Department of Botany

Annexure-IA

New course structure of the M. Sc Botany program is as under:

Semester I

Course Code	Course Title	Credit	Internal Assessment Marks	University Exam Marks	Max. Marks
Core Courses					
Bot-150	Algae and Lichens: Structure and Diversity	04	40	60	100
Bot-151	Bryophytes and Pteridophytes: Structure and Diversity	04	40	60	100
Bot-152	Anatomy and Developmental Biology of Angiosperms	04	40	60	100
Bot-153	Cell Biology	02	20	30	50
Bot-154	Molecular Biology	02	20	30	50
Laboratory Courses					
Bot-160	Lab Course based on Bot-150, Bot-151 and Bot-152	06	75	75	150
Bot-161	Lab Course based on Bot-153 and Bot-154	02	25	25	50
	Total	**24**	**260**	**340**	**600**

Semester II

Course Code	Course Title	Credit	Internal Assessment Marks	University Exam. Marks	Max. Marks
Core Courses					
Bot-250	Gymnosperms: Structure and Diversity	02	20	30	50

Bot-251	Mycology and Plant Pathology	04	40	60	100
Bot-252	Plant Taxonomy	04	40	60	100
Bot-253	Bacteria and Viruses: Structure and Diversity	02	20	30	50
Open Choice Elective Courses. Students are required to opt any one the following courses					
Math- 201	Mathematical Tools for Real World Problems	04	40	60	100
IT.- 202	Soft Skills in Information Technology	04	40	60	100
Comp-203	Computer Applications and Operations	04	40	60	100
Bio-204	Fundamentals of Biotechnology	04	40	60	100
Zol- 207	Nutrition, Health and Hygiene	04	40	60	100
Arab- 208	Fundamentals of Arabic Language	04	40	60	100
Eng- 209	Applied English	04	40	60	100
Edu. 210	Higher Education	04	40	60	100
Eco-211	Principles of Banking	04	40	60	100
HT-212	Basics of Tourism and Travel Agency	04	40	60	100
HT-213	Tourism Resources of J&K	04	40	60	100
Mgt-214	Business Communication & Soft Skills	04	40	60	100
Edu-215	Instructional Technology	04	40	60	100
Laboratory Courses					
Bot-260	Lab Course based on Bot-250 and Bot-252	04	50	50	100
Bot-261	Lab Course based on Bot-251 and Bot-253	04	50	50	100
	Total	**24**	**260**	**340**	**600**

Semester III

Course Code	Course Title	Credit	Internal Assessment Marks	University Exam	Max. Marks
Core Courses					
Bot-350	Cytology and Cytogenetics	04	40	60	100
Bot-351	Reproductive Biology of Angiosperms	04	40	60	100
Bot-352	Plant Resources and Utilization	04	40	60	100
Bot-353	Biostatistics and Bioinformatics	02	20	30	50
Choice Based Complimentary Electives					
Bot-354	Recombinant DNA Technology	02	20	30	50
Bot-355	Forest Ecology-I	02	20	30	50
Bot-356	Plant Biotechnology-I	02	20	30	50
Bot-357	Biodiversity and Conservation-I	02	20	30	50
Laboratory Courses					
Bot-360	Lab Course based on Bot-350, Bot-351 and Bot-352	06	75	75	150
Bot-361	Lab Course based on Bot-353 and Bot-354/355/356/357	02	25	25	50
	Total	**24**	**260**	**340**	**600**

Semester IV

Course Code	Course Title	Credit	Internal Assessment Marks	University Exam	Max. Marks
Core Courses					
Bot-450	Ecology and Environmental Biology	04	40	60	100
Bot-451	Plant Physiology and Biochemistry	04	40	60	100
Bot-452	Biotechnology and Genetic Engineering of Plants and Microbes	02	20	30	50

Bot-453	Dissertation	04	20	80	100
Choice Based Complimentary Electives					
Bot-454	Stress Biology	02	20	30	50
Bot-455	Forest Ecology-II	02	20	30	50
Bot-456	Plant Biotechnology-II	02	20	30	50
Bot-457	Biodiversity and Conservation-II	02	20	30	50
Laboratory Courses					
Bot-460	Lab Course based on Bot-450 and Bot-454/455/456/457	04	50	50	100
Bot-461	Lab course based on Bot- 451 and Bot-452	04	50	50	100
	Total	**24**	**260**	**340**	**600**

Program outcomes (PO's) of M. Sc Botany Program

PO1: *Deeper understanding*

To have a deeper understanding of a subject by the student for its application in addressing societal and scientific issues

PO2: *Research and development*

To prepare students for research and development in respective areas

PO3: *Problem solution*

Problem solving by applying reasoning and technical inputs

PO4: *Environment and sustainable development*

To study and understand the impact of development on environment safety and its significance for sustainable ways of development

PO5: *Lifelong learning*

Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PO6: *Leadership and self-reliance*

Impart leadership abilities to the students to lead and excel in their respective fields. Also, the training will make students self-reliant.

Program Specific Outcomes (PSO's) of M. Sc Botany Program

PSO 1: Development of understanding about lower plant groups; Algae, Lichens, Bryophytes, Pteridophytes, and Bacteria and Viruses

PSO 2: Development of understanding about Fungi – the non-chlorophyllous plants

PSO 3: Development of understanding in the area of Molecular Biology (glance of Structure of nucleic acids, their replication, transcription, translation along with other important aspects of posttranscriptional and translational modifications)

PSO 4: Development of understanding in the area of Cell Biology (glance of cell structure, programming of cell cycle, study of cellular organelles, chromosomal structure & behavior and other important aspects pertaining to this)

PSO 5: Development of understanding in the area of Plant Physiology and Biochemistry (glance of physiological processes, adaptation of plants, their anatomy, biochemical aspects of different cellular processes)

PSO 6: Development of understanding in the area of reproductive behavior of flowering plants

PSO 7: Development of understanding in the area of principles of taxonomy and systematics in plants, plant identification methods and their utilization

PSO 8: Development of understanding on ecology and environmental biology

PSO 9: Development of understanding of statistical tools and their applicaton in biological sciences

PSO 10: Development of understanding about different components of forest ecology, ecological processes and their relation with different biodiversity elements

PSO 11: Development of understanding about plant biotechnology and applications of genetic engineering in both plants and microbes

M. Sc. Botany, Semester I

Course Code: Bot-150 **Maximum marks: 100**

Course Title: Algae & Lichens: Structure & Diversity **Internal Assessment Marks: 40**

Credits: 04 **University Examination Marks: 60**

Course Objectives:

Representing two most interesting plant groups on planet earth and growing at all kinds of habitats, algae and lichens represent rich resource for human use particularly in agriculture, medical and biotechnology based industry. This necessitates knowledge about their structural diversity, biology and utility.

Unit I: Algal diversity – I

1.1 Modern trends in classification of algae
1.2 Salient features of Chlorophyta and Bacillareophyta with special reference to structure and composition of cell and cell wall, flagella, chloroplasts, pyrenoids, eye spot and overall body form
1.3 Salient features of Xanthophyta, Phaeophyta and Rhodophyta with special reference to structure and composition of cell and cell wall, flagella, chloroplasts, pyrenoids, eye spot and overall body form
1.4 Salient features of Euglenophyta and Dinophyta with special reference to structure and composition of cell and cell wall and overall body form

Unit II: Algal diversity – II

2.1 Salient features of Chrysophyta, and Cryptophyta with special reference to structure and composition of cell and cell wall and overall body form

2.2 Evolutionary aspects of thallus organization and sex in algae

2.3 Algal pigments and reserve food material: a comparative account of all the algal groups

2.4 Ecological adaptations of algae to diverse habitats (terrestrial, fresh water, marine); modes of perennation in algae

Unit III: Reproduction and importance of algae

3.1 Reproduction and life cycle patterns in Chlorophyta, Xanthophyta, Phaeophyta and Rhodophyta

3.2 Economic importance of algae (a general account), algae as pollutants and pollution indicators; algal blooms

3.3 Toxic algae and their role, algae as parasites and pathogens

3.4 Algal biofertilizers, algae in biotechnology, algae as space food

Unit IV: Lichen diversity and systematics

4.1 Classification of lichens: basis for classification

4.2 Morphology of lichen thallus: Ascolichens, Basidiolichens and Lichen imperfectii; ultrastructure of lichenized symbionts (phycobionts, mycobionts)

4.3 Reproduction of lichens – morphology of reproductive structures; vegetative, sexual and asexual modes of reproduction; dispersal of lichens

4.4 In vitro lichen culture and its importance

Unit V: Physiology and importance of lichens

5.1 Development of symbiotic relationships between phyco - and mycobiont; physiological and evolutionary significance of symbiosis in lichens; parasymbionts

5.2 Water relations, photosynthesis and carbohydrate mobilization in lichens

5.3 Respiration, nitrogen metabolism and minimal requirements of lichens

5.4 Lichens as primary colonisers in ecological succession, heavy metal accumulators, pollution indicators, sources of natural dyes and paedogenesis, lichens as food and fodder

Course Outcomes:

1. *Teach students identification, structure, function and ecology of algae and lichens.*
2. *Demonstrate the use of algae and lichens as economically important organisms.*
3. *Develop hands-on approaches to study algae and lichens populations and their growth forms in the surrounding environment.*
4. *Economic importance of algae (a general account), algae as pollutants and pollution Indicators.*

Books recommended:

1. Ahmadjian, V. and Hale, E. M. (1973). The Lichens, Academic Press.
2. Barsanti, L. and Gualieri, P. (2005). Algae: Anatomy, Biochemistry and Biotechnology, 1st edition, CRC Press.
3. Doyle Alisha, M. and Jayden, A. B. (2011). Algal Biofuels: Where We've Been, Where We're Going, 1st edition. Nova Publishers.
4. James, G., Wilcox, L. W. and Graham, L. M. (2008). Algae, 2nd edition. Benjamin Cummings Publishers
5. Hawksworth, D. and Hill, D. (1984). The Lichen-forming Fungi**.** Blackie. Chapman & Hall.
6. Christiaan, H. (1996). Algae: An Introduction to Phycology. Cambridge University Press
7. Nash, T. H. (2008). Lichen Biology, Cambridge University Press.
8. Philip, S. (1997). A Biology of the Algae, 3rd edition. McGraw-Hill College Publishers.
9. Purvis, W. (2000). Lichens. Smithsonian Books.
10. Round, F. E. (1986). The Biology of Algae. Cambridge University Press, Cambridge.
11. Sandgren, C. D. (1995). Chrysophyte Algae: Ecology, phylogeny and development, 1st edition. Cambridge University Press.
12. Sarabhai, B. P and Arora, C. K. (1995). Text Book of Algae. Anmol Publications Pvt. Limited.
13. Sharma, O. P. (1986). Textbook of Algae. Tata McGraw-Hill Education.

Course code: Bot-151 **Maximum Marks: 100**

Course Title: Bryophytes and Pteridophytes: Structure and Diversity **Internal Assessment Marks: 40**

University Examination Marks: 60

Credits: 04

Course Objectives:

Bryophytes and Pteridophytes represent important stages in the evolution of plant kingdom particularly the terrestrial habit. The course is designed to equip students with knowledge about the diversity and biology of these plants.

Unit I: Bryophytes - diversity in structure and reproduction

1.1 General characters of bryophytes, criteria used for classification, classification as given by Proskauer (1957), alternation of generation in the life history of bryophytes, bryophytes as amphibians of plant kingdom.

1.2 Hepaticopsida: distinguishing features, morphology and anatomy of sporophyte and gametophyte, vegetative and sexual reproduction in Marchantiales (*Riccia, Marchantia*) and Jungermanniales (*Pellia, Porella)*.

1.3 Anthocerotopsida: distinguishing features, morphology and anatomy of sporophyte and gametophyte, vegetative and sexual reproduction in *Anthoceros, Notothylus*

1.4 Bryopsida: distinguishing features, morphology and anatomy of sporophyte and gametophyte, vegetative and sexual reproduction in *Funaria, Polytrichum.*

Unit II: Bryophytes - origin, evolution and ecological importance.

2.1 Theories of origin of bryophytes from algal and pteridophyte ancesstors, their affinities with the two groups.

2.2 Evolution of sporophyte in bryophytes; apospory and apogamy, and factors affecting their occurrence in bryophytes.

2.3 Ecological importance of bryophytes: as indicators of air and water pollution.

2.4 Biochemical and molecular mechanisms of dessication tolerance in bryophytes.

Unit III: Pteridophytes – diversity in structure and reproduction

3.1 General characters of pteridophytes, principles and modern trends in pteridophyte classification as given by Riemers (1956).

3.2 Distinguishing features of Psilopsida and Lycopsida. Morphology, anatomy, vegetative and sexual reproduction in *Psilotum , Lycopodium* and *Selaginella.*

3.3 Distinguishing features of Sphenopsida. Morphology, anatomy, vegetative and sexual reproduction in *Equisetum.*

3.4 Distinguishing features, life history and classification of Pteropsida; study of vegetative development, reproduction in *Adiantum, Marsilea, Salvinia and Azolla.*

Unit IV: Pteridophytes - origin, evolution and economic importance

4.1 Origin of Pteridophytes from algal and bryophyte ancesstors, antithetic theory.

4.2 Apospory and apogamy , their significance in pteridophytes; Telome theory.

4.3 Soral and prothallial evolution in ferns; economic importance of pteridophytes.

4.4 Stelar system and evolution in pteridophytes, heterospory and seed habit in pteridophytes.

Unit V: Fossils of bryophytes, pteridophytes and geological time scale.

5.1 Geological time scale: concepts of epoch, era, period; origin of important plant groups during different periods in geological history.

5.2 Fossils- types, causes of fossil formation, methods to study fossils and reorganization of fossil genera.

5.3 Fossil bryophytes: *Naiadita lanceolate, Sporogonites exuberans, Hepaticites kidstonii.*

5.4 Fossil pteridophytes*: Rhynia, Calamites, Sphenophyllum. Lepidodendron.*

Course Outcomes:

1. *To provide theoretical and practical knowledge on biology and diversity of Bryophytes and Pteridophytes to the students.*
2. *To develop understanding on the range of variation in structural and reproductive diversities of Bryophytes and Pteridophytes*
3. *To impart knowledge on the distribution, conservation status and economic and ecological importanceof Bryophytes and Pteridophytes.*

4. *To understand the significance of bryophytes as pioneer plants on land and their role in the origin of Pteridophytes.*
5. *To understand the role of Pteridophytes in the origin of seed plants and or seed habit.*

Books recommended:

1. Agashe, S. N. (1995). Paleobotany. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
2. Arnold, A. C. (2005). An Introduction to Pteridophytes. Agrobios, Jodhpur
3. Chopra, R. N. (2005). Biology of Bryophytes. New Age International Publishers.
4. Chopra, R. N. and Kumar, P. K. (1988). Biology of Bryophytes. John Wiley & Sons, New York.
5. Langton, R. B. E. (2009). Bryophytes and Lichens. Cambridge University Press.
6. Parihar, N. S. (1996). Biology and Morphology of Pteridophytes. Central Book Depot, Allahabad.
7. Parihar, N. S. (1996). Bryophytea. Central book report, Allahabad.
8. Parihar, N. S. (1976). Biology and Morphology of Pteridophytes. Central Book Depot. Allahabad.
9. Parihar, N. S. (1980). Bryophytes: An Introduction to Embryophyta, Vol I. Central Book
10. Rashid, A. (1998). An Introduction to Pteridophyta: diversity, development and differentiation. Vikas Publishing House, Noida.
11. Rashid, A. (1998). An Introduction to Bryophyta: diversity, development and differentiation. Vikas Publishing House, Noida.
12. Sharma, O. P. (1990). Text Book of Pteridophyta. MacMillan India Ltd., Delhi.
13. Sundar Rajan, S. (1999). Introduction to Pteridophytes. CSIR; New Delhi
14. Shaw, A. J. (2000). Bryophyte Biology. Cambridge University Press.
15. Sporne, K. R. (1996). The Morphology of Pteridophytes. B I Publishing Pvt. Ltd., Bombay.
16. Sporne, K. R. (1986). The Morphology of Pteridophytes. Hutchinson University Library, London.
17. Stewart, W. N. and Rothwell, G. W. (2005). Paleobotany and the Evolution of Plants, 2nd edition. Cambridge University Press.
18. Zoltán, T., Slack, N. G. and Stark, L. Y. (2011). Bryophyte Ecology and Climate Change. Cambridge University Press.
19. Vanderpoorten, A. and Bernard, G. (2009). Introduction to Bryophytes. Cambridge University Press.
20. Vashista, B. R., Sinha, A. K . and Kumar, A. (2008). Botany for Degree Students – Bryophyta. S. Chands Publication.

