B.Sc. (H) BOTANY

THREE-YEAR FULL-TIME PROGRAMME
(Six-Semester Course)

COURSE CONTENTS

(Effective from the Academic Year 2010-2011)

UNIVERSITY OF DELHI

DELHI – 110 007

Course Structure

YEAR-1

PART I: Semester – 1

Paper 1	LSPT 101	Biology-I (Introduction to Biology)
Paper 2	BTHT 101	Biodiversity I: Algae and Microbiology
Paper 3	CHCT 301	Chemistry-I
Paper 4	ENAT 101*/ CSAT 101*	Technical writing and Communication in English / Computational skills

PART I: Semester – 2

Paper 5	BTHT 202	Biodiversity II: Mycology & Phytopathology
Paper 6	BTHT 203	Biodiversity III: Archegoniatae
Paper 7	CHCT 402	Chemistry -II
Paper 8	ENAT 201*/ CSAT 201*	Technical writing and Communication in English / Computational skills

***The college will have an option to take either of the two papers in a particular semester for a particular course, while students have to appear in both the papers**

In addition, there shall be one qualifying paper in self-learning mode called Environmental Studies offered in Semester-2

YEAR-2

PART II: Semester – 3

Paper 9	BTHT 304	Plant Resource Utilization
Paper 10	MACT 303	Mathematics and Statistics
Paper 11	CBHT 301	Cell Biology - I
Paper 12	MBHT 301	Molecular Biology - 1

PART II: Semester – 4

Paper 13	BTHT 405	Plant Development and Anatomy
Paper 14	BTHT 406	Ecology and Phytogeography
Paper 15	CBHT 402	Cell Biology II
Paper 16	MBHT 402	Molecular Biology - II

YEAR-3

PART III: Semester – 5

Paper 17	BTHT 507	Plant Systematics & Evolution
Paper 18	BTHT 508	Plant Physiology
Paper 19 a/b	BTHT 509 / LSPT 409	Environmental Management / Bioinformatics
Paper 20	GGHT 501	Genetics & Genomics -I

PART III: Semester – 6

Paper 21	BTHT 610	Plant Metabolism & Biochemistry
Paper 22	BTHT 611	Reproductive Biology of Angiosperms
Paper 23	BTHT 612	Plant Biotechnology
Paper 24	GGHT 602	Genetics & Genomics - II

PREAMBLE

The ongoing B.Sc. (H) Botany course was introduced by the Faculty of Sciences from the academic year 2005-2006. The new course that will be effective from the academic year 2010-2011, will follow the Semester mode. It has been prepared keeping in view the unique requirements of B.Sc. (H) Botany students.

The contents have been drawn-up to accommodate the widening horizons of the discipline of Biological Sciences. They reflect the current changing needs of the students; specifically, the subjects on Mathematics and Statistics and Computation skills have been included. A special feature of this program has been the introduction of six new papers on Cell and Molecular Biology and Genetics that cover major disciplines in newer areas of Biological Sciences where tremendous progress has been made during the past decade. A new paper on Biotechnology will also provide a glimpse of the application aspect. The endeavor has been to provide students with the latest information alongwith due weightage to the concepts of classical botany so that students are able to understand and appreciate the current inter-disciplinary approaches in the study of plant sciences and its role in societal development.

The course content also lists the new practical exercises so that the students get a hands-on experience of the latest techniques that are currently in use.

Paper 1-LSPT 101: BIOLOGY-I (INTRODUCTION TO BIOLOGY)

THEORY **Marks: 100**

Unit 1. Biological systems, evolution and biodiversity

a. Introduction to concepts of biology **(Ch 1 Campbell) (4 Periods)**

Themes in the study of biology; A closer look at ecosystem; A closer look at cell; The process of Science; Biology and everyday life

b. Evolutionary history of biological diversity (**Ch 25 Campbell) (6 Periods)**

Early earth and the origin of life; Major events in the history of life; Mechanism of Macroevolution; Phylogeny and the tree of life

c. Classifying the diversity of life **(Ch 25 Raven) (8 Periods)**

Kingdoms of Life –Prokaryotes, Eukaryotes, Archaea

d. Darwinian view of life and origin of species **(Ch22, 24 Campbell) (10 Periods)**

Darwin's theory of evolution; The evolution of populations; Concepts of species; Mechanism of speciation

e. Genetic approach to Biology **(Ch 1 Griffiths) (8 Periods)**

Patterns of inheritance and question of biology; Variation on Mendel's Law; The molecular basis of genetic information; The flow of genetic information from DNA to RNA to protein; Genetic Variation; Methodologies used to study genes and gene activities; Developmental noise; Detecting macromolecules of genetics; Model organisms for the genetic analysis; Distinction between Phenotype and Genotype

