Department of Botany, Kargil Campus, University of Ladakh

Syllabus for PG Course in Botany, Semester I (NEP) for the Academic Session 2022 and Onwards

Course Structure for the semester I

Table 1: Courses, Credit and marks distribution for PG Botany Semester I

Course Title	Course code	Credits	Marks
Microbiology and Mycology	PG-BO-C-101	04	100
Algae and Bryophyta	PG-BO-C-102	04	100
Cytogenetics and Plant Breeding Or Principles of Plant Pathology	PG-BO-E-103 Or PG-BO-E-104	04	100
Practical (based on PG-BO-C-101)	PG-BO-L-105	04	100
Multidisciplinary Practical Approaches in Biology	PG-BO-L-106	02	50
Minor project	PG-BO-MP-107	02	50
Total		**20**	**500**

Marks distribution and Examination pattern

Marks distribution pattern: 4 credit courses have 100 marks and 2 credit courses have 50 marks. The marks distribution pattern, in percentage terms, for internal and external assessments respectively is 30:70 for theory and 50:50 for practicals.

Examination pattern

1. **Theory**

    a. Internal assessment

It carries 30 marks for each of the three theory papers and would be conducted in the form of presentations, assignments, objective and/or descriptive questions.

    b. Semester end (final examination)

Question paper for semester end examination in theory shall have the following pattern:

Section – A: Short answer type questions. This section shall be compulsory and it will have one question with four parts one from each unit, each part carrying 3.5 marks. (14 Marks in total)

Section – B: **Long Answer Type Questions**
This section will have 4 questions with internal choice each question carrying 14 marks. (56 marks in total)

Thus, a student has to attempt 5 questions in all.

2. **Practical**

The assessment of the practical course will be done in two parts, each carrying 50% of marks for the course

1. Internal examination and
2. External examination

Department of Botany

Semester I

Course title: MICROBIOLOGY AND MYCOLOGY
Course Code: PG-BO-C-101
No. of lectures: 60

Objective: To acquaint the students with the diversity of the microbial world, variation in their structural and reproductive patters and their direct and indirect role in the human welfare.

Unit I

Viruses: General characteristics; origin, chemical nature and ultrastructure.
Replication, transmission and isolation: Mechanisms of viral replication; difference between DNA and RNA viruses; transmission (ways and vectors); isolation and purification of plant viruses; economic importance of viruses
Virus-like agents: Structure, replication and transmission of viroids, important diseases caused by viroids (Potato spindle tuber, Cadang-cadang of coconut); virions, and prions - concept, decoysstructural aspects and evolutionary importance

Unit II

Eubacteria: Origin and evolution, classification criteria and diversity; bacterial growth and nutrition, ultra-structural details; reproduction types; ecological and economic importance. Bacterial endospores structure, types and their formation
Archaea-bacteria: General account, major types (methanogens, extreme halophiles, extreme thermophiles); structural variations (comparison with eubacteria and eukaryotes); evolutionary significance
Cyanobacteria: Salient features, cyanobacterial symbiosis, endosymbiotic evolution, biological and ecological importance

Unit III

Fungi: General characteristics, cell ultra-structure; thallus organization; cell wall composition; nutrition (saprobic, biotropic and hemibiotrophic); reproduction (vegetative, asexual and sexual); heterothallism; heterokaryosis, parasexual life cycle; recent trends in classification of fungi.
Structural diversity and mode of reproduction: Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina

Unit IV

Fungi in Industry: Role of fungi in production of wine, beer, bread, organic acids, amino acids and vitamins; Food spoilage by fungi

Fungi in Medicine: Fungal metabolites used in medicine and production of antibiotics

Mycorrhizae: Fungi as bio-fertilizers, with special reference to phosphorus nutrition, stress (biotic and abiotic) mitigation, general account of fungal symbionts of forest tree species; role of mycorrhizae in plant conservation.

Essential readings:

1. Aneja, K. R. 2016. Laboratory Manual of Microbiology and Biotechnology, Medtech, New Delhi.
2. SubbaRao, N. S. 2018. Advances in Agricultural Microbiology, 2nd Edition, Medtech, New Delhi
3. Jane, F., Vincent R. R., Glenn F. R., Theodora H. and Anna M. S. 2020. Principles of Virology, 5th Edition ASM Press
4. George, M. 2012. Text Book of Fungi, Including Morphology, Physiology, Pathology, Classification. Rare Books Club

Further readings

1. Goldman, E., and Lorrence H. G. (eds.). 2021. Practical handbook of microbiology. 4th edition CRC press
2. Hutkins, R. W. 2008. Microbiology and technology of fermented foods. John Wiley & Sons
3. Okafor, N., and Okeke, B. C. 2018. Modern Industrial Microbiology and Biotechnology, 2nd Edition, CRC Press, Boca Raton
4. Shahid, A. and Naseem A. 2018. Pathogenic Fungi in Plant Organisms. Write and Print Publications.
5. SubbaRao, N. S. 2018. Soil Microbiology, 5th Edition, Medtech, New Delhi
6. Willey, J. M., Sherwood, L. M. and Woolverton, C. J. 2017. Prescott's Microbiology, 10th Edition, McGraw-Hill, USA

Course title: ALGAE AND BRYOPHYTA
Course Code PG-BO-C-102
No. of lectures: 60

Objective: To familiarize the students with cryptogamic plants, diversity in their habit and habitat, and heir ecological and economic significance for the human race.

Unit I

Algae: Habitat diversity (terrestrial, freshwater, marine); range of thallus organization; evolutionary relationships; cell ultrastructure; reproduction (vegetative, asexual, sexual); criteria for classification of algae (pigments, reserve food, flagella).

Classification and salient features: Modern trends in algal classification (Lee, 2008)

General account of Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta with reference to cell wall, flagella, chloroplasts, pyrenoids, eye spots and reserve food products.

Morphology and reproduction: Chlorophyta (*Ulothrix*), Charophyta (*Chara*), Xanthophyta (*Vaucheria*), Bacillariophyta (*Navicula*), Phaeophyta (*Fucus*) and Rhodophyta (*Batrachospermum*)

Unit II

Origin of Bryophytes- Evolution of gametophyte and sporophyte; fossil bryophytes; habitat diversity of bryophytes

Classification of bryophytes- latest recommended by ICBN

Liverworts and Hornworts: Morphology, anatomy and reproduction of Marchantiales (*Marchantia*), Metzgeriales (*Pellia)*, Jungermanniales (*Porella*) and Anthocerotales (*Anthoceros)*

Unit III

Moses

Morphology, anatomy and reproduction: Funariales (*Funaria*), Sphagnales (*Sphagnum***)** and Polytricales (*Polytrichum*).

Life-cycle of Bryophytes: Different types of Life cycles, Alternation of generation, Apospory and Apogamy

Unit IV

Economic importance of algae: Algal blooms, their impact on the aquatic ecosystems, useful and harmful algae; role of algae in biotechnology, toxic algae

Economic importance of bryophytes: Ecological importance of bryophytes, symbiotic associations of bryophytes.

Essential readings:

1. Goffinet, B. and Shaw, A. J. (Eds). 2008. Bryophyte Biology (2nd Edn.), Cambridge University Press, Cambridge.
2. Lee, R. E. 2008. Phycology, Cambridge University Press, Cambridge.
3. Rashid, A. 1999. An Introduction to Bryophyta, Vikas Publ. House, Pvt. Ltd.
4. Shaw, A. J. and Bernard, G. (eds.). 2000. Bryophyte biology, Cambridge University Press

Further readings:

1. Bilgrami, K. S., Saha., L. C. and Saha, L. 2004. A textbook of Algae. CBS Publications
2. Granéli, E. and Jefferson T. T. (Eds.) 2006. Ecology of harmful algae. Vol. 189. Berlin: Springer
3. Kashyap, S.R. 1932. Liverworts of Western Himalayas and Punjab Plains, Researchco
4. Publications, New Delhi,
5. Marshall, N. L. 2018. Mosses and Lichens: A Popular Guide to the Identification and Study of Our Commoner Mosses and Lichens, Their Uses, and Methods of Preserving, Forgotten Books
6. Singh, V. and Pande P. C. 2017. A Textbook of Botany Biodiversity (Microbes Fungi Algae and Archegoniate, Rastogi Publications
7. Vander poorten, A. and Goffinet, B. 2009. Introduction to Bryophytes, Cambridge University Press, New York.

