vs. analytical; applied vs. fundamental; quantitative vs. qualitative; conceptual vs. empirical); Research methods vs. methodology; literature-review and its consolidation; library research; field research; laboratory research.

Unit 2 (1 Credit)

Biosafety measures in Microbiology and Genetic Engineerining Laboratories; data collection, analysis and documentation; maintaining a laboratory record; tabulation and generation of graphs; imaging of tissue specimens and application of scale bars.

Unit 3 (1 Credit)

Methodology and scientific writing: numbers, units, abbreviations and nomenclature used in scientific writing; Structure and contents of a research paper; writing references; scientific writing and ethics; introduction to research impact, journal impact and author impact.

Unit 4 (1 Credit)

Synopsis writing; structure and contents of a research proposal; presenting research proposals; power point presentation; poster presentation; introduction tocopyright-academic misconduct/plagiarism.

Suggested readings:

1. Dawson, C. 2002. Practical Research Methods. UBS Publishers, New Delhi.
2. Kothari, C.R. 2019. Research Methodology: Methods and Techniques. 4th edition. New Age International Publishers.
3. Ruzin, S.E. 1999. Plant Microtechnique and Microscopy. Oxford University Press, New York, U.S.A.
4. Stapleton, P., Yondeowei, A., Mukanyange, J. and Houten, H. 1995. Scientific Writing for Agricultural Research Scientists – a Training Reference Manual. West Africa Rice Development Association, Hong Kong.

BOT-401 **Industrial, Agricultural and Environmental Microbiology**

Total Credits:4
(Contact Hours: 75)
Total Marks: 100

Course Objectives:

- To develop an understanding of the uses of microbes in industry and agriculture.
- To impart knowledge of role of microbes in environment:
- To enrich students with knowledge regarding basic, advanced and applicable concepts in emerging areas of Industrial Microbiology.

Learning Outcomes:

On successful completion of the course, students will be able to:

- Understand how microorganisms are involved in the manufacture of industrial products and designing of bioreactors.
- Understand the process of medium formulation & design for microbial fermentation, underlying principles of upstream and down- stream processing and sterilization process.
- Learn about the different methods for microbial isolation and detection from different habitats.
- Understand the basic principles of environmental microbiology and their application in waste water treatment, bioremediation and role of microbes in agriculture.

(Theory) **Credits:3**

(Contact hours: 45)

Unit 1 (1 Credit)

Scope and importance of microbes in industry, agriculture and environment. Institutes of microbial research of national and international importance; Industrial fermentation: solid-state and liquid state (stationary and submerged) fermentations; batch and continuous fermentations; Bioreactors/ fermenters: components of a typical bioreactor, types of bioreactors.

Unit 2 (1 Credit)

Industrial production of important microbial products: enzyme (amylase), organic acid (citric acid), alcohol (ethanol), antibiotic (penicillin), vitamin (cobalamin) and Baker's yeast. Biogas production; Soil Microbiology: soil microflora and its enumeration, agriculturally important microbes, Microbial biostimulants; rhizosphere, phyllosphere and mycorrhizae; Concepts of microbial bioremediation. Principles and degradation of common pesticides, organic (hydrocarbons, oil spills) and inorganic (metals) matter, biosurfactants.

Unit 3 (1 Credit)

Aerobiology: droplet nuclei, aerosol, assessment of air quality, airborne diseases and their control, enumeration of microbes from air; Water microbiology: fresh water and marine ecosystems. Water borne diseases and their control; Waste management: sources and types of solid waste, methods of solid waste disposal for different types of wastes. Principle and design of Sewage Treatment Plans (STPs).

Unit 4 **(Practical)** **Credit: 1**
(Contact Hours: 30)

1. Hydrolysis of casein / starch by microorganisms.
2. Alcohol production by yeast using sugar/ jaggery.
3. Isolation of microbes (bacteria & fungi) from rhizosphere.
4. Isolation of microorganisms from water.
5. Determination of BOD, COD, TDS and TOC of water samples.
6. Determination of coliforms in water samples using eosin methylene blue (EMB) medium.
7. A visit to any educational institute/ industry to understand the uses of microbes for industrial applications and a report to be submitted for the same.