Unit 2. Chemical context of living systems

a. Chemistry of life **(Ch 2 Campbell) (6 Periods)**

The constituents of matter; Structure of an atom; The energy level of electron; The formation and function of molecules depend on chemical bonding between atoms; Chemical reaction make or break chemical bonds

b. Water and life **(Ch 3 Campbell) (5 Periods)**

The water molecule is polar; Properties of water; Ionization of water

c. Carbon and life **(Ch 4 Campbell) (5 Periods)**

Organic chemistry-the study of carbon compounds; What makes carbon special? Properties of organic compounds

d. Structure and function of biomolecules **(Ch 5 Campbell) (8 Periods)**

Most macromolecules are Polymers; Carbohydrates act as fuel and building materials; Lipids are group of hydrophobic molecules; Protein have diverse structures and functions; Nucleic acids store and transmit hereditary information

LSPP 101: BIOLOGY-I (INTRODUCTION TO BIOLOGY)

PRACTICALS **Marks: 50**

1. To learn a) use of microscope b) principles of fixation and staining.
2. Preparation of Normal, molar and standard solutions, phosphate buffers, serial dilutions
3. Use of micropipettes
4. Separation of A) amino acids B) chloroplast pigments by paper chromatography.
5. To perform gram staining of bacteria.
6. To study the cytochemical distribution of nucleic acids and mucopolysaccharides with in cells/tissues from permanent slides.
7. To perform quantitative estimation of protein using the Lowry's method. Determine the concentration of the unknown sample using the standard curve plotted.
8. To separate and quantify sugars by thin layer chromatography.
9. To raise the culture of *E. coli* and estimate the culture density by turbidity method. Draw a growth curve from the available data.
10. Isolation of genomic DNA from *E.coli*.

SUGGESTED BOOKS

1. Campbell, N.A. and Reece, J. B. (2008) Biology 8th edition, Pearson Benjamin Cummings, San Francisco.
2. Raven, P.H et al (2006) Biology 7th edition Tata McGrawHill Publications, New Delhi
3. Griffiths, A.J.F et al (2008) Introduction to Genetic Analysis, 9th edition, W.H. Freeman & Co. NY

Paper 2-BTHT 101 – Biodiversity-I -ALGAE AND MICROBIOLOGY

THEORY **Marks: 100**

SECTION A: ALGAE

Unit 1: Introduction **(Ch 1 Lee) (7 Periods)**

General characteristics; Ecology and distribution; range of thallus organization; Cell structure and components; cell wall, pigment system, reserve food (of only groups represented in the syllabus), flagella; and methods of reproduction, classification; criteria, system of Fritsch, and evolutionary classification of Lee (only upto groups); significant contributions of important phycologists (F.E. Fritsch, G.M. Smith, R.N. Singh, T.V. Desikachary, H.D. Kumar, M.O.P. Iyengar)

Unit 2: Cyanophyta **(Ch 2 Lee) (6 Periods)**

Ecology and distribution; thallus organization; cell structure; chromatic adaptation; physiology; reproduction; economic importance; role in biotechnology; morphology and life cycle of *Nostoc*

Unit 3: Chlorophyta **(Ch 5 Lee) (3 Periods)**

General characteristics; range of thallus organization; pigment systems; methods of reproduction; evolutionary significance of *Prochloron;* morphology and life cycles of *Chlamydomonas, Volvox, Oedogonium, Coleochaete*

Unit 4: Charophyta **(Lee, Bold) (3Period/ 1 Period)**

General characteristics; morphology and life cycle of *Chara;* fossils, evolutionary significance

Unit 5: Xanthophyta **(3 Period)**

General, characteristics; range of thallus organization; methods of reproduction; morphology and life cycle of *Vaucheria*

Unit 6: Phaeophyta **(Ch 19 Lee) (6 Period)**

characteristics; range of thallus structure; methods of reproduction; morphology and life cycles of *Ectocarpus* and *Fucus.*

Unit 7: Rhodophyta **(Ch 4 Lee; Cole & Sheath Ch 12, 13, 14) (5 Period)**

General characteristics; range of thallus organization; methods of reproduction; morphology and life cycles of *Polysiphonia*

Unit 8: Applied Phycology **(Ch 23 Lee) (3 Period)**

Role in ecosystem; aquaculture, industry, biotechnology, agriculture

SECTION B: MICROBIOLOGY

Unit 1: General Microbiology (Ch 10, 11 Pelczar) (2 Periods/14 Periods)

Introduction to microbial world, microbial nutrition, growth and metabolism.

