

**DEPARTMENT OF BOTANY, NORTH-EASTERN HILL UNIVERSITY, SHILLONG-793022**  
**M. Sc. (BOTANY) CHOICE BASED CREDIT SYSTEM (CBCS) SYLLABUS, 2017**

The M.Sc. (Botany) programme of the University comprises of four semesters spread over a period of two years. Students would be required to earn 72 credits for the award of M.Sc. (Botany) degree. The credits earned shall have a minimum of 60 credits by way of core courses offered by the Department and 12 credits by way of open courses offered by the Department and other Departments of the University. They would be required to earn 6 open credits each in third and fourth semesters respectively. The Department shall announce the open courses available for. Students shall convey in writing to the Department at the start of the session, the list of open courses they would be registering for.

The M.Sc. degree programme in Botany shall comprise 9 core courses through regular classroom teaching spread over four semesters. Each core course shall comprise of one theory paper worth 4 credits (100 marks) and one practical paper worth 2 credits (50 marks). Students shall be evaluated by way of continuous assessment comprising 25% of credit value (25 marks for theory and 12.5 marks for practical papers respectively) and end semester examination comprising 75% of credit value (75 marks Theory and 37.5 marks practical). The duration of end semester examination for theory papers shall be 3 hours and practical papers 4 hours.

In addition to this, as part of core curriculum, students will be required to opt in the third semester for specialization through project work worth 6 credits (150 marks) in one of the nine broad areas listed below. Project work will be allotted in third semester and project report will have to be submitted and evaluated in fourth semester.

<b>Course Code</b>	<b>Course Title</b>	<b>Credit</b>	<b>Max. Marks</b>
<b>Semester – I</b>			
BOT (C) 101	Microbiology, Mycology and Plant Pathology (T)	4	100
BOT (C) 102	Microbiology, Mycology and Plant Pathology (P)	2	50
BOT (C) 103	Algae, Bryophytes and Pteridophytes (T)	4	100
BOT (C) 104	Algae, Bryophytes and Pteridophytes (P)	2	50
BOT (C) 105	Gymnosperms and Plant Anatomy (T)	4	100
BOT (C) 106	Gymnosperms and Plant Anatomy (P)	2	50
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		<b>18</b>	<b>450</b>
<b>Semester –II</b>			
BOT (C) 201	Angiosperm Taxonomy, Economic Botany and Ethnobotany (T)	4	100
BOT (C) 202	Angiosperm Taxonomy, Economic Botany and Ethnobotany (P)	2	50
BOT (C) 203	Plant Biochemistry and Molecular Biology (T)	4	100
BOT (C) 204	Plant Biochemistry and Molecular Biology (P)	2	50
BOT (O) 205	Stress Biology (T)	2	50
BOT (O) 206	Bioprocess Development (T)	2	50
BOT (O) 207	Techniques in Molecular Biology (T)	2	50
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		<b>18</b>	<b>450</b>
<b>Semester –III</b>			
BOT (C) 301	Genetics, Cytogenetics and Plant Breeding (T)	4	100
BOT (C) 302	Genetics, Cytogenetics and Plant Breeding (P)	2	50
BOT (C) 303	Plant Physiology (T)	4	100
BOT (C) 304	Plant Physiology (P)	2	50
BOT (O) 305	Biodiversity and Phytogeography (T)	2	50
BOT (O) 306	Environmental Pollution and Conservation (T)	2	50
BOT (O) 307	Biostatistics (T)	2	50
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		<b>18</b>	<b>450</b>

**Semester –IV**

BOT (C) 401	Plant Reproductive Biology and Biotechnology (T)	4	100
BOT (C) 402	Plant Reproductive Biology and Biotechnology (P)	2	50
BOT (C) 403	Plant Ecology and Ecosystem Analysis (T)	4	100
BOT (C) 404	Plant Ecology and Ecosystem Analysis (P)	2	50
BOT (C) 405	Project Work	6	150
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		<b>18</b>	<b>450</b>

**Broad areas for specialization through Project Work:**

1. Plant Ecology 2. Microbial Ecology 3. Plant Molecular Biology 4. Advanced Plant Physiology 5. Taxonomy and diversity of angiosperms 6. Development and Reproduction of angiosperms 7. Plant Biotechnology 8. Plant Genetics and Cytogenetics 9. Lower plants

**Abbreviation: BOT – Botany; C – Core Course; O – Open Course; T- Theory; P – Practical.**

## **BOT (C) 101: Microbiology, Mycology and Plant Pathology (4 Credits)**

- Unit I Ecological groups of microorganisms based on O<sub>2</sub> requirement, carbon sources, temperature (psychrophiles, mesophiles, thermophiles, hyperthermophiles), extremophiles (acidophiles, alkalophiles, halophiles, barophiles), and nutrition (saprophytism, parasitism and symbiosis); microbial growth; batch culture: synchronous and continuous culture.
- Unit II Microorganisms in food, food spoilage and food poisoning; fermented foods and method of food preservation (physical and chemical); microbes in industrial production of alcohol, organic acids and antibiotics; bio-fertilizers: types and mass production; microbes in bioremediation.
- Unit III Criteria used in the classification of fungi with reference to vegetative and reproductive structures; parasexuality; mushroom cultivation and its importance; wood decay fungi and their importance; interaction between microbes and roots of higher plants: rhizosphere microflora and its significance, mycorrhizal fungi: types and applications.
- Unit IV 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; biological control of plant diseases; biopesticides: introduction, types of microbial species as fungal and bacterial insecticides.

### **Suggested readings**

- Agrios, G.N. (2008). Plant Pathology (5<sup>th</sup> edition). Academic Press, Reed Elsevier India Private Ltd., New Delhi, India.
- Atlas, R.M. and Bartha, R. (1997) (4<sup>th</sup> Edition) Microbial Ecology: Fundamental Applications. Benjamin/Cummings Science Pub. USA.
- Blakeman, J.P and Williamson, B. (1994). Ecology of Plant pathogens. CAB International. UK.
- Dubey, R.C. and Maheshwari, D.K. (1999). A text book of Microbiology, S. Chand & Company Ltd., New Delhi, India.
- Eugene, L.M. (2008). Environmental Microbiology- from genome to biogeochemistry. Blackwell Publishing Australia, Australia.
- Harley, H.L and Smith, S.E. (1983). Mycorrhizal symbiosis. Academic Press, USA.
- Jeffery, C.P. (2014). Fundamental of Microbiology. 10<sup>th</sup> edition. Jones and Bartlett Publishers, USA.
- Madigan, M.T., Martinko, J.M. and Parker, J. (2006). Brock Biology of Microorganisms, 11<sup>th</sup> Edition. Prentice Hall International, Inc., USA.
- Mehrotra, R.S. (1995). Plant Pathology. Tata Mc Graw Hill, New Delhi, India.
- Mehrotra, R.S. and Aggarwal, A. (2003). Plant Pathology. 2<sup>nd</sup> edition. Tata Mc Graw Hill, New Delhi, India.
- Mehrotra, R.S. and Aneja, K.R. (1990). An Introduction to Mycology. Wiley Eastern. New Delhi, India.
- Michael, J., Carlile, S., Watkinson, C. and Gooday, G.W. (1994). The fungi (2<sup>nd</sup> edition). Academic Press. USA.
- Mishra, R. R. (1996). Soil Microbiology. CBS Publ. New Delhi, India.
- Prescot, L.M., Harley, J.P. and Klein, D.A. (2005). Microbiology. 6<sup>th</sup> Edition Mc Graw – Hill International Edition. USA.
- Sarbhoy, A.K. (2002). Text book of Mycology, ICAR. New Delhi, India.
- Singh, R.P. (2012). Plant Pathology. Second edition. Kalyani Publishers, New Delhi, India.