Suggested readings:

1. Atlas, R.M. and Bartha, R. 2009. Microbial Ecology: Fundamentals and Applications. Pearson, San Francisco.
2. Bertrand, Jean-Claude, Caumette, P. Lebaron, P, Matheron, R., Normand, P., and Sime Ngando, T. 2015. Environmental Microbiology: Fundamentals and Applications. Springer.
3. Casida, J.R. 2019. Industrial Microbiology. 2nd Edition. New Age International Publishers, New Delhi.
4. Mohapatra, P.K. 2008. Textbook of Environmental Microbiology. I.K. International Publishing House Pvt. Ltd.
5. Patel, A.H. 2008. Industrial Microbiology. McMillan India limited.
6. Pelczar, M.J. Jr., Chan E.C.S. and Krieg, N.R. 2010. Microbiology: An application-based approach. McGraw Hill Education Pvt. Ltd., Delhi.
7. Reed, G. 2004. Prescott and Dunn's Industrial Microbiology. 4th Edition. CBS Publishers and Distributors Pvt. Ltd.
8. Sharma, P.D. 2016. Environmental Microbiology. Rastogi Publications.
9. Singh, R.P. 2020. Microbiology. Kalyani Publishers.
10. Stanbury, P.F., Whitaker, A. and Hall, S.J. 2017. Principles of Fermentation Technology. Elsevier Publication.
11. Tortora, G.J., Funke, B.R. and Case. C.L. 2007. Microbiology. 9th edition. San Francisco, SF: Pearson Benjamin Cummings.
12. Willey, J.M. 2023. Prescott's Microbiology. 12th edition. McGrew Hill.

BOT-402 **Forestry and Agroforestry** **Total Credits: 4**
(Contact Hours: 75)
Total Marks: 100

Course Objectives:

- To impart knowledge of forest, its classification and commercial importance in the field of agroforestry and nursery management.

Learning Outcomes:

After the completion of the course, the students will be able to:

- Understand about types of forests, forest resources and their management, and policies governing forest management, forest-based industries and trade patterns of forest based raw materials.
- Develop understanding about the concept of agriculture and agroforestry, reflect on the traditional agroforestry systems in India.
- Develop the knowledge and qualities of business in the sector of forestry by preparing nursery and to established business related to nursery.

(Theory) **Credits: 3**
(Contact Hours:45)

Unit 1 (1 Credit)

Forests: Definition, role, benefits; history of forestry in India. Classification of forests according to Champion and Seth, (1968) and as per FSI and Indian Forest Act 1972; Farm forestry, social forestry, Joint Forest Management. Forest-based industries in the developed and developing countries; Trade patterns of forest based raw materials including Non- Wood Forest Products (NWFPs); Forest policies, rules and acts in India.

Unit 2 (1 Credit)

General Silvicultural Principles: Ecological and physiological factors influencing vegetation, natural and artificial regeneration of forests; Nursery management: Propagation concept of plants and importance; site selection, planning and layout of nursery. Types of nurseries and preparation of beds; Pre-sowing treatments and methods of seed sowing. Preparation of ingredient mixture. Water budgeting, grading, and hardening of seedlings. Vegetative propagation techniques – macro- and micropropagation; Nursery practices for some tree species: *Tectona grandis*, *Acacia* sp. and *Dalbergia sissoo*

Unit 3 (1 Credit)

Definition, roles and benefits of agroforestry; social, ecological, and economic reasons for agroforestry; Components of Agroforestry, provisioning and regulator services of agroforestry; Tree Management: structure and growth of trees, crown and root architecture; Crop planning and management: selection of suitable crops, management of nutrients, water and weeds.

Unit 4 **(Practical)** **Credit: 1**
(Contact Hours: 30)

1. Study of morphology and phenology of tree species growing in an area.
2. Studies on light and below ground interactions in agroforestry systems.
3. Preparation of production and planning schedule for bare root and containerized nurseries. Nursery site and bed preparation.
4. Pre-sowing treatments and sowing methods of small, medium and large sized seeds.
5. Pricking and transplanting of pricked out stock within nursery in transplant beds.

Suggested readings:

1. Beazley, M. 1981. The International Book of Forest. Simon and Schuster, Inc., New York, USA.
2. Champion, H.G. and Seth, S.K. 1968. A Revised Survey of the Forest Types of India. Manager of Publications, Government of India, New Delhi. India.
3. Duryea, M.L. and Landis, T.D. 1984. Forest nursery manual: production of bare root seedlings. Martinus Nijhoff. Hague.
4. Dwivedi, A.P. 1989. Text Book of Silviculture. International Book Distributors Dehra Dun, India.
5. Grebner, D.L., Bettinger, P. and Siry, J.P. 2013. Introduction to Forestry and Natural Resources. Academic Press, London, UK.
6. Huxley, P. (1999). Tropical Agroforestry. Wiley.
7. Kumar, B.M. and Nair, P.K.R (eds). 2011. Carbon Sequestration Potential of Agroforestry Systems: Opportunities and challenges. Advances in Agroforestry 8. Springer Science, The Netherlands.
8. Kumar, V. 1999. Nursery and plantation practices in forestry, Scientific publication. Jodhpur. Chaturvedy, A.N. 1994. Technology of forest nurseries, Khanna Bandhu, Dehradun.
9. Mather, A.S. 1990. Global Forest Resources. Belhaven Press, London, UK.
10. Mehta, T. 2008. Hand Book of Forest utilization. International Book Distributors Dehra Dun, India.
11. Michael, P. 1984. Ecological Methods for Field and Laboratory Investigations. Tata McGraw-Hill Publications New Delhi.
12. Nair, P.K.R. 1993. An Introduction to Agroforestry. Kluwer Academic Publishers, Dordrecht, The Netherlands.
13. Pathak, P.S. and Newaj, R. (eds.). 2003. Agroforestry: Potentials and Opportunities. Agrobios, Jodhpur.
14. Persson, R. 1992. World Forest Resources. Periodical Experts, New Delhi, India. Westoby, J. 1991. Introduction to World Forestry. John Wiley & Sons.

BOT-403 **Ecosystem Analysis** **Total Credits:4**
(Contact Hours: 75)
Total Marks: 100

Course Objectives:

- To impart knowledge of ecosystem and its components. To understand the concept of productivity, biogeochemical cycles and ecological energetics.

Learning Outcomes:

After the completion of the course, the students will be able to.

- Gather in-depth knowledge on the basic concepts of ecosystem.
- Understand the functions of ecosystem.
- Learn the practical aspects of ecosystem analysis.
- Develop an understanding of how the ecological principles can be applied to the management of ecosystem.

(Theory) **Credits:3**
(Contact hours: 45)

Unit 1 (1 Credit)

Ecoenergetics: trophic level energy efficiency, primary and secondary productivity; Primary productivity of terrestrial and aquatic ecosystems of the world, methods for measuring primary productivity; Biogeochemical cycles: concepts of pool, flow and residence time and turnover rate; Nitrogen ans sulphur cycle.

Unit 2 (1 Credit)

Ecosystem development: concept of ecosystem development, ecosystem attributes of a developing and a matured ecosystem; models of community succession during ecosystem development; Ecosystem stability: concept of ecosystem homeostasis/ homeorhesis, resistance and resilience.

Unit 3 (1 Credit)

Ecosystem degradation and its restoration: causes and consequences of ecosystem degradation with reference to forest and grassland ecosystems of north-east India; Ecosystem restoration strategies with special reference to degraded forest lands, shifting cultivation fallows and coalmine affected lands of north-east India.

Unit 4 **(Practical)** **Credit:1**
(Contact Hours: 30)

1. Study of physico-chemical properties of soil: texture, moisture content and water holding capacity.
2. Estimation of phytomass and its distribution in different compartments in grassland communities.
3. Estimation of primary productivity of a terrestrial ecosystem by harvest method.
4. Estimation of primary productivity of an aquatic ecosystem using light and dark bottle method.

Suggested readings:

1. Ambasht, R.S. and Ambasht, N.K. 2023. A Text Book of Plant Ecology. 16th edition. CBS Publishers and Distributors, New Delhi.
2. Begon, M. and Harper, J.L. 2000. Essentials of Ecology. Blackwell Publishing.
3. Begon, M. Townsend, C.R. and Harper, J.L. 2006. Ecology from Individuals to Ecosystem. 4th edition. Blackwell Publishers.
4. Dash, M.C. 2001. Fundamentals of Ecology. 2nd edition. McGraw hill Companies.
5. Hill, M.K. 2020. Understanding Environmental Pollution. 4th edition. CambridgeUniversity Press, Cambridge.
6. Koromondy, E.J. 2017. Concepts of Ecology. 4th edition. Pearson Education.
7. Krebs, C. 2008. The Ecological World View. CSIRO publishing.
8. Misra, R. and Puri, G.S. 2018. Manual of Plant Ecology. Scientific publishers.
9. Misra, R. 2012. Ecology Workbook. Scientific Publishers, Jodhpur.
10. Mitra, D., Guha, J. and Chaudhury, S.K. 2000. Studies of Botany. Vol II. Moulik Library, Kolkata.
11. Molles, M.C. 2015. Ecology – Concepts and Applications. 7th edition. McGraw Hill Education.
12. Odum, E.P. 2017. Fundamentals of Ecology. 5th edition. Cengage India Private Limited.
13. Sharma, P.D. 2013. Ecology and Environment. Rastogi Publishers.
14. Singh, J.S., Singh, S.P. and Gupta, S.R. 2014. Ecology, Environmental Science and Conservation. S. Chand publishing, Delhi.
15. Tiwari, S.C. 2005. Concepts of Modern Ecology. Bishen Singh Mahendra Pal Singh, Dehradun.
16. Townsend, C. R., Begon, M. and Harper, J.L. 2006. Essentials of Ecology. 2nd edition. Blackwell Publishers.