Virus : **(Ch 20, 21 Pelczar) (6 periods)**

Discovery, physiochemical and biological characteristics;Classification; replication, lytic and lysogenic cycle ; special types: DNA virus (coliphage T-2), RNA virus (TMV). Economic importance; Symptoms, Transmission and management of diseases caused by viruses on plants.

Bacteria **(Ch 13- 16 Pelczar) (6 periods)**

General characteristics, comparison of Archaebacteria and Eubacteria , Wall-less forms (L forms, Mycoplasma and sphaeroplasts), cell structure, nutrition; reproduction: vegetative, asexual, sexual (conjugation, transformation , transduction), Economic importance**.**

Unit 2: Applied microbiology (Ch 7, 8, 25, 26, 27, 29 Pelczar) (4 Period)

Microbial culturing technique, culture media, and microbial growth, microbes used in agriculture, mycorrhizae, environmental management and industry, Indian Institutes and their research activities in microbiology

BTHP 101 – Biodiversity-I -ALGAE AND MICROBIOLOGY

PRACTICALS **Marks: 50**

SECTION A

Study of the vegetative and reproductive structures in *Nostoc, Chlamydomonas, Volvox, Oedogonium, Coleochaete, Chara, Vaucheria,* Bacillariophyta, *Ectocarpus, Fucus, Polysiphonia, Procholoron* through, EM, temporary preparations and permanent slides.

SECTION B

1. EMs/models of viruses and virus infected plants.
2. Types of bacteria from temporary/permanent slides/EM. Study of bacterial infected plants and root nodules. Gram staining.

SUGGESTED READINGS- SECTION A

1. Bold, H.C. & Wayne, M.J. 1996 (2nd Ed.) Introduction to Algae.

2. Van den Hoek, C.; Mann, D.J. & Jahns, H.M. 1995. Algae: An introduction to Phycology. Cambridge Univ. Press.

3. Lee, R.E. 2008. Phycology, Fourth Edition, Cambridge University Press, USA.

4. Kumar, H.D. 1999. Introductory Phycology. Aff. East-west Press Pvt ltd., Delhi.

SUGGESTED READINGS- SECTION B

1. Pelczar, M.J. (2001) Microbiology, 5th edition, Tata Mc Graw-Hill Co, New Delhi.

2. Presscott, L. Harley, J. and Klein, D. (2005) Microbiology, 6th edition, Tata Mc Graw-Hill Co. New Delhi.

Paper 3-CHCT 301: CHEMISTRY-I

THEORY **Marks: 100**

Section A: Inorganic Chemistry **(30 Periods)**

Unit 1 : Atomic Structure: Recapitulation of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Need of a new approach to Atomic structure.

What is Quantum mechanics? Time independent Schrodinger equation ($H \Psi = E\Psi$) and meaning of various terms in it. Significance of Ψ and Ψ^2, Schrodinger equation for hydrogen atom in Cartesian coordinates (x,y,z). Need of polar coordinates, transformation of Cartesian coordinates (x,y,z) into polar coordinates (r,θ,ϕ). Radial and angular parts of the hydogenic wavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals. (Only graphical representation), Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distances with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_r and m_s. Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (m_s).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

Unit 2: Chemical Bonding and Molecular Structure

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and salvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Lande equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: *VB Approach* Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of, linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures.

Section B: Physical Chemistry **(30 Periods)**

Unit 3: Chemical Thermodynamics

What is thermodynamics? State of a system, state variables, intensive and extensive variables, concept of heat and work, thermodynamic equilibrium, thermodynamic properties, various types of systems and processes. First Law of thermodynamics. Calculation of work (w), heat (q), changes in internal energy (ΔU) and enthalpy (ΔH) for expansion or compression of ideal gases under isothermal and adiabatic conditions for both reversible and irreversible processes. Calculation of w, q, ΔU and ΔH for processes involving changes in physical states.

Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution.

Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data.

Variation of enthalpy of a reaction with temperature – Kirchhoff's equation.

Various statements of Second Law of thermodynamics, Carnot cycle, concept of entropy, Gibbs free energy and Helmholtz energy, Calculations of entropy change and free energy change for reversible and irreversible processes under isothermal and adiabatic conditions. Criteria of spontaneity. Gibbs - Helmholtz equation. Maxwell's relations.

Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

Unit 4: Ionic Equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect, Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions.

Solubility and solubility product of sparingly soluble salts -applications of solubility product principle.

Qualitative treatment of acid base titration curves (calculation of pH at various stages of HCl –NaOH titration only). Theory of acid – base indicators.