CYTOGENETICS AND PLANT BREEDING

Course Code: PG-BO-E-103

No. of lectures: 60

Objective: It is important to understand the genetics and cytogenetics to understand the principles of breeding. This information is essential for improvement of crop plants. This course aims at equipping the students with basic and modern knowledge in the subject of genetics and principles of heredity.

Unit I

Chromosomes: Chromosome morphology; molecular organization of nucleosome, solenoid concept.

Gene concept: Allele concept, multiple alleles, isoalleles, pseudoallele

Molecular organization: Centromere and telomere; euchromatin and heterochromatin, transposons

Specialized chromosomes: Structure, occurrence and behavior of B- and sex chromosomes; polytene and lampbrush chromosomes

Nucleolus and NORs: Structure and function

Unit II

Haploid and monoploid: Origin, occurrence, production and meiosis of monoploids and haploids

Autopolyploids: Origin and production of autopolyploids: concept of chromosome and chromatid segregation

Allopolyploids: Types, genome constitution and analysis of *Triticum*, *Arachis*, *Brassica* and *Gossypium*

Aneuploidy: Origin, occurrence, production, meiosis and detection of monosomics, trisomics (primary, secondary, tertiary), nullisomics and tetrasomics

Unit III

Recombination: Holliday's model of recombination at molecular level, role of Rec A and Rec B,C,D enzymes; site-specific recombination

Linkage: Concept of Linkage, evolution of linkage, cis- and trans- arrangement of linked gene

Mapping: Chromosome mapping, genetic markers, concept of molecular maps; correlation of genetic and physical maps; somatic cell genetics as an alternative approach to gene mapping

Population genetics: Hardy-Weinberg equilibrium and factors affecting allelic frequencies

Unit IV

Mutation: Spontaneous and induced mutations, point mutation, transitions, transversions, physical and chemical mutagens, molecular basis of mutations

Chromosome aberrations: Breeding behavior and genetics of complex translocation heterozygotes, translocation tester sets; Robertsonian translocations.

Breeding behavior: Breeding behavior and genetics of inversion heterozygotes.

Alien addition and substitution: Production, characterization and utility of alien addition and substitution lines

Essential readings:

1. Hartl, D.L. and Jones, E.W. Genetics – An Analysis of Genes and Genomes 2012. Jones & Bartlett Publishers.
2. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Scott, M.P., Bretscher, A., Ploegh, H. and Matsudaira, P. 2013. Molecular Cell Biology. 7th Edn. W. H. Freeman and Company. New York.
3. Russel, P. J. 2016. Genetics. Little Brown
4. Snustad, D. P. and Simmons, M.J. 2003. Principles of Genetics, J. Wiley and Sons, USA

Further readings:

1. Brown, T.A. 2017. Genomes-4 4th edition, CRC Press
2. Brown, T. A. 2020. Gene cloning and DNA analysis: an introduction, John Wiley & Sons.
3. Cutter, A. D. 2019. A primer of molecular population genetics. Oxford University Press, USA.
4. Gupta, P. K. 2013. Genetics, Rastogi Publications
5. Jocelyn, E., Krebs, E. S., Goldstein, L. B. 2017. Genes XII, Oxford University Press, NY.
6. Karp, G. 2016. Cell and Molecular Biology – Concepts and Experiments, John Wiley and Sons Inc.
7. Krebs, J. E. 2014. Lewin‘s Genes XI, John Wiley and Sons Inc.

Course title: PRINCIPLES OF PLANT PATHOLOGY

Course Code: PG-BO-E-104
No. of lectures: 60

Objectives: this course aims at providing the students the knowledge of various plant diseases. It aims at discussing and making students understand the mechanisms used by various pathogens to gain entry into the plant tissue and breach their first line of defense. Better understanding of these processes help control and manage the diseases better.

Unit I

Plant diseases: Concept and significance; disease triangle
Inocula of plant pathogens: Production, types and survival
Dispersal of infectious plant pathogens: Active and passive dispersal
Plant disease forecast: Epidemic forecast, disease warning systems and important examples of plant disease forecast systems.

Unit II

Pre-penetration of pathogen: Pre-penetration activities of the pathogens on host surface; direct penetration through intact plant surfaces, penetration through wounds and natural openings
Post-penetration: Inter -and intra-cellular development of pathogens involving growth and reproduction of the pathogen.
Defense mechanism in plants: Concept of PAMPs, Morphological and histological defense structures, cytoplasmic defense reaction in response to infection by pathogens
Biochemical defense mechanisms, phytoalexins, Pathogenesis-related (PR) proteins

Unit III

Enzymes in plant disease: Enzymatic degradation of cell wall substances (microbial cellulases, pectinases, hydrolases)
Microbial toxins: Microbial toxins in plant disease, non-host specific and host specific toxins
Growth regulators: Role in plant diseases
Polysaccharides: Role of in plant diseases (EPS, O- antigens)

Unit IV

Regulatory and biological methods for diseases management: Quarantine and inspection, antibiosis, fungistasis
Cultural methods: Eradication of secondary hosts, crop rotation, rouging, tillage, sanitation, creating conditions unfavorable to the pathogens, nutritional and soil amendments.
Chemical methods: Requisites of a good fungicide, protective and systemic fungicides, seed and soil treatment by fungicides.

Breeding for disease resistance: Important methods for developing resistant varieties, types of plant resistance to pathogens, genetics of virulence in pathogen and resistance in host plant

Essential readings:

1. Agrios, G.N. 2012. Plant Pathology. 5th Edn. Academic Press, London.
2. Aneja, K. R., Merothara, R. S. 2015. An Introduction to Mycology, New age International Publication
3. Mehrotra, R.S. and Aggarwal. A. 2003. Plant Pathology, Tata McGraw Hill.

Further readings:

1. Bhatnagar, D., Lillehoj, E. B. and Arora, D.K. 1992. Handbook of Applied Mycology: Mycotoxins in Ecological Systems. Vol. 5. Marcel Dikker Inc.
2. Ownley, B. H. and Trigiano, R. N. (eds.). 2016. Plant Pathology Concepts and Laboratory Exercises, Boca Raton
3. Schumann, G. L., D'Arcy, C. J. 2021. Essential Plant Pathology, 2nd Edition. Amer Phytopathological Society
4. Sharma, R.P. and Salunkhe, D.K. 1991. Mycotoxins and Phytoalexins, CRC Press, Boca Raton
5. Sumbali G. and Mehrotra, R.S. 2009. Principles of Microbiology. 1st Edn. Tata McGraw Hill Publishing Co. Ltd. New Delhi.
6. Sumbali, G. 2010. The Fungi. 2nd Edn. Narosa Publishing House, New Delhi.
7. Waller J. M., Lenne, J. M. and Waller S. J. 2001. Plant Pathologist's Pocket Book. 3rd Edn. CDBI Publishers.