- Tate, R.L. (2000). Soil Microbiology. 2<sup>nd</sup> edition. John Wiley and Sons, Inc. New York, USA.
- Tortora, G.J., Funke, B.R. and Case. C.L (2008). Microbiology– An Introduction. 9<sup>th</sup> edition. Dorling Kindersley (India), New Delhi, India.
- Van Elsas, J.D., Trevors, J.T., Wellington, E.M.H. (1997). Modern Soil Microbiology, Marcel Dekker Inc. USA.
- Webster, J. (2007). An introduction to Fungi. Cambridge University Press, UK.
- Webster, J. and Weber, R.W.S. (2007). An introduction to Fungi. Cambridge University Press, UK.
- Willey, J.M., Sherwood, L.M. and Woodverton, C.J. (2011). Prescott’s Microbiology. 8<sup>th</sup> edition. Mc Graw Hill. New Delhi, India.
- Wulf, C. and Anneliese, C. (2000). Biotechnology: A textbook of industrial microbiology. Panima Publishing Corporation, New Delhi, India.

**BOT (C) 102: Microbiology, Mycology and Plant Pathology (Practicals) (2 Credits)**

1. Calibration of microscope and measurement of dimension of microbial cells.
2. Collection and identification of causal organisms from diseased plant materials.
3. Isolation, identification and enumeration of bacteria and fungi from soil, litter and air.
4. Preparation and maintenance of pure cultures.
5. Gram staining of bacterial cultures.
6. Study of the antagonistic effect between pathogenic isolates and test fungi.
7. Study of different mycorrhizal associations.
8. Effects of temperature on the growth of microbes.
9. Measurement of fungal growth by weight determination.
10. Carbohydrate fermentation tests.

**Suggested readings**

- Aneja, K.R. (1996). Experiments in Microbiology, Plant Pathology and Tissue culture. Wishwa Prakashan. New Delhi, India.
- Barnett, H.L. and Hunter, B.B. (1972). Illustrated genera of imperfect fungi. Burges Publ. Co. USA.
- Benson, H.J. (1990). Microbiological Applications- A laboratory manual in General Microbiology. Wm. C. Brown Publishers. USA.
- Blakeman, J. P and Williamson, B. (1994). Ecology of plant pathogens. CAB International. UK.
- Cappuccino, J.G. and Sherman, N. (1999). Microbiology- A laboratory manual (Fourth Edition). Addison Wesley. Switzerland.
- Domsch, K.H., Gams, W. and Anderson, T.H. (1980). Compendium of Soil Fungi. Academic Press. New Delhi, India.
- Ellis, M.B. (1993). Dematiaceous Hyphomycetes. International Mycological Society, UK.
- Gilman, J.C. (1967). A Manual of Soil Fungi. Oxford and IBH Publishing Co. Netherlands.
- Johnson, L.F. and Curl, E.A. (1972). Methods for Research on the Ecology of Soil Borne Plant Pathogens. Burgess Publi. Co. USA.
- Stevens, F.L. (1985). The Fungi which cause Plant Disease. IBS. New Delhi, India.

### **BOT (C) 103: Algae, Bryophytes and Pteridophytes (4 Credits)**

- Unit I Criteria for algal classification; classical and poly-phasic classification systems; general overview of algal divisions: diagnostic characters and reproduction of major algal divisions viz., Chlorophyta, Rhodophyta and Chrysophyta (Xanthophyceae, Bacillariophyceae and Phaeophyceae); Cyanobacteria, diversity of light harvesting pigments, food reserves, extracellular products and flagellar structures in algae.
- Unit II Algal ecology: distribution in diverse habitats; algae as biological monitor of water pollution; symbiotic algal associations; mass cultivation methods of algae.
- Unit III Origin and classification of bryophytes; vegetative and sexual reproduction; mechanism of dehiscence of capsules and dispersal of spores in bryophytes; evolution of gametophytes and sporophytes; association of bryophytes with microorganisms; anisospory and sexual dimorphism; biologically active compounds in bryophytes; ecological and economic importance of bryophytes.
- Unit IV Origin of pteridophytes: theories of algal and bryophytean origins; classification; morphological, anatomical and reproductive diversity; telome theory; enation theory; stelar evolution; heterospory and seed habit; apogamy and apospory; ecological and economic importance of pteridophytes.

#### **Suggested readings**

- Barsanti, L. and Gualtieri, P. (2014). Algae- Anatomy, Biochemistry and biotechnology- Taylor & Francis, New Delhi.
- Bold, H.C. and Wynne, M.J. (1978). Introduction to the algae. Prentice Hall of India Private Ltd., New Delhi.
- Bux, F. and Chisti, Y. (2016). Algae Biotechnology: Products and Processes. Springer, International Pub. Switzerland.
- Geissler and Greene, S.W. (1982). Bryophyte Taxonomy, methods, practices and floristic exploration. J Cramer, Germany.
- Hoek, Van den, Mann, DG, Janes, H.M. (1995). Algae-An Introduction to Phycology, Cambridge University Press, New Delhi.
- Kumar, H.D. (198). Introductory Phycology. East West Press Private Ltd., New Delhi.
- Lee, R.L. (2008). Phycology (4th Edition) Cambridge University, New Delhi.
- Shaw, A.J. and Goffinet, B. (2000). Bryophyte Biology. Cambridge University Press.
- Parihar, N.S. (1996). The Biology and Morphology of Pteridophytes. Central Book Depot, Allahabad.
- Stevenson, R.J., Bothwell, M.L., Lowe, R.L. (1996). Algal Ecology-Fresh Water Benthic Ecosystems. Academic Press.

**BOT (C) 104: Algae, Bryophytes and Pteridophytes (Practicals) ( 2 Credits)**

1. Study of morphological features of common freshwater, terrestrial and marine algae from Chlorophyta, Rhodophyta and Chrysophyta, and their identification.
2. Study of morphology, anatomy and reproductive structures of some representatives of bryophytes.
3. Study of morphology, anatomy and reproductive structures of some representative pteridophytes.

**Suggested readings**

- Barsanti, L. and Gualtieri, P. (2014). Algae- Anatomy, Biochemistry and biotechnology- Taylor & Francis, New Delhi.
- Bux, F, and Chisti, Y. (2016). Algae Biotechnology: Products and Processes. Springer, International Pub. Switzerland.
- Geissler, and Greene, S.W. (1982). Bryophyte Taxonomy, methods, practices and floristic exploration. J Cramer, Germany.
- Parihar, N.S. (1996). The Biology and Morphology of Pteridophytes. Central Book Depot, Allahabad

## **BOT (C) 105: Gymnosperms and Plant Anatomy (4 Credits)**

- Unit I History and recent systems of classification of gymnosperms; origin and evolution of gymnosperms; affinities of gymnosperms with pteridophytes and angiosperms; distribution of gymnosperms in India; economic importance of gymnosperms; salient structural features and affinities of fossil gymnosperms; pro-gymnosperms; Pteridospermales; Cycadeoidales (Bennettitales); Pentoxylales; Cordaitales.
- Unit II Diversity, morphology, anatomy, reproduction and affinities of living gymnosperms: Cycadales, Ginkgoales, Taxales, Coniferales, Ephedrales, Gnetales, and Welwitschiales.
- Unit III Shoot development: shoot apical meristem; organization, ultrastructure and histochemistry of lateral and intercalary meristems; differentiation of xylem; procambium vs. vascular cambium; factors influencing the activity of vascular cambium; wood development in relation to environmental factors; current trends and prospects in plant anatomy.
- Unit IV Leaf development: leaf meristem, and histogenesis; stomatal ontogeny and classification; ultrastructure of guard cells; secretory glands and laticifers; transfer cells; fine structure of plasmalemma, microtubules and microfibrils; origin and development of primary and lateral roots; phloem: sieve tubes, sieve cells, differentiation and ultrastructure of cellular organelles; phloem protein and its function.