CHCP 301: CHEMISTRY-I

PRACTICALS **Marks: 50**

Section A: Inorganic Chemistry

Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
4. Estimation of Fe(II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu(II) ions iodometrically using $Na_2S_2O_3$.
6. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.

Section B: Physical Chemistry

(I) **Surface tension measurement** (use of organic solvents excluded)

Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

(II) **Viscosity measurement** (use of organic solvents excluded)

Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.

(III) **Kinetic studies**

Study of the kinetics of the following reaction by integrated rate method: Acid hydrolysis of methyl acetate with hydrochloric acid volumetrically

SUGGESTED BOOKS

1. Barrow, G. M. 2007 *Physical Chemistry* Tata McGraw-Hill
2. Castellan, G. W. 2004 *Physical Chemistry* 4th edition. Narosa .
3. Kotz, J. C., Treichel, P. M. & Townsend, J. R. 2009 *General Chemistry* Cengage Learning India Pvt. Ltd.: New Delhi
4. Mahan, B. H. 1998 *University Chemistry* 3rd Ed. Narosa .
5. J. D. Lee: *A new Concise Inorganic Chemistry*, E L. B. S.
6. F. A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry*, John Wiley.
7. Douglas, McDaniel and Alexader : *Concepts and Models in Inorganic Chemistry*, John Wiley.
8. James E. Huheey, *Ellen Keiter and Richard Keiter : Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Publication.
11. Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th edition.
12. Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th edition.
13. Senior Practical Physical Chemistry, B.D.Khosla, R. Chand & Co.

Paper 4/8-ENAT 101/201: TECHNICAL WRITING AND COMMUNICATION IN ENGLISH

Marks: 100

Unit 1

Communication: Language and communication, differences between speech and writing, distinct features of speech, distinct features of writing.

Unit 2

Writing Skills; Selection of topic, thesis statement, developing the thesis; introductory, developmental, transitional and concluding paragraphs, linguistic unity, coherence and cohesion, descriptive, narrative, expository and argumentative writing.

Unit 3

Technical Writing: Scientific and technical subjects; formal and informal writings; formal writings/reports, handbooks, manuals, letters, memorandum, notices, agenda, minutes; common errors to be avoided.

SUGGESTED READINGS

1. M. Frank. Writing as thinking: *A guided process approach, Englewood Cliffs,* Prentice Hall Reagents.

2. L. Hamp-Lyons and B. Heasely: Study Writing; *A course in written English.* For academic and professional purposes, Cambridge Univ. Press.

3. R. Quirk, S. Greenbaum, G. Leech and J. Svartik: *A comprehensive grammar of the English language*, Longman, London.

4. Daniel G. Riordan & Steven A. Panley: *"Technical Report Writing Today"* - Biztaantra.

Additional Reference Books

5. Daniel G. Riordan, Steven E. Pauley, Biztantra: (2004 *Technical Report Writing Today*, 8th Edition

6. *Contemporary Business Communication*, 2004.Scot Ober, Biztantra, 5th Edition

Paper 4/8-CSAT 101/201: COMPUTATIONAL SKILLS

THEORY **Marks: 100**

Computer Fundamentals **(12 Periods)**

Introduction to Computers: Characteristics of Computers, Uses of computers, Types and generations of Computers; Basic Computer Organization - Units of a computer, CPU, ALU, memory hierarchy, registers, I/O devices; User Interface with the Operating System, System Tools

Data Representation **(8 Periods)**

Binary representation of integers and real numbers, 1's Complement, 2's Complement, Addition and subtraction of binary numbers, BCD, ASCII, Unicode;

Networks terminology **(4 Periods)**

Types of networks, router, switch, server-client architecture

Multimedia **(4 Periods)**

Introduction, Characteristics, Elements, Applications

Problem Solving **(10 Periods)**

Notion of algorithms, stepwise methodology of developing an algorithm, developing macros in spreadsheet

General Awareness **(4 Periods)**

IT Act, System Security (virus/firewall etc.), I-Tax, Reservations, Banking.

CSAP 101/201: COMPUTATIONAL SKILLS

PRACTICALS **Marks: 50**

1. Defined projects will be done by the students and evaluated by the instructor.
2. Document Preparation
3. Presentation Software
4. Familiarizing with the Operating System, Control Panel, Networking Configuration, Firewall setting
5. Spreadsheet Handing, Working with worksheets, Creating a spreadsheet, entering and formatting information, basic functions and formulas, creating charts, tables and graphs.

SUGGESTED BOOKS

[1] V Rajaraman, **Fundamentals of Computers,** 4th edition, PHI.

[2] Anita Goel, **Fundamentals of Computers;** Forthcoming title in Pearson-Education

Note: Use of Open Office/Star Office is recommended, as they are freely downloadable.