Course Code: Bot-I52 **Maximum Marks: 100**

Course Title: Anatomy and Developmental Biology of Angiosperms **Internal Assessment Marks: 40**

Credits: 04 **University Examination Marks: 60**

Course Objectives:

The study of plant anatomy has important industrial implications; structure determines its utilitarian value and marketability as timber. The study of development biology enables the student to understand the processes and the basis of plant development in general and different tissue systems in particular. The course is designed to create awareness among students about these basic science disciplines.

Unit I: Plant development and organization

1.1 General organization of angiosperm plant body; major tissue systems and their distribution in the plant body.
1.2 Organization of Shoot Apical Meristem (SAM); development of epidermis with reference to its derivatives: stomata and trichomes.
1.3 Organization of Root Apical Meristem (RAM); development of lateral roots; general anatomy of roots in dicots and monocots.
1.4 Development of leaf from shoot apical meristem; leaf anatomy and diversity in form, phyllotaxy.

Unit II: Primary and secondary vascular tissues

2.1 Primary vascular tissues: structure and components of xylem and phloem; cambium structure, development and types.

2.2 Differentiation of primary xylem and primary phloem from procambium; cytodifferentiation of tracheary elements.

2.3 Secondary growth: development of secondary vascular tissues from cambium; anomalous secondary growth; secondary growth in monocots.

2.4 Cork: structure, ontogeny, function and commercial importance of cork.

Unit III: development and anatomy of flower

3.1 Morphological nature of flower, floral evocation and factors affecting it: temperature, photoperiod; co-evolution of flower with pollinators.

3.2 Origin of flower on SAM: genetics of floral organ determination, floral organ identity genes, homeotic mutants in *Arabidopsis*.

3.3 Anatomy and vascular structure of floral organs: sepals, petals, stamen, carpel; homology of floral appendages.

3.4 Adnation of floral parts with specific reference to origin of inferior ovary; vestigial and inverted vascular bundles.

Unit IV: Fruit and seed development

4.1 Important fruit types (fleshy and dry) and their morphology; anatomy of simple and complex fruits.

4.2 Fruit development, growth and ripening: molecular and biochemical control.

4.3 Seed: development of seed; histological structure of seed coat, vascular supply of seed coat.

4.4 Seed dormancy and its significance; gene expression during dormancy, role of ABA in seed dormancy.

Unit V: Anatomy in relation to systematics and ecology

5.1Use of wood anatomy in systematics: nodal anatomy, variability in stomatal apparatus.

5.2 Ecological wood anatomy: hard and soft woods, growth rings, hydraulic architecture; industrial implications of wood structure.

5.3 Anatomical specializations/modifications in leaves and roots under different ecological conditions: drought stressed roots, leaves of alpine and epiphytic plants.

5.4 Anatomy and pollution: effect of air pollutants, UV radiation, insecticides and herbicides on anatomy of plant parts.

Course Outcomes:

1. *The syllabus is designed to know the structure of the different tissues and how these tissues differ from one another and their role in plant biology. Studying anatomy allows students to know the structure, function, ecology and development*
2. *Flowers role in reproduction and end product of flower (fruits) are also included which include the key fruits use in daily life and their morphology, anatomy and part used to create awareness among students*

3. *To study the effects of environmental pollutants on the morphology and anatomical features of diverse plant groups and the damage caused by these pollutants*
4. *To aware students about the seed dormancy and associated phytohormones in dormancy.*

Books recommended:

1. Cutler, D. F., Botha T., and Stevenson, D. W. (2008). Plant Anatomy: An Applied Approach. Blackwell Publishing, USA.
2. Dickison, W. C. (2007). Integrative Plant Anatomy. Academic Press.
3. Eames, A. J. (1983). Morphology of Vascular Plants. Stanford University Press, NewYork
4. Eames, A. J., Lawrence, H. and Daniels, M. (1972). An Introduction to Plant Anatomy. TaTa McGraw Hill Publishing Company, New Delhi.
5. Esau, K. (2006). Anatomy of Seed Plants. John Wiley and Sons, New Jeresy.
6. Evert, R. F. (2006). Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function, and Development, Third Edition. John Wiley and Sons, New Jeresy.
7. Fahn, A. (1990). Plant Anatomy, Pargamon Press.
8. Mauseth, J. D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.
9. Raghavan, V. (2008). Developmental Biology of Flowering Plants. Springer-Verlag, New York.
10. Rudall, P. (1994). Anatomy of Flowering Plants: An Introduction to Structure and Development. Cambridge University Press, England.
11. Sporne, K. R. (1974). The Morphology of Angiosperms. B. I. Publications, Pvt. Ltd., Bombay.

Course Code: Bot-153 **Maximum Marks: 50**

Course Title: Cell Biology **Internal Assessment Marks: 20**

Credits: 02 **University Examination Marks: 30**

Course Objectives:

The present course has been devised to familiarize students with the structural and functional aspects of cell, the basic unit of life, and its different organelles. Knowing the components of cells and how they work is fundamental to all biological sciences.

Unit I: Microscopy, cell architecture and cell organelles

1.1. Microscopy: Light microscopy; Principles and applications of Bright field microscopy and Fluorescence microscopy; confocal microscopy; Electron microscopy: principles and applications of scanning electron microcopy (SEM) and transmission electron microscopy (TEM).
1.2. Cell architecture: Cell theory, structure of Prokaryotic and Eukaryotic cells (plant cell); Plant cell wall: ultrastructure and functions.
1.3. Plasma membrane: Fluid Mosaic Organization (model) and functions; membrane proteins – peripheral, integral and transmembrane proteins; active and passive transport, channels, pumps and carriers.
1.4. Nucleus: Ultrastructure, nuclear membrane and nuclear pore complex, nucleolus, transport of proteins and RNAs across nuclear membrane.

Unit II: Cell organelles - structure and function

2.1. Mitochondria: Structure and functions, genome organization, protein import and mitochondrial assembly (protein targeting to the mitochondrial inner membrane, outer membrane and intermembrane space)

2.2. Chloroplast: Structure and functions; genome organization, import and sorting of chloroplast proteins. Peroxisomes: structure, functions of peroxisomes, peroxisome assembly and import of peroxisomal proteins.

2.3. Endoplasmic Reticulum: Structure, types, overview of protein sorting, protein targeting to ER (Cotranslational and Posttranslational translocation of proteins into the ER), protein folding and processing in the ER, protein misfolding and unfolded protein response, protein export from ER.

2.4.Golgi complex: organization of Golgi, protein glycosylation within Golgi, mannose phosphoralation, protein sorting and export from the Golgi apparatus, mechanism of vesicular transport and vesicle fusion.

Unit III: Cytoskeleton, cell cycle and cell death

3.1. Lysosomes: structure and functions, endocytosis, phagocytosis and autophagy. Ribosomes: structure of prokaryotic and eukaryotic ribosomes.

3.2. The cytoskeleton: Organization and role of microtubules, microfilaments and associated motor proteins and intermediate filaments.

3.3. The cell cycle: Phases of cell cycle, cyclin-dependent kinases and cyclins, cell cycle check points and role of p53 and Rb (retinoblastoma) proteins in regulation of cell cycle.

3.4. Programmed cell death-PCD (Apoptosis): Caspases: the executioners of apoptosis, Central regulators of apoptosis: role of the Bcl-2 family in PCD.

Course Outcomes:

1. *Students will understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially membranes, and organelles*
2. *To study the cell their composition and role govern by them and know the technique to study the diverse cells*
3. *To introduce the different organelles in a cell their individual role and composition any symptoms associated with the deficiency of any proteins/genes*
4. *To know the process of apoptosis and role of it.*
5. *Students will understand how these cellular components are used to generate and utilize energy in cells*

Books recommended:

1. Albert, B., Bray, D., Raff, M., Roberts, K. and Watson, J. D. (2015). Molecular Biology of the Cell. Garland Publishing Inc., New York. 6th Ed.
2. Brown, T. A. (2016). Gene Cloning – An Introduction. Blackwell Publishing. (7th edition).
3. Clark, D. P. (2005). Molecular Biology: Understanding the Genetic Revolution. Elsevier Academic Press, UK.
4. Cooper, G. M. and Hausman, R. E. (2016). The Cell: A Molecular Approach. ASM Press, Washington DC. 7th Ed.
5. Karp, G. (2007). Cell and Molecular Biology. John Wiley and Sons Singapore Pvt. Ltd. 7th Ed.

6. Kornberg, A. and Baker, A. T. (2005). DNA Replication. W.H. Freeman & Company. 2nd Ed.
7. Krebs E, J., Goldstein S, E. and Kilpatrick, T. S. (2013). Lewins Gene XI. Jones and Bartlett publishers, Inc.
8. Lodish, H., Berk, A., Zipursky, S., Matsudaira, P., Baltimore, D. and Darnell, J. (2016). Molecular Cell Biology. W. H. Freeman and Company, 8th Ed.
9. Wayane, R. (2009). Plant Cell Biology. Academic Press.

Course code: Bot-154 **Maximum Marks: 50**

Course Title: Molecular Biology **Internal Assessment Marks: 20**

Credits: 02 **University Examination Marks: 30**

Course Objectives:

The course familiarizes students with Molecular aspects of cell which chiefly deal with interactions among various systems of a cell, including those between DNA, RNA and proteins and learning how these are regulated.

Unit I: DNA - structure, replication, damage and repair

1.1. DNA: DNA structure and types, DNA as genetic material (experimental proof); satellite, repetitive, unique DNA sequences and concept of melting temperature (Tm).

1.2. Mechanism of DNA replication (Semi-conservative), Rolling – Circle Replication; bidirectional replication in Eukaryotes.

1.3. Chromosome organization: Nucleosome organization, molecular organization and role of centromeric and telomeric regions in organization of eukaryotic chromosomes.

1.4. DNA damage and repair mechanisms. Oxidative damage, alkylating agents, intercalating agents, radiations (UV); direct repair, base excision, nucleotide excision and mismatch repair.

Unit II: Transcription and regulation of gene expression

2.1. RNA: Structure, types and properties of RNA (mRNA, tRNA, rRNA); microRNA (miRNA), small interfering RNAs (siRNAs), Piwi-interacting RNA (piRNA).

2.2. Transcription: RNA polymerases, accessory proteins, mechanism of transcription, major differences between prokaryotes and eukaryotes (at transcriptional level).

2.3. Post-transcriptional modifications in eukaryotes: Capping, polyadenylation, splicing, RNA editing and their importance.

2.4. Regulation of gene expression: Prokaryotes (lactose *(lac)* operon and trpyptophan *(trp)* operon) and Eukaryotes (activators, repressors, histone modifications (histone code), DNA methylation and RNA interference).

III: Translation and post-translational modifications

3.1. Genetic code: Concept, degeneracy, wobble hypothesis.

3.2. Translation: Mechanism of protein synthesis, initiation, elongation and termination, major differences between prokaryotes and eukaryotes (at translational level), inhibitors of translation.

3.3. Post-translational modifications: protein folding (chaperones and enzymes), proteolytic cleavage, glycosylation and attachment of lipids.

3.4. Post-translational modifications: protein phosphorylation, ubiquitin mediated protein degradation (ubiquitin-proteasome pathway).

Course Outcomes:

1. *Paper provides basic concepts on the functioning of cell.*
2. *Familiarize students about different aspects of nucleic acids and their interaction with surrounding cellular system.*
3. *Helps student in developing abilities to understand the fascinating aspects of hereditary material and information of gene functioning.*
4. *Increases interest of students to unravel mysteries regarding DNA and RNA functioning and their correlation with the protein functions in cell.*

Books recommended:

1. Albert, B., Bray, D., Raff, M., Roberts, K. and Watson, J. D. (2015). Molecular Biology of the Cell. Garland Publishing Inc., New York. 6th Ed.
2. Clark, D. P. (2005). Molecular Biology: Understanding the Genetic Revolution. Elsevier Academic Press, UK.
3. Cooper, G. M. and Hausman, R. E. (2016). The Cell: A Molecular Approach. ASM Press, Washington DC. 7th Ed.
4. Karp, G. (2007). Cell and Molecular Biology. John Wiley and Sons Singapore Pvt. Ltd. 7th Ed.
5. Kornberg, A. and Baker, A. T. (2005). DNA Replication. W.H. Freeman & Company. 2nd Ed.

6. Krebs E, J., Goldstein S, E. and Kilpatrick, T. S. (2013). Lewins Gene XI. Jones and Bartlett publishers, Inc.
7. Lodish, H., Berk, A., Zipursky, S., Matsudaira, P., Baltimore, D. and Darnell, J. (2016). Molecular Cell Biology, W. H. Freeman and Company, 8th Ed.
8. Burton, E. Tropp & David Freifelder (2012). Molecular Biology, 4th edition. Jones and Bartlett India Pvt. Ltd. New Delhi
9. David P. Clark & Nanette J. Pazdernik (2013). Molecular Biology. Elsevier Academic Press, UK. 2nd Ed.
10. James, D. Watson, Baker and Bell. (2013). Molecular Biology of the Gene. Cold Spring Harbor Laboratory Press, New York. 7th Ed.
11. Krebs E, J., Goldstein S, E., Kilpatrick T. S. (2013). Lewins Gene XI. Jones and Bartlett Publishers, Inc.

Course Code: Bot-160 **Maximum Marks: 150**

Course Title: Lab Course on Bot-150, Bot-151 & Bot-152

University Examination Marks: 75 Internal Assessment Marks: 75

Credits: 06

1. A comparative study of the morphology of the vegetative and reproductive structures of representative members of each of the following groups of algae with the objective to appreciate structural diversity of form within and across these groups.
   2.1. Chlorophyta : *Volvox; Ulothrix / Spirogyra / Zygnena; Oedogonium; Chara.*
   2.2. Bacillariophyta : *Navicula ; Pinnularia*
   2.3. Xanthophyta : *Botrydium ; Heterochloris*
   2.4. Phaeophyta : *Fucus ; Sargassum / Laminaria ; Ectocarpus*
   2.5. Rhodophyta : *Botrachospernum ; Polysiphonia*
   2.6. Euglenophyta ; Dinophyta : *Euglena ; Dinothrix / Ceratium*
2. Comparative study of the morphology of the following lichen taxa:
   3.1 Foliose Lichens: D*ermatocarpon sp., Hyperphyscia sp.*
   3.2 Crustose lichens: *Caloplaca sp.*
   3.3 Leprose lichens: *Lepraria sp.*
3. Study of the spatial relationship between algal and fungal components in the Thallus of *Dermatocarpon sp.* by cutting T.S of the thallus and using differential staining.
4. Extraction of dye from various lichen types using organic and inorganic reagents.
5. Representative samples of major groups of Bryophytes and Pteridophytes will be scrutinized for the morphology of the vegetative and reproductive structures with the objective to appreciate the structural diversity within and across these groups.
   a. Bryophytes:
      1.1.a. : Marchantiales: *Marchantia/ Plagiochasma*; Jungermaniales: *Pellia.*
      1.2.b : Anthocerotales: *Anthoceros* ; Sphagnales*: Sphagnum*
      1.3.c : Funariales : *Funaria;* Polytrichales : *Polytrichum*
   b. Pteridophytes:
      1.2.a : Psilopsida: *Psilotum*; Lycopsida: *Lycopodium / Selagenella.*
      1.2.b : Sphenopsida : *Sphenophyllum / Equisetum*
      1.3.c : Pteropsida : *Dryopteris / Aspedium / Asplenium / Adiantum ; Marsilea / Salvinea*
6. Study the anatomy of root, leaf and stem of monocots and dicots before and following secondary growth.
7. Study the anatomy of taxa following anomalous secondary growth.
8. Study the types of stomata, trichomes, cystoliths and nectarines.
9. Anatomy of soft and hard woods.
10. *Comparative study of the anatomy of the leaf and stem of hydrophytes, xerophytes and mesophytes.