### **Suggested readings**

- Andrews, H.N. (1961). Studies in palaeobotany. McGraw Hill.
- Arnold, C. A. (1947). An Introduction to Palaeobotany. McGraw Hill.
- Beck, B. (1988). Origin and evolution of gymnosperms. Columbia University Press.
- Behnke, S. (1990). Sieve Elements. Springer-Verlag.
- Bhatnagar, A.K. and Moitra, A. (1996). Gymnosperms. New Age International Press.
- Buvat, R. (1988). Ontogeny, Cell differentiation and Structure of Vascular Plants. Springer-Verlag.
- Chamberlain, C.J. (1934). Gymnosperms, structure and evolution. Univ. of Chicago Press.
- Cutter, E.G. (1971). Plant Anatomy: Experiment and Interpretation. Vols. 1 & 2. Edward Arnold.
- Esau, K. (1972). Plant Anatomy. John Wiley.
- Fahn, A. (1990). Plant Anatomy. Pergamon Press.
- Gartner, (1995). Plant Stems: Physiology and Functional Morphology. Springer-Verlag.
- Howell, S. H. (1998). Molecular Genetics of Plant Development. Cambridge Univ. Press.
- Iqbal, M. (1990). The Vascular Cambium, John Wiley.
- Iqbal, M. (1994). Growth Patterns in Vascular Plants. Timber Press.
- Johansen, D.A. (1940). Plant Microtechnique, 2<sup>nd</sup> Ed. Tata McGraw-Hill.
- Mauseth, J.D. (1988). Plant Anatomy. The Benjamin Cummings Publ.
- Mattheck, C. (1995) Wood- The internal optimization of Trees. Springer-Verlag.
- Sporne, K.R. (1965). The morphology of Gymnosperms. Hutchinson & Co.
- Steeves, T. and Sussex, I.M. (1988). Patterns in Plant Development. Cambridge Univ. Press.
- Trivedi, B.S and Singh, D.K. (1965). Structure and reproduction of Gymnosperms. Shashidhar Malaviya Prakashan.

**BOT (C) 106: Gymnosperms and Plant Anatomy (Practicals) (2 Credits)**

1. Study of anatomy of vegetative and reproductive parts of the following genera of gymnosperms: *Cephalotaxus*, *Cryptomeria*, *Cupressus*, *Ginkgo*, *Gnetum*, *Pinus*, *Podocarpus* and *Taxus* (students shall collect specimens and prepare permanent slides).
2. Study of vegetative and reproductive stages of gymnospermous fossil genera through specimens and permanent slides.
3. Maceration and clearing technique.
4. Technique of temporary and permanent microscopic preparations.
5. Study of shoot and root apical meristems and lateral meristem.
6. Study of different types of wood.
7. Study of phloem tissue.
8. Microscopic examination of different types of leaves to understand the internal structure.
9. Study of Kranz anatomy of C<sub>4</sub> plants.

**Suggested readings**

- Cutter, E.G. (1971). Plant Anatomy: Experiment and Interpretation. Vols. 1 & 2. Edward Arnold.
- Sporne, K.R. (1965). The morphology of Gymnosperms. Hutchinson & Co.
- Trivedi, B.S. and Singh, D.K. (1965). Structure and reproduction of Gymnosperms. Shashidhar Malaviya Prakashan.



## **BOT (C) 201: Angiosperm Taxonomy, Economic Botany and Ethnobotany ( 4 Credits)**

- Unit I Taxonomic hierarchy; species concept and speciation; theories pertaining to evolution of angiosperms; important Indian and world herbaria; taxonomic literature (floras, taxonomic accounts, revisionary studies); computer-aided taxonomic studies.
- Unit II Systems of classification: artificial, natural and phylogenetic systems; merits and demerits of major systems of classification: Linnaeus, Bentham and Hooker, Englerian and Ranalian schools; Angiosperm Phylogeny Group (APG) system of flowering plant classification and salient features of APG III and IV systems; biosystematics; direct and indirect methods of plant identification; practice of taxonomic key; diversity and taxonomic studies of flowering plants of north-eastern India.
- Unit III Salient features of International Code of Botanical Nomenclature (ICN); principles of the code; ranks of taxa; rules of priority and limitations of principles of priority; effective and valid publications; definitions: synonym, basionym, tautonym, and superfluous name; *nomen nudum*, later homonym, legitimate and illegitimate names; type method and typification; *nomen alternatum*.
- Unit IV Economic botany: uses, active principles, and value addition of the following medicinal and aromatic plants: *Aquilaria*, *Taxus*, *Mentha*, *Ocimum* and *Stivia*. Ethnobotany: use of plants by the tribal societies in north-eastern India for subsistence, medicine and cultural purposes.

### **Suggested readings**

- A.P.G. (Angiosperm Phylogeny Group). (1998). An ordinal classification for the families of flowering plants. *Ann. Missouri Bot. Gard.* 85: 531-553.
- A.P.G. II. (2003). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. *Bot. J. Linnean Soc.* 141: 399-436.
- A.P.G. III. (2009). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. *Bot. J. Linnean Soc.* 161: 105-121.
- A.P.G. IV. (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Bot. J. Linnean Soc.* 181: 1-20.
- Cronquist (1968). *The evolution and classification of flowering plants.* Nelson.
- Hutchinson, J. (1967). *Key to the families of the flowering plants of the World.* E. Arnold.
- Heywood, V.H. (1968). *Modern methods in plant taxonomy.* Acad. Press.
- Jain, S.K. and Rao, R.R. (1977). *A handbook of field and herbarium methods.* Today & Tomorrow.
- Jain, S.K. (1981). *Glimpses of Indian ethnobotany.* Oxford.
- Lawrence, G.H.M. (1967). *Taxonomy of vascular plants.* Oxford & IBH.
- Naik, V.N. (1990). *Introductory plant taxonomy.* Longman.
- Nair, P.K.K. (1980). *Modern trends in plant taxonomy.* Vikas Publ.
- Radford, A. E. (1986). *Fundamentals of Plant Systematics.* Harper Row.
- Simpson, Micheal.G. (2010). *Plant systematic.* Academic press.
- Sivarajan, V. V. (1990). *Introduction to principles of plant taxonomy.* Oxford & IBH.
- Takhtajan, A. (1969). *Flowering plants Origin and dispersal.* Oliver & Boyd.
- Taylor, D. W. and Hickey, L. (1996). *Flowering Plant Origin, Evolution and Phylogeny.* Chapman & Hall

**BOT (C) 202: Angiosperm Taxonomy, Economic Botany and Ethnobotany (Practicals) (2 Credits)**

1. Use of floras and manuals for identification of locally available monocot and dicot taxa up to species level.
2. Field and herbarium methods, and preparation of herbarium specimens/museum specimens. (Students are required to submit at least twenty herbarium/museum specimens).
3. Familiarity with taxonomic softwares.
4. Field excursion.