Course title: PRACTICAL

Course Code: PG-BO-L-105

Laboratory Exercises based on PGBOC-101 (Microbiology and Mycology)

- Demonstration of various staining techniques for bacteria (Gram staining, negative/ indirect staining, cell wall staining and endospore staining)
- Demonstration of the presence of nitrogen fixing organisms (Rhizobium sp.) in root nodules of legumes
- Symptomatology of plant diseases caused by bacteria (leaf spot of peach, angular leaf spot of cotton, and citrus canker)
- Symptomatology of plant diseases caused by virus. (Tobacco mosaic virus, Tomato aspermy virus, Cauliflower mosaic virus, Tobacco leaf curl virus, bean common mosaic virus and yellow vein mosaic virus)
- Morphological characters of some microfungi (*Curvularia*, *Alternaria*, *Fusarium*, *Penicillium*, *Colletotrichum*, *Aspergillus*, *Mucor*, *Rhizopus*, *Syncephalastrum*, *Chaetomium*, *Peronospora*, *Phyllactinia* and *Uncinula*)
- Morphological characters of some macrofungi (*Agaricus*, *Morchella*, *Pleurotus*, *Geastrum* and *Calocybe*)

Course title: Multidisciplinary practical approaches in biology
Course Code: PG-BO-L-106
Section I

- Morphological study of the representative members of Algae: Anabaena, Nostoc, *Pediastrum*, *Volvox*, *Hydrodictyon*, *Ulva*, *Clostridium*, *Chara*, *Botrydium*, *Enteromorpha*, *Padina*, *Bulbochaete*, *Ceramium* and *Batrachospermum*
- Study of morphological, anatomical and reproductive structures of various bryophytes viz. *Riccia*, *Marchantia*, *Pellia*, *Porella*, *Anthoceros*, *Polytrichum*, *Andreaea*, and *Funaria*

- Study of Mendelian and non-Mendelian inheritance patterns
- Study of the effect of translocation heterozygosity on chromosome pairing, chromosome disjunction and pollen and seed fertility
- Study of the meiosis of complex translocation heterozygotes
- Preparation of molar solutions
- Preparation of percent solutions
- Principle and working of some lab equipment (microscope, centrifuge, laminar airflow)

Section II

- Meiotic chromosome study and behaviour (*Ranunculus* sp., *Tulipa* Sp., *Allium cepa*. *Tradescantia canaliculata*, and *Papaver somniferum*)
- Karyotype analysis and preparation of ideogram.
- Techniques of preparation of permanent and semi-permanent slides
- Study of somatic chromosomes from root tip squashes
- Comparative effect of various pretreating agents on somatic chromosomes
- Study of polytene chromosomes in *Chironomus*
- Study of characteristics and behavior of B chromosomes in an appropriate material
- Study of sex chromosomes of *Spinacea*, *Rumex*/ *Cannabis*, *Mirabilis*

Or

- Sterilization of equipment and glassware, preparation of culture media (PDA) pour plating and slants
- Isolation, purification, culturing and sub-culturing of fungal pathogens
- Symptomatology of plant diseases caused by fungi (Brown leaf spot of rice, Red rot of sugarcane, Late blight of potato, Early blight of potato, Smut of bajra, Yellow or stripe rust of wheat, Loose smut of wheat, Ergot of rye, Tikka disease of groundnut
- Field diseases of local crop plants.

Minor project: PG-BO-MP-107

Semester II

Course Structure for the semester II

Table 1: Courses Credit and marks distribution for PG Botany Semester II

Nature of the course	Course Title	Course code	Credits	Marks
Core	Cell and Molecular Biology	PG-BO-C-201	04	100
Core	Taxonomy of Angiosperms	PG-BO-C-202	04	100
Core	Pteridophyta and Gymnosperms	PG-BO-C-203	04	100
Multidisciplinary	Medicinal plants and Herbal Resource Management	PG-BO-M-204	02	50
Practical	Practical	PG-BO-L-205	04	100
	Minor project	PG-BO-P-206	02	50
Total			**20**	**500**

Marks distribution and Examination pattern

Marks distribution pattern: 4 credit courses have 100 marks and 2 credit courses have 50 marks. The marks distribution pattern, in percentage terms, for internal and external assessments respectively is 30:70 for theory and 50:50 for practicals.

Examination pattern

3. **Theory**

c. Internal assessment

It carries 30 marks for each of the three theory papers and would be conducted in the form of presentations, assignments, objective and/or descriptive questions.

d. Semester end (final examination)

Question paper for semester end examination in theory shall have the following pattern:

Section – A: Short answer type questions. This section shall be compulsory and it will have one question with four parts one from each unit, each part carrying 3.5 marks. (14 Marks in total)

Section – B: Long Answer Type Questions

This section will have 4 questions with internal choice each question carrying 14 marks. (56 marks in total)

Thus, a student has to attempt 5 questions in all.

4. **Practical**

The assessment of the practical course will be done in two parts, each carrying 50% of marks for the course

3. Internal examination and
4. External examination

Course title: CELL AND MOLECULAR BIOLOGY
Course Code: PG-BO-C-201
No. of lectures: 60

Objectives: To familiarize the students with structural and functional aspects of sub-cellular organelles. To acquaint the students with important aspects of expression of genes and their regulation.

Unit I

Cell wall and plasma membrane: Fluid mosaic model of membrane structure, functions of biological membranes; membrane proteins – integral and transmembrane; signal transduction; concept of carriers, pumps, channels and receptors

The cytoskeleton: Organization and role of microtubules, microfilaments and intermediate filaments, motor proteins.
Nucleus: structure of nuclear membrane and nuclear pore complex, transport of proteins and RNAs across nuclear membrane.

Unit II

Chloroplasts and Mitochondria: mt- and cp-genome organization, protein import, concept of endo-symbiotic origin.
Golgi complex and ER: Role in protein sorting and transport, signal peptide, Lysosomes – endocytosis and phagocytosis (development of phagosome).
The cell cycle: Phases of cell cycle (G1, S, G2, M and G0 phases), regulation of cell cycle progression, role of cyclin and cyclin-dependent kinases
Cell death: Types of cell death (apoptosis), programmed cell death in the life cycle of plants (with reference to leaf senescence).

Chromosome techniques: In-situ hybridization: GISH, FISH and confocal microscopy.

Unit III

DNA: DNA structure A, B & Z forms; single stranded DNA; supercoiling of DNA, mechanism of DNA replication (replisome, theta replication) DNA damage and repair mechanisms, important enzymes in the process of DNA repair.
Transcription: RNA polymerase, introns and their significance, transcription factors, mechanism of transcription, major differences between prokaryotes and eukaryotes (at transcription level).
RNA processing: Post transcriptional modifications, RNA editing, splicing of introns, spliceosome.

Unit IV

Ribosomes - Structure and assembly, t-RNA and genetic code; Types of RNA- mRNA, tRNA and rRNA; their structure and biosynthesis; concept of micro-RNAs

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

Regulation of gene expression: Prokaryotes (Lac operon, tryptophan operon) and eukaryotes (role of promoters, activators, repressors and DNA methylation)

Essential readings:

1. Berk, A., Kaiser, C.A., Lodish, H., Amon, A., Ploegh, H, Bretscher, Monty Krieger, A., Martin, K.C. (Eds). (2016). Molecular Cell Biology. Freeman & Co., US
2. Brown, T. A. (2020). Gene cloning and DNA analysis: an introduction. John Wiley & Sons.
3. Karp, G. 2016. Cell and Molecular Biology – Concepts and Experiments. John Wiley and Sons Inc.
4. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Scott, M.P., Bretscher, A., Ploegh, H. and Matsudaira, P. 2013. Molecular Cell Biology. 7th Edn. W. H. Freeman and Company. New York.

Further readings:

1. Dashek, W. V., and Miglani, G. S., (Eds.) 2017. Plant cells and their organelles. John Wiley & Sons
2. Malacinski G.M. 2008. Freifelder's Essentials of Molecular Biology, 4th Edition, Jones & Bartlett, USA.
3. Morgan. D. O. 2007. The Cell Cycle, Principles of Control. OUP/New Science Press
4. Primrose, S.B. and Twyman, R.M. (2006) Principles of Genetic Manipulation and Genomics. Seventh Edition. Blackwell Publishing, UK.
5. Perdew, G. H., Vanden-Heuvel, J. P., and Peters, J. M. (Eds.). (2006). Regulation of gene expression: molecular mechanisms. Totowa, NJ: Humana press.
6. Pollard, Thomas D., et al. 2016. Cell biology, Elsevier Health Sciences
7. Sadava, D. E. 1992. Cell Biology – Organelle Structure and Function. Jones & Barlert Publishers.
8. Wilson, K. and Walker. J. 2016. Principles and techniques of Biochemistry and Molecular Biology. Cambridge Press

Course title: TAXONOMY OF ANGIOSPERMS
Course Code: PG-BO-C-202
No. of lectures: 60

Objectives: the aim of this course is to acquaint the students with basic principles of classification. This course also aims to explain to them the interrelationships among various plant groups. In this course classification of plants is discussed based on use of new techniques. The course also aims at providing information regarding various herbaria and botanical gardens.

Unit I

Introduction to taxonomy: Taxonomy, systematics, classification, plant collection and documentation, methods of plant collection, plant description and illustration as taxonomic tools.
Origin of Angiosperms: Place of origin, monophyletic and polyphyletic concepts, origin of monocotyledons.