**Available material will be used*

Course outcomes

- The objective of this laboratory course is to provide the students practical skills in discipline centric electives.
- The objective of this laboratory course is to provide the students practical skills in studying reproductive biology of different plant sp.
- Students will also be acquainted with techniques used in the identification and characterization of lichens
- Students will learn the dissection procedures used in the preparation of samples for studying their structures.
- It will provide training to students in performing anatomical studies pertaining to different plant sp.

Course Code: Bot-161 **Maximum Marks: 50**

Course Title: Lab Course on Bot-153 & Bot-154 **University Examination Marks: 25**

Credits: 02 **Internal Assessment Marks: 25**

1. Lab demonstration of light and fluorescence microscopic techniques.
2. *Study the process of somatic cell division in root tips of *Allium sativum* (garlic)/ *Aillum cepa* (onion)/*Aillum tuberosum.*
3. *Study the structure of somatic chromosomes of *Allium cepa*/ *Vicea faba,* describe the salient features of the karyotype and preparation of ideogram.
4. *Study meiotic behaviour of chromosomes of *Phlox drumondii*, *Allium sp or Eremurus persicus*.
5. Isolate chloroplasts from leaf tissues of spinach.
6. Study the variation in chloroplast shape in spinach, *Ulothrix* and *Spirogyra*.
7. Study the diversity in cell structure in a given sample of plant tissue (onion peel xylem cells)
8. Demonstration of cytoplasmic movement in staminal hairs of *Tradescantia.*
9. Study transport across the semi permeable membrane by using potato osmoscope.
10. Grams staining of prokaryotic cell -*Escherichia coli.*
11. Detect protein and fat bodies in *Solanum tuberosum*, and *Phaseolus vulgaris* by using histochemical techniques.
12. Demonstration of variability in starch grains.
13. Isolation of plant genomic DNA (*Brassica* sp)
14. Agarose gel electrophoresis of DNA
15. Restriction digestion of total genomic DNA
16. Preparation of restriction maps from gel pictures.
17. Demonstration of Southern blotting technique.
18. Separation of crude (total) proteins by PAGE in Beans.

**Available material will be used*

Course outcomes

- The objective of this laboratory course is to provide the students practical skills in discipline centric electives.
- The objective of this laboratory course is to provide the students practical skills in basic molecular biology
- Demonstrate practical skills in different laboratory equipment's and their handling

- The objective of this laboratory course is to provide some practical skills pertaining to different techniques of molecular biology

M. Sc. Botany, Semester II

Course Code: Bot-250 **Maximum Marks: 50**

Course Title: Gymnosperms: Structure and Diversity **Internal Assessment Marks: 20**

University Examination Marks:30

Credits: 02

Course Objectives:

Gymnosperms are a dominant element of Himalayan forests and a major source of timber. The present course is designed to equip students with knowledge about the diversity and biology of these plants which will help in their conservation and sustainable utilization.

Unit I: Structural diversity and reproduction of Cycadales, Ginkgoales and Coniferales

1.1 Classification of Gymnosperms: modern trends, classification proposed by Sporne (1965) and Sandra Holmes (1986).
1.2 Cycadales and Ginkgoales: morphology and anatomy of vegetative organs.
1.3 Cycadales and Ginkgoales: morphology and anatomy of reproductive organs; life cycle.
1.4 Coniferales: morphology and anatomy of vegetative and reproductive organs, life cycle.

Unit II: Structural diversity and reproduction of Ephedrales, Welwitschiales and Gnetales

2.1 Ephedrales, Welwitschiales and Gnetales: morphology and anatomy of vegetative organs.
2.2 Ephedrales, Welwitschiales and Gnetales: morphology and anatomy of reproductive organs; life cycle.
2.3 Structural complexity of female gametophytes of gymnosperms.
2.4 Economic importance of gymnosperms.

Unit III: Fossil gymnosperms

3.1 Progymnosperms: concept and general account.
3.2 Brief account of families of Pteridospermales: Lygenopteridaceae, Medullosaceae, Caytoniaceae and Glossopteridaceae.
3.3 General account of Cycadeoidales and Cordaitales.
3.4 Distribution of fossil gymnosperms in the world and living gymnosperms in India.

Course Outcomes:

1. *The general aim of this course is to provide theoretical and practical knowledge on biology and diversity of Gymnosperms to the students. The specific objectives are to:*
2. *To understand the range of variation in structural and reproductive diversities of among different gymnosperm groups.*
3. *To impart knowledge on the distribution, conservation status and economic and ecological importance of Gymnosperms.*
4. *Discuss the type of seeds produced by the gymnosperms*
5. *State which period saw the first appearance of gymnosperms and explain when they were the dominant plant life*

Books recommended:

1. Agashe, S. N. (1995). Paleobotany. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
2. Bhatnagar, S. P. and Moitra, A. (1996). Gymnosperms. New Age International Publishers, New Delhi.
3. Bhatnagar, S. P. and Naitrea, A. (1996). Gymnosperms: Encyclopedia of Plant Anatomy. Gebruder boraegar, Berlin.
4. Sporne, K. R. (1967). The Morphology of Gymnosperms.
5. Stewart, W. N. and Rothwell, G. W. (2005). Paleobotany and the Evolution of Plants. 2nd edition. Cambridge University Press.

Course Code: Bot-251 **Maximum Marks: 100**

Course Title: Mycology and Plant Pathology **Internal Assessment Marks: 40**

Credits: 04 **University Examination Marks: 60**

Course Objectives:

Knowledge regarding Mycology plays a pivotal role in making students understand the diversity, structure and reproduction in the kingdom Fungi. Knowledge about plant pathology enables students appreciate the range and kind of diseases caused to plants and animals by various fungal pathogens and the management practices to contain these diseases.

Unit I: Fungi: general introduction

1.1 General characteristics of fungi and their distinctiveness in living organisms; composition of fungal cell wall and septa, ultrastructure of cell wall.
1.2 Thallus organization in fungi: unicellular, coenocytic and multicellular; main growth forms of fungi.
1.3 Mode of nutrition in fungi: saprobic, biotrophic and symbiotic; fungi as decomposers.
1.4 Reproduction in fungi; degeneration of sex organs in fungi; homothallism and heterothallism; parasexuality.

Unit II: Fungi: classification

2.1 Recent trends and criteria used in the classification of fungi with reference to vegetative and reproductive structures.
2.2 General account of Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina.
2.3 Mycotoxin producing storage fungi and major mycotoxins produced by them.
2.4 Factors responsible for fungal growth and mycotoxin production in agricultural commodities.

Unit III: Fungi: economic importance

3.1 Role of fungi in industries with reference to production of medicines (antibiotics), organic acids (citric acid) and food (cultivation of yeast, button and oyster mushrooms; food value of *Morchella* spp.).
3.2 Plant diseases caused by fungi in cereals: loose smut of wheat, black stem rust of wheat, false smut of paddy and brown spot of maize.

3.3 Symptoms, causal organisms and control measures of downy mildew of grapes and powdery mildew of cucurbits.

3.4 Fungal diseases of human beings and crop plants: apple scab, red rot of sugarcane and tikka disease of groundnut.

Unit IV: Pathogenesis: introduction and mechanism

4.1 Concept of diseases in plants; significance of plant diseases; disease triangle and disease cycle; pathogenecity and Koch's postulates.

4.2 Production, types and survival of inocula of plant pathogens; active and passive dispersal of plant diseases.

4.3 Pathogenecity with reference to viral plant diseases (TMV, etc.).

4.4 Pre-penetration activities of pathogens on host surface, direct penetration through intact plant surfaces, penetration through natural openings, post-penetration development.

Unit V: Pathogenesis and defence mechanisms

5.1 Plant disease epidemic forecast, important examples of plant disease forecast system; disease warning systems.

5.2 Defence mechanisms in plants: morphological, histological, cytoplasmic and biochemical; Phytoalexins; pathogenesis-related (PR) proteins.

5.3 Role of enzymes, growth regulators, and toxins (host specific and non-host specific) in plant diseases.

5.4 Integrated disease management- general account of plant disease control (quarantine, chemical and biological methods).

Course Outcomes:

1. *Make students understand the diversity, structure and reproduction in the kingdom Fungi.*

2. *To provide an insight to the students about the technique to isolate and identify fungi and maintain them in pure cultures.*
3. *Study the diseases caused by biotic and abiotic agent in plants.*
4. *Study the mechanism of disease development by pathogens.*
5. *Understand the interaction between plant and pathogen in relation to the overall environment.*
6. *Demonstrate an understanding of the principles of plant pathology and the application of these principles for the control of plant disease.*
7. *Demonstrate skills in laboratory and field related to mycology and plant pathology.*

Books recommended:

1. Agrios, G. N. (2012). Plant Pathology, 5th Edn. Academic Press, London.
2. Alexopoulus, C. J., Mims, C.W. and Blackwell, M. (1996). Introductory Mycology. John Wiley & sons Inc. New York.
3. Burns, R. (2010). Plant Pathology: Techniques and Protocols. Humana Press Inc., USA.
4. Lane, C. R., Beales, P. A. and Hughes, K. J. D. (2012). Fungal Plant Pathogens. CABI Publishing, UK.
5. Schumann, G. L. and D'Arcy, C. J. (2009). Essential Plant Pathology. Amer Phytopathological Society, USA.
6. Singh, R. S. (2014). Introduction to principles of plant pathology. Oxford & Ibh Publishing Co Pvt Ltd.
7. Sumbali, G. (2010). The Fungi, 2nd Edn. Narosa Publishing House, New Delhi.
8. Webster, J. and Weber, R.W.S. (2007). Introduction to Fungi. Cambridge University Press, USA.

Course Code: Bot-252 **Maximum Marks: 100**

Course Title: Plant Taxonomy **Internal Assessment Marks: 40**

Credits: 04 **External Examination Marks: 60**

Course objectives:

This course has been designed to make students aware of the vast diversity in plants around us and to prepare them theoretically and practically to study and analyze this diversity scientifically. Sound theoretical knowledge of taxonomy will go long way in elucidating the natural grouping of flowering plants which exists in the biodiversity around us, and will also help in sustained utilization of bioresources for human welfare.

Unit 1: Plant taxonomy: bases and historical background

1.1 Classification, taxonomy, systematics; historical background of angiosperm classification (concept of artificial, natural and phylogenetic approaches to classification).
1.2 Importance of and need for taxonomy: importance of taxonomy in biology; relevance of taxonomy to society; need for taxonomy in unraveling biodiversity.
1.3 Bentham & Hooker's and Engler & Prantl's systems of classification (outline and merits & demerits).
1.4 Takhtajan's system of classification (outline and merits & demerits); Angiosperm Phylogeny Group (APG) (outline of APG classification).

Unit II: Plant taxonomy: components

2.1 Plant description: taxonomic characters and character states; vegetative and floral characters; diagnostic characters; characters and definition of taxa; essentials of good plant description.
2.2 Plant identification: principles for identification; methods of identification: taxonomic keys and their types, construction and use of dichotomous keys; essentials of practical plant identification.
2.3 Plant nomenclature: need for scientific names; ICN - brief history and operative principles, valid publication, priority of publication, author citation, type method (concept and kinds), synonyms, name changes.
2.4 Plant classification: taxonomic categories - species, infra- and supra-specific categories; taxonomic hierarchy; numerical and cladistic approaches to classification (general account).

Unit III: Plant taxonomy: sources of evidence

3.1 Morphology, anatomy and palynology (role as sources of taxonomic evidence in angiosperms).
3.2 Cytotaxonomy: concise account of cytological characters of taxonomic value in angiosperms - chromosome number and morphology (karyotypes), chromosome banding.
3.3 Chemotaxonomy: general account of chemical constituents of taxonomic significance - primary and secondary plant metabolites.
3.4 Molecular taxonomy: taxonomic value of amino acid sequencing; role of DNA sequencing in taxonomy (overview); DNA barcoding – concept and limitations.

Unit IV: Variation, species concepts and speciation

4.1 Types of variation: intra- and inter-specific variation; continuous and discontinuous variation; developmental-, environmental-, and genetic variation; causes of variation in populations.

4.2 Species and species concepts: species as basic unit of taxonomy; species concepts (concise account of taxonomic-, biological and phylogenetic species concepts).

4.3 Speciation: abrupt- and gradual speciation; phyletic and additive speciation, modes of additive speciation (concise account of allopatric-, parapatric-, and sympatric speciation).

4.4 Isolation and speciation: geographical and ecological isolation; reproductive isolation: pre-zygotic mechanisms (temporal, behavioral, mechanical, and gametic), and post- zygotic mechanisms (hybrid inviability, hybrid sterility, and hybrid breakdown).

Unit V: Primitive and advanced angiosperms

5.1 Taxonomic description of basal angiosperms: Amborellaceae, Nymphaeaceae, Annonaceae and Magnoliaceae .

5.2 Taxonomic description of basal (Acoraceae and Alismataceae) and petaloid (Liliaceae and Orchidaceae) monocots.

5.3 Taxonomic description of commelinid monocots (Arecaceae and Poaceae).

5.4 Taxonomic description of eudicots (Ranunculaceae) and core eudicots (Caryophyllaceae).

Course Objectives:

1. *The course of Plant Taxonomy deals with history and importance of taxonomy*
2. *It deals with classification of angiosperms and enables the students to understand different systems of classifications, both classical and modern.*
3. *The students are made to understand principles and methods of identification including construction of keys, plant nomenclature and ICN.*
4. *The course will enable students to understand the role of other approaches of biology to unravel mysteries of Plant Taxonomy.*
5. *The course will also enable students to understand the various concepts of origin of variation and speciation.*
6. *The students will be able to learn about primitive and advanced angiosperm families both in mono- as well as dicots.*
7. *Overall the course content will enable the students learn all the basic and advanced concepts of Plant taxonomy and their extension to field studies.*

Books recommended:

1. Cole, A. J. (1969). Numerical Taxonomy. Academics Press, London.
2. Cronquist, A. (1981). An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.
3. Davis, P. H. and Heywood, V. H. (1973). Principles of Angiosperm Taxonomy. Robert E. Kreiger Pub. Co., New York
4. Grant, V. (1971). Plant Speciation. Columbia University Press, New York.
5. Harrison, H. J. (1971). New Concepts in Flowering Plant Taxonomy. Hieman & Co-Educational Books Ltd., London.
6. Heywood, V. H. and Moore, D. N. (1984). Current Concepts in Plant Taxonomy. Academic Press, London.
7. Jeffrey, C. (1968). An Introduction to Principles of Plant Taxonomy.
8. Jones, S. B. Jr. and Lunchsinger, A. E. (1986). Plant Systematics, 2nd Edition. McGraw Hill Book Co., New York.
9. Lawrence, G. H. M. (1951). Taxonomy of Vascular Plants. Oxford & IBH Publ. Co., Pvt. Ltd.
10. Nordenstam, B; El Gazaly, G and Karsas, M. (2000). Plant Systematics for 21st Century. Portland Press Ltd., London.
11. Radford, A. E. (1986). Fundamentals of Plant Systematics. Harper & Row Publications, U.S.A.
12. Simpson, M. G. (2006). Plant Systematics. Elsevier Academic Press, USA.
13. Singh, G. (2010). Plant Systematics. Science Publishers, USA.
14. Sivirajan, V. V. (1991). Introduction to Principles of Plant Taxonomy. Oxford, IBH.
15. Solbrig, O. T. (1970). Principles and Methods of Plant Systematics. The MacMillan Co. Collier – MacMillan Ltd, London
16. Stace, C. A. (1989). Plant Taxonomy and Biosystematics, 2nd Edition. Edward Arnold Ltd., London.
17. Takhtajan, A. L. (1997). Diversity and Classification of Flowering Plants. Columbia University Press, New York.
18. Walter, S. Judd et al., (2010). Plant Systematics: Phylogenetic Approach. 3rd edition. Springer.
19. Woodland, D. W. (1991). Contemporary Plant Systematics. Prentice Hall, New Jersey.