Reference manual for Open Office available at: http://www.openffice.org

Reference manual for Star Office available at: http://www.sun.com/software/staroffice/

Paper 5- BTHT 202: Biodiversity II-MYCOLOGY AND PHYTOPATHOLOGY

THEORY **Marks: 100**

SECTION A: MYCOLOGY (Fungi and allied organisms)

Unit I: Introduction (Ch **1 Webster & Weber, Ch 1 Alexopoulos et al.) (10 periods)**

Definition; Why study fungi? General characteristics; Ecology and Distribution; Thallus organization; EM of haustorium and septum; Wall composition; Nutrition; Growth; Reproduction and spores; Heterokaryosis and parasexuality; Sexual compatibility; Life cycle patterns.

Unit 2: Myxomycota **(Ch 2 Webster & Weber, Ch 29 Alexopoulos et al.) (3 periods)**

Introduction, Occurrence; Importance (*Physrum* as an experimental tool); General characteristics; Thallus organization; Reproduction

Unit 3: Oomycota **(Ch 5 Webster & Weber, Ch 23 Alexopoulos et al.) (5 periods)**

General characteristics; Ecology; Significance; Thallus organization; Reproduction; Classification; Generalized life cycle of the class with special emphasis on the reproductive structures of *Phytophthora, Albugo***.**

Unit 4: Zygomycota **(Ch 7 Webster &Weber, Ch 5 & 6 Alexopoulos et al.) (4 periods)**

General characteristics; Ecology; Significance; Thallus organization; Reproduction; with special reference to *Rhizopus.*

Unit 5: Ascomycota **(Ch 8 Webster & Weber) (8 periods)**

General characteristics; Ecology; Significance; Thallus organization; Reproduction; Classification with special reference to Yeasts (S*accharomyces),Eurotium (Aspergillus), Penicillium,* General account of Powdery mildews*, Neurospora, Peziza*

Unit 6: Basidiomycota **(Ch 18 Webster & Weber) (7 periods)**

General characteristics; Ecology; Significance; Thallus organization; Reproduction; Classification with special reference to Wheat Rusts (*Puccinia),* Loose & Covered Smuts; Mushrooms (*Agaricus)*; Mushroom cultivation

Unit 7: Deuteromycota **(Ch 8 Alexopoulos et al.) (3 periods)**

General characteristics; Ecology, Significance; Thallus organization; Reproduction; Classification with special reference to *Alternaria,* and *Colletotrichum*

Unit 8: Applied Mycology **(Ch 18 Wickens) (8 periods)**

Role of fungi in biotechnology, Application of fungi in food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations);

Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides); Medical mycology.

Unit 9: Lichens (Ch 16 Webster & Weber) (3 periods)

Occurrence, General Characteristics; Growth forms and range of thallus organization; Nature of association of algal and fungal partners; Reproduction; Ecological significance; Applied importance.

SECTION B: PHYTOPATHOLOGY

Unit 10: **Plant Pathology (Ch 1 Agrios) (4 periods)**

Introduction: Definition; Importance; Terms and Concepts; Classification; Causes; Symptoms; Host-Pathogen relationships

Unit 11: (Ch 2, 7, 8 Agrios) (5 periods)

Geographical distribution of diseases; etiology; symptomology; disease cycle and environmental relation; prevention and control of plant diseases, and role of quarantine.

BTHP 202: Biodiversity II-MYCOLOGY AND PHYTOPATHOLOGY

PRACTICALS Marks: 50

SECTION A

1. Study of Phaneroplasmodium from actual specimens and/or photograph. Study of *Physarum* sporangia.
2. Study of symptoms of plants infected with *Albugo*; asexual and sexual structures through sections/tease mounts and permanent slides.
3. *Rhizopus:* Students to culture Black bread mould in the laboratory to study asexual stage from temporary mounts. Sexual stages of mould to be studied from permanent slides.
4. *Aspergillus* and *Penicillium* : *as*exual stages from tease mounts.
5. *Neurospora*: Asexual and sexual stage from culture/permanent slides/ photographs.
6. *Peziza*: Habit; sectioning through ascocarp, and permanent slides.
7. *Puccinia*: Herbarium specimens of Wheat Rusts- (Black, Brown and Yellow) and infected barberry leaves; section/tease mounts of spores on wheat, and permanent slides of both the hosts.