Evolutionary trends in angiosperms: Co-evolution with animals, evolution of xylem, stamens and pollen grains, carpel and inferior ovary.

Approaches to plant classification: Artificial, natural and evolutionary approaches (historical account); phenetics (basic principles, selection of characters, character x taxon matrix, similarity matrix, phenogram construction and classification); cladistics (concept, terminology, taxon and character selection, character analysis, cladogram construction and classification)

Unit II

Taxonomic characters and sources: Characters (kinds and criteria); Role of morphology, cytology, palynology, phyto-chemistry, molecular biology in plant taxonomy
Taxonomic categories and hierarchy: Taxonomic categories (supra-specific, species and infra-specific); taxonomic hierarchy (structure and properties)

Unit III

Taxonomic tools and institutions: Herbarium (preparation and role); botanic gardens (concept and importance); taxonomic literature (an overview); Botanical Survey of India (organization and role).
Plant identification: Methods of identification; dichotomous keys (kinds and construction); polyclaves (a brief account); cyber-taxonomy (concept and scope), e-floras and e-herbaria

Unit: IV

Scientific nomenclature: Brief overview of various nomenclature codes - Viral, Bacteriological, International Code for Nomenclature of Cultivated Plants (ICNCP), International Code for Nomenclature of algae, fungi and plants (ICN); principles of ICN

Practice of nomenclature: Type method (concept and kinds); author citation; effective and valid publication; basionyms and synonyms; homonyms; autonyms and tautonyms

Essential readings:

1. Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P.F. and Donoghue, M.J. 2015. Plant Systematics: A Phylogenetic Approach. Edn. 4th. OUP USA
2. Simpson, M. G. 2018. Plant Systematics, 3 edn. Elsevier Academic Press. USA.
3. Singh, G. 2019. Plant Systematics, 3 edn. Oxford & IBH Publishing Co Pvt. Ltd.
4. Stace, C.A. 1990, Plant Taxonomy and Biosystematics, Cambridge Univ. Press.

Further readings:

1. Cole, A.J. 1969. Numerical Taxonomy, Academic Press, London.
2. Davis, P.H. and Heywood, V.H. 1973. Principles of Angiosperm Taxonomy, Robert E. Kreiger Publ. Co. New York.
3. Grant, W.F. 1984. Plant Biosystematics, Academic Press, London.
4. Harrison, H.J. 1971. New Concepts in Flowering Plant Taxomony, Hieman Educational Books Ltd., London.
5. Heslop-Harrison, J. 1967, Plant Taxonomy, English Language Book Soc. & Edward Arnold Publ. Ltd., U.K.
6. Heywood, V.H. and Moore, D.M. 1984. Current Concepts in Plant Taxonomy, Academic Press, London.
7. Jones, A.D. and Williams, A.D. 1971, Variations and Adaptations in Plant Species, Hieman & Co. Educational Books Ltd. London.
8. Pandey, A., Kasana, S. 2021. Plant systematic, 1st Edn. CRC Press.

Course title: PTERIDOPHYTA AND GYMNOSPERMS
Course Code: PG-BO-C-203
No. of lectures: 60

Objectives: To impart knowledge about important plant groups some of which have ruled the earth for millions of years. To provide relevant information about origin, evolution and diversification of these plants on the surface of the earth

Unit I

Pteridophytes: General characteristics; origin and evolution, telome theory; stelar evolution, economic importance

Classification: Sporne (1975) up to ordinal level

Fossil Pteridophytes: structural features and evolutionary significance of Psilophytales (*Psilophyton*), Lepidodendrales (*Lepidodendron*), Calamitales (*Calamites*)

Unit II

Diversity, morphology, anatomy and reproduction in: Psilopsida (Psilotales), Lycopsida (Lycopodiales, Selaginellales, Isoetales), Sphenopsida (Equisetales), Ophioglossales, Eusporangiate ferns (Marattiales), Leptosporangiate ferns (Filicales, Marsileales, Salviniales) (Demonstration of each order with representative genera)

Unit III

Gymnosperms: General characteristics, origin and evolution, economic importance

Classification: (Sporne 1965, Christenhusz et al., 2011); economic importance

Diversity and distribution: Distribution in India; gymnosperms of Ladakh (an overview)

Fossil gymnosperms: Structural features and evolutionary significance of Pteridospermales, Cycadeoidales, Cordaitales

Unit IV

Diversity, morphology, anatomy and reproduction in: Cycadales (*Cycas*), Ginkgoales (*Ginkgo*), Coniferales (*Pinus*), Taxales (*Taxus*), Ephedrales (*Ephedra*), Gnetales (*Gnetum*), Welwitschiales (*Welwitschia*)

Essential readings:

1. Bierhorst, D.W. 1971. Morphology of Vascular Plants, Mac Millan Co.
2. Biswas, C. and Johri, B. M. 2014. The Gymnosperms Spinger
3. Coulter, J. M and Chamberlain, C. J. 2019. Morphology of gymnosperms, Alpha Edition
4. Khullar, S.P. 2000. An Illustrated Fern Flora of West Himalayas (Vols. I and 2), International Book Distributors, Dehradun

Further readings:

1. Merryweather. J. 2020. Britain's Ferns: A Field Guide to the Club-mosses, Quill worts, Horsetails and Ferns of Great Britain and Ireland
2. Mohanty, C. 2018. Text Book Of Bryophytes, Pteridophytes, Gymnosperms And Paleobotany, Kalyani Publications
3. Parihar, S. N. 1989. The Biology and Morphology of Pteridophytes (Diversity and Differentiation), Vikas Publishing House.
4. Rashid, A. 1999. An Introduction to Pteridophytes (Diversity and Differentiation), Vikas Publishing House.
5. Sharma, O. P. 2017. Pteridophyta , McGraw Hill
6. Sporne, K.R. 1982. The Morphology of Pteridophytes, B.I., Publications, Bombay, Delhi,Madras

Course title: MEDICINAL PLANTS AND HERBAL RESOURCE MANAGEMENT
Course Code: PG-BO-M-204
No. of lectures: 60

Objectives: this course is aimed at providing the knowledge of traditional systems of medicines used in Indian, also bringing attention towards various threats that medicinal plants face and methods of their conservation.

Unit: I

Diversity and distribution: Medicinal plants (MPs) in Ladakh
Different threats: Causes and concerns of MP diversity of Ladakh
Assessment of population status: MP's of Ladakh in accordance with IUCN guidelines
Data collection: methods, documentation and exchange, importance of threat assessment with respect to conservation of medicinal plants

Unit: II

Commercial potential: MPs in Trans-Himalayan region of Ladakh
Role of MPs: World pharmaceutical industry
Genetic diversity: Assessment of status and its role in conservation of MPs
Linkage between traditional knowledge holders, policy makers and industry: NGO's and their role in commercialization of MP's based on traditional knowledge

Suggested readings:

1. Brill, S., and Dean, E. 2010. Identifying and harvesting edible and medicinal plants in wild (and not so wild) places, William Morrow Paperbacks.
2. Busia, K. 2016. Fundamentals of Herbal Medicine: History, Phytopharmacology and Phytotherapeutics. Xlibris UK
3. Griggs, B. 1997. Green Pharmacy: The History and Evolution of Western Herbal Medicine. Healing Arts Press

Further readings:

1. Axe, J. 2021. Ancient Remedies: Secrets to Healing with Herbs, Essential Oils, CBD, and the Most Powerful Natural Medicine in History. Little, Brown Spark
2. Gupta, V.K. 2021. Medicinal Plants: Phytochemistry, Pharmacology and Therapeutics Vol. 2. Daya Pub. House.
3. Kenneth, T. 1998. Spices, condiments and seasonings, Springer Science & Business Media.
4. Mathe, A. 2015. Medicinal and Aromatic Plants of the World. Springer.
5. Storl, W.D. 2017. The Untold History of Healing: Plant Lore and Medicinal Magic from the Stone Age to Present. North Atlantic Books

6. Upadhyay, S. K., and Singh, S. P. 2021. Bioprospecting of Plant Biodiversity for Industrial Molecules, Wiley
7. Wickens, Gerald E. 2012. Economic botany: principles and practices, Springer Science & Business Media