Course Code: Bot-253 **Maximum Marks: 50**

Course Title: Bacteria and Viruses: **Internal Assessment Marks: 20**

Structure and Diversity **University Examination Marks: 30**

Credits: 02

Course Objectives:

The course is designed to acquaint students with the enormous diversity that microbes exhibit and equip them with the understanding of their structure and biology.

Unit I: Viruses: biology and diversity

1.1 General characteristics; origin and nature; symptomatology; diversity, genome organization: single stranded RNA, double stranded RNA, single stranded DNA and double stranded DNA viruses, virus like agents: viroids, prions- structure and importance.

1.2 Viruses: nomenclature and taxonomy; International Committee on taxonomy of viruses; basis of classification.

1.3 Isolation and purification of viruses; infection cycle with reference to RNA and DNA containing viruses (*Tobacco mosaic virus*, TMV, *Cotton leaf curl virus*, CLCuV, *Cauliflower Mosaic virus*, CaMV); mechanism of virus replication (TMV, CLCuV, CaMV.)

1.4 Virus transmission (general account): mechanical, seeds mediated; insects: aphids, whitefly, hoppers, nematodes.

Unit II: Bacterial diversity

2.1 Bacterial classification and its basis; International Code of Nomenclature for Bacteria-salient features.

2.2 Archaebacteria: major groups - methanogenic, extreme halophiles, thermoacidophiles-diversity of form (general account); ultrastructure of cell and cell wall; phytoplasmas-general characteristics.

2.3 Cyanobacteria: diversity of form (general account), ultrastructure of cell and cell wall; heterocysts: ultra structure and functions.

2.4 Eubacteria: diversity of form (general account), ultra structure of cell and cell wall.

Unit III Nutrition, reproduction and utility of bacteria

3.1 Nutritional types of bacteria; nutritional mutants and their importance in genetic and physiological studies.

3.2 Modes of bacterial reproduction and recombination: asexual and sexual- conjugation, transformation and transduction.

3.3 Utility of bacteria in industry: material processing, energy production, waste processing; importance of cyanobacteria.

3.4 Bioremediation, corrosion resistance, production of drugs and manufacture of polymers.

Course Outcomes:

1. *Make students understand the diversity in structure and functioning of prokaryotes.*
2. *Study the mechanism of disease development by pathogens.*
3. *To provide insight of the technique in isolation, identification and maintenance of pure cultures.*
4. *Understand the interaction of pathogen with host in relation to infectivity.*
5. *Demonstrate skills in controlling microbial diseases in day to day life.*

Books recommended:

1. Ananthanarayan, R. and Paniker, C. K. J. (2009). Textbook of Microbiology. University Press Pvt. Limited.
2. Clifton, A. (1958) Introduction to the Bacteria. McGraw Hill Book Co; New York.
3. Ingraham, J. L. and Ingraham, C. A. (2005). Microbiology: An Introduction. Cengage Learning Ltd.
4. Kale, V. and Bhusari, K. (2007). Applied Microbiology. Himalaya Publishing House.
5. Khan, J.A. and Dijstra, J. (2012). Plant viruses as molecular pathogens. CRC Press.
6. Khan, J.A. and Dijkstra J (2007). Handbook of Plant Virology, Taylor and Francis.
7. Madigan, M. T. Martinko, J. M. and Parker Jack. (I996): Brock's Biology of Microorganisms, 8th edition. Prentice Hall, NJ. U.S.A.
8. Madigan, M. T. Martinko, J. M. and Parker Jack. (2000). Brock's Biology of Microorganisms, 9th edition. Prentice Hall. NJ. U.S.A.
9. Maloy, S. R., Cronan Jr, J. E. and Freifelder, D. (2006) Microbial Genetics. Narosa Publishing House.
10. Mandahar, C.L. (1978). Introduction to Plant Viruses. Chand & CO. Ltd., Delhi.
11. Pelczar, M. J., Chan, E. C. S and Kreig, N. R. (1993). Microbiology. Tata McGraw Hill Education Private Limited, New Delhi.
12. Pommerville, J. C. (2011). Alcamo's Fundamentals of Microbiology. Jones and Bartlet Publishers. LLC.
13. Prescott, L. M., Harley, J.P. and Klein, D. A. (1992). Microbiology, WCB Publishers.
14. Schlegel, H. G. (2012). General Microbiology. Cambridge University Press.
15. Sumbali, G. and Mehrotra, R. S. (2009). Principles of Microbiology, 1st edition. Tata McGraw Hill Publishing Co. Ltd. New Delhi.

Course Code: Bot-260 **Maximum Marks: 100**

Course Title: Lab Course based on Bot-250 **Internal Assessment Marks: 50**

(gymnosperms) and Bot-252 (plant taxonomy) **University Examination Marks: 50**

Credits: 04

1. Representative specimens of major groups of gymnosperms (enlisted below) will be scrutinized for morphology of the vegetative and reproductive structures with the objective to appreciate the structural diversity within and across groups:
   Cycadales: *Cycas* ; Ginkgoales : *Ginkgo;* Coniferales : *Pinus* and *Cedrus;* Ephedrales : *Ephedra;* Gnetales : *Gnetum.*
2. Study of anatomy of root, stem and leaf of representative gymnosperm taxa prescribed in theory course.
3. Collection of local gymnosperm taxa and their identification on the basis of leaf characters.
4. Botanical trips within and outside the campus; collection of plant specimens, compilation of field notes, and preparation and processing of herbarium specimens.
5. Preparation and uses of botanical keys (bracket and indented keys)
6. Identification of locally available plants upto species level using keys
7. Taxonomic description of the available important families of flowering plants.
8. To study inter familial, inter generic and inter specific variation using suitable plant material.
9. Collection, processing and preservation of 50 herbarium specimens to be submitted by each student at the time of examination. This exercise will carry 10 marks.

Course outcomes

- The objective of this laboratory course is to provide the students practical skills in discipline centric electives.
- The objective of this course is to familiarize students with the basic concepts and applications of performing taxonomic studies
- The students will be able to understand and differentiate the vegetative and reproductive structures of different plant group
- Students will have indepth knowledge of different gymnosperms regarding anatomy of root, stem and leaf.

Course Code: Bot-261 **Maximum Marks: 100**

Course Title: Lab Course based on Bot-251 **Internal Assessment Marks: 50**

(Mycology and plant pathology) and Bot-253 **University Examination: Marks: 50**

(Bacteria and viruses). **Credits: 04**

1. Morphological characters of some microfungi (species of *Curvularia, Alternaria, Fusarium, Pennicillium, Colletotrichum, Trichothecium, Aspergillus, Mucor, Rhizopus, Syncephalastrum, Chaetomium, Emericella, Peronospora, Phyllactinia* and *Uncinula*).
2. Morphological characters of some macrofungi (species of *Agaricus, Morchella, Pleurotus, Geastrum* and *Calocybe*).
3. To create spore prints of some macrofungi (*Agaricus bisporous* and species of *Pleurotus*).
4. Symptoms and histopathology of field diseases of local crop plants.
5. Preparation of PDA, sterilization, plating and making of slants.
6. Isolation, purification, culturing and subculturing of fungal pathogens.
7. Gram staining of bacteria
8. Culture of bacteria from any available source (soil, different water samples, etc.) to study the morphological features of bacterial colonies and structure of bacteria.
9. Diversity and structure of Cyanobacteria: species of *Nostoc, Anabaena* and *Oscillatoria.*
10. Microscopy (structure, principle and working mechanism): Light Microscope, Fluorescence Microscope, Scanning Electron Microscope.
11. Mechanical transmission of plant viruses.
12. To determine the dilution end point of viruses.
13. To determine the thermal inactivation point of viruses.
14. To determine the *in vitro* longevity of viruses.

Course outcomes

- The objective of this laboratory course is to provide the students practical skills in discipline centric electives.
- The objective of this laboratory course is to provide practical skills on basic microbiological techniques
- Enable students to acquire expertise in the field of microbiology.
- Demonstrate practical skills in different laboratory equipment's and their handling
- It will provide training to students to isolate and manipulate industrially important microorganisms.

M. Sc. Botany, Semester III

Course Code: Bot- 350 **Maximum Marks: 100**

Course Title: Cytology and Cytogenetics **Internal Assessment Marks: 40**

Credits: 04 **University Examination Marks: 60**

Course Objectives:

The course is designed to make students aware about the structure and functions of chromosomes and chromosomal aberrations, both numerical and structural. It will help students understand and appreciate the anomalies in chromosomal behavior and their impact on the survival of species.

Unit I: Chromosome organization

1.1 Structure of eukaryotic chromosome; nucleosome model; banding patterns for identification of chromosomes (Q, C, N, G and R bands).
1.2 Morphology of chromosomes: centromeres, secondary constriction; knob; telomeres; satellite and nucleolar organizer region (NOR).
1.3 Different forms of chromosomes; somatic metaphase chromosomes; meiotic prophase chromosomes; polytene chromosomes; B chromosomes; lampbrush chromosome.
1.4 Karyotype symmetry; chromosome numbers; symbols & terminology; euchromatin and heterochromatin.

Unit II: Chromosomal aberrations (structural)

2.1 Duplications: origin, occurrence and production of duplications; chromosome pairing in duplication heterozygotes.

2.2 Deficiencies: types of deficiencies; production of deficiencies through irradiation; meiosis and breeding behavior of deficiency heterozygotes.

2.3 Inversions: types of inversions; origin, occurrence and production of inversions; meiotic pairing in inversions heterozygotes.

2.4 Interchanges: natural origin and artificial induction of interchanges; cytological behavior of interchanges; Robertsonian translocations.

Unit III: Chromosomal variation (numerical) and its evolutionary significance

3.1 Haploidy in higher plants: origin occurrence and production of haploids; detection of haploids; phenotypic effects and uses of haploids in plant breeding.

3.2 Polyploidy in higher plants – autopolyploidy: origin and occurrence of autopolyploids in nature; induced autopolyploidy; phenotypic effects of autopolyploidy; meiotic behavior in autopolyploids.

3.3 Allopolyploidy: criteria for distinction between auto - and allopolyploids; spatial arrangement of chromosomes of different genomes in hybrids and allopolyploids; evolutionary significance of allopolyploidy.

3.4 Aneuploidy: classification of aneuploids; aneuploids in diploids vs. polyploids; trisomics in diploids; tetrasomics in plants; evolutionary significance of aneuploidy.

Unit IV: Molecular cytogenetics- I

4.1 Chromosomal DNA content and C-value paradox; chromosomal DNA evolution.

4.2 Repetitive DNA; techniques for detecting repetitive DNA; chemical complexity vs sequence (kinetic) complexity.

4.3 Estimation of GC-AT content in genome.

4.4 Chromosomal microdissection and microcloning: introduction, application and limitations.

Unit V: Molecular cytogenetics-II

5.1 Construction of cytogenetic maps using chromosome specific markers.

5.2 Construction of restriction maps; use of partial digests, end labeling and hybridization in restriction mapping.

5.3 GISH: application of GISH in identification of component genomes in allopolyploids, interspecific hybrids, intergeneric hybrids and somatic hybrids.

5.4 FISH: application of FISH in physical mapping of repetitive and single copy DNA sequences in plant chromosomes.

Course Outcomes:

1. *The course will be focusing to develop the understanding on Chromosome, structure, forms, special types and study of asymmetry in the karyotypes.*
2. *It also will deal with the development of understanding on different types of structural chromosomal aberrations and their consequences on the growth and development of the Cell and Organism.*
3. *The course will enable students to learn about numerical chromosomal changes and the evolutionary consequences.*
4. *The course will help students understand and appreciate the anomalies in chromosomal behavior and their impact on the survival of species.*
5. *The students will be made to understand the Molecular approaches for study of Cytology and Cytogenetics.*

Books recommended:

1. Gupta, P. K. (2005). Genetics and Cytogenetics. Rastogi Publications, Meerut.
2. Hartk, D. L. and Jones, E.W. (1998). Genetics: Principles and Analysis (Fourth Edition). Jones and Bartlett Publishers, Massachusetts, USA.
3. Khush, G. S. (1973). Cytogenetics of Aneuploids. Academic Press, New York, London.
4. Sharma, A. K. and Sharma, A. (1980). Chromosome Techniques- Theory and Practice. Butterworth and Co. (Publishers) Ltd., London. .
5. Sinha, U. and Sinha, S. (1998). Cytogenetics, Plant Breeding and Evolution. Vikas Publishing House, Pvt. Ltd., New Delhi.
6. Singh, R. (2015). Plant Cytogenetics - 2nd Edition. CRC Press.
7. Snustad, D. P. and Simmons, M. J. (2011). Principles of Genetics, 6th Edition. Wiley.
8. Swanson, C. P. (1957). Cytology and Cytogenetics. Prentice-Hall, Inc., New Jersey.
9. Swanson, C. P., Merz, T. and Young, W. J. (1967). Cytogenetics. Prentice-Hall, Inc., New Jersey.

Course Code: Bot-351 **Maximum Marks: 100**

Course Title: Reproductive Biology of Angiosperms **Internal Assessment Marks: 40**

University Examination Marks: 60

Credits: 04

Course Objectives:

Teaching of reproductive biology is important in making students understand modes of reproduction in flowering plants, their population structure and generation of variability. The course so framed on these aspects includes classical as well as experimental approaches to the phenomena of sporogenesis, gametogenesis, fertilization, embryogenesis and seed development.

Unit I: Sex expression and breeding systems

1.1 Essence of sexual reproduction, costs and benefits of sex, various concepts; sex differentiation at the level of individual; inflorescence and flower.

1.2 Factors affecting sex expression; chromosomal, genetic, hormonal and environmental control of sex expression.

1.3 Breeding systems: concept and types; contrivances, advantages and disadvantages of inbreeding (selfing) and apomixis.

1.4 Contrivances, advantages and disadvantages of outbreeding (out-crossing); inbreeding depression, heterosis; concept of mixed mating and its advantages.

Unit II: Development of male and female gametophytes

2.1 Male gametophyte: general account of microsporogenesis, pollen wall development, development of male gametophyte, diversity in pollen structure (NPC system) .

2.2 Genetic control of pollen development; male sterility and pollen abortion.

2.3 Female gametophyte: development, organization and types of embryosacs, nutrition of Embryosac, embryosac haustoria.

2.4 Ovule determination and gene function during megagametogenesis.

Unit III: Pollination, fertilization and apomixis

3.1 Pollination: process, types and contrivances favoring them, modes of pollination (biotic: insects, mammals, birds; abiotic: wind, water), consequences of pollination.