**Suggested readings**

Heywood, V.H. (1968). Modern methods in plant taxonomy. Acad. Press.

Hutchinson, J. (1967). Key to the families of the flowering plants of the World. E. Arnold.

Jain, S.K. and Rao, R.R. (1977). A handbook of field and herbarium methods. Today & Tomorrow.

## **BOT (C) 203: Plant Biochemistry and Molecular Biology (4 Credits)**

- Unit I Carbohydrates and their derivatives: synthesis and inter-conversions; lipids: biosynthesis of fatty acids and their regulation; phospholipids and their role in signal transduction in cells; amino acids: structure and function, properties of amino acids; proteins: structure and function, folding and sub-unit assembly, post translational processing.
- Unit II Enzymes: structure of active site, mechanisms of action, kinetics of enzymes catalysed reactions, regulation of enzyme activity; industrial enzymology: principles of immobilized enzyme technology; applications of immobilized enzymes.
- Unit III Structure of nucleic acids: DNA and its A, B and Z conformations, t-RNA, r-RNAs; DNA replication: machinery and mechanism in prokaryotes and eukaryotes; RNA transcription: machinery and mechanism in prokaryotes and eukaryotes; RNA processing: processing of hnRNA; RNA editing; genetic code and exceptions to its universality.
- Unit IV Translation: machinery and mechanism (tRNA charging, initiation in prokaryotes and eukaryotes, elongation and termination); regulation of gene expression in prokaryotes and eukaryotes; recombinant DNA technology: restriction enzymes and construction of hybrid DNA; gene cloning: cloning vehicles (plasmids, bacteriophages, YAC, BAC); construction and screening of genomic DNA and cDNA libraries; polymerase chain reaction (PCR): principle, primer designing, applications; introduction to RT-PCR, and Q RT-PCR.

### **Suggested reading**

- Alberts, B., Johnson A., Lewis J., Morgan.D., Raff.M., Roberts K. and Walter P.(2015). Molecular Biology of the Cell, 6<sup>th</sup> Edition, Garland Science Publ., New York.
- Birge, E.A. (2000). Bacterial and bacteriophage genetics. Springer.
- Brown, T.A. (1989).Genetics a molecular approach. Van Nostrand.
- Boyer, R. (1999). Concept in Biochemistry. Brooks/Cole Publ.
- Buchanan, B.B., Grissem, W. and Jones R.L. (2015). Biochemistry and Molecular Biology of Plants, Wiley Blackwell, Sussex, UK
- Conn, E.E. and Stumpf, P.K. (1994). Outlines of Biochemistry. Wiley Eastern.
- Dennis, D.T. (1998). Plant metabolism. Longman.
- Dey, P.M. and Harborne, J.B. (1997). Plant Biochemistry. Acad. Press.
- Heldt, H. (1997). Plant Biochemistry and Molecular Biology. Oxford Univ. Press.
- Krebs, J.E., Goldstein E.S. and Kilpatrick S.E. (2014). Lewin's Genes XI, Jones and Barlett, Burlington.
- Lea, P.J. and Leagood, R.C. (1999). Plant Biochemistry and Molecular Biology. Wiley.
- Lewin, B. (2002). Genes VIII. Oxford.
- Lodish H., Berk A., Kaiser C.A.,Krieger M., Scott M.P., Bretscher A., Ploegh H. And Matsudaira P. (2008). Molecular Cell Biology, 6<sup>th</sup> Edition, W.H. Freeman, New York.
- Misra, A.K. (2011). Fundamentals of Cell and Molecular Genetics, Panima Publ., New Delhi.
- Nelson, D.L. and Cox, M.M. (2013). Lehninger Principles of Biochemistry. 6<sup>th</sup> Edition, Freeman and Company, New York.
- Sinden, P.R.R. (1994). DNA structure and function. Acad. Press.
- Stryer, L. (1993). Biochemistry. W.H. Freeman.
- Walker, J.M. and Rapley, R. (2002). Molecular Biology and Biotechnology. Panima.
- Watson, J.D., Baker T.A., Bell S.P., Gann A., Levine M. and Losick R. (2014). Molecular Biology of the Gene, 7<sup>th</sup> Edition, Cold Spring Harbor Laboratory Press, New York.

**BOT (C) 204: Plant Biochemistry and Molecular Biology (Practicals) (2 Credits)**

1. Estimation of starch from plant tissues by iodine reaction.
2. Estimation of sugars from plant tissues by dinitrosalicylic acid.
3. Estimation of amino acids from plant tissues by ninhydrin reaction.
4. Estimation of soluble protein content from plant tissues by Lowry's method.
5. Separation of soluble proteins by (a) gel filtration (b) gel electrophoresis.
6. Assay of phosphatase activity in plant cells.
7. Assay of nitrate reductase activity in cells.
8. Isolation of plant DNA and its agarose gel electrophoresis.
9. Spectrophotometric estimation of DNA.
10. DNA digestion by general and restriction endonucleases.

**Suggested readings**

Boyer, R.F. (2012). Biochemistry Laboratory: Modern Theory and Techniques, Pearson Prentice Hall, New Jersey

Plumer, D. T. (1993). An Introduction to Practical in Biochemistry. Tata McGraw Hill.

## **BOT (O) 205: Stress Biology ( 2 Credits)**

- Unit I Essential nutrients, deficiencies and plant disorders; chelates; treating nutritional deficiencies; heavy-metal stress and homeostasis; molecular mechanism of mineral nutrition in plants.
- Unit II Stress: osmotic, temperature, salinity, anaerobic and oxidative; responses of plants to environmental stress; oxidative burst; stress induced gene expression and signaling.

### **Suggested readings**

- Aducci, P. (1997). Signal Transduction in Plants. Birkhauser Verlag.
- Bernle, J.D. and Black, M. (1992). Seed Physiology and Biochemistry. Springer-Verlag.
- Buchanan, B.B., Wilhelm, G. and Russel, J. (2003). Biochemistry and Molecular Biology of Plants. ASPB. US.
- Dennis, D.T. (1997). Plant Metabolism. John Wiley.
- Dey, P.M. and Harborne, J.B. (2000) Plant Biochemistry. Academic Press .
- Encyclopedia of Plant Physiology. Springer-Verlag. (Annual Series).
- Gresshoff, P.M. (2000). Plant Biochemistry. John Wiley.
- Goodwin T. W. and Mercer E. I. (1983). Introduction to Plant Biochemistry. Pergamon Press.
- Hopkins, W.G. and Hunter N.P. (2003). Introduction to Plant Physiology. John Wiley & Sons.
- Krauss, G. (1999) Biochemistry of Signal Transduction & Regulation. John Wiley.
- Lender, D. W. (2001). Photosynthesis. Marcel Dekker.
- Lincoln, T. and Zeiger E. (2002). Plant Physiology. Palgrave Macmillian.
- Lehninger, A.L. (1993). Principle of Biochemistry. CBS.
- Leopold, A.C. and Kreidman, P.E. (1980). Plant growth and development. Tata MacGraw Hill.
- Mattoo, A.K. and Shuttle, J.C. (1995). The Plant hormone Ethylene. CRC. Press.
- Mukherji, S. and Ghosh, A.K. (1996). Plant Physiology. Tata- McGraw Hill.
- Noggle, G.R. and Fritz, C.J (1989). Introductory Plant Physiology. Prentice Hall
- Seigler, D. S. (1994). Plant secondary metabolism. Narosa
- Srivastava, H.S. (1994). Plant Physiology. Rastogi and Co.
- Thomas, B. and Vince-Prue, D. (1997). Photoperiodism in plants. Academic Press.