BOT-404 **Fungi and Plant Pathology (Minor)** **Total Credits:4 (Contact Hours: 60) Total Marks: 100**

Course Objectives:

This course is designed to

- Familiarize the students with classification, structure, life cycle and importance of Fungi.
- To acquaint with various plant diseases, causal organisms and their control.

Learning Outcomes:

On completion of this course, the students will be able to:

- Identify different types of fungi; have a basic understanding about the structure and life cycle of fungi.
- Understand the mechanism of transmission of plant diseases.
- Learn about Integrated pest management.
- Identify diseases in some crop plants and measures for their prevention and control.

(Theory)

Unit 1 (1 Credit)

Fungi- general characteristics and classification (Ainsworth, 1973); Range of vegetative structure and reproduction types in fungi; General characteristics of Mastigomycotina, Zygomycotina, Ascomycotina, Basiodiomycotina and Deuteromycotina.

Unit 2 (1 Credit)

Life cycle of *Phytophthora*, *Rhizopus* and *Agaricus;* Growth forms, structure and economic importance of lichens; Economic importance of fungi.

Unit 3 (1 Credit)

Symptomology and identification of plant diseases with reference to fungi, bacteria and viruses; role of enzymes and toxins in pathogenesis; effect of temperature, pH and moisture on the development of plant diseases; Chemical and biological control of plant diseases.

Unit 4 (1 Credit)

Host parasite interaction, Concept of integrated pest management; Disease symptoms, disease cycle and control measures of early blight of potato, White rust of crucifers and Black stem rust of wheat; Biopesticides: introduction, types of microbial species as fungal and bacterial insecticides.

Suggested readings:

1. Agrios, G.N. 2006. Plant Pathology. Reed Elsevier India, New Delhi.
2. Agrios, G.N. 2008. Microbiology and Plant Pathology. 5th edition. McMillan Publishing Co. N. York.
3. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 1996. Introductory Mycology. 4th edition, John Wiley and Sons (Asia) Singapore.
4. Dube, H.C. 2022. An Introduction to Fungi. 4th revised edition. Scientific Publishers, India.
5. Hait, G., Bhattacharya, K. and Ghosh, A. 2013. A Text Book of Botany. Volume I. New Central Book Agency, Kolkata.
6. Mehrotra, R.S. 1995. Plant Pathology. 12th edition. Tata McGraw Hill Publishers Com. Pvt, Ltd.
7. Mehrotra, R.S. and Aneja, K.R. 1990. An Introduction to Mycology. New Age International, New Delhi.
8. Mitra, D. Guha, J. and Chaudhury, S.K. 2000. Studies in Botany. Moulik Library, Calcutta.
9. Vashistha, B.R., Sinha, A.K. and Kumar, A. 2016. Botany for Degree Students-Fungi. S. Chand & Co., New Delhi.
10. Webster, J. and Weber, R. 2007. Introduction to Fungi. 3rd edition. Cambridge University Press, Cambridge.

8th SEMESTER

BOT-450 **Tools and Techniques in Plant Sciences** **Total Credits: 4**
(Contact Hours: 75)
Total Marks: 100

Course Objectives:

- To provide a foundation and understanding of principles and techniques in microscopy, centrifugation, radioisotopes, spectrophotometry, chromatography, electrophoresis and advanced methods for characterization of biomolecules.

Learning Outcomes:

On completion of the course, the students will be able to:

- Understand the principles of microscopy and knowledge to analyze plant samples using electron microscopy and flow Cytometer.
- Acquire the knowledge of application of centrifugation and spectrophotometery.
- Apply basic knowledge of chromatographic techniques and use of radioisotopes for analysis of biological samples.
- Practice methods for characterizing protein and nucleic acids and electrophoresis equipment for preparation of gels and extraction of various bio molecules and perform PCR operations.
- Perform and undertake research projects using various tools and techniques in plant sciences and develop scientific temperament and research attitude.