3.2 Pollen – stigma interactions and pollen tube guidance; pollen recognition by the stigma, guidance of the pollen tube in the style and to the ovules.

3.3 Fertilization: mechanism of syngamy and double fertilization, and their significance.

3.4 Apomixis: different mechanisms, genetics of apomicts, methods to identify apomicts.

Unit IV: Analysis of fertilization process

4.1 Nuclear migration and cellular communication in the embryo sac, preferential fertilization.

4.2 Genetic and molecular control of embryogenesis. Gene expression during early and late embryogenesis and transition to germination.

4.3 Embryo maturation; synthesis of maturation proteins; genetic regulation of embryo maturation, embryo dormancy.

4.4 Cellular organization of endosperm; the odyssey of free nuclei to a cellular tissue. Accumulation of storage products.

Unit V: Experimental analysis of fertilization process & genetic blocks

5.1 Cell cycle and fertilization, pollen tube attraction, synergid degeneration and gamete delivery.

5.2 In-vitro studies of fertilization, Ca^{++} waves, sites of fusion and egg activation.

5.3 Types, genetics and significance of self-incompatibility; female specificity determinants; biochemical and structural characteristics of S – proteins.

5.4 S-locus- F-box genes: male specificity genes; other genes modulation S1 response.

Course Outcomes:

1. *The course will make the students to understand the concept of sex expression, factors controlling differentiation of sex, costs and benefits of sex in flowering plants.*

2. *The students will be able to understand the development of male and female gametes both classical as well as molecular concepts.*
3. *The course will enable the students to understand the mechanisms of pollination, contrivances of self and cross pollination in flowering plants.*
4. *The course will also enable the students to understand the signalling mechanisms of pollen tube guidance to ovary.*
5. *It will also make the students to learn about the process of fertilization, double fertilization, embryo and endosperm development.*
6. *The course will make the students understand the concepts of sexual incompatibility, both classical and molecular and its significance in generation of variation.*

Books Recommended:

1. Raghavan, V. (2008). Developmental Biology of Flowering Plants. Springer-Verlag, New York.
2. Raghvan, V. (2006). Double Fertilization. Springar Verlag, Berlin-Heidelberg.
3. Johri, B. M. (2001). Reproductive Biology of Plants. Springer Berlin Heidelberg
4. Bhojwani, S. S. and Bhatnagar, S.P. (2000). The Embryology of Angiosperms. 4th Edn. Vikas Publishing House, New Delhi.
5. Geber, M. A., Dawson, T. E. and Delph, L. F. (1999). Gender and Sexual Dimorphism in Flowering Plants. Springer Berlin-Heidelberg.
6. Howell, S. H. (1998). Molecular Genetics of Plant Development. Cambridge University press, Cambridge.
7. Shivanna, K. R. and Sawhney, V.K. (1997). Pollen Biotechnology for Crop Production and Improvement. Cambridge University Press, Cambridge.
8. The Plant Cell. Special Issue on Reproductive Biology of Plants, Vol. 5(10) (1993). The American Society of Plant Physiologists. Rockvills, Maryland, USA.
9. Shivanna, K. R. and Rangaswamy, N.S. (1992). Pollen Biology-A Laboratory Manual. Springar-Verlag, Berlin.
10. Steeves, T. A. and Sussex, I. M. (1989). Patterns in Plant development. 2nd Edn. Cambridge Univ. Press, Cambridge.
11. Shivanna, K. R. and Johri, B. M. (1986). The Angiosperm Pollen: Structure and Function. Wiley Eastern Ltd., New York.

Course Code: Bot-352 **Maximum Marks: 100**

Course Title: Plant Resources and Utilization **Internal Assessment Marks: 40**

Credits: 04 **University Examinations Marks: 60**

Course Objectives:

This course has been designed with the objective to acquaint the students with plant bioresources, their traditional and non-traditional uses, current status and recent developments in value addition and future prospects.

Unit I: Plant resources: origin, domestication and improvement

1.1 Prehistoric plant human interactions; discovery of plant use to humans, resurgence of interest in plant bioresources due to plant explorations and ethnobotanical studies during 19^{th} and 20^{th} centuries.

1.2 Origin of cultivated plants: Vavilovian concept of Centres of origin of crop plants; Centres of origin of maize, rice and wheat; concept of primary and secondary Centres of origin of crop plants

1.3 Domestication of crop plants; beginning of agriculture; dissemination and spread of agriculture; domestication and evolution of crop plants.

1.4 Plant use improvement: development of improved agricultural crops through plant breeding; evolution of high yielding crop varieties through genetic engineering; uses and production of improved varieties in wheat, rice and maize.

Unit II: Plant resources in the service of mankind-traditional uses-I

2.1 Food supplements: *Agaricus bisporous*, *Hippophae rhamnoides* (distribution, botany, classification, part and method of use, nutritive value)

2.2 Spices and condiments: *Crocus sativus*, *Piper nigrum* (distribution, botany, classification, parts used and method of use).

2.3 Sources of beverages: non-alcoholic: *Camellia sinensis* (tea) and *Coffea arabica* (coffee); alcoholic: *Vitis vinifera* (grapes) (distribution, botany, classification, part and method of use).

2.4 Fodders and fibres: Fodders: *Grewia optiva* and *Morus alba* (distribution, botany, part and methods of use); Fibers: *Gossypium* spp., *Chorchorus capsularis* (distribution, botany, classification, part used and durability).

Unit III: Plant resources in the service of mankind-traditional uses-II

3.1. Timbers: *Pinus roxburghii*, *Dalbregia sissoo*, *Tectona grandis* (distribution, botany, classification, wood structure and properties).

3.2. Dye-yielding plants: definition; history and sources of natural dyes, commonly used dye plants: *Lawsonia inermis* and *Indigofera tinctoria.*

3.3. Less used colouring matter: balsam, marigold, *Punica granatum*, *Reinwardtia indica* (distribution, botany, part used and commercial importance).

3.4. Bio-preservatives: (mustard, sugar) (distribution, botany, part used and commercial importance).

Unit IV: Medicinal plants

4.1. Medicines: antioxidants (*Ginkgo biloba*); adaptogens (*Eleutherococcus senticosus, Cordyceps sinensis*) (distribution, botany, classification, part and method of use, and medicinal value).

4.2. Anodynes (*Atropa belladona, Zingiber officinale*); laxatives (*Aloe vera* and *Plantago ovata*) (distribution, botany, classification, part and method of use, and medicinal value).

4.3. Aromatic oils (*Thymus serpyllum* and *Lavandula angustifolia*) (distribution, botany, classification, part and method of use, and medicinal value).

4.4. Anti-cancerous (*Taxus baccata* subsp*. wallichiana, Podophyllum hexandrum*) (distribution, botany, classification, part and method of use, and medicinal value).

Unit V: Other useful plants

5.1. Bio-sweeteners (*Stevia rebaudiana* and *Glycyrrhiza glabra*) (distribution, botany, classification, part and method of use and efficacy).

5.2. Bio-flavors (*Vanilla planifolia* and *Fragaria virginiana*) (distribution, botany, classification, part and method of use and efficacy).

5.3. Bio-gums (*Caesalpina spinosa, Trigonella foenum-graecum*) (distribution, botany, classification, part and method of use and efficacy)

5.4. Bio-cosmetics (*Aloe vera* and *Santalum album*) (distribution, botany, classification, part and method of use).

Course Outcomes:

1. *Paper will help to understand different kinds of bioresources.*
2. *Evolution and domestication (how domestication started)*
3. *It will help to understand the beginning of agriculture and its diversification and centre of origin of different bioresources.*
4. *As paper directly related with the various bioresources it will also make student aware about the different types of bioresources e.g. in service of mankind (as medicine, as fuel, as fodder, as timber, as fibre, as dye yielding plants, as bio flavour, bio-gum, bio preservatives and as bio-cosmetics)*
5. *Paper also projects the use of bioresources for bioprospection.*

Books recommended:

1. Anonymous (1970-1988). The Wealth of India: Raw Materials, Vol. I-XI. CSIR. New Delhi. (Reprinted 1984-1989).
2. Judd, W. S., Campbell, C. S., Kollogg, E. A., Stevens, P. F. and Donohue, M. J. (2008). Plant Systematics: Phylogenetic Approach. Sircuier Associates, Inc.
3. Sharma, O. P. (2001). Hill's Economic Botany, Tata McGraw-Hill Pub. Ltd.
4. Sharma, R. (2006). Growth and Development of Agriculture. Biotech Book.
5. Singh, R.V. (1982). Fodder Trees of India, Oxford & IBH Publishing Co.
6. Singh, B. P. and Srivastava, U. (2013). Plant Genetic Resources in Indian Perspective, Theory and Practices. ICAR Publication
7. Vankar, S.P. (2006). Handbook on Natural Dyes for Industrial Applications (with Color Photographs). National Institute of Industrial Research, Delhi.

Course Code: Bot-353 **Maximum Marks: 50**

Course Title: Biostatistics and Bioinformatics **Internal Assessment Marks: 20**

University Examination Marks: 30

Credits: 02

Course Objectives:

Mathematics and statistics are making deep in-roads into biology and it is therefore, necessary to provide sound foundation of these subjects to students who can build on this later in life.

Unit I: Introduction to computer and its applications

1.1. Basic computer organization (input/output unit), storage unit, control unit, Central Processing Unit; primary and secondary memory (RAM, ROM, PROM, EPROM, EEPROM, hard disk, compact disk and flash drives).

1.2. Computer softwares (definition, relationship between software and hardware, types of softwares); Operating system: concept and functions; some popular operating systems (Microsoft Windows); Internet: definition and practical utility.

1.3. Bioinformatics: brief history, introduction, application and limitations.

1.4. Databases: introduction, sequence and structural databases, information retrieval from biological databases: NCBI, EMBL, PIR, Swiss Prot.

Unit II: Basics of biostatistics

2.1. Statistics: definition, history, applications and limitations; concept of biometry, population and samples.

2.2. Data collection and tabulation, primary and secondary data, methods of collecting primary data, sources of secondary data, editing of primary and secondary data, rule of tabulation, parts and types of tables and role of tabulation of data.

2.3. Frequency distribution: classification of data, histogram, frequency polygon, cumulative frequency curves, designs and limitations of graph.

2.4. Measures of central tendency: arithmetic mean, median, mode; their merits and demerits.

Unit III: Application of biostatistics

3.1 Measures of dispersion: standard deviation, standard error and coefficient of variation; Tests of significance: T-test, F-test and X^2 test

3.2 Binomial, Poisson and Normal distribution; Deviation, properties and applications of normal distribution

3.3 Correlation: types, methods; Karl Pearson's coefficient) and regression (linear) analysis and their uses

3.4 Principles of experimental designs: Completely Randomised Designs (CRD) and Randomised Block Designs (RBD); ANOVA: One way ANOVA and Two way ANOVA

Course Outcomes:

1. *Develop curiosity about Computers, Bioinformatics and Biostatisticsto students who can build on this later in life.*
2. *Construct knowledge about the various applications of Mathematics and Statistics to the students.*
3. *Solve mathematical and statistical problems with fellow class mates as well as individually.*
4. *Analyze information based on mathematical data rather than accumulating and memorizing it.*

Books recommended:

1. Gupta, S.P. (2005). Statistical Methods. Sultan Chand and Sons, New Delhi.
2. Gupta, C.B. and Gupta, V. (2005). An Introduction to Statistical Methods. Vikas Publishing House Pvt Ltd, New Delhi.
3. Ghosh, Z. and Bibekanand M. (2008). Bioinformatics: Principles and Applications. Oxford University Press.
4. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2005). Fundamentals of Statistics. The World Press Pvt. Ltd, Kolkata.
5. Sinha, P.K. and Sinha, P. (2005). Computer Fundamentals. BPB Publication.
6. Rajaraman, V. (2004). Fundamentals of Computers. Prentice-Hall of India Pvt. Ltd., New Delhi.

Course Code: Bot-354 **Maximum Marks: 50**

Course Title: Recombinant DNA Technology **Internal Assessment Marks: 20**

Credits: 02 **University Examination Marks: 30** **Choice-based Complimentary Elective**

Course Objectives:

The course has been designed to acquaint the students with concepts of Recombinant DNA technology. The course content is so designed as to make students aware about the materials and methods being used in the transfer of DNA and its expression in the target organisms. Also students will learn about the vast scope of the subject.

Unit 1: Introduction to recombinant DNA technology

1.1 Overview of recombinant DNA technology. Restriction and modification systems, restriction endonucleases and other modifying enzymes used in manipulating DNA molecules.
1.2 Separation of DNA by gel electrophoresis. Extraction and purification of plasmid DNA.
1.3 Plasmids, cosmids, binary, shuttle and bacteriophages as vectors for gene cloning. Cloning vectors based on *E. coli*, plasmids, pBR322, pUC8, pGEM3Z.
1.4 Joining of DNA fragments: DNA ligases, ligation of DNA molecules. sticky ends, blunt ends, linkers and adapters.

Unit 2: Introduction of DNA into Living Cells

2.1 Transformation: The uptake of DNA by Bacterial Cells. Preparation of Competent *E. Coli* Cells. Selection of transformants.

2.2 Identification of recombinants, recombinant selection with pBR322. Insertional inactivation of an antibiotic resistance.

2.3 Introduction of phage DNA into bacterial Cells: Transfection, in vitro packaging of Lambda (λ) cloning vector. Identification of recombinant phages.

2.4 Introduction of DNA into non-bacterial cells. Transformation of individual cells. Transformation of whole organism.

Unit 3: Applications of recombinant DNA technology

3.1 Applications in medicine - production of recombinant pharmaceuticals, such as insulin, human growth hormone, factor VIII; recombinant vaccines, gene therapy.

3.2 Applications in agriculture - plant genetic engineering, herbicide resistant crops, problems with genetically modified plants, safety concerns.

3.3 DNA sequencing, Sanger Dideoxynucleotide sequencing, Maxam-Gilbert Sequencing, automated sequencing techniques, next generation sequencing

3.4 Polymerase chain reaction (PCR) – principle, technique and applications.

Course Outcomes:

1. *The course acquaints the students with concepts of Recombinant DNA technology.*
2. *The course content is so designed as to make students aware about the materials and methods being used in the transfer of DNA and its expression in the target organisms.*
3. *Also students will learn about the vast scope of the subject.*

Books recommended:

12. Brown, T. A. (2016). Gene Cloning – An Introduction. Blackwell Publishing. (7th edition).
13. Primrose, S. B. and Twyman, R. M. (2014) Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing (Oxford).
14. Glick B. R., Pasternak, J. J. and Patten, C. L. Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th edition. ASM Press (Washington DC).

15. Williams, J., Ceccarelli, A. and Wallace, A. (2001). Genetic Engineering, 2nd edition. Springer-Verlag, New York Inc.

Course Code: Bot-355 **Maximum Marks: 50**

Course Title: Forest Ecology-I **Internal Assessment Marks: 20**

Credits: 02 **University Examinations Marks: 30**

Choice-based Complimentary Elective

Course Objectives:

This course is designed to provide students with the conceptual background needed to understand the complexity of interactions that occur within a forest ecosystem over time.

Unit I: Forest and forest environment

1.1. Forest and forest environment: what are forests; importance of forests in environmental conservation, wildlife, and biodiversity.

1.2. Forest ecosystem concept: introduction, composition & structure of forest ecosystem.

1.3. Forest stand, pure & mixed stand, even & uneven aged stand, use of mixed stand, irregular stands.

1.4. Relationship between man and forest in the Himalaya; major and minor forest produce; forests for food.

Unit II: Forest ecosystem functions

2.1. Forest ecosystem function: Primary productivity of forest ecosystems; methods of measurement; productivity patterns.