8. Mushrooms: Specimens of button stage and full-grown mushroom; sectioning of gills of *Agaricus,* study of basidiocarp from permanent slides; Photograph of fairy ring, edible and poisonous fungi (two each), bioluminesecent mushroom to be shown.
9. Specimens/photographs and tease mounts of *Alternaria,* and *Colletotrichum.*
10. Applied mycology: Photographs of Mycorrhizae, fungi used in medicine (*Cylindriocarpon, Tolyposporium, Ganoderma, Cephalosporium* – **any one**), fungi used as biological control agents (fungi used in control of seedling, soil borne, post harvest diseases and in control of nematodes, insects & weeds – **any one**), photographs / mounts of spores of fungi causing human infections along with pictures of patients suffering from such infections (*Aspergillus, Candida, Cryptococcus, Histoplasma, Microsporum, Trichophyton* – **any one**).
11. Study of growth forms of lichens (crustose, foliose, fruticose) **on different substrata**. Study of thallus and reproductive structures (soredia, apothecium) through permanent slides

SECTION B

12. White rust of Crucifers, Early & Late blight of potato, Herbarium/museum specimens of the diseased plants.

Students should submit six specimens of fungal growth at the time of examination.

SUGGESTED READINGS

1. Agrios, G.N. 1997 Plant Pathology, 4th edition, Academic Press, U.K.
2. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 1996 Introductory Mycology, 4th edition, John Wiley and Sons (Asia) Singapore.
3. Singh, R.S. 998 Plant Diseases. 7th edition, Oxford & IBH, New Delhi.
4. Webster, J. and Weber, R. 2007 Introduction to Fungi. 3rd edition, Cambridge University Press, Cambridge.
5. Wickens, G.E. 2004 Economic Botany: Principles and Practices, Springer. Kuwer Publishers, Dordrecht, The Netherlands

Paper 6-BTHT 203: Biodiversity III-ARCHEGONIATAE (BRYOPHYTES, PTERIDOPHYTES AND GYMNOSPERMS)

THEORY **Marks: 100**

Unit 1: Introduction **(5 Periods)**

Characteristic features and life cycle patterns of Bryophytes **(Ch 1,10 Parihar)**; Pteridophytes **(Ch 1, 11 Parihar, Ch 13 Eames)**; and Gymnosperms **(Ch 1 Bhatnagar and Moitra)**; Classification; Habit and Habitat; Adaptations to land habit.

Unit 2: Structure and Reproduction in Bryophytes **(Ch2-7, 9 Parihar) (14 Periods)**

Comparative account of Morphology and Anatomy of *Riccia, Marchantia, Pellia, Porella, Anthoceros, Sphagnum and Funaria;* Reproduction and evolutionary trends in *Riccia, Marchantia* , *Anthoceros* and *Funaria* (developmental stages not included).

Unit 3: Structure and Reproduction in Pteridophytes **(Ch 2, 4,5 9,10 Parihar) (14 Periods)**

Comparative account of Morphology and Anatomy of *Rhynia, Psilotum, Selaginella, Equisetum, Pteris, Marsilea*; Reproduction and evolutionary trends in *Selaginella*; *Equisetum*; and *Pteris* (developmental details not included).

Unit 4: Evolutionary concepts in Pteridophytes **(Ch 11 Parihar) (5 Periods)**

Telome theory; Stelar evolution; Heterospory and seed habit Apogamy and Apospory. **Unit 5:**

Structure of Gymnosperms: **(Ch 6, 13-16, Bhatnagar and Moitra) (9 Periods)**

Morphology and anatomy of *Cycas, Pinus, Ephedra, Gnetum.*

Unit 6: Reproduction in Gymnosperms **(Ch 6, 13-16 Bhatnagar and Moitra) (9 Periods)**

Reproduction and evolutionary trends in *Cycas, Pinus, Ephedra, Gnetum,* (developmental stages and EM studies not included).

Unit 7: Importance **(Ch 18 Bhatnagar and Moitra) (4 Periods)**

Ecological and Economic importance of Bryophytes (Glime and Saxena), Pteridophytes and Gymnosperms.

BTHP 203: Biodiversity III-ARCHEGONIATAE (BRYOPHYTES, PTERIDOPHYTES AND GYMNOSPERMS)

PRACTICALS **Marks: 50**

Study of habit, Vegetative thallus organization and structure, reproductive structures of the following taxa: *Riccia, Marchantia, Pellia*, Porella*, Anthoceros, Sphagnum*, Funaria, Psilotum, Selaginella, Equisetum, Marsilea, Pteris, Cycas, Ephedra, Gnetum** and through specimens, temporary mounts and permanent slides (Fresh material whichever available).