(Theory) **Credits:3**
(Contact hours: 45)

Unit 1 (1 Credit)

Principles and application of microscopy - light microscopy; phase contrast microscopy; fluorescence microscopy; electron microscopy (TEM and SEM): sample preparation, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching; Chromatography: principle; techniques: plane chromatography (paper & thin layer chromatography), column chromatography; adsorption chromatography, partition chromatography (GLC), ion exchange chromatography and affinity chromatography (HPLC).

Unit 2 (1 Credit)

Centrifugation: basic principle, types and uses of centrifuges (differential and density gradient centrifugation, sucrose density gradient, $CaCl_2$ gradient, analytical centrifugation, ultracentrifugation); Radioisotopes: use in biological research, auto-radiography, pulse chase experiment; Spectrophotometry: principle and its application in biological research.

Unit 3 (1 Credit)

Extraction of bio-molecules: DNA, RNA and protein; qualitative and quantitative methods. Types of PCR and applications - colony PCR, multiplex PCR, nested PCR and RT-PCR; Electrophoresis: principle; AGE, PAGE, SDS-PAGE; characterization of proteins and nucleic acids; mass spectrometry (GC-MS, LC-MS, HR LCMS, NMR); X ray diffraction, X ray crystallography.

Unit 4 **(Practical)** **Credit:1**

(Contact Hours: 30)

1. Amplification of plant DNA using PCR.
2. Isolation of chloroplasts by differential centrifugation.
3. Separation of soluble plant proteins by SDS-polyacrylamide gel electrophoresis.
4. Spectrometric estimation of total sugar by Anthrone method.
5. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining and Fluorescence).
6. To separate amino acids by ion-exchange chromatography.
7. To separate phytochemicals / sugars by thin layer chromatography.

Suggested readings:

1. Aneja, K.R. 2014. Laboratory manual of microbiology and biotechnology. MedTech, New Delhi.
2. Bisen, Prakash Singh, and Sharma, Anjana. 2012. Introduction to Instrumentation in Life Sciences. CRC Press.
3. Patil, C.S. 2017. Advanced Analytical Techniques. ABE Books, New Delhi.
4. Plummer, D.T. 2017. An Introduction to Practical Biochemistry. 3rd edition.Tata McGraw-Hill Publishing Co. Ltd. New Delhi.
5. Ruzin, S.E. 1999. Plant Microtechnique and Microscopy. Oxford University Press, New York. U.S.A.
6. Sawhney S.K. and Singh, Randhir. 2011. Introductory Practical Biochemistry. Narosa Publishing House Pvt Ltd, New Delhi.
7. Twyman, R.M. 2004. Principles of Proteomics. BIOS Scientific Publisher, New York.
8. Upadhyay, A., Upadhyay, K. and Nath, N. 2002. Biophysical Chemistry: Principles and Techniques. 3rd Revised edition. Himalaya Publishing House.
9. Westermeier, R and T. Naven. 2002. Proteomics in Practice: A Laboratory Manual of Proteome Analysis. Weinheim: Wiley-VCH.
10. Willard, H.H, Merritt L.L, Dean J.A and Settle F.A. 1986. Instrumental Methods of Analysis. 7th edition. Wadsworth Publishing Co.
11. Wilson, K, Hoffmann, A, Walker, J.M, & Cloke, S. 2018. Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.

BOT-451 **Physiology and Genetics of Plants (Minor)** **Total Credits:4 (Contact Hours: 60) Total Marks: 100**

Course Objectives:

- This course will provide an introduction to basic principles of plant function, primarily covering physical processes in plants, metabolism, and introducing principles of growth and development.
- This course also aims at developing an understanding of genetical basis of life activities and methods of crop improvement.

Learning Outcomes:

On completion of this course, students should be able to:

- Describe how cell, tissue and whole-plant structures are related to their function.
- Explain the role of nutrients and hormones in plants and describe the process of photosynthesis and nitrogen fixation.
- Gain understanding of Cell cycle; and organization and inheritance of hereditary material.
- Understand basic principles of Mendelian genetics and learn about chromosomal aberrations.
- Understand basic principles of crop improvement; process of plant hybridization and learn about genetically modified plants.

(Theory)

Unit 1 (1 Credit)

Water relations in plants: Concept of chemical potential, water potential in plants, movement of water in plants; soil-plant-atmosphere continuum; membrane transport proteins: Ion channels, carriers and pumps.