2.2. Forest litter: types of litter and coarse woody debris, litter fall, forest floor litter mass; importance of forest litter.

2.3. Litter decomposition and factors affecting it, such as microbes, fauna, abiotic factors and litter characters.

2.4. Nutrient cycling and nutrient conservation strategies. Water cycle in a forested area: impact of forest on precipitation apportionment, role of water in nutrient cycling.

Unit III: Changes in forest ecosystems

3.1. Eco-physiology of forest trees: characteristics of tropical trees; shoot growth in forest trees.

3.2. Phenology of trees; forest seed dormancy and germination; regeneration ecology of forest trees.

3.3. An idea of forest succession with particular reference to Himalaya.

3.4. Attributes of species of different successional stages, recovery measures of disturbed sites, species selection for disturbed sites in Himalaya.

Course Outcomes:

1. *Paper provides basic concepts regarding the different ecological process*
2. *Interaction between different components that occurs within a forest ecosystem over a period of time.*
3. *Highlights the need of forest ecosystem and ecosystem services in present scenario.*
4. *Paper highlighted the structure and function of the forest ecosystem.*
5. *Different aspect of this paper will help in to know health of the forest ecosystem.*

Books recommended:

1. Barnes, B. V, Zak, D. R, Denton, S. R. and Spurr, S. R. (1998). *Forest Ecology* (4th edition). John Wiley and Sons.
2. Champion, H. G. and Seth, S. K. (1968). *A Revised Survey of the Forest Types of India* (Reprinted 2004). Natraj Publicaiton, Dehradun.
3. Diwedi, A. P. (1993). *Forestry in India*, Surya Publications, Dehradun.
4. Evans, J. and Turnbull, J. (2004). *Plantation Forestry in the Tropics* (3rd Edition). Oxford University Press.
5. Kimmins, J. P. (2004). *Forest Ecology* (2nd edition). Pearson Education.
6. Newton, A. (2007). *Forest Ecology and Conservation.* Oxford University Press.
7. Perry, D. A. (1994). Forest Ecosystems. The Johns Hopkins University Press. Baltimore
8. Puri, G. S., V. M. Mehar-Homji, R. K. Gupta and R. K. Puri (1960). Forest Ecology. Oxford and IBH Pub. Co., New Delhi.
9. R. H. Waring and W. H. Schlesinger. (1985). Forest Ecosystems: Concepts and Management. Academic Press, Orlando.
10. Raymond, Y. A. and Ronald G. L. (2003). *Introduction to Forest Ecosystem*: S*cience and Management* (3rd edition). John Wiley and Sons.
11. Richards, P. W. (1996). The *Tropical Rain Forest* (2nd edition). Cambridge University Press.
12. Singh, S. P. and Singh, J. S. 1992. Forests of the Himalaya: Structure, Functioning and Impact of Man. Gyanodaya Prakashan, Nainital, India, pp 294.
13. Whitmore, T. C. (1998). *The Tropical Rain Forest*. Oxford University Press.

Course Code: Bot-356 **Maximum Marks: 50**

Course Title: Plant Biotechnology-I **Internal Assessment Marks: 20**

Credits: 02 **University Examination Marks: 30**

Choice-based Complimentary Elective

Course Objectives:

The course is designed to provide students an insight into non - conventional methods of plant propagation and the use of these methods in storage and conservation of germplasm.

Unit I: Plant tissue culture

1.1 Plant tissue culture- history; lab requirements and general techniques; culture environment and culture media.

1.2 Cell culture and concept of plasticity and cellular totipotency; plant growth regulators.

1.3 Plant regeneration: somatic embryogenesis, haploid production through andro-, and gynogenesis and triploid production.

1.4 *In vitro* pollination; wide hybridization; somatic cell hybridization (hybrids and cybrids); embryo culture and embryo rescue.

Unit 2: Germplasm storage, conservation, protection and uses

2.1 Protoplast isolation and culture, plant germplasm storage by cryopreservation, advantages of cryopreservation.

2.2 Bio-control agents and biopesticides; biological control of crop pests; biological control of pathogens and weeds; mycoherbicides.

2.3 Production of secondary metabolites (SMs); strategies used to optimize product yield.

2.4 Commercial aspects of SMs, scale up, economic outlook and success stories.

Unit 3: Material production

3.1 Production of pathogen - free plants, virus elimination by heat treatment, virus elimination by meristem culture.

3.2 Single cell proteins (SCP) - health benefits and advantages of single cell proteins (*Spirulina*, *Chlorella*, *Scenedesmus*); Yeast as SCP.

3.3 Biofuel production: ethanol, biogas, hydrogen, concept and applications.

3.4 Mushroom cultivation**,** important edible mushrooms, nutritive and medicinal value of edible mushrooms; mushroom cultivation and its advantages.

Course Outcomes:

1. *Provide students an insight of the non - conventional methods of plant propagation.*
2. *Develop curiosity about use of non - conventional methods in storage and conservation of germplasm.*
3. *Acquaint students with knowledge pertaining to Biotechnology and genetic engineering of plants.*
4. *Realize the role of various International Organizations for the protection and safeguard of environment.*

Books recommended:

Bhojwani, S. S. (2013). Plant Tissue Culture: Applications and Limitations. Elsevier, Amsterdam.

1. Bhojwani, S. S. and Razdan, M. K. (2008). Plant Tissue Culture: Theory and Practice. North Holland, An imprint of Elsevier.
2. Das, H. K. (2010).Text Book of Biotechnology. Wiley India.
3. Hammond, J. H., Mcgarvey, P. and Yusibov, V. (eds). (2000). Plant Biotechnology Springer Verlag, Heidelberg.
4. Narayanswamy, S. (1994). Plant Cell and Tissue Culture. Tata McGraw-Hill Publishing Company Ltd., New Delhi.
5. Razdan, M. K. (2011). Introduction to Plant Tissue Culture, 2nd edn. Oxford and IBH Publishing CO. Pvt. Ltd., New Delhi.

Course Code: Bot-357 **Maximum marks: 50**

Course Title: Biodiversity and Conservation-I **Internal Assessment Marks: 20**

Credits: 02 **University Examination Marks: 30**

Choice-based Complimentary Elective

Course Objectives:

The course provides essential knowledge and cutting edge practical methodologies that are fundamental to the study of biodiversity, its measurement, valuation and uses.

Unit I: Concepts, components and magnitude of biodiversity

1.1. Biodiversity: concept and definition; scope and distribution of biodiversity.
1.2. Biodiversity through ages: biodiversity patterns through geological times; current centers of biodiversity.
1.3. Components of biodiversity: genetic diversity, species/organismal diversity, ecological/ecosystem diversity, landscape/pattern diversity, agro-biodiversity, biocultural diversity and urban biodiversity.
1.4. Magnitude of biodiversity: Estimates of biodiversity at global level; extent of known biodiversity in India and Jammu & Kashmir Himalaya.

Unit II: Measuring biodiversity

2.1. Extent and measurement of genetic diversity; measuring of species diversity: sampling unit – shape, size and number, issue of scale.

2.2. Approaches for measuring biodiversity: floral and faunal surveys; physiognomic, phytosociological and grid methods; their advantages and disadvantages.

2.3. Biodiversity surrogates (types and use); role of remote sensing and GIS in biodiversity assessment and monitoring.

2.4. Modern approaches to measuring organismal diversity: species richness, species evenness, measurement of biodiversity at spatial level (α, β, γ diversity); Shannon-Wiener Index and Simpson Index.

Unit III: Value and uses of biodiversity

3.1. Values of biodiversity: instrumental/utilitarian values and their types, direct use

values.

3.2. Indirect/non-consumptive use values: ethical and aesthetic values, anthropocentrism, biocentrism, eco-centrism and religions; intellectual value.

3.3. Methodologies for valuation of biodiversity: Changes in productivity method and Contingent Valuation method.

3.4. Methodologies for valuation of biodiversity: Hedonic Pricing method and Travel Cost method (introduction); ecological economics for estimation of ecosystem services (introduction).

Course Outcomes:

1. *Provide essential knowledge and cutting edge practical methodologies that are fundamental to the study of biodiversity.*
2. *Demonstrate the distribution of biodiversity at the genetic, organismal, community, and global scales to the students.*
3. *Understand the methods of measurementof the Biodiversity to the students.*
4. *Describe the usesand valuation procedures of biodiversity to the students to realise their importance.*

Books recommended:

1. Trivedy, R. K.; Goel, P. K. and Trisal, C. L. (1998). Practical Methods in Ecology and Environmental Science. Enviro Media Publishers, Karad Maharashtra.

2. Magurran, A. E. (1988). Ecological Diversity and its Measurement. Princeton University Press, USA.

3. Misra, R. (2013). Ecology Workbook. Scientific Publishers, India.

4. Groom, M. J., Meffe, G. R. and C. R. Carroll. (2006). Principles of Conservation Biology. Sinauer Associates, Inc., USA.

5. Krishnamurthy, K. V. (2003). Textbook of Biodiversity. Science Publication.

6. Primack, R. (2006). Essentials of Conservation Biology. Sinauer Associates, Inc., USA.

7. Hambler, C. (2004). Conservation. Cambridge University Press.

8. Van Dyke, F. (2008). Conservation Biology: Foundations, Concepts and Applications,

2nd edition. Springer.

Course Code: Bot-360 **Maximum Marks: 150**

Course Title: Lab Course based on Bot-350 **Internal Assessment Marks: 75**

(Cytology and cytogenetics), **University Examination Marks: 75**

Bot-351 (Reproductive biology of angiosperms),

and Bot-352 (Plant resources and utilization)

Credits: 06

1. *Idiogram preparation and determination of karyotype asymmetry in *Allium cepa, Allium sativum*, etc.
2. Determining ploidy level of the individual on the basis of karyotypic analysis and meiosis in male track.
3. *Preparing somatic complements from the root tip cells of *Allium cepa/Allium sativum.*
4. Studying pollen mitosis in *Tradescantia* sp.
5. *Studying meiosis in male track of: *Allium cepa*; *Aloe vera*; species of *Delphinium, Papaver*, *Tradescantia.*
6. Chromosomal anomalies from the permanent slides as multivalent formation, bridge and laggard, unequal chromosomal separation, desynapsis, aneuploidy, etc.
7. Demonstration of FISH and GISH techniques.
8. *Studying structure of dicot and monocot seed, albuminous and exalbuminous seeds.
9. Studying seed dormancy and methods to break dormancy.
10. *Studying methods of vegetative propagation in plants, its comparison to sexual reproduction.
11. *Study of flower as a composite organ of sexual reproduction: accessory vs. essential organs, reproductive apparatus.
12. Study of microsporogenesis and microgametogenesis by making acetocarmine squashes of anthers at different developmental stages.
13. *Field study of various types of flowers with different pollination mechanisms i.e. pollination effected by wind, thrips, bees, butterflies and birds.
14. Emasculation, bagging and hand pollination to study pollen germination, seed set and fruit development using self-compatible and obligate out-crossing system.
15. Study of nuclear and cellular endosperm through dissections and staining.
16. Isolation of various zygotic, mature embryos, globular, heart-shaped, torpedo- shaped from suitable materials.
17. To study different types of ovules.
18. Study heteromoprhic self incompatibility in *Reinwardtia indica*.
19. *Exploration, collection, identification of a few economically important plants *Withania somnifera*, *Abelmoschus* sp., *Phyllanthus emblica.*
20. Variability introduced in cultivated plants through (tailoring) to suit human fancy, taste and need, through classical methods of plant improvement-selection, hybridization: rose, apple, mango, rice, maize, seedless guava and grapes.

21. Collect, describe, identify and classify wild bioresources, including wild relatives of crop plants and look for similarities and differences with the cultivated relatives. Wild relatives of: Pear, Amla, Olive, Okra, *Ficus* sp., *Plantago* sp., and *Vitis* sp.
22. Tailoring of plant resources through biotechnology interventions - photograph of GM plants like Bt cotton, Flavr savr tomato, Golden rice
23. Aquatic plant resources: Lotus, Water chestnut, *Euryale ferox*, *Typha* sp., *Nymphaea* sp.,
24. Subterranean plant resources: potatoes, sweet potato, *Tapioca* sp., *Zingiber* sp., *Dioscorea* sp., *Curcuma* sp., Groundnut, *Acorus* sp.,
25. Terrestrial plant resources: herbs, shrubs, trees: fruits: food, fodder, medicinal, fruits, fibres, dyes.
26. *Important characters – timbers (hard and soft woods), fuels, medicine, fodder, foliage, food, rubber plants.
27. Plant resources used to produce multiple products through processing: maize (maize floor, popcorn, cakes); soyabean; potato; *Camelia* sp.; wheat and *Linum* sp.

** Available material will be used*

Course outcomes:

- The course helps student in developing understanding of Chromosome, their structure and forms, special types and study of asymmetry in the karyotypes.
- It helps students in understanding different types of chromosomal aberrations and their consequences on the growth and development.
- The course helps students to understand and appreciate the anomalies in chromosomal behavior and their impact on the survival of species.
- The course helps students in performing study of nuclear and cellular endosperm through dissections and staining.
- Helps students to identify and classify different wild bioresources

Course Code: Bot-361 **Maximum Marks: 50**

Course Title: Lab Course based on Bot-353 (Biostatistics and bioinformatics), Bot-354 (Recombinant DNA technology), Bot-355 (Forest ecology-I), Bot-356 (Plant Biotechnology-I) and Bot-357 (Biodiversity and Conservation-I)

University Examination Marks: 25

Internal Assessment Marks: 25

Credits: 02

1. Calculate central tendencies: mean, median and mode from the data provided.
2. Draw frequency distribution curve and frequency polygons from the data provided.
3. Calculate Standard Deviation and Standard Error from the given data.
4. Subject the available data to χ^2 analysis and compare the mean values by applying t-test.
5. To study the phenology and leafing pattern of different tree species.
6. To determine the biomass and NPP of tree species by dimension analysis method.
7. Study the regeneration status of the important tree species of Pir Panjal Biodiversity Park.
8. To determine the litter accumulation in a forest stand.
9. To determine periodic girth increment of different forest trees of Pir Panjal Biodiversity Park.
10. Understanding the concept of sampling: Random sampling, sample size, quadrat, transect and point method for the study of community structure.
11. Study the community structure using quadrat method by establishing minimum size and minimum number of quadrats.
12. Study of community structure and assessing frequency of the species as assessed by Raunkiaer (1934). Prepare a frequency diagram and divide the species into classes based on percentage frequency (Raunkiaer, 1934).
13. Study of community structure and assess the density and abundance of the species.
14. Study of community structure and assessment of cover and basal area of species present and determine the IVI (Importance Value Index) of the species.
15. Field demonstration of GPS (Global Positioning System) and its utility in biodiversity studies.
16. Preparation of culture media with various supplements for plant tissue culture.
17. Preparation of explants of *Valleriana wallichii* for inoculation under aseptic conditions.
18. Attempt *in vitro* andro- and gynogenesis in plants (*Datura stramonium*).
19. Isolation of plant protoplast by enzymatic and mechanical methods and attempt fusion by PEG (available material).
20. Study Biological control of Pathogens- Control of *Fusarium* by *Trichoderma.*
21. Study of Single cell proteins (SCP)- Spirulina, Chlorella and Yeast.
22. Mushroom cultivation (species of *Pleurotus* or *Agaricus*).

Course outcomes

- Students will acquire knowledge about miscellaneous topics such as searches in bioinformatics databases
- The course help students in determining the biomass and regeneration status of the important tree species
- The objective of this laboratory course is to provide practical skills on basic Bioinformatics.
- Demonstrate practical skills in different laboratory equipment's and their handling.
- The students will be able to understand the principle and working procedures of performing tissue culture of different plant samples.