## **BOT (O) 206: Bioprocess Development (2 Credits)**

Unit I Plant growth promoting microbes (PGPM) and their mass production for agriculture and forestry; principles and usage of bioreactors; types of bioreactors; microbial fermentation.

Unit II Environmental monitoring of GEMs; bioconversion of waste products by microbes with special reference to biogas and organic compost; steroid biotransformations.

### **Suggested readings**

- Alexander, N.G. and Hiroshi, N. (1998). Microbial Biotechnology. W.H. Freeman & Co., USA.
- Crueger, W. and Crueger, A. (2000). Biotechnology: A textbook of industrial microbiology Panima Publishing Corporation, India.
- Edward, A.B. (1992). Modern Microbiology – principles and application, WMC Brown Publishers, USA.
- Flickinger, M.C. and Drew, S.W. (1999). Encyclopedia of bioprocess technology. Vol 1-5
- Mansi, E.M.T.E.L. and Bryle, C.F.A. (2002) Fermentation Microbiology and Biotechnology Taylor & Francis Ltd, UK.
- Stanbury, P.F., Whitaker, A. and Hall, S.J. (1997). Principles of Fermentation Technology, Pergamon Press, Oxford.
- Tortora, G.J., Funke, B.R. and Case. C.L (2008). Microbiology– An Introduction. 9<sup>th</sup> edition. Dorling Kindersley (India), New Delhi, India.
- Young, M.M. (2004). Comprehensive Biotechnology. The principles, applications and regulations of biotechnology in industry, agriculture and medicine, Vol 1, 2, 3 and 4 Reed Elsevier India Private Ltd, India.

## **BOT (O) 207: Techniques in Molecular Biology (2 Credits)**

Unit I Microscopy: fluorescence, confocal, fluorescence resonance energy transfer (FRET), and atomic-force microscopy (AFM/SFM); spectrophotometry; chromatography: gel filtration, adsorption and ion exchange; protein digestion and profiling.

Unit II Electrophoresis; blotting: southern, western, northern, south-western, nucleotide sequencing and analysis; gene reporter assays.

### **Suggested readings**

- Alberts, B., Dennis, B., Lewis, J., Martin, R., Roberts, K, Watson, J. D (2002). Molecular Biology of the Cell. Garland.
- Birge, E.A. (2000). Bacterial and bacteriophage genetics. Springer.
- Boyer, R. (1999). Concept in Biochemistry. Brooks/Cole Publ.
- Brown, T.A. (1989). Genetics a molecular approach. Van Nostrand.
- Conn, E.E. and Stumpf P.K. (1994). Outlines of biochemistry. Wiley Eastern.
- Dennis, D.T. (1998). Plant metabolism. Longman.
- Dey, P.M. and Harborne, J.B. (1997). Plant biochemistry. Acad. Press.
- Heldt, H. (1997). Plant biochemistry and molecular biology. Oxford Univ. Press.
- Lea, P.J. and Leagood, R.C. (1999). Plant biochemistry and molecular biology. Wiley.
- Lewin, B. (2002). Genes VIII. Oxford.
- Lodish, H. *et al.* (1996). Molecular cell biology. Sc. American Books.
- Nelson, D.L. and Cox, M.M. (2000). Lehninger principles of biochemistry. Macmillan Worth.
- Plumer, D.T. (1993). An introduction to practicals in biochemistry. Tata McGraw Hill.
- Sinden, P.R.R. (1994). DNA structure and function. Acad. Press.
- Stryer, L. (1993). Biochemistry. W.H. Freeman.
- Walker, J.M. and Rapley, R. (2002). Molecular biology and biotechnology. Panima.
- Watson, J.D. *et al.* (2004). Molecular biology of the gene. Pearson Education.
- Zubay, G. (1993). Biochemistry. W.C. Brown.

## **BOT(C) 301: Genetics, Cytogenetics and Plant Breeding (4 Credits)**

- Unit I Modern gene concept: genetic fine structure, cis-trans test; eukaryotic gene organization, introns and exons; organization of eukaryotic chromosomes; linkage and genetic recombination, linkage groups; mutations: induced and spontaneous; physical and chemical mutagens and their mode of action; DNA damage and repair; molecular mechanism of mutation and recombination.
- Unit II Chromosomal aberrations in plants: origin, and meiotic and breeding behaviours of structural aberrations; breeding behaviour of interchange heterozygotes and permanent hybrids; interchange tester sets; euploidy and aneuploidy; origin, and meiotic and breeding behaviours of monosomics and primary trisomics; monosomic analysis.
- Unit III Origin, and meiotic and breeding behaviours of haploids, autopolyploids and allopolyploids; genome constitution and analysis; genome and chromosome engineering: synthesis of tetraploid, hexaploid and octoploid triticales; alien chromosome additions and substitutions; chromosome fragment transfers and crop improvement; Giemsa banding of chromosomes; fluorescence *in situ* hybridization (FISH) vs. genomic *in situ* hybridization (GISH).
- Unit IV Phenotypic variance and its components; heritability of traits and its estimation; gene frequency in a population, genetic equilibrium and Hardy-Weinberg law, barriers to gene flow and mechanism of speciation; heterosis and hybrid vigour; concept of combining ability; male sterility and its application in hybrid seed production.

### **Suggested readings**

- Al-Khayri J.M., Jain S.M. and Johnson D.V. (Eds.) (2015). Advances in Plant Breeding Strategies: Breeding, Biotechnology and Molecular Tools, Springer, London
- Allard, R. W. (1960). Principles of Plant breeding. John Wiley.
- Ayala, F. J. and Kiger, J.A. (1980). Modern Genetics. Benjamin Cummings.
- Bass, H.W. and Birchler J.A.(2012). Plant Cytogenetics, Springer, New York
- Brooker R.J. (2012). Genetics: Analysis and Principles, 4<sup>th</sup> Edition, McGraw Hill, New York.
- Brown, T.A. (1989). Genetics- a molecular approach. Chapman & Hall.
- Brown, T.A. (1999). Genomes. John Wiley & Sons.
- Brown J. And Caligari P.D.S. (2008). An Introduction to Plant Breeding, Blackwell Publishing, Oxford.
- Chopra, V.L. (1989). Plant Breeding. Oxford & IBH.
- Clark, M.S. and Wall, W.J. (1996). Chromosomes. Chapman & Hall.
- Gupta, P.K. (1995). Cytogenetics. Rastogi & Co.
- Gupta, P.K. (1998). Genetics and Biotechnology in Crop Improvement. Rastogi & Co.
- Griffiths A.J. F. et al. (2000). An Introduction to Genetic Analysis. W. H. Freeman.
- Hartl, D.L. (1991). Basic Genetics. Jones & Bartlett.
- Hartl, D.L. and Jones E. W. (2001). Genetics-Analysis of Genes & Genomes. Jones and Bartlett.
- Hartwell, L.H., Hood L., Goldberg, M.L., Reynolds A.E. and Silver L.M. (2011). Genetics: from Genes to Genomes, 4<sup>th</sup> Edition, McGraw Hill, New York
- Jain, H.K. (1999). Genetics. Oxford-IBH.
- Misra, A.K. (2011). Fundamentals of Cell and Molecular Genetics, Panima Publ., New Delhi.
- Poehlman, J.M. and Sleper, D.A. (1995). Breeding Field Crops. Iowa State University Press.
- Sharma, J.R. (1994). Principles & Practices of Plant Breeding. Tata-McGraw Hill.
- Simmonds, N.W. (1979). Principles of crop improvement. Longman.