Unit 2 (1 Credit)

Mineral nutrition: micro and macro nutrients, criteria of essentiality, physiological roles and deficiency symptoms of N, P, K, Mg, Mn; Photosynthesis: mechanism of light dependant reaction; C_3 and C_4 cycle; Respiration: glycolysis, Kreb's cycle; Physiological roles of auxins, gibberellins and cytokinins.

Unit 3 (1 Credit)

Cell division: stages of Mitosis and meiosis; Mendel's laws of inheritance; ultrastructure of chromosome (nucleosome solenoid model). Gene mutations: Spontaneous and induced mutations; Molecular basis of mutations- base substitutions and frameshift mutations; Physical and chemical mutagens. Structural chromosomal aberrations in plants; polyploidy.

Unit 4 (1 Credit)

Introduction to crop improvement: general procedure of hybridization; Inbreeding depression and Hybrid vigour; Role of induced mutations in crop improvement; Introduction to Genetically Modified Plants (GMP's).

Suggested readings:

1. Bhatla, S.C. and Lal, M.A. 2018. Plant Physiology: Development and Metabolism. Springer Nature, Singapore Pvt. Ltd.
2. Devlin, R.M. 2017. Outline of Plant Physiology. Scientific International.
3. Gardner, E.J., Simmons, M.J. and Snustad, D.P. 2002. Principles of Genetics. 8th edition. John Wiley & Sons Inc.
4. Ghosh, A., Hait, G. and Bhattacharya, K. 2015. A Textbook of Botany: Vol III. New Central Book Agency, Kolkata.
5. Gupta, P.K. 2014. Genetics. Rastogi Publications, Meerut.
6. Jain V.K. 2017. Fundamentals of Plant Physiology. S Chand Publishers.
7. Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T. 2018. Lewin's genes XII. Jones and Barlett.
8. Mitra, D., Guha, J. and Chaudhury, S.K. 2000. Studies in Botany Vol II. Moulik Library, Kolkata.
9. Mukherjee, S. and Ghosh, A.K. 2009. Plant Physiology. 3rd edition. New Central Book Agency.
10. Nelson, D. L. and Cox, M. M. 2012. Lehninger Principles of Biochemistry. 8th edition. W.H. Freeman and Co. Publishers.
11. Pandey, S.N. and Sinha, B.K. 2001. Plant Physiology. 3rd edition. Vikas Publishing House Pvt. Ltd, New Delhi.
12. Salisbury, F.B and Ross, C.W. 2006. Plant Physiology. 3rd edition. CBS Publishers and Printers, New Delhi.
13. Taiz, L. and Zeiger, E. 2002. Plant Physiology. Sinauer Associates, USA.
14. Simmons, M.J. and Snustad, D.P. 2010. Principles of Genetics. 5th edition. John Wiley.
15. Singh. B.D. 2013. Plant Breeding. Kalyani Publishers. New Delhi.
16. Singh. B.D. 2022. Fundamental of Genetics. Medtech Science Press, New Delhi.
17. Strickberger, M.W. 2015. Genetics. Pearson Education India.
18. Verma, S.K. 2013. Text book of Plant Physiology and Biochemistry. S. Chand & Company, New Delhi.

BOT-452 **Project/Dissertation** **Total Credits: 12**
(Contact Hours:360)
Total Marks: 300

1. Identification of the research problem, Writing of synopsis proposal, Presentation of the synopsis (Credits: 3)

2. Dissertation (Credits: 5)

3. Presentation on dissertation and Viva-Voce (Credits: 4)

BOT-453 **Statistical Analyses and Bioinformatics** **Total Credits:4**
Contact Hours: 120)
Total Marks: 100

Course Objectives:

- To familiarise and equip students with knowledge of statistics as applied in the field of biology
- To gain knowledge and awareness of the basic principles and concepts of bioinformatics
- To use existing software effectively to extract information from large databases and to use this information in computer modelling

Learning Outcomes:

After the completion of the course, the students will have:

- Knowledge of biostatistics and its applications in biology.
- Fundamental concepts, principles, methodologies and application of bio-statistics.
- Knowledge of various types of data collection, tabulation, representation and interpretation of data by using basic statistical tools.
- Understanding of the core concepts of bioinformatics.
- Basic skills that can be applied in the areas of bioinformatics.