PRACTICAL
Course Code: PG-BO-L-205
Section I

- Study of electron micrograph (SEM) of the plant cell and different cell organelles
- Cell wall staining with calcofluor
- Plant DNA extraction using standard protocols.
- Isolation of plant DNA and its quantification by spectrophotometric method
- Separation of Protein Standards by SDS-PAGE
- Northern, Southern and Western blotting
- Isolation of nuclei and identification of histones by SDS-PAGE
- Demonstration for Silver Staining of Protein Gels
- Demonstrate osmosis through biological membrane
- Preparation of agarose gel
- Isolation of plasmid DNA from an appropriate host by alkali lysis method
- Study the effect of some restriction enzymes on DNA
- Detection of structural changes in the chromosomes using FISH technique
- Work out interspecific variation using zymograms and mt DNA-RFLP

Section II

- Preparation of herbaria of different types of leaves, inflorescences and fruits.
- Taxonomic description of various botanical families: Ranunculaceae, Brassicaceae, Fabaceae, Rosaceae, Malvaceae, Asteraceae, Apiaceae, Solanaceae, Poaceae, Liliaceae.
- Study of various placentation types
- Comparative morphology of different species of a genus and different genera of a family
- Construction of dichotomous keys for identification

Section III

- Study of important fossil Pteridophytes (*Aglaophyton, Rhynia, Asteroxylon* and *Calamites*) from permanent slides.
- Study of morphological, anatomical and reproductive structures of the representative Pteridophytes viz. *Equistem, Dryopteris, Azolla, Lycopodium, Psilotum, Ophioglossum, Selaginella, Marsilea* and *Pteris*
- Study of important fossil gymnosperms from prepared slides and specimens
- Study of morphological, anatomical and reproductive structures of representative Gymnosperms, such as *Pinus, Cedrus, Abies, Picea, Taxus, Cephalotaxus, Taxodium, Gnetum, Ephedra, Ginkgo* and *Cycas*

Minor project PG-BO-P- 206

Semester III

Table 1: Courses, Credit Marks and distribution for PG Botany Semester III

Nature of the course	Course Title	Course code	Credits	Marks
Core I	Plant Physiology	PG-BO-C-301	4	100
Core II	Embryology and Reproductive Biology of Angiosperms	PG-BO-C-302	4	100
Core III	Biodiversity and Conservation Biology	PG-BO-C-303	4	100
Practical courses (skill based)				
Core	Laboratory Couse	PG-BO-L-304	4	100
Core	Skill based Project work	PG-BO-P-305	2	50
Opt one of the following or MOOCs course or course from any other sister department of same credits				
Multidisciplinary	Plant Resource Utilization Or Seed Technology Or Mushroom Cultivation Technology	PG-BO-OE-306 Or PG-BO-OE-307 Or PG-BO-OE-308	2	50
Total			20	500

Marks distribution and Examination pattern

Marks distribution pattern: 4 credit courses have 100 marks and 2 credit courses have 50 marks. The marks distribution pattern, in percentage terms, for internal and external assessments respectively is 30:70 for theory and 50:50 for practicals.

Examination pattern

5. **Theory**

e. Internal assessment

It carries 30% marks for each of the three theory papers and would be conducted in the form of presentations, assignments and examinations based on objective and/or descriptive questions.

f. Semester end (final examination)

Question paper for semester end examination in theory shall have the following pattern:

Section – A: Short answer type questions. This section shall be compulsory and it will have one question with four parts one from each unit, each part carrying 3.5 marks. (14 Marks in total)

Section – B: Long Answer Type Questions
This section will have 4 questions with internal choice each question carrying 14 marks. (56 marks in total)

Thus, a student has to attempt 5 questions in all. Two credit courses will have the same pattern except for reduction in marks and no. of questions to the half.

6. **Practical**

The assessment of the practical course will be done in two parts, each carrying 50% of marks for the course

5. Internal examination and
6. External examination

Dissertation: Assessment of dissertation is divided into two components internal and external. The internal component shall include field work, lab work and dissertation writing and the external component shall be based on viva. The marks distribution for internal and external components shall be 75:25.

Course title: PLANT PHYSIOLOGY
Course Code: PG-BO-C-301
No. of lectures: 60

Objectives: this course aims at providing information about vital physiological processes operating in the plants. it includes the roles various enzymes play in these processes. It also aims to explain the concept of structure-function relationship to the students.

Unit I

Enzymes: General concept, allosteric mechanism, regulatory and active sites, isozymes and co-enzymes, mechanism of enzyme catalysis

Enzyme kinetics: Michaelis-Menton equation and its derivation

Membrane transport, translocation of water and solutes: Diffusion, osmosis, ion channels, active transport, membrane pumps, plant water relations (water potential and its components); mechanism of water transport through xylem; phloem transport; phloem loading and unloading; membrane transport proteins and processes

Unit II

Signal transduction: General concept; diversity in protein kinases and phosphatases, heterotrimeric G-protein complex; phospholipid signaling, calcium-mediated signaling, annexins, CyclicAMP (cAMP), signal transduction pathways, second messengers, regulation of signaling pathways

Plant photoreceptors: Phytochromes and cryptochromes: discovery, structure, photochemical and biochemical properties, cellular localization and responses.

Unit III

Photosynthesis: Evolution of photosynthetic apparatus, light harvesting complexes, photo-oxidation of water.

Mechanism of electron and proton transport, energy flow pathways, cyclic, non-cyclic and pseudo-cyclic pathways. Carbon assimilation-Calvin cycle, C4 cycle, difference between C3 and C4 pathways, CAM pathways, photorespiration and its significance

Plant respiration: Glycolysis, TCA cycle; electron transport system and recent advances in mechanism of ATP synthesis; cyanide resistant respiration

Nitrogen fixation in plants: Biological nitrogen fixation, nodule formation and nod factors, mechanism of nitrate uptake and reduction; ammonium assimilation

Unit: IV

Plant growth regulators and elicitors: Mechanism of action and physiological effects of auxins, gibberellins, cytokinins, ethylene, abscisic acid, brassinosteroids, polyamines, jasmonic acid and salicylic acid.

Secondary metabolites: Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles

The control of flowering: Photoperiodic control of flowering, endogenous clock and its regulation; vernalization and its significance

Essential readings:

1. Taiz, L. and Zeiger, E. 2020. Introduction to Plant Physiology. 6th Edn. Sinauer Associates, Inc.
2. Wilson K. and Walker. J. 2016. Principles and techniques of Biochemistry and Molecular Biology. Cambridge Press
3. Hopkins, G.W. and Hunner, N.P.A. 2008. Introduction to Plant Physiology. 4th Edn. Wiley and Sons. Inc. New York, U.S.A

Further readings:

1. Buchanan, B.B., Gruissem, W. and Jones, R.L. 2015. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologist, Maryland, USA.
2. Galston, A.W. 1989. Life Processes in Plants, Scientific American Library, SpringerVerlag, New York, U.S.A.
3. Grossniklaus, U, 2019. Plant Development and Evolution, Elsevier
4. Murneek, A. E., 2018. Vernalization and Photoperiodism, Palala Press
5. Nelson, D.L., Cox, M.M. and Lehninger, A. L. 2013. Principles of Biochemistry, Worth Publishers Inc. New York, USA.
6. Thomas, B. and Vince- Prue, D. 1997. Photoperiodism in Plants. 2nd Edn. Academic Press. San Diego, U.S.A.

Course title: EMBRYOLOGY AND REPRODUCTIVE BIOLOGY OF ANGIOSPERMS
Course Code: PG-BO-C-302
No. of lectures: 60

Objectives: Basic concepts of plant reproduction including the phenomena of sporogenesis and gametogenesis, fertilization and embryogenesis and seed development have been included in this course to make students understand these vital processes in plant reproduction which shape plant population structure.

Unit I

Modes of reproduction in plants: Vegetative and sexual reproduction- general account
Flower development: floral evocation, floral organ formation, flowering in perennials, seasonal flowering, polycarpy and biennial bearing, role of accessory organs
Male and female gametophyte: Structure of anther, role of tapetum, micro-sporogenesis and development of pollen, regulation of asymmetric first pollen mitosis, control of second pollen mitosis and sperm cell differentiation, female gametophyte development- initiation, patterning, cell fate specification and maintenance of cell identities of female gametophyte.