*Only through permanent slides

SUGGESTED READINGS

1. Bhatnager, S.P. and Moitra, A. 1996 Gymnospersm. New Age International (P) Ltd. Publishers, New Delhi.
2. Buchanan, B., Gruissem, W. and Jones, R. 2000 Biochemistry and Molecular Biology of Plants. American Society of Plant Biologists.
3. Raven, P.H., Johnson, G.B., Losos, J.B. and Singer, S.R. 2005 Biology. Tata MC Graw Hill.
4. Richardson, D.H.S. 1981 The Biology of Mosses. John Wiley and Sons, New York.
5. Sambamurty 2008 A Textbook of Bryophytes, Pteridophytes, Gymnosperms and Paleobotany. IK International Publishers.
6. Shaw, A.J. and Goffinet, B. (2000) Bryophyte Biology. Cambridge University Press.
7. Vander-Poorteri 2009 Introduction to Bryophytes. COP.
8. Parihar, N.S. 1991. Bryophytes. Central Book Depot, Allahabad.
9. Parihar, N.S. 1996. The Biology and Morphology of Pteridophytes. Central Book Depot, Allahabad.
10. Bhatnagar S.P. and Mohitra A 1996 Gymnosperms. New Age Publishers, New Delhi

Paper 7-CHCT 402: CHEMISTRY-II

THEORY **Marks: 100**

Section A: Basic Organic Chemistry **(30 Periods)**

Unit 1: Fundamentals of Organic Chemistry

Concept of hybridization of carbon. Cleavage of a covalent bond: homolysis and heterolysis. Electronic effects and their applications (inductive, electromeric, hyperconjugation and resonance). Structure and stability of reactive intermediates (carbocations, carbanions and free radicals). Relative strength of carboxylic acids (aliphatic, aromatic and halo-substituted aliphatic), alcohols, phenols and nitro-phenols. Relative basic strength of amines (aliphatic and aromatic) Intermolecular and intramolecular forces: types of intermolecular forces and their characteristics (ion-dipole, dipole-dipole, dipole-induced dipole and dispersion forces). Intermolecular and intramolecular hydrogen bonding. Effect of intermolecular and intramolecular forces on properties such as solubility, vapour pressure, melting and boiling points of organic compounds.

Unit 2: Stereochemistry

Conformations w.r.t. ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newman, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds) . Threo and erythro; D and L; *cis* - *trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

Section B: Chemistry of Biomolecules **(30 Periods)**

Unit 3: Carbohydrates

Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

Unit 4: Amino Acids, Peptides and Proteins

Preparation of Amino Acids: Strecker synthesis, using Gabriel's phthalimide synthesis. Zwitter ion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis.

CHCP 402: CHEMISTRY-II

PRACTICALS **Marks: 50**

Organic Chemistry

1. Detection of extra elements (N,S,Cl,Br,I) in organic compounds (containing up to two extra elements).
2. Systematic **Qualitative Organic Analysis** of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, 1^o amines) and preparation of one derivative.

SUGGESTED BOOKS

1. T. W. Graham Solomons : Organic Chemistry*, John Wiley and Sons*.
2. Arun Bahl and B. S. Bahl : *Advanced Organic Chemistry,* S. Chand.
3. E. L. Eliel: *Stereochemistry of Carbon Compounds*, Tata McGraw Hill.
4. I. L. Finar: *Organic Chemistry* (Vol. I & II), E. L. B. S.
5. R. T. Morrison & R. N. Boyd: *Organic Chemistry*, Prentice Hall.
6. Textbook of Practical Organic Chemistry, A.I. Vogel, Prentice Hall, 5^{th} edition.
7. Practical Organic Chemistry, Mann F. G. & Saunders B. C, Orient Longman, 1960.

Paper 9-BTHT 304: PLANT RESOURCE UTILIZATION

THEORY **Marks: 100**

Unit 1: Origin of Cultivated Plants

(Ch 13&14, Chrispeels & Sadava, Ch 1 Kochhar, Ch 1 Wickens) (6 Periods)

Concept of centres of origin, their importance with reference to Vavilov's work; examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversty.

Unit 2: Cereals

(Ch 3 Kochhar, Chs 6-10 Wickens, Ch 10 Slater et al.) (4 Periods)

Wheat and Rice, Role of dwarf varieties in green revolution; brief account of millets and pseudocereals.

Unit 3: Legumes **(Ch 5 Kochhar)(2 Periods)**

General account, importance to man and ecosystem; chief pulses grown in India.

Unit 4: Fruits **(Ch 7 Kochhar) (4 Periods)**

Mango, Citrus, Papaya.

Unit 5: Sugars and starches **(Ch 4 Kochhar) (6 Periods)**

Ratooning and nobilization of sugarcane, products and by products of sugarcane industry; Potato (Tuber anatomy and propagation methods) and comparative account with cassava.