Sinh R.J. (2003) Plant Cytogenetics, 2<sup>nd</sup> Edition, CRC Press, London  
Snustad, D.P. and Simmons, M. J. (2000). Principles of Genetics. John Wiley and Sons.  
Strickberger, M.W. (2008). Genetics. Third Edition, Phi Learning.  
Sybenga, J. (1972). General Cytogenetics. North Holland.  
Tamarin, R.H. (2002). Principles of Genetics. Tata McGraw-Hill.

**BOT(C) 302: Genetics, Cytogenetics and Plant Breeding (Practicals) (2 Credits)**

1. Preparation of materials and study of somatic chromosomes of some common plants, camera lucida drawing and karyotype preparation.
2. Collection of flower buds and study of meiosis of some common plants.
3. Study of meiosis of some aberrant plants.
4. Isolation of chlorophyll mutants following irradiation treatments.
5. Numerical exercises on linkage and crossing over.
6. Numerical exercises on  $\chi^2$  for independence of attributes and goodness of fit.
7. Giemsa banding of chromosomes.

**Suggested readings**

Elrod, S. and Stansfield, W. (2004). Genetics. Tata McGraw-Hill.  
Fukui, K. and Nakayam, S. (1996). Plant Chromosomes: Laboratory Methods. CRC Press.  
Hartl D., Jones, E.W. and Lozovsky E.R. (2006). Essential Genetics, 4<sup>th</sup> Edition, Jones and Bartlett, London  
Sharma, A.K. and Sharma, A. (1999). Plant Chromosomes: Analysis, Manipulation and Engineering. Harwood Academic Publishers.

### **BOT(C) 303: Plant Physiology (4 Credits)**

- Unit I Water relation in plants: chemical potential of water, water potential in plants, soil-plant-atmosphere continuum; movement of water in plants; membrane transport proteins.
- Unit II Bioenergetics: laws of thermodynamics and their significance in free energy changes in biological systems; organization of the light absorbing pigment systems; mechanisms of photoexcitation of chlorophyll and electron transport chain; carbon fixations in photosynthesis; regulation of CO<sub>2</sub> fixation activity in plant cells; glycolysis and its regulation; fatty acid oxidation, mechanisms of oxidative decarboxylation of pyruvic acid; mitochondrial electron transport and oxidative phosphorylation; biological nitrogen fixation and assimilation of ammonia.
- Unit III Plant growth regulators: auxins, gibberellins, cytokinins, abscisic acid, ethylene-physiological effects and mechanism of action; hormone receptors; steroids as plant growth regulators; brassinosteroids- types, physiological effects and mechanism of action.
- Unit IV Dormancy: types and mechanism of regulation; flowering: photoperiodism and vernalization; biochemical mechanisms involved in flowering; partitioning of assimilates during different phases of plant growth.

#### **Suggested readings**

- Aducci, P. (1997). Signal Transduction in Plants. Birkhauser Verlag.
- Annual Reviews of Plant Physiology and Molecular Biology. Academic Press (Annual Series)
- Bernle, J.D. and Black, M. (1992). Seed Physiology and Biochemistry. Springer-Verlag.
- Bruce, A., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K. and Walter, P. (2014). Molecular Biology of the Cell. Taylor and Francis.
- Buchanan, B.B., Gruissem, W. and Russell L. J. (2015). Biochemistry and Molecular Biology of Plants, 2nd Edition. Wiley Intl.
- Dennis, D. (1997). Plant Metabolism. John Wiley.
- Dey, P.M. and Harborne, J.B. (2000) Plant Biochemistry. Academic Press.
- Encyclopedia of Plant Physiology. Springer-Verlag. (Annual Series).
- Goodwin, T.W. and Mercer E.I. (1983). Introduction to Plant Biochemistry. Pergamon Press.
- Gresshoff, P.M. (2000). Plant Biochemistry. John Wiley.
- Grotewold, E. and Chappell, J. (2015). Plant Genes, Genomes and Genetics. Wiley- Blackwell
- Hopkins, W.G. and Hunter N.P. (2003). Introduction to Plant Physiology. John Wiley & Sons.
- Krauss, G. (1999) Biochemistry of Signal Transduction & Regulation. John Wiley.
- Lender, D.W. (2001). Photosynthesis. Marcel Dekker.
- Lincoln, T. and Zeiger, E. (2002). Plant Physiology. Palgrave Macmillian.
- Leopold, A.C. and Kreidman P.E. (1980). Plant growth and development. Tata MacGraw Hill.
- Mattoo, A.K. and Shuttle, J.C. (1995). The Plant hormone Ethylene. CRC. Press.
- Mukherji, S. and Ghosh, A.K. (1996). Plant Physiology. Tata- McGraw Hill.
- Nelson, D.L. and Cox, M.M. (2013). Lehninger Principle of Biochemistry. 6<sup>th</sup> Edition. Freeman and Company, New York.
- Noggle, G.R. and Fritz, C.J (1989). Introductory Plant Physiology. Prentice Hall
- Seigler, D.S. (1994). Plant secondary metabolism. Narosa
- Srivastava, H.S. (1994). Plant Physiology. Rastogi and Co.
- Taiz, L., Zeiger, E., Møller, I.M..and Murphy, A. (2014). Plant Physiology and Development. Sinauer Associates.
- Thomas, B. and Vince-Prue, D. (1997). Photoperiodism in plants. Academic Press.

**BOT(C) 304: Plant Physiology (Practicals) ( 2 Credits)**

1. Study of the effect of organic compounds on membrane permeability.
2. Determination of water potential in plant tissues.
3. Isolation of plant pigments and determination of their absorption spectra.
4. Estimation of chlorophyll a, b and total chlorophyll content of plant tissues.
5. Measurement of Hill reaction activity by Winkler's method: effect of light wavelength and light intensity.
6. Assay of auxin activity by Avena hypocotyl elongation.
7. Assay of amylase induction by GA in plant tissues.
8. Assay of effect of cytokinin on chlorophyll degradation by leaf disc method.

**Suggested readings**

Aducci, P. (1997). Signal Transduction in Plants. Birkhauser Verlag.

Annual Reviews of Plant Physiology and Molecular Biology. Academic Press (Annual Series)

Bernle, J.D. and Black, M. (1992). Seed Physiology and Biochemistry. Springer-Verlag.

Buchanan, B.B., Wilhelm, G. and Russel, J. (2003). Biochemistry and Molecular Biology of Plants. ASPB. US.

## **BOT (O) 305: Biodiversity and Phytogeography (2 Credits)**

- Unit I      Biodiversity: global distribution patterns; status of biodiversity in India and world; monitoring and documentation of biodiversity; biodiversity hotspots; IUCN categories of threatened species; major drivers of biodiversity change; principles of conservation; biodiversity management approaches; Indian case studies on conservation/management strategy viz., protected areas network including biosphere reserve.
- Unit II      Phytogeography: static and interpretive plant geography; principles and concepts of phytogeography; botanical regions of India; forest types of India; major terrestrial biomes; theory of island biogeography; endemism.