Unit II

Pollination, pollen-pistil interaction and fertilization: Pollination mechanisms, pollination syndromes, structure of pistil, pollen germination and compatible pollen-stigma interactions, sporophytic and gametophytic self-incompatibility, pollen tube growth and guidance, double fertilization

Unit III

Embryogeny: Endosperm development, types; embryogenesis - landmarks of embryo pattern formation, embryogenesis in dicots and monocots, unique embryogenesis in Gramineae, reduced embryos, storage products.
Polyembryony and apomixes, types and importance

Unit IV

Seed: Structure, seed dormancy and its type, methods to overcome seed dormancy, bud dormancy
Seed germination- metabolism of nucleic acids, proteins and mobilization of food reserves
Seedling growth: hormonal control of seedling growth, gene expression during growth, use of mutants in understanding the process
Dynamics of fruit growth and development; biochemistry of fruit ripening

Essential readings:

1. Bhojwani, S.S. and Bhatnagar, S.P and Dantu. P. K. 2018. The Embryology of Angiosperms, Vikas Publishing House, New Delhi.
2. Faegri, K. and Vander-Pijl, L. 1979. The Principles of Pollination Ecology. 3rd edition, Pergamon Press, Oxford.
3. Johri, B.M. 2015. Embryology of Angiosperms, Springer

Further readings:

1. Atwell, B.J., Knedermann, P.E. and Jumbull, C.G.N. 1999. Plants in Action-Adaption in Nature: Performance in cultivation, MacMillan Education, Sydney, Australia.
2. Batygina, T.B. 2020. Embryology of Flowering Plants Terminology and Concepts. Vol.1. Taylor & Francis
3. Lersten, N.R. 2004. Flowering Plant Embryology: With Emphasis on Economic Species. Edn.1st. Blackwell Publishing
4. Ingrouille, M., Eddie, B. 2006. Plants: Diversity and Evolution. Cambridge University Press
5. Ramawat, K.G., Jean-Michel Mérillon, J.M., Shivanna, R.K. 2014. Reproductive Biology of Plants. CRC Press.
6. Kigel, Jaime, (ed.). 1995. Seed development and germination. Vol. 41. CRC press.
7. Niklas, Karl J. 2016. Plant evolution. University of Chicago Press.

PGBOC-303: BIODIVERSITY AND CONSERVATION BIOLOGY

No. of lectures: 60

Unit: I

Biodiversity: Concept of biodiversity (a historical perspective); magnitude of global biodiversity (an overview); components of biodiversity (species richness and evenness); levels of biodiversity – organizational (genetic, species and ecosystem), spatial (alpha, beta, gamma, delta); values of biodiversity (direct use, indirect use, option and existence values)

Unit: II

Conservation biology: Principles and characteristics; genetic variation (magnitude, loss and its consequences); species extinction (concept and causes - ultimate and proximate); the IUCN scheme of threatened species, summary of latest IUCN Red List; IUCN scheme of threatened ecosystems; ecosystems at risk (tropical rain forests, coral reefs, mangroves, wetlands).

Unit: III

Conservation strategies and policies: *in situ* conservation strategies (concept of protected areas network); IUCN's scheme of PA management categories; National Parks and Wildlife Sanctuaries in India (an overview); Biosphere Reserve (concept, design and distribution in India); *ex situ* conservation strategies (botanical gardens, field gene banks, seed banks, *in vitro* repositories,

cryobanks, DNA banks); biodiversity hotspots (concept, criteria and conservation implications); global conservation efforts (organizations & conventions); Indian conservation efforts (legislations and policies)

Unit: IV

Measurement and monitoring of biodiversity: sampling unit – shape, size and number, issue of scale; phylogenetic and functional diversity (concept and applications); biodiversity surrogates (types and use); role of remote sensing and GIS in biodiversity assessment and monitoring; biodiversity informatics (concept and applications); global informatics initiatives - Global Biodiversity Information Facility (GBIF), Encyclopedia of Life (EoL); Biodiversity Heritage Library (BHL).

Essential readings:

1. Cardinale, B., Primack, R., and Murdoch, J. 2019. Conservation Biology. OUP USA
2. Chaurasia, O. P., Ahmad, Z. and Ballabh. B. 2007. Ethnobotany and Plants of Trans Himalaya. SSPH
3. Christopher, E., Steven, M., Grodsky, M., and Rupp, S. P. 2019. Renewable energy and wildlife conservation, Hopkins University Press, Baltimore, USA.
4. Laladhas, K.P., Nilayangod, P. and Oommen, O. 2017. Biodiversity for sustainable development. Springer.

Further readings:

1. Dietl, P. and Flessa, K. L. 2018. Conservation Paleobiology: science and practice. Gregory University of Chicago Press, Chicago, USA
2. Fred, V. O. and Lamb, R. L. 2016. Conservation Biology. Springer Nature Switzerland AG
3. Joel, B. 2018. Extreme conservation: life at the edge of the world, University of Chicago Press, Chicago, USA
4. Maiti, P.K. and Maiti, P. 2017. Biodiversity: Perception, Peril and Preservation. PHI Learning
5. Rice, S.A. 2017. Encyclopedia of Biodiversity. FACTS ON FILE INC
6. Wilson, E. O. 1988. Biodiversity, Chicago State University Press

Laboratory Course
Code: PG-BO-L-304
Section I

- Determination of water potential of potato tuber tissues by gravimetric method
- Determination of osmotic potential of onion epidermal peels by plasmolytic method
- Determination of stomatal frequency and stomatal index of a given leaf material.
- Determination of effect of organic solvents on membrane permeability of plant tissues.
- Study of effect of temperature on membrane permeability of plant tissues.
- Study of the physiological effects of auxins, gibberellins and cytokinins.
- Estimation of membrane permeability of a given plant tissue by measuring conductivity of leachates.
- Determination of chlorophyll a and chlorophyll b ratio in C3 and C4 plants.
- Determination of the respiratory quotient (RQ) for germinating seeds by Ganong's Respirometer.
- Ascorbic acid extraction and quantitative estimation from plant tissues
- Determination of effect of time and enzyme concentration on the rate of reaction of enzyme e.g. acid phosphatase, nitrate reductase, catalase
- Determination of effect of substrate concentration of activity of an enzyme
- Study of degree of dissociation of an electrolyte by plasmolytic method

Section II

- Study flower as organ of sexual reproduction: accessory vs. essential organs, reproductive apparatus
- Study of diversity of vegetative propagation in plants, its comparison to sexual reproduction
- Study of microsporogenesis and microgametogenesis by making acetocarmine squashes of anthers of different developmental stages
- Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (from locally available plant species)
- Test for pollen viability using stains and in-vitro germination. Pollen germination using hanging drop and sitting drop cultures: Suspension culture and surface culture
- Estimating percentage and average pollen tube length in vivo
- Field study of several types of flowers with different pollination mechanisms i.e., pollination effected by wind, thrips, bees, butterflies and birds
- Estimation of Pollen-Ovule ratio to determine operative mode of pollination
- Isolation of zygotic, globular, heart-shaped, torpedo shaped and mature embryo from suitable material
- Study of structure of dicot and monocot seeds, albuminous and exalbuminous seeds
- Study of seed dormancy and methods to break dormancy

Section III

- Evaluation of threat status of medicinal plants using IUCN criteria
- Preparation of an inventory of RET (Rare, Endangered and Threatened plants) in Kargil Campus
- Measurement of species diversity by using various biodiversity indices.
- Measurement of species evenness and similarity index.
- Measurement of alpha, beta and gamma diversity.
- Field demonstration of GPS (Global Positioning System) and its utility in biodiversity studies.
- Study of various economically and ethno-botanically important plants of Ladakh
- Field study of various threatened endemic plants of Kashmir Himalaya.
- Field demonstration of *in situ* and *ex situ* conservation strategies through visit to the national parks, sanctuaries, botanical garden, herbaria and museums.