M. Sc. Botany, Semester IV

Course Code: Bot-450 **Maximum Marks: 100**

Course Title: Ecology and **Internal Assessment Marks: 40**

Environmental Biology **University Examination Marks: 60 Credits: 04**

Course Objectives:

The course is designed to help students in understating principles of ecology, environmental biology, and the relationship of humans with the natural world.

Unit I: Ecology and autecological concepts

1.1 Ecology: definition, history, scope and subdivisions; role of ecology in sustainable development.
1.2 Characteristics of populations: size, density, dispersion, age, structure, natality and mortality; factors affecting population growth.
1.3 Intra-specific and inter-specific interactions: competition, coexistance, mutualism, commensalism and prey-predator interactions.
1.4 Genecology: ecological amplitude, ecads, ecotone, ecotypes, ecospecies, coenospecies, k–selection and r–selection populations.

Unit II: Ecosystem ecology

2.1 Concept of ecosystem: structure, function and classification: primary productivity (methods of measurement, global patterns, controlling factors and scope); gross productivity.

2.2 Energy dynamics: trophic organization; energy flow pathways, food chains and food webs, ecological pyramids; ecological efficiency.

2.3 Ecosystem stability: concept (resistance and resilience); ecological perturbations (natural and anthropogenic); successional evolution of ecosystems.

2.4 Major vegetation ecosystems and soil types of the world and India.

Unit III: Community dynamics

3.1 Succession: definition, concept and causes; classification of successions; successional changes – autogenic and allogenic, primary and secondary, autotrophic and heterotrophic.

3.2 Retrogressive changes in succession: concept of climax or stable communities, ecological balance and survival thresholds.

3.3 Concept of limiting factors: Liebig and Shelford's laws of limiting factors and their significance.

3.4 Biogeochemical cycling: concept; carbon cycle, nitrogen cycle and sedimentary cycles; nutrient uptake and cycling.

Unit IV: Ecotoxicology

4.1 Principles and mechanism of toxicity; toxicants in the environment, factors affecting concentration of toxicants in environment.

4.2 Biotransformation, bioaccumulation, biomagnification (a general account); ecotoxicology of herbicides.

4.3 Toxicity of heavy metals: Pb, Hg, Cd and As (general account of each): mutagens and immunotoxic agents.

4.4 Risk and hazards; risk analysis, risk management, environmental toxicants and human health – role of FAO, WHO and EPA.

Unit V: Environmental Impact Assessment

5.1 Environmental impact assessment (EIA): introduction, origin and development, aims and objectives of EIA, development of EIA in India.

5.2 Requirements for impact assessment: main steps of impact assessment: pre-study, study period and post-study period activities.

5.3 Methods of EIA: adhoc method, checklists, matrix, networks, evaluation systems, modeling and computer - aided assessment.

5.4 Writing of environmental impact statement, environmental management plan, environmental auditing, cost and benefit analysis; role of public participation in environmental decision making.

Course Outcomes:

1. *Understand mechanisms by which organisms interact with other organisms and with their physical environment.*
2. *Describe biotic and abiotic factors that influence the dynamics of populations.*
3. *Appreciate the inter-relationship between organism in population and communities.*
4. *Understand principles of toxicology and the harmfuleffects of toxic metals on humans and environment.*
5. *Realize the role of various International Organisations for the protection and safeguard of environment.*

Books recommended:

1. Douglas, J. Futuyma (1998). Evolutionary Biology, (3rd Edition). Sinauer Associates.
2. Eldon, D., Enger, Bradley, Smith, F. (1995). Environmental Science. W C Brown Publications.
3. Grant, W. E. and Swannack, T. M. (2008). Ecological Modelling. Blackwell.
4. Kormondy, E. J. (Ed.) (1999). Concepts of Ecology. Prentice Hall.
5. Michael, P. (1984). Ecological Methods of Field and Laboratory Investigations. Tata McGraw Hill.
6. Miller, G. Tyler, Jr. (2005). Sustaining the Earth, 7th edition. Brooks/Cole- Thomson Learning, Pacific Groove, California.
7. Odum, E. P. (1991). Fundamentals of Ecology (III Edn). Saunders and Com.
8. Ramade, F. (1981). Ecology of Natural Resources. John Wiley and Sons.
9. Wilkinson, D. M. (2007). Fundamental Processes in Ecology: An Earth System Approach. Oxford.

Course Code: Bot-451 **Maximum Marks: 100**

Course Title: Plant Physiology and Biochemistry **Internal Assessment Marks: 40**

Credits: 04 **University Examination Marks: 60**

Course Objectives:

The course is intended to provide the students up-to-date knowledge about fundamental physiological/biochemical processes in plants viz. mineral nutrition, photosynthesis, respiration, nitrogen metabolism and growth regulators.

Unit I: Mineral nutrition and translocation

1.1. Macro and micro nutrients; role and their associated deficiencies and plant disorders.
1.2. Membrane transport: Active and passive transport mechanism; transport proteins.
1.3. Water potential and its components; mechanism of water transport through xylem; transpiration (process, principle and significance).
1.4. Mechanism of translocation in phloem; phloem loading and unloading.

Unit II: Photochemistry and photosynthesis

2.1. Photosynthesis: concept, historical background, photosynthetic pigments (types and role), photosystems (concept, constitution and role).

2.2. Electron transport system; mechanism of electron transport pathways (cyclic and non-cyclic electron transport).

2.3. Carbon assimilation pathways: Calvin cycle (C3 pathway), C4 pathway ; relative efficiency of C3 and C4 plants.

2.4. Crassulacean acid metabolism (CAM) pathway; photorespiration and its significance.

Unit III: Respiration and lipid metabolism

3.1. Respiration: concept and significance; mechanism-glycolysis, citric acid cycle and pentose phosphate pathway

3.2. Mitochondrial electron transport system, process and major steps; ATP synthesis, cyanide resistant respiration.

3.3. Lipid metabolism: lipids, their classification and role; fatty acid biosynthesis.

3.4. β-Oxidation of fatty acids (purpose and process); glyoxylate cycle and its significance.

Unit IV: Enzymes and nitrogen metabolism

4.1. Enzymes: concept, definition, properties and classification; kinetics of single-substrate enzyme catalyzed reactions- Michaelis-Menton equation and its significance.

4.2. Mechanism of action of enzymes; enzyme inhibition and specificity.

4.3. Nitrogen metabolism: nitrogen in environment; mechanism of nitrate uptake and assimilation; ammonium assimilation; need for nitrogen in metabolism.

4.4. Biological nitrogen fixation; nodule formation and nod factors, importance of nitrogen fixation, nitrogen fixing plants.

Unit V: Photoreceptors and plant growth regulators

5.1. Phytochromes and cryptochromes: discovery, structure, photochemical and biochemical properties, cellular localization and responses; role of phytochromes and cryptochromes in plants.

5.2. Photoperiodism: concept and types of photoperiods; vernalization: process and role.

5.3. Physiological effects and mechanism of action of auxins, gibberellins, cytokinins and ethylene.

5.4. Physiological effects and mechanism of action of abscisic acid, salicylic acid, jasmonic acid, brassinosteroids and polyamines.

Course Outcomes:

1. *The course is designed to know the role of macronutrients and micronutrients in the soil and deficiencies caused by excess/low of these nutrients. And the tranport of protein/nutrient in the cell and their utility towards the agricultural benefits*
2. *Students will be able to explain how plants acquire and use the energy and material resources needed to complete their life cycle, highlighting relationships between structure and function, and coordination of development, resource acquisition and environmental responses within and across cells, tissues and organs.*
3. *To know the general process of photosynthesis in all the plants on the earth and know the efficient plant, as higher photosynthesis leads to higher productivity*
4. *To know the general metabolism in plants such as respiration, lipid biosynthesis and other key process such as nitrogen metabolism*

Books recommended:

1. Hopkins, W.G. and Huner, N. P. A. (2009). Introduction to Plant Physiology. Wiley. 4th edition.

2. Taiz, L. E., Zeiger, I. M., Muller and Murphy, A. (2015). Plant Physiology and Development. Sinauer Associates. 6th edition.

3. Davies, P.J. (2004) Plant Hormones Biosynthesis, Signal Transduction, Action. Kluwer Academic Publishers.

4. Salisbury, F. B. and Ross, C.W. (1992). Plant Physiology. Belmont, Calif.: Wadsworth Pub. Co., 4th edition.

5. Pareek, A., Sopory, S. K., Bohnert, H. J. and Govindjee (2010). Abiotic Stress Adaptation in Plants. Springer, Netherlands.

6. Ashraf, M. Ozturk, M. Athar, Habib-ur-Rehman (2009). Salinity and Water Stress Improving Crop Efficiency. Springer, Netherlands

7. Srivastava, L. M. (2002). Plant growth and development: Hormones and Environment. Academic Press. 1st edition.

Course Code: Bot-452 **Maximum Marks: 50**

Course Title: Biotechnology and Genetic Engineering of Plants and Microbes **Internal Assessment Marks: 20**

University Examination Marks: 30

Credits: 02

Course Objectives:

Biotechnology and genetic engineering concern with the manipulation of genetic material for improvement of bioresources for human welfare. This course will help students learn the science and basic techniques of genetic manipulation and educate them with the scope of the subject.

Unit I: Introduction to genetic engineering

1.1 Molecular tools employed in genetic engineering: restriction enzymes – types, nomenclature, cleavage patterns; ligases – types and nature of action; modification enzymes.

1.2 Vectors: properties of an ideal vector; types of vectors, plasmids, cosmids, phagemids, shuttle vectors, bacteriophages, bacterial artificial chromosomes (BAC).

1.3 Nucleic acids: purification, yield analysis, amplification and its applications.

1.4. Expression of heterologous genes in prokaryotes (bacteria) and eukaryotes (yeast).

Unit II: Genetic engineering techniques

2.1 Polymerase Chain Reaction: principle, variations in PCR (RT, qRT, Ligase, Inverse), applications and importance.

2.2 Site-directed mutagenesis using PCR, primers, linkers and adapters.

2.3 Preparation of cDNA libraries; construction and screening of genomic libraries.

2.4 DNA sequencing - chemical degradation, enzymatic methods and next generation sequencing.

Unit III: Transgenic science in plants and microbes

3.1. Transformation in plants: *Agrobacterium* - mediated and direct methods; success stories of transgenic plants- Bt cotton and Golden rice.

3.2. Biopharming - plants as bioreactors for recombinant proteins.

3.3. Microbial biotechnology: genetic manipulation in microbes for the production of antibiotics and enzymes.

3.4 Engineering microbes for the production of insulin, growth hormones and for clearing oil spills.

Course Outcomes:

1. *Acquaint students with the enormous diversity that microbes exhibit and equip them with the understanding of their structure and biology.*
2. *Understand mechanisms by which organisms interact with other organisms and with the environment.*
3. *Describe biotic and abiotic factors and appreciate inter-relationship between organisms in communities.*
4. *Understand concerns with the manipulation of genetic material for improvement of bioresources for human welfare.*
5. *Help students learn the science and basic techniques of genetic manipulation and educate them with the scope of the subject*

Books recommended:

1. Brown, T. A. (2016). Gene Cloning – An Introduction. Blackwell Publishing. (7^{th} edition).
2. Clark, D. P. (2005). Molecular Biology: Understanding the Genetic Revolution. Academic Press.
3. Clark, D. P. and Pazdernik, N. J. (2009). Biotechnology: Applying the Genetic Revolution. Elsevier Inc.
4. Primrose S. B. and Twyman R. M. (2014). Principles of Gene Manipulation and Genomics, Seventh edition.
5. Williams, J., Ceccarelli, A. and Wallace, A. (2001). Genetic Engineering, Second edition. Springer – Verlag, New York Inc.

Course Code: Bot-454 **Maximum Marks: 50**

Course Title: Stress Biology **Internal Assessment Marks: 20**

Credits: 02 **University Examination Marks: 30**

Choice-based Complimentary Elective

Course Objectives:

The course is intended to make students aware about the concepts of abiotic and biotic stress in plants as well as adaptations and bioengineering approaches developed to overcome this stress.

Unit I: Abiotic stress and adaptations

1.1. Salinity stress: effects on growth and photosynthesis of plants; various adaptations of plants to avoid and overcome salinity stress (ion homeostasis and salt tolerance).

1.2. Water deficit: effects of water deficit on plant growth and development, resistance to water deficit (avoidance and tolerance), stomatal signaling during water stress and role of ABA.

1.3. Heavy metal toxicity: Effects of heavy metals on plants, mechanism of heavy metal detoxification, role of phytochelatins in heavy metal stress tolerance.

1.4. Ozone toxicity: effects of ozone on plants, ozone tolerance mechanisms in plants.

Unit II: Biotic stress and plant defense

2.1. Plant defenses against pathogens: role of cutin, waxes and suberin; effectors and resistance (*R*) genes.

2.2. Hypersensitive response, role of phytoalexins in counteracting biotic stress, role of salicylic acid and its signaling during biotic stress.

2.3. Jasmonate induced defense responses in plants; jasmonic acid biosynthesis and its signaling during biotic stress.

2.4. Role of alkaloids, cyanogenic glycosides and glucosinolates in biotic stress tolerance.

Unit III: Bioengineering plants for stress tolerance

3.1. Transgenic approaches for improved stress tolerance: *Arabidopsis* as a model system.

3.2. Adoption of genetically modified (GM) crops; future, challenges in agriculture; GM strategies for insect and virus resistance, glyphosate tolerance – case studies.

3.3. RNA interference (RNAi) – role in virus and bacterial disease management.

3.4. Building stress tolerance through over-producing trehalose in transgenic plants.

Course Outcomes:

1. *Studies on the physiology and mechanism of induction of abiotic stresses in plants with particular reference to deficiencies and toxicities of metals, ozone, salt stress water stress, and methods to overcome these stresses.*
2. *Aware students for the production of improved transgenic varieties via regulating osmolytes and to know about GM crops and strategies for its tolerance.*
3. *Methods for tolerance against biotic stress via signaling molecules such as salicylic acid and jasmonic acid and role display by alkaloid*
4. *To aware the students regarding the phytohormones and their implication towards agricultural point of views*

Books recommended:

1. Hopkins, W. G. and Huner, N. P. A. (2009). Introduction to Plant Physiology. Wiley. 4th Ed.

2. Taiz, L. E., Zeiger, I. M., Muller and Murphy, A. (2015) Plant Physiology and Development. Sinauer Associates. 6th Ed.

3. Davies P. J. (2010) Plant Hormones Biosynthesis, Signal Transduction, Action. Kluwer Academic Publishers. 3rd Edition

4. Pareek, A., Sopory, S. K., Bohnert, H. J. and Govindjee (2010). Abiotic Stress Adaptation in Plants. Springer Netherlands.

5. Ashraf, M. Ozturk, M. Athar, Habib-ur-Rehman (2009). Salinity and Water Stress Improving Crop Efficiency. Springer Netherlands

Course Code: Bot-455 **Maximum marks: 50**

Course Title: Forest Ecology-II **Internal Assessment Marks: 20**

Credits: 02 **University Examination Marks: 30** **Choice-based Complimentary Elective**

Course Objectives:

This course is designed to acquaint students with the types of forests; its structure, functioning and policies and laws related to management and conservation. It also provides information on forest ecosystem services.

Unit I: Structure and functioning of forests

1.1. Major forest types of the world; forest cover and forest types of India, with special reference to J&K; Jammu and Kashmir State Forest Policy 2011 (brief account).

1.2. Structure of major forest types in India: tropical rain forests, monsoon forests, temperate coniferous and temperate deciduous forests, boreal forests and timber line areas.

1.3. Abiotic factors affecting forest ecosystem: climatic factors (solar radiation, wind, temperature, precipitation; edaphic factors (soil profile, physical and chemical properties of forest soil).