(**Practical**)

1. Problems based on calculation of measures of central tendency.
2. Problems based on measures of variation- range, standard deviation, standard error.
3. Problems based on calculation of correlation coefficient.
4. Test of significance using t-test and goodness of fit using chi-square test.
5. Basics of excel: Data entry and statistical data analysis.
6. Data representation as line graphs, bar graphs and pie charts.
7. Retrieval of nucleotide and protein sequence data thought curated bioinformatics repositories such as GenBank, EMBL and UniProt.
8. Using BLASTN, BLASTP, BLASTX and interpretation of results.
9. Multiple sequence alignment using Clustal Omega ans MUSCLE.
10. Construction of phylogenetic trees using MEGA and PHYLIP.
11. Retrieval of 3D structure of proteins from PDB, and visualisation with Swiss PDB viewer.
12. Assembly, editing and analysis of DNA sequences.
13. Submission of DNA/protein sequences to GenBank.

Suggested readings:

1. Antonisamy, B., Premkumar, Prasanna S., Christopher, Solomon. (2017). Principles and Practice of Biostatistics. Elsevier India.
2. Banerjee, Pranab Kumar (2007). Introduction to Bio-statistics. S. Chand and Company.
3. Baxevanis, A. D., & Bader, G. D. (Eds.). (2020). Bioinformatics (4th ed.). Wiley. https://www.wiley.com/en-us/Bioinformatics%2C%2B4th%2BEdition-p-9781119335580
4. Bosu O and Thukral SK (2007) Bioinformatics- Databases, Tools and Algorithms. Oxford University Press
5. Buffalo, V. (2015). Bioinformatics data skills: Reproducible and robust research with open source tools. O'Reilly Media.
6. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics II Edition. Benjamin Cummings.
7. Caride, A., & Felberbaum, B. (2006). Practical bioinformatics. Garland Science.
8. Danniel W.W. (1987) Biostatistic, New York. John Wiley Sons

9. Das, N.G. (2017). Statistical Methods (Combined edition volume 1 & 2). McGraw Hill Education (India) Private Limited, Noida, Uttar Pradesh.
10. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2013). Fundamentals of Statistics. Vol-I. Word Press Pvt. Limited.
11. Kulkarni A.P. (2022). Basics of Biostatistics (2ed). CBS Publishers And Distributors Pvt. Ltd., New Delhi.
12. Parker R. E. (1979). Introductory statistics for biology. E.L.B.S London
13. Pevsner, J. (2015). Bioinformatics and functional genomics. 3rd edition Wiley-Blackwell.
14. Rao, P.S.S. Sunder and Richard, J. (2012). Introduction to Biostatistics and Research Methods (5th Edition). PHI Learning Pvt. Ltd.
15. Saha, Indranil and Paul, Bobby. (2021). Essentials of Biostatistics & Research Methodology 3rd edition. Academic Publishers.
16. Sundarrao, P.S.S and Richards, J. Christian (2012). An introduction to biostatistics. 5th Edition, P.H.I Learning private limited, New Delhi
17. Xiong, J. (2006). Essential bioinformatics. Cambridge University Press.Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.

BOT-454 **Fundamentals of Genetic Engineering** **Total Credits:4**
(Contact Hours: 120)
Total Marks: 100

Course Objectives:

- To provide students with basic concepts in Genetic Engineering and practical aspects of recombinant DNA technology.
- To provide hands-on training in modern and advanced techniques of Genetic Engineering

Learning Outcomes:

After the completion of the course, the students will:

- Understand the concept of genetic engineering including the techniques, applications and limitations.
- Learn the technical know-how on versatile techniques in recombinant DNA technology.
- Understand the application of genetic engineering techniques in basic and applied experimental biology.
- Apply learned knowledge to future research.

(Practical)

1. Extraction of DNA from plant tissues by CTAB method.
2. Isolation of plasmid DNA from *E. coli.*
3. Restriction digestion of plasmid DNA and gel electrophoresis.
4. Preparation of competent cells by $CaCl_2$ and transformation in *E. coli.*
5. Colony PCR for selection of recombinant cells in *E. coli.*
6. Immunodetection of rbcL in plant extracts by western blotting.
7. Detection of genetic variations in plants by RAPD and SCOT markers.
8. Isolation of RNA from plant tissues using RNAzol-RT.
9. Visualisation of isolated RNA by denaturing gel electrophoresis.
10. Analysis of plant gene expression by semi-quantitative RT-PCR.