SKILL BASED PROJECT WORK

PG-BO-P-305

Course title: PLANT RESOURCE UTILIZATION
Course Code: PG-BO-OE-306
No. of lectures: 30

Objectives: Plants are important components of not only the diet but many articles of daily use of humans. The present course aims at explaining to the students origin and evolution of various plants and their uses in our daily life. To provide information about various useful materials extracted from plants

Unit I

Plant biodiversity: Concept, utilization and concerns

World centers of origin and domestication of cultivated plants: Vavilov's and de Candolle's concept, centers and non-centers, secondary centers of origin, plant introduction

Threatened species: concept and conservation strategies

Green revolution: Concept, concerns, benefits and adverse consequences.

Unit II

Beverages: Origin, evolution, domestication and processing of tea and coffee

Sugars and starch: origin, evolution, domestication, extraction and utilization of cane sugar and beet sugar.

Paper making: sources of raw material and processing of paper

Psychoactive drugs: Sources, chemistry of action, use and misuse of *Papaver somniferum* and *Cannabis sativa*

Rosaceous fruits of Ladakh: General account, botany and uses with special reference to apricot, apple, pear, peach and almond

Essential readings:

1. Chandel, K.P.S., Shukla, G. and Sharma, N. 1996. Biodiversity in Medicinal and Aromatic Plants in India- Conservation and Utilization, National Bureau of Plant Genetic Resources, New Delhi.
2. Simpson, B., Molly Ogorzaly. 2013. Plants in our World: Economic Botany. McGraw Hill

Further readings:

1. Heywood, V. 1995. Global Biodiversity Assessment, United National Environment Programme. Cambridge University Press, Cambridge, U.K.
2. Kocchar, S.L. 2016. Economic Botany. Cambridge English
3. Martha, J.G. 2006. Principles of Conservation Biology, Sinauer Associates, Inc., Publishers, USA.
4. Rindos, D. 1987. The Origins of Agriculture: An Evolutionary Perspective. Elsevier
5. Sammbamurthy, A.V.S.S., Sammbamurthy, N.S. 2008**. A Textbook of Modern Economic Botany. CBS Publishers & Distributors Pvt.ltd.**
6. Singh, J.S., Singh S.P., Gupta, S.R. 2014. Ecology, Environment Science and Conservation, S. Chand & Company, Private Ltd., New Delhi.

SEED TECHNOLOGY
Course Code: PG-BO-OE-307
No. of lectures: 30

Unit I

Seed Production: General Principles- seed production in self and cross pollinated and vegetatively propagated crops; Hybrid seed production; Maintenance of inbred lines and breeders seeds; Synthetic and composite seeds; Improved seed and their identification, germplasm Banks.
Seed Processing: Harvesting- seed drying, seed cleaning and gracing; equipment needed

Unit II

Seed Storage: types of storage structure; seed factors affecting storage life; effect of relative humidity; temperature and moisture on storage
Seed Quality Testing: Sampling, purity, germination, viability, moisture determination; weight determination; testing for cultivar purity
Use of advanced technology for seed testing; seed vigour concepts and methods of evaluation

Essential readings:

1. Amarjit, B. 2018. Handbook of Seed Science and Technology. Taylor & Francis.
2. Arterbury, S. 2018. Seed Science and Technology. Scitus Academics.
3. Grass, L., and Gregg. B. 2001. Seed processing. A training manual, No. 631.531 GRA. CIMMYT

Further readings:

1. Hans-Ferdinand, L. and Jackson, J. F. 2013. Seed analysis. Vol. 14. Springer Science & Business Media
2. Kozlowsk, T. T. 2012. Seed Biology: Importance, Development, and Germination (Physiological ecology). Academic Press.
3. Linskens, H. F. and Jakson, J.F. 2020. Seed Analysis. Springer Nature
4. Mathad R.C. 2015. Vegetable Seed Processing. New India Publishing Agency

MUSHROOM CULTIVATION TECHNOLOGY
Course Code: PG-BO-OE-308
Number of lectures 30

Objectives: This course introduces cultivation techniques of mushrooms which is a prized food worldwide. The aim of this course is to boost entrepreneurial skills in students by teaching them course with practical applications

Unit: I

Mushrooms: Introduction and general morphology of mushrooms; mushroom diversity

Mushroom biology: Components of applied mushroom biology; mushroom science, mushroom and biotechnology

Nutritional and medicinal value of mushrooms: Poisonous and non-poisonous mushrooms; edible mushrooms, cultivation in India and world; medicines from mushrooms; mushroom production and consumption; world mushroom development industry movements

Unit: II

Mushroom cultivation technology: Steps in mushroom cultivation

Compost - materials used in composting and different formulations, compost preparation, methods of compost preparation

Spawn: Definition, kinds of spawn, different spawning techniques, spawn running, post spawning management and handling during spawn running

Essential readings:

1. Fletcher, J. T., and Gaze. R. H. 2007. Mushroom pest and disease control: a color handbook, Elsevier.
2. Lynch, T. 2018. Mushroom Cultivation: An Illustrated Guide to Growing Your Own Mushrooms at Home. Quarry Books.

Further readings:

1. Stamets, P. 2000. Growing Gourmet and Medicinal Mushrooms. Ten Speed Press
2. Stamets, P. 2011. Growing gourmet and medicinal mushrooms.. Ten speed press.
3. Suman, B. C., Sharma V.P. 2007. Mushroom Cultivation in India. Daya Publishing House.
4. Tradd. C. 2014. Organic mushroom farming and myco-remediation: Simple to advanced and experimental techniques for indoor and outdoor cultivation, Chelsea Green Publishing.

Semester IV

Table 1: Core and Elective Courses and Credit distribution for PG Botany Semester IV

Nature of course	Course Title	Course code	Credits	Marks
Core I	Plant Anatomy	PG-BO-C-401	04	100
Core II	Plant Ecology	PG-BO-C-402	04	100
Core III	Biostatistics and Biotechniques	PG-BO-C-403	04	100
Core IV	Project/Dissertation	PG-BO-D-404	08	200
Total			20	500

Marks distribution and Examination pattern

Marks distribution pattern: 4 credits are equal to 100 marks. The marks distribution pattern, in percentage terms, for internal and external assessments is 30:70 respectively.

Examination pattern

7. **Theory**

g. Internal assessment

It carries 30% marks for each of the three theory papers and would be conducted in the form of presentations, assignments and examinations based on objective and/or descriptive questions.

h. Semester end (final examination)

Question paper for semester end examination in theory shall have the following pattern:

Section – A: Short answer type questions. This section shall be compulsory and it will have one question with four parts one from each unit, each part carrying 3.5 marks. (14 Marks in total)

Section – B: **Long Answer Type Questions**
This section will have 4 questions with internal choice each question carrying 14 marks. (56 marks in total)

Thus, a student has to attempt 5 questions in all. Two credit courses will have the same pattern except for reduction in marks and no. of questions to the half

Dissertation: Assessment of dissertation is divided into two components internal and external. The internal component shall include field work, lab work and dissertation writing and the external component shall be based on viva. The marks distribution for internal and external components shall be 75:25

PLANT ANATOMY

Course Code: PG-BO-C-401
No. of lectures: 60

Objectives: this part of the course aims at acquainting the students with the basic cell and tissues types that enter into the fundamental organization of plants. It endeavors to make them appreciate the variation in the cellular types and diversity in their functions and to provide them knowledge about the concepts of secondary growth and special structures in plants.