### **Suggested readings**

- Barnes, R.S.K. (1998). Diversity of living organisms. Blackwell Sciences Ltd., U.K.
- Barthlott, W. and Winiger, W. (2001). Biodiversity. Springer-Verlag, New York.
- Eldredge, N. (1992). Systematics, Ecology and Biodiversity Crisis. Cambridge University Press, New York.
- Frankel, O.H., Anthony, H.D. and Burdo, J.J. (1995). Conservation of Plant Biodiversity. Cambridge University Press, Cambridge. pp 299.
- Groombridge, B. (1992). Global biodiversity: status of the earth's living resources, a report compiled by the World Conservation Monitoring Centre. Chapman and Hall, London.
- Heywood, V.H. and Watson, R.T. (1995). Global biodiversity: Assessment. Cambridge University Press, Cambridge.
- Lomolino, M.V., Riddle, B.R., Whittaker, R.J. and Brown, J.H. (2010). Biogeography. 4<sup>th</sup> edition. Sinauer Associates, Inc., Sunderland, Massachusetts, USA.
- Magurran, A.E. and McGill, B.J. (2011). Biological diversity. Oxford University Press, Oxford.
- Reaka-Kulda, L.M., Wilson, D.E. and Wilson, E.O. (1997). Biodiversity II. Understanding and protecting our biological resources. Joseph Henry Press, Washington.
- World Resources Institute (1992). Global Biodiversity Study: Guidelines for action to save, study and use earth's biotic wealth sustainably and equitably.

**BOT (O) 306: Environmental Pollution and Conservation Theory (2 Credits)**

Unit I Environmental pollution: sources of air, soil and water pollution, parameters to assess the pollution level, effects of pollution on plants and ecosystems and pollution abatement; global environmental change: climate change: greenhouse gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, CFCs: sources, trends and role), consequences of climate change, ozone depletion.

Unit II Human impacts on forest ecosystems; soil erosion and its control; shifting cultivation and its ecological implications; coal mining problem of northeast India; eco-restoration of degraded ecosystems; environmental impact assessment (EIA).

**Suggested readings**

Cain, M.L., Bowman, W.D. and Hacker, S.D. (2014). Ecology. Third Edition. Companion Website.

Cunningham, W.P. and Saigo, B.W. (1999). Environmental Science. WCB, McGraw Hill.

Hunter, M.L. (1996). Fundamentals of Conservation Biology. Blackwell Science, Oxford.

Johnson, E.A. and Miyanishi, K. (2007). Plant Disturbance Ecology: the process and the response.

Jones, A.M. (1997). Environmental Biology. Routledge Publications, London and New York.

Mooney, H.A. and Gordon, M. (1983). Disturbance and Ecosystems components of Response. Springer Verlag. Berlin Heidelberg, New York, Tokyo.

Primack, R.B. (2014). Essentials of Conservation Biology. Sixth Edition. Sinauer Associates, Inc. Sunderland, Massachusetts, USA.

### **BOT (O) 307: Biostatistics (2 Credits)**

Unit I Basic statistics: measures of central tendency; measures of variation: standard deviation, coefficient of variation, standard error; sampling distribution; probability distributions (binomial, poisson and normal); frequency distribution.

Unit II Difference between non-parametric and parametric statistics; chi-square test; tests of significance: Students' 't' test, 'z' test, analysis of variance and 'F' test: one-way ANOVA; correlation and regression; basic introduction to multivariate statistics.

#### **Suggested readings**

Bizhop, O.N. (1980). Statistics of Biology. Longman press.

Gomez K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. John Wiley & Sons.

Hoshmand, A.R. (1998). Statistical methods for environmental and agricultural sciences. CRC press, New York.

Panse, V.G. and Sukhatme, P.V. (2000). Statistical methods for agricultural workers. ICAR, New Delhi.

Parker R.E. (1979). Introductory statistics for Biology. Edward Arnold.

Silverton J.W. (1982). Introductory statistics for Biology. Edward Arnold.

Zar, J.H. (1984). Biostatistical analysis. Prentic-Hall International.

## **BOT(C) 401: Plant Reproductive Biology and Biotechnology (4 Credits)**

- Unit I Development of flower (e.g. *Arabidopsis*); development of anther, ultrastructure of tapetum and its role in pollen development; microsporogenesis, male sterility, male gametophyte development, heterogeneity in sperm cells; pistil and stigma types; megasporogenesis; polarity and ultrastructure of embryo sac; pollen tube attraction by synergids.
- Unit II Pollen–pistil interaction; methods to overcome incompatibility; endosperm: types, endosperm haustoria and their functions; ultrastructure and polarity of zygote, formation of tetrad, quadrant and octant proembryos; difference between monocot and dicot embryos, structure of function of suspensor; polyembryony and apomixes; parthenocarpy.
- Unit III Tissue culture: role of *in vitro* tissue culture in plant biotechnology, anther culture, ovary culture, somatic hybridization and production of cybrids, embryo culture and rescue, clonal propagation, cryopreservation and germplasm storage, somatic embryogenesis, artificial seeds, somaclonal variations and gametoclonal variation; virus free plants; secondary metabolite production from cell cultures.
- Unit IV Transgenesis: methods and applications; useful gene transfers; genetic engineering of plants for insect control, herbicide resistance, resistance against viruses, quality improvement, and increased shelf-life.

### **Suggested readings**

- Bewley J.D. and Black. M. (1994). Seeds: physiology of Development and germination. Plenum Press.
- Bhojwani, S.S. and Bhatnagar, S.P. (200). The Embryology of Angiosperms, Vikas Publishing House.
- Chawla H.S. (2010). Introduction to plant Biotechnology. 3<sup>rd</sup> edition. Oxford& IBH Publishing Company Pvt. Ltd., New Delhi
- Dubey R.C. (2015). A textbook of Biotechnology. 5<sup>th</sup> edition. S. Chand Publishing.
- Endress, P.K. and Frus F.M. (1994). Early Evolution of flowers. Springer-verlag.
- Jogdand S.N. (2009). Gene Biotechnology. Himalaya Publisher.
- Johri, B.M. (1984). Embryology of angiosperms. Springer-Verlag.
- Leins, P., Tucker S.C. and Endress, P.K.(1988). Aspects of flower development. J. Cramer.
- Meeuse, A.D. (1966). Fundamentals of phytomorphology. Ronald Press Co.
- Maheswari, P. (1950). An Introduction to the embryology of Angiosperms. McGraw Hill Book Co.
- Shivanna, K.R. and Rangaswamy, N.S. (1992).Pollen Biology: A laboratory Manual. Springer-verlag.
- Shivanna, K.R. and Johri, B.M. (1985). The angiosperm pollen structure and function. Wiley eastern.
- Singh B.D (2015). Biotechnology: Expanding Horizons. Kalyani Publishers.
- Slater A, Scott N.W and Fowler M.R (2008). Plant Biotechnology: The Genetic Manipulation of Plants. 2<sup>nd</sup> edition. Oxford University Press.
- Stewart Jr. C.N. (2016). Plant Biotechnology and Genetics: Principles, Techniques and Applications. 2<sup>nd</sup> edition. Wiley Publishers.
- Raghavan, V. (1966). Embryogenesis in angiosperms. Cambridge Univ. Press.
- Raghavan, V. (1999). Development Biology of flowering plants. Springer-verlag.
- Sattler, R. (1978). Theoretical Plant morphology. Leiden University Press.

- Shivanna, K.R. and Sawhney, V.K. (1997). Pollen biotechnology for crop production and improvement. Cambridge University Press.
- Sporne, K.R. (1974). The morphology of angiosperms. Hutchinson Univ. Press.
- Stephen, H. Howell (1998). Molecular genetics of plant development. Cambridge Univ. Press.
- Swamy, B.G.L. and Krishnamurthy, K.V. (1980). From flower to fruit Tata McGraw Hill Book Co.