1.4. Biotic factors affecting forest ecosystem: competition, epiphytes, climbers, weeds, wild animals and man; diseases of important forest tree species (teak, pine and deodar); rots in hardwood and softwood and their preventions.

Unit II: Forest ecosystem: services and management

2.1. Ecosystem services: definitions, concepts, background especially in relation to the Himalayan Forests.

2.2. Markets for ecosystem services: carbon science; carbon market; water, wildlife, biodiversity, wildlife habitat and other services.

2.3. Ecosystem services: global and national scenario; advantages, and peoples participation in conservation and management.

2.4. Principles of forest management; scope and objectives of forest management; ecosystem management, development of forest management in India.

Unit –III: Forest policy and laws

3.1. Forest policy- concept, objectives and scope; Jammu and Kashmir State Forest Policy 2011.

3.2. National Forest Policy- 1894, 1952 and 1988: concept, objectives and scope (general account).

3.3. Forest laws: Indian Forest Act- 1927; Wildlife Protection Act 1972 concept, objectives and scope (general account).

3.4. Forest Conservation Act; Forest Rights Act; Social Forestry; Urban Forestry: concept, objectives and scope.

Course Outcomes:

1. *Paper describes various forests of India in general and Jammu and Kashmir in particular.*
2. *Paper highlighted forest policies of the India and J&K state.*
3. *Paper provides information on various factors responsible for forest ecosystem.*
4. *It also deals with the different issues, policies and laws related to the management and conservation.*
5. *Further, paper also covers the role of different factors responsible for the loss, threats and impact climate of change on forest ecosystem.*

Books recommended:

1. Barnes, B. V.; Zak, D. R., Denton, S. R. Spurr. (1998). *Forest Ecology* (4th edition). John Wiley and Sons.
2. Champion, H. G. and Seth, S.K. (1968). *A Revised Survey of the Forest Types of India* (Reprinted 2004). Natraj Publicaiton, Dehradun.
3. Diwedi, A. P. (1993). *Forestry in India.* Surya Publications, Dehradun.
4. Evans, J. and Turnbull, J. (2004). *Plantation Forestry in the Tropics* (3rd Edition). Oxford University Press.
5. Kimmins, J. P. (2004). *Forest Ecology* (2nd edition). Pearson Education.
6. Newton, A. (2007). *Forest Ecology and Conservation.* Oxford University Press.
7. Perry, D. A. (1994). Forest Ecosystems. The Johns Hopkins University Press. Baltimore.
8. Puri, G. S., V. M. Mehar-Homji, R. K. Gupta and R. K. Puri (1960). Forest Ecology. Oxford and IBH Pub.Co. New Delhi.
9. Waring, R. H. and Schlesinger W. H. (1985). Forest Ecosystems: Concepts and Management. Academic Press, Orlando.
10. Raymond, Y.A. and Ronald G.L. (2003). *Introduction to Forest Ecosystem* S*cience and Management* (3rd edition). John Wiley and Sons.
11. Richards, P. W. (1996). The *Tropical Rain Forest* (2nd edition). Cambridge University Press.
12. Singh, S. P. and Singh, J. S. (1992). Forests of the Himalaya: Structure, Functioning and Impact of Man. Gyanodaya Prakashan, Nainital, India.
13. Whitmore, T. C. (1998). *The Tropical Rain Forest*. Oxford University Press.

Course Code: Bot-456 **Maximum Marks: 50**

Course Title: Plant Biotechnology-II **Internal Assessment Marks: 20**

Credits: 02 **University Examination Marks: 30**

Choice-based Complimentary Elective

Course Objectives:

Human population is increasing at fast rate. Plant resources required to sustain the ever increasing population need also be increased/ improved. Conventional methods for plant improvement are not able to deliver fully. Therefore, to adopt high throughput technologies is need of the hour. Manipulation of genome by incorporating desirable genes is the option available. This course is intended to give some idea to students how (crop) plants yield and stress tolerance can be transformed to improve in quality, through biotechnological interventions.

Unit I Plant transformation techniques

1.1 *Agrobacterium* - mediated gene transfer in plants for the development of transgenics.
1.2 Virus induced gene silencing (VIGS vectors), plant viruses as non-integrative vectors, plant virus as vector: criteria.
1.3 RNA plant viruses as vectors, mono-partite viruses,.
1.4 Direct methods of gene transfer in plants: particle bombardment, electroporation, microinjection, liposome-mediated transformation, silicon carbide fibre-mediated transformation.

Unit II Biotechnology for stress resistance in plants

2.1 Biotechnology for enhancing cold and heat stress tolerance in plants; secondary effects of abiotic stress – production of ROS, genes involved in scavenging of ROS.
2.2 Biotechnology for enhancing drought and salt stress tolerance in plants.
2.3 Biotechnology for enhancing plant resistance against fungal pathogens; anti - microbial proteins.
2.4 Biotechnology to enhance viral resistance in plants: pathogen-derived resistance; protein mediated, nucleic acid mediated, antisense RNA, RNAi and ribozyme-based approaches to enhance resistance in plants.

Unit III Biotechnology for improving crop yield and quality (value addition)

3.1 Biotechnology in enhancing photosynthesis and improving fruit ripening.
3.2 Golden rice: nutritionally improved rice through biotechnology, termination gene technology.

3.3 Metabolic engineering (an overview), improving the value of ornamental plants (variations in flower colour through gene manipulation, senescene).

3.4 Bioplastics: biodegradable plastic from plants through biotechnological interventions.

Course Outcomes:

1. *The course is intended to impart to students essential knowledge pertaining to use of plant resources in fulfilling the demand of increasing population.*
2. *Provide essential knowledge and cutting edge practical methodologies that are fundamental to the study of plants.*
3. *Demonstrate the need of high throughput technologies over conventional methods for plant improvement.*
4. *Demonstrate the strategies and measures for manipulation of genome by incorporating desirable genes pertaining to specific traits.*
5. *Intends to give students an understanding of plants (crop) yield and stress tolerance.*
6. *Explain the measures in transforming plants with desired traits for quality improvement through biotechnological interventions.*

Books Recommended:

1. Albert, B., Bray, D., Raff, M., Roberts, K and Watson, J. D. (2004). Molecular Biology of the Cell. Garland Publishing Inc., New York. 6th Ed.
2. Bansal, M. P. (2013). Molecular Biology and Biotechnology Basic Experimental Protocols. TERI.
3. Clark, D. P. and Pazdernik, N. J. (2009). Biotechnology Applying the Genetic Revolution. Elsevier.
4. Das, H. K. (2010).Text Book of Biotechnology. Wiley India.
5. Desmond, S. T. Nicholl. (2008). An Introduction to Genetic Engineering, 3rd Edition. Cambridge University Press.
6. Primrose, S. B. and Twyman, R. M. (2007). Principles of Gene Manipulation and Genomics. Blackwell Publishing, Oxford, UK.
7. Slater, A., Scott, N. and Fowler, M. (2012). Plant Biotechnology: the Genetic Manipulation of Plants. Oxford University Press.
8. Wink, M. (2006). An Introduction to Molecular Biotechnology. Wiley – Vch, Verlag, Gmbh& Co, KGaA, Weinheim, Germany.

Course Code: Bot-457 **Maximum marks: 50**

Course Title: Biodiversity and Conservation- II **Internal Assessment Marks: 20**

Credits: 02 **University Examination Marks: 30**

Choice-based Complimentary Elective

Course Objectives:

The course is intended to impart to students essential knowledge pertaining to loss of biodiversity, threats it faces, and to the strategies and measures in place for its conservation.

Unit 1: Loss of and threats to biodiversity

1.1 Loss of biodiversity: Species extinction, types of extinctions, causes of species extinction, estimates of extinction rates; genetic erosion and its causes.

1.2 Habitat loss and degradation; deforestation; expanding agriculture; desertification (causes and consequences on biodiversity).

1.3 IUCN threat categories; invasive species: their introduction pathways, biological impacts of invasive species on terrestrial and aquatic ecosystems.

1.4 Anthropogenic threats: Urbanization, overexploitation, pollution, impact of climate change; natural threats to biodiversity.

Unit II: Conservation of biodiversity: national and international efforts

2.1. Global efforts for conserving biodiversity: international conservation organizations (UNESCO, IUCN, WWF, UNEP, WCMC, TRAFFIC, ICIMOD).

2.2. Global efforts for conserving biodiversity: multilateral treaties (Ramsar Convention, WHC, CITES, CBD); role of CBD in biodiversity conservation.

2.3 National efforts for conserving biodiversity: Biological Diversity Act (2002) and Rules (2004); National Biodiversity Authority (2004); National Environment Policy (2006); National Biodiversity Action Plan (2008); Indian Biodiversity Information Network.

2.4 Biodiversity hotspots (concept, criteria and conservation implications); biodiversity hotspots of India and their conservation scenario.

Unit III Conservation of biodiversity: strategies

3.1. *In situ* conservation: Protected Areas (PAs); international Pas - Ramsar sites, World Heritage sites, Biosphere reserves; national parks, wildlife sanctuaries; *in situ* conservation of aquatic ecosystems.
3.2. *Ex situ* conservation: botanical gardens and arboreta; field gene banks, seed banks, reserve forests, sacred groves; zoological parks/zoos and aquaria.
3.3. *In vitro* conservation: Tissue culture and propagation; cryopreservation of cells, tissues and organs; *in vitro* and cryo-banks; DNA and genomic resources banks, conservation in permofrost conditions.
3.4. National and international institutions involved in conservation: IBPGR, Indian gene banks for plant, animal and microbial genetic resources; NBPGR, National Genetic Resources Advisory Council; International agricultural research centres.

Course Outcomes:

1. *The course is intended to impart to students essential knowledge pertaining to loss of biodiversity and threats it faces.*
2. *Explain the consequences of human activity (current economic and social issues) on the loss of biodiversity.*
3. *Demonstrate the strategies and measures in place for the conservation of biodiversity.*
4. *Explain the conservation and management of biodiversity at global level and the role of Conservation Organisations as well.*
5. *Understand the legislative implications for the conservation and management of biodiversity in India.*

Books recommended:

1) Engels J. M. M., Visser, L. (Editors). (2003). A Guide to Effective Management of Germplasm Collections. IPGRI Handbooks for Genebanks No. 6. IPGRI, Rome, Italy. Available in English and Spanish.
2) FAO/IPGRI. (1994). Genebank Standards. Food and Agriculture Organization of the United Nations, Rome and International Plant Genetic Resources Institute, Rome. Available in English, Spanish, French and Arabic.
3) Groom, M. J., Meffe, G. K. and Carroll, C. R. (2006). Principles of Conservation Biology. Sircuier Associates, Inc.
4) Singh, J. S., Singh, S. P. and Gupta, S. R. (2006). Ecology Environment and Resource Conservation, Anamaya Publishers, New Delhi.
5) Krishnamurthy, K. V. (2003). Textbook of Biodiversity. Science Publication.
6) Primack, R. (2006). Essentials of Conservation Biology. Sinauer Associates, Inc., USA.
7) Hambler, C. (2004). Conservation. Cambridge University Press.
8) Van Dyke, F. (2008).Conservation Biology- Foundations, Concepts & Applications, 2nd Edition, Springer.

Course Code: Bot-460 **Maximum Marks: 100**

Course Title: Lab Course based on Bot-450 (Ecology and Environmental Biology), and Bot-454 (Stress Biology), Bot-455 (Forest Ecology-II), Bot-456 (Plant Biotechnology-II) and Bot-457 (Biodiversity and Conservation-II)

University Examination Marks: 50

Internal Assessment Marks: 50

Credits: 04

1. To determine the minimum size of the quadrat by species area curve method.
2. To study the community characteristics by quadrat method by determining frequency, density and abundance of different species in the community.
3. To study life forms of plants in a selected area using Raunkiaer's scheme.
4. To compare the biomass and net primary production of managed and unmanaged sites.
5. Analyse the structure of different Himalayan forests with special emphasis on tree and ground layer.
6. To study the biotic components of a pond ecosystem.
7. To study the physico-chemical properties of different soil samples.
8. Volumetric analysis of different soil samples by EDTA titration.
9. Exploratory trip for plant collection/ visit to National Parks/Wildlife Sanctuaries/Botanical gardens/Herbaria.
10. Estimation of proline content by the method of Bates *et al.*, 1973.
11. Estimation of glycinebetaine content under abiotic stress.
12. Quantitative estimation of peroxidase activity in seedlings in the absence and presence of salt stress.
13. Superoxide dismutase activity in seedlings in the absence and presence of salt stress
14. Changes in catalase activity in response to abiotic stress.
15. Estimation of hydrogen peroxide content in a given material under abiotic stress.
16. Estimation of lipid peroxidation in a given material under abiotic stress.
17. Estimation of ascorbic acid content under heavy metal stress/copper/chromium stress.
18. Estimation of glutathione content under abiotic stress.
19. Estimation of the sugar content (trehalose) in the given material.
20. To investigate the effect of abiotic stress on morphological and physiological parameters of a given plant material.

21. Role of plant growth regulators in mitigating stress.
22. Isolation of plasmid DNA from recombinant clones.
23. Preparation of MS culture media with various supplements for tobacco in vitro culture.
24. Preparation of competent cells of *E. coli* for genetic transformation.
25. Culture *Agrobacterium tumefaciens* and attempt transformation of Tobacco as model plant.
26. Isolate plant genomic DNA by modified CTAB method
27. Generate molecular profiles (RAPD, ISSR) of some economically important species.

Course outcomes:

- To elucidate students with basic training of plant tissue culture.
- Students will learn different techniques pertaining to plant biotechnology.
- Demonstrate practical skills in different laboratory equipment's and their handling.
- The objective of this laboratory course is to provide practical skills on basic genetic engineering techniques.
- Train students with basic techniques in Genetic Engineering.

Course Code: Bot-461 **Maximum Marks: 100**

Course Title: Lab Course based on Bot-451(Plant Physiology and Biochemistry) and Bot-452(Biotechnology and Genetic Engineering of Plants and Microbes).

Internal Assessment Marks: 50

University Examination Marks: 50

Credits: 04

1. To separate chloroplast pigments by paper chromatography.
2. To measure the concentration of chlorophyll and carotenoids in a given plant leaf material.
3. Determination of Q10 of water absorption of a given plant material.
4. To determine the stomatal indices on the upper and lower epidermis using different leaf material
5. Determination of water potential of potato tuber tissues by gravimetric method.
6. Determination of osmotic potential of onion epidermal peels by plasmolytic method.
7. Determination of effect of organic solvents on membrane permeability of plant tissues.
8. Study of effect of temperature on membrane permeability of plant tissues.
9. Estimation of nitrate reductase activity in a given plant material.
10. Estimation of carbonic anhydrase activity in a given plant material.
11. Isolation of plant and bacterial genomic DNA (*Brassica* sp, *E. coli*).
12. Isolation of RNA from the leaves of *Catharanthus roseus*, *Valleriana wallichii* and *Brassica* sp. by using Trizol method.
13. Isolation of plasmid DNA from *E. coli.*
14. Agarose gel electrophoresis of DNA.
15. Restriction digestion of total genomic DNA.
16. Preparation of competent bacterial cells.
17. Demonstration of restriction maps.
18. Elution of target DNA fragments from agarose gel.
19. Demonstration of Northern/Western/Southern Blotting technique.
20. Amplification of given DNA sample by PCR

Course outcomes:

- The objective of this laboratory course is to provide the students practical skills in discipline centric electives.
- The objective of this course is to familiarize students with the basic concepts and applications of modern techniques used in Cell and Molecular Biology.

- The students will be able to understand the principle and working of different centrifugation techniques.
- The students will be able to understand the principle and working of different Electrophoretic and molecular biology techniques.