Unit I

Plant growth and development: Unique features of plant growth and development- polarity and cell division

Cell wall: Origin, growth, structure and composition, special structures of cell walls: fine structure of plasmodesmata, pits and their types

Diversity of cell types in plants: Structure and arrangement of parenchyma and collenchyma Sclerenchyma- origin, development and structure of fibers and sclereids

Unit II

Epidermis: Structure in root and aerial parts, origin composition and functionsof cuticle

Stomata and trichomes: Origin, structure, classification and distribution of stomata, structural diversity, origin and functions of plant trichomes

Xylem: Origin and elements, structure and functions of tracheary elements

Phloem: Origin and elements, structure and functions of sieve tube elements and companion cells

Unit III

Meristems: Types and composition; structure, cytohistological zonation and function of shoot and root apical meristem

Vascular cambium: Organization, formation of secondary xylem and phloem, factors influencing cambial activity

Secondary xylem: Basic structure; storied and non-storied wood; growth rings

Secondary phloem: Structure of sieve tube elements and companion cells; nature and development of cell wall of sieve elements

Periderm: Components and development; structure and products of phellogen, phellem and phelloderm

Concept of rhytidome, polyderm and wound periderm

Unit IV

The leaf: Concept of phyllotaxy, formation and expansion; control of form

Salt glands and hydathodes: General account of structure and distribution in plants

Nectaries: Variation in structure; an overview of glandular structures of carnivorous plants, role of nectaries in pollination

Osmophores: Structure and role of stinging hairs

Laticifers: Structure and development of articulated and non-articulated laticifers

Essential readings:

1. Bewley, J.D. and Black, M. 2012. Seeds: Physiology of Development and Germination, Plenum Press, New York.
2. Fahn, A. 1982. Plant Anatomy. 3rd Edn. Pergamon Press, Oxford
3. Fosket, D.E. 1994. Plant Growth and Development: A Molecular Approach, Academic Press, San Diego.

Further readings:

1. Atwell, B.J., Kriedermann, P.E. and Jumbull, C.G.N. 1999. Plants in Action: Adaptation in Nature, Performance in Cultivation, McMillan Education, Sydney, Australia Burgess, J. 1985. An Introduction to Plant Cell Development, Cambridge University Press, Cambridge.
2. Cutler D.F., Bother, C.E.G. and Stevenson, D.W. 2008. Plant Anatomy: An Applied Approach, Blackwell Publishing, USA.
3. Dickison, W.C. 2000. Integrative Plant Anatomy, Academic Press Inc
4. Evert, R.F. and Eichhorn. 2006. Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function, and Development, 3rd Edition, John Wiley and Sons Inc., New Jersey.
5. Howell, S.H. 1998. Molecular Genetics of Plant Development, Cambridge University Press, Cambridge.
6. Steeves, T.A. and Sussex, I.M. 1989. Patterns in Plant Development. 2nd Edn. Cambridge University Press, Cambridge.

PLANT ECOLOGY
Course Code: PG-BO-C-402

No. of lectures: 60

Objectives: This course aims at discussing the basic components in the ecosystem we live in. This course also includes study of various kinds of interactions among the living organisms and the abiotic environment, population growth patterns and biogeography.

Unit I

Ecosystem organization: Biotic component-food chains, food web, trophic cascades; abiotic component-soil formation, soil profile development, soil horizons and soil classification.

Ecosystem function: Primary production (gross and net primary production, controlling factors and methods of measurement), energy flow pathways, ecological efficiencies; litter accumulation and decomposition (mechanisms, substrate quality and climatic factors).

Unit II

Population ecology: Population characteristics; population growth curves; population regulation; life history strategies (*r* and *K* selection); concept of metapopulation – demes, interdemic extinctions, age structured populations.

Habitat and niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

Unit III

Community ecology: Nature of communities; community structure and attributes; species diversity and its measurement, richness and evenness; edges and ecotones, guilds

Community development: Temporal changes (cyclic and non-cyclic); mechanism of ecological succession (relay floristic and initial floristic composition; facilitation, tolerance and inhibition models, resource ratio hypothesis); changes in ecosystem properties, concept of climax and its characterization.

Community stability: Diversity- disturbance, and diversity stability relationships; ecology of plant invasion- process of invasion.

Global bio-geochemical cycles: Biogeochemical cycles of C, N, P and S (pathways, processes, budgets and anthropogenic impact)

Unit: IV

Diversity Patterns: Species abundance distribution, diversity patterns (latitudinal gradient contributory factors and explanatory theories)

Biogeography: MacArthur and Wilson's island biogeography equilibrium theory-limitations and modifications; colonization vs. extinction, species area relationship

Biomes: types (terrestrial and aquatic), distribution and unique features

Essential readings:

1. Odum, E. P. Barret, G. W. 2005. Fundamentals of Ecology. 5th edition. Saunders, Philadelphia.
2. Smith, T. M and Smith, R. L., 2015. Elements of Ecology, Pearson Education Ltd., England
3. Stiling. P. 2021. Ecology: Global Insights and Investigations, McGraw Hill

Further readings:

1. Ali, M. Diversity of Ecosystems, 2012. In Tech.
2. Begon, M., Townsend, C.R. and Harper, J.L. 2006. Ecology from Individuals to Ecosystems. 4th Edn. Blackwell Publishing¸ USA.
3. Chapman, J.L. and Reiss, 1998. M.J. Ecology: Principles and Applications, Cambridge University Press.
4. Claude, F., Christiane, F., Medori, P. and Devaux, J. 2001. Ecology: Science and Practice. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
5. Eisner, T. and Meinwald, J. 1995. Chemical Ecology: The Chemistry of Biotic Interaction,. National Academies Press.
6. Kormondy, E.J. Concepts of Ecology. 2017. 4th edition. Prentice Hall of India Pvt. Ltd. New Delhi.
7. Schulze E. D., Buchmann, E., Clemens, S., Müller-Hohenstein, K., Scherer-Lorenzen, M. 2020. Plant Ecology, Springer
8. Trevor, B. and Graham, R. 2005. An Introduction to Molecular Ecology, Oxford University Press.

BIOSTATISTICS AND BIOTECHNIQUES
Course Code: PG-BO-C-403

No. of lectures: 30

Objectives: To acquaint the students with various statistical methods commonly used in hypothesis testing and drawing inferences biological sciences. To train the students in various methods of data collection and its processing. This course introduces various biophysical methods that are routinely used in botany with an aim to acquaint the students with methods and machinery helpful in lab exercises.

Unit: I

Data types and collection: Data types- data on ratio, interval, ordinal and nominal scales; continuous and discrete data; methods of primary and secondary data collection and their limitations, frequency and cumulative frequency distributions.

Processing and analysis of data: measures of central tendency- arithmetic mean, mode, median; measures of dispersion- mean deviation, variance, standard deviation, coefficient of variation.

Unit: II

Sampling techniques: Principles and various steps in sample survey; procedures and practices involved in simple, systematic, stratified, cluster and multistage random sampling

Testing of hypothesis: Basic concepts, procedure for hypothesis testing; test difference between two means (independent and paired samples); test of proportions and of goodness of fit

Simple correlation and regression: Basic idea, scatter diagram, calculation of an estimated correlation coefficient, significance tests for correlation coefficients; simple linear regression-calculation of regression coefficient, standard errors and significance test.

Unit: III

Biophysical methods: Concepts of spectroscopy, laws of photometry, Beer-Lambert's law, use of various spectroscopic techniques like UV-Visible, NMR, and Mass spectroscopy in biology, flow-cytometry

Radio-labeling Techniques: Properties of different radio-isotopes and their applications in biology, Safety guidelines

Unit: IV

Chromatography: Principles and applications of paper, thin layer, column chromatography, HPLC, ion exchange, affinity and gas liquid chromatographic techniques

Electrophoretic and Centrifugation Techniques: Gel electrophoresis, ultra- centrifugation

Microscopy: Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM

Essential readings:

1. Singh, R.K. and Chaudhary, B.D. 1999. Biometrical methods in Quantitative Genetic Analysis, Kalyani Publishers, New Delhi.
2. Sokal, R.R. and Rohlf, F.J. 2012. Biometry, W.H. Freeman and Company, New York
3. Ruzin, S. E. 1999. Plant Microtechnique and Microscopy Oxford University Press
4. Kumar, P. 2016. Fundamentals and Techniques of Biophysics and Molecular Biology, pathfinder publication

Further readings

5. Norman, G.R. and Streiner, D.L. 2008. Biostatistics- the Bare Essentials, BC Decker Inc., Hamilton, Canada.
6. P. Satguru. Elements of Biostatistics. 2018. Rastogi publications
7. Christian, Gary D. Analytical chemistry. 2007. John Wiley & Sons
8. Dewan, S. K. 2019. Organic Spectroscopy NMR IR Mass and UV, CBS.
9. Murphy, Douglas B., and Michael W. Davidson. 2012. Fundamentals of Light Microscopy and Electronic Imaging, John Wiley & Sons
10. Andri, B. 2016. Chromatography: Principles and Instrumentation, Excelic Press

DISSERTATION PG-BO-D-404