**BOT(C) 402: Plant Reproductive Biology and Biotechnology (Practicals) ( 2 Credits)**

1. Study of microsporogenesis and gametogenesis in anthers
2. Tests for pollen viability using stains and *in vitro* pollen germination
3. Estimating percentage of pollen germination and pollen viability *in vitro*
4. Preparation of dissected whole mounts of endothecium, tapetum and ovule
5. Study of nuclear and cellular endosperm and suspensor through dissections and staining
6. Isolation of globular, heart shaped and torpedo stages of embryos from suitable seeds
7. Induction of callus and somatic embryogenesis
8. Preparation of artificial seeds
9. Isolation of protoplasts
10. Clonal propagation of forest plants

**Suggested readings**

- Bhojwani, S.S. and Bhatnagar, S.P. (200). The Embryology of Angiosperms, Vikas Publishing House.
- Bhojwani, S.S and Razdan, M.K. Revised edition- (Studies in Plant Science) (2004). Plant tissue culture: theory and Practice, Elsevier Publications, Netherlands.
- Purohit S.S. (2006). A Laboratory Manual of Plant Biotechnology. 2<sup>nd</sup> revised edition. Agrobios, India.
- Shivanna, K.R. and Rangaswamy, N.S. (1992). Pollen Biology: A laboratory Manual. Springer-verlag.
- Vasil, I.K. and Thorpe, T.A. (2010). Plant Cell and Tissue culture. Kluwer Academic Publishers Springer Pvt. Ltd. India.



### **BOT (C) 403: Plant Ecology and Ecosystem Analysis (4 Credits)**

- Unit I Concepts relating to limiting factors; physical environmental factors (soil, water, light, temperature and fire) and their interactions with the biotic components.
- Unit II Population ecology: characteristics of a population; population growth curves and models; survivorship curves, life-table analysis and age structured populations; life history strategies (r and K selection); concept of metapopulation; demes and dispersal; interdemec extinctions; types of population interactions; inter- and intra-specific competition; population regulation; symbiosis, allelopathy.
- Unit III Community ecology: nature of communities; community structure and attributes; life-forms and biological spectrum; levels of species diversity and its measurement; quantitative methods of studying plant communities; edges and ecotones; concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement; ecological succession: types, mechanisms, changes involved in succession, concept of climax.
- Unit IV Ecosystem ecology: ecosystem structure and function; flow of energy; primary productivity and its measurement; primary productivity of terrestrial and aquatic ecosystems of the world; biogeochemical cycles (carbon, nitrogen, phosphorus, sulphur); development of ecosystem; ecosystem stability-ecosystem resistance and resilience; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (freshwater, marine, estuarine).

#### **Suggested readings**

- Begon, M. Harper J.L. and Townsend, C.R. (2015). Ecology: Individual, Populations and Communities. Blackwell Scientific Publisher.
- Cain, M.L., Bowman, W.D. and Hacker, S.D. (2014). Ecology. Third Edition. Companion Website.
- Daubermire R. (1974). Plants and environment. John Wiley & Sons.
- Hanson, H. C. and Churchill E. D. (1963). Plant Communities. Reinhold.
- Kormondy E. J. (1996). Concepts of ecology. Prentice-Hall.
- Odum, E.P. (1983). Basic Ecology. Holt Saunders International.
- Odum, E.P. and Barrett, G.W. (2009). Fundamentals of Ecology. 5<sup>th</sup> Edition. Thomson.
- Singh, J.S., Singh, S.P. and Gupta, S.R. (2014). Ecology, Environmental science and Conservation. S. Chand&Company Pvt. Ltd. New Delhi.
- Underwood A.J. (1997). Experiments in ecology. Cambridge University Press.
- White, J. (1985). Studies on plant demography. Academic Press.
- Whittaker, R.H. (1975). Communities and Ecosystems. McMillan.
- Wild, A. (1994). Soils and the environment. Cambridge University Press.

**BOT (C) 404: Plant Ecology and Ecosystem Analysis (Practicals) (2 Credits)**

1. Study of interactions between plants and environment
  - a) Study of microclimatic conditions in open and closed communities
  - b) Study of plastic response of plant species under contrasting environmental conditions
2. Study of physico-chemical properties of soil: (a) texture, (b) porosity, (c) water holding capacity and (d) TKN
3. Study of analytical characters of plant community using plot and plot-less methods
4. Study of cohort survivorship in plant populations and life-table analysis
5. Estimation of phytomass and its distribution in different compartments in grassland communities
6. Determination of leaf-area index in the grassland community
7. Estimation of primary productivity of plant community by (a) harvest method and (b) light and dark bottle method
8. Estimation of rate of carbon dioxide evolution from different soils by alkali absorption method

**Suggested readings**

- Anderson, J.M. and Ingram J.S.I. (1993). Tropical soil biology and fertility: A handbook of methods. CAB International.
- Misra, R. (1968). Ecology Workbook. Oxford & IBH.
- Muller-Dombois, D. and Ellenberg, H. (1974). Aims and Methods of vegetation ecology. John Wiley & Sons.
- Odum, E.P. (1971). Fundamentals of Ecology. W. B. Saunders.
- Poole, R.W. (1974). An Introduction to Quantitative Ecology. Mc Graw Hill Inc.
- Zar, J. H. (1984). Biostatistical analysis. Prentice-Hall International.

## **BOT (C) 405: Project Works ( 6 Credits)**

### **Broad areas for specialization through Project Work**

Plant Ecology  
Microbial Ecology  
Plant Molecular Biology  
Advanced Plant Physiology  
Taxonomy and Biodiversity of angiosperms  
Development and Reproduction of angiosperms  
Plant Biotechnology  
Plant Genetics and Cytogenetics  
Lower plants

### **Attachment of students and allotment of topic for Project Work**

Each faculty will be assigned a minimum of number of students to be decided by the Department. Attachment of students shall be done on the basis of their choice and marks secured by them in the last end Semester examination for which the results are available. The teacher will assign one topic to the student and communicate the same to the Head of the Department by the middle of III<sup>rd</sup> Semester. Modification in the topic, if absolutely necessary may be allowed during the first month of the IV<sup>th</sup> semester and not thereafter. The Head of the Department will notify the final list of topics allotted to the students. The student will work in the M. Sc. Lab or Research lab of the concerned teacher during two days in a week as per the timetable. The teacher will provide regular necessary guidance by way of discussion, tutorials and any other method, which she or he deems fit for the successful completion of work assigned to the student and will maintain the attendance. The workload for each teacher will be equivalent to five theory and six practical hours per week per student attached.

### **Evaluation scheme for Project Work**

For continuous evaluation, she/he will be required to give two seminars, first within two months of the start of IV<sup>th</sup> semester and the second before submission of her/ his project work in the end of the semester. Each seminar will be evaluated for 37.5 marks by the supervisor and Head's nominee. The marks obtained by the student in the two seminars will be averaged to obtain the total marks of continuous evaluation. The end semester examination will be based on the evaluation of project work (75 marks for dissertation + 25 marks for seminar + 12.5 marks for viva- voce). At the time of examination, the student will submit project report and will give a brief presentation of the work done by her/him, which will be followed by viva-voce examination. The end semester evaluation of the seminar and viva-voce will be done by a board comprising the external examiner in the concerned broad areas, supervisor and Head's nominee. However, the dissertation will be evaluated by the concerned external examiner only. The external examiners shall be called in nine broad areas to evaluate the project work. In case the external examiner is not able to come, the Dean of the School, as per existing practice may constitute an internal Board.