Suggested readings:

1. Brown, T. A. 2006. Gene Cloning and DNA Analysis-An Introduction. Blackwell University Press.
2. Green MR and Sambrook J (2012) Molecular Cloning: A laboratory manual Vol 1, Vol 2 and Vol 3. Cold Spring Harbor Laboratory Press
3. Kammermeyer, John (2019) Genetic Engineering Fundamentals, CRC Press; 1st edition (2 December 2019); CRC Press
4. Nicholl, D. S. T. (2023). An Introduction to Genetic Engineering (4th ed.). Cambridge: Cambridge University Press.

BOT-455 **Bioeconomy and Entrepreneurship** **Total Credits: 4 (Contact Hours:60) Total Marks: 100**

Course Objectives:

- To identify the role and importance of biological resources and processes in the modern economy.
- To raise awareness of the importance of new technologies based on biological processes to meet socio-economic challenges and to achieve the sustainable development goals.
- To highlight the importance of entrepreneurship for the modern economy.
- To enable students, understand the concepts of Bioeconomy.
- To motivate the students to explore various entrepreneurial opportunities.

Learning Outcomes:

After the completion of the course, the students will

- Understand of the principles of bio-business management.
- Understand the concepts of bioeconomy.
- Be equipped to explore various entrepreneurial opportunities.
- Learn how to establish bio-based start-up or spin-off endeavours.

Unit 1 (1 Credit)

Concept of resource economics; bioresource elasticity; introduction to bio-business; SWOT analysis of bio-business; development of entrepreneurship; stages in entrepreneurial process; entrepreneurship in India; Small scale industries: definition, characteristics, need and rationale, objectives, scope, market feasibility study, technical feasibility study, financial feasibility study, social feasibility study; global bio-business and industry future trends.

Unit 2 (1 Credit)

Development and integration of economics and bioscience; benefits and challenges of knowledge-based bioeconomy; development of resource efficient bioeconomy; economic growth, development, and innovation in terms of bioeconomy; regulation of renewable resources; role of bioeconomy in sustainable development; tools supporting the transition to a bioeconomy.

Unit 3 (1 Credit)

Inter- and trans disciplinary approaches in bioeconomy, primary production; biobased resources and value chains; processing of biobased resources; markets, sustainability management and entrepreneurship opportunity in biobased product; food security and healthy nutrition in the context of the bioeconomy; use of biomass for production of fuel and chemicals; role of biotechnology in bioeconomy, circular economy.

Unit 4 (1 Credit)

Business opportunity, essential requirement, marketing, strategies, schemes, challenges and scope-with case study on plant cell and tissue culture technique, polyhouse culture; herbal drug production; nutraceuticals; value added herbal products; mushroom culture; bio-ethanol production using agri-waste and algal source; opportunities under start-up schemes; MSME and bio-business entrepreneurship; funding opportunities for bio-business.

Suggested readings:

1. Bisset, N.G. and Wich, M. 2001. Herbal Drugs and Phytopharmaceuticals. 2nd edition, CRC.
2. Hine, D. and Kapeleris, J., 2006. Innovation and entrepreneurship in biotechnology, an international perspective: Concepts, theories and cases. Edward Elgar Publishing.
3. Jayashree, W. 2001. Intellectual Property Rights in the WTO and developing countries. Oxford University Press.
4. Jogdand, S.N. 2007. Entrepreneurship and Business of Biotechnology. Himalaya Publishing Home.
5. Khanka, S.S. 2006. Entrepreneurship Development. S. Chand & Co Publishing.
6. Lewandowski, I., 2018. Bioeconomy: Shaping the transition to a sustainable, biobased economy (p. 356). Springer nature.
7. Lusier, R. 1996. Management Fundamentals - Concepts, Application, Skill Development. Cengage Learning
8. Puri, R.S. 2009. Practical Approach to IPR. IK Intl. Ltd.
9. Rallapalli, R and Bali, G. 2007. Bioethics and Biosafety. APH Publication.
10. Sateesh, M.K. 2008. Bioethics and Biosafety. IK Publishers.
11. Shimasaki, C. ed., 2020. Biotechnology Entrepreneurship: Leading, Managing and Commercializing Innovative Technologies. Academic Press.
12. Sinha, N.K., Sidhu, J.S., Barta, J., Wu, J.S.B., Cano, P.M. 2013. Handbook of Fruits and Fruit Processing. John Wiley & Sons, Ltd.
13. Tripathi, P.C. and Reddy, P.N. 2012. Principles of Management. 5th edition. Tata McGraw Hill.
14. Wildman R. 2006. Handbook of Nutraceuticals and Functional Foods. CRC, Publications.