Unit 6: Spices **(Ch 9 Kochhar) (6 Periods)**

Listing of important spices, their family and part used; with special reference to fennel, saffron, clove, turmeric and all spices; common adulterants of spices.

Unit 7: Beverages **(Ch 11 Kochhar) (6 Periods)**

Tea, coffee and cocoa, their processing and some common adulterants.

Unit 8: Oils and Fats **(Ch 6 Kochhar, Ch 9 Wickens) (8 Periods)**

General description with details of groundnut, coconut, linseed and *Brassica* spp and their use related health implications.

Unit 9: Essential Oils **(Ch 17 Kochhar) (3 Periods)**

General account and comparison with fatty oils.

Unit 10: Natural Rubber **(Ch 14 Kochhar) (3 Periods)**

Para Rubber, tapping and processing, Various substitutes of Para Rubber.

Unit 11: Drug Yielding Plants **Ch 15 Kochhar, Ch16 Wickens) (4 Periods)**

Therapeutic and habit forming drugs with special reference to *Cinchona*, *Digitalis*, *Rauvolfia*, *Papaver* and *Cannabis*.

Unit 12: Masticatories and Fumitories **(3 Periods)**

Tobacco and Health hazards. **(Ch 10 Kochhar)**

Unit 13: Timber plants **(3 Periods)**

General account with special reference to teak and pine. **(Ch 12 Kochhar, Ch 12 Wickens)**

Unit 14: Fibres **(3 Periods)**

Classification based on the origin of fibres, Tetraploid cotton and Jute. **(Ch 2 Kochhar, Ch 14 Wickens)**

BTHP 304: PLANT RESOURCE UTILIZATION

PRACTICALS **Marks: 50**

Study of the following through habit sketches temporary preparations permanent slides photographs specimens products microchemical tests etc. to bring out the economic importance: **Cereals**: Wheat, Rice, Millets and Pseudo cereals; **Legumes**: Soyabean, groundnut and gram, **Fruits**: mango, citrus and papaya; **Sugars and starches**: sugarcane, potato, cassava; **Spices**: black pepper, coriander, fennel; **Beverages**: tea, coffee, cocoa; **Oils and Fats**: Coconut, mustard and linseed **Essential-oil yielding plants**: Rosa, *Cymbopogon, Vetiveria, Santalum* and *Eucalyptus*; **Fiber-yielding plants**: *Gossypium, Corchorus,* jute; **Woods**: *Tectona, Pinus* **Rubber***: Hevea brasiliensis*; **Drug yielding plants:** *Cinchona, Digitalis, Rauvolfia, Papaver, Cannabis*; **Fumitory plants**: Tobacco

Each student should submit a theoretical project on any one of the topic pertaining to the course content. Some of the suggested topics for this purpose are: Biofuels; Biocides; Newer drug plants; Germplasm conservation; IPR, MTA; Heterosis; Selection methods of breeding; Conventional and non conventional plant breeding methods, GM crops, Quarantine Practices in a botanical conservation.

In the Practicals, students should also be shown a few standing crops under field conditions wherever possible and to made aware of constraints faced by the farming community for increasing crop productivity. This could be integrated with the project reports that students have to submit. Students should also be made to understand India's productivity status for various economically important plants in relation to that of other countries and their economic ramifications.

SUGGESTED READINGS

1. Kochhar, S.L. 2009 Economic Botany in Tropic. Macmillan and Co. New Delhi.
2. Wickens, G.E. 2004 Economic Botany: Principles and Practices, Springer. Klwer Publishers, Dordrecht, The Netherlands.
3. Chrispeels, M.J. and Sadava, D. 1977 Plants, Food and People. San Francisco: W. H. Freeman & Co.
4. Swaminathan. M and Kochhar, S.L. 1989 Plants and Society. Macmillan Publishers Ltd.
5. Harlan, J.R. (1992). Crops and Man. 2nd ed. Madison W D: American Society of Agronomy.
6. Chrispeels, M.J. and Sadava, D.E. 1994 Plants, Genes and Agriculture. Jones & Bartlett Publishers.
7. Slater, A., Scott, N.W. & Fowler, M.R. 2008 Plant Biotechnology: The Genetic Manipulation of Plants, Oxford University Press.

Paper 10-MACT 303: MATHEMATICS AND STATISTICS

Marks: 100

Unit 1 **(24 Periods)**

Sets. Functions and their graphs : polynomial, sine, cosine, exponential and logarithmic functions. Motivation and illustration for these functions through projectile motion, simple pendulum, biological rhythms, cell division, muscular fibres etc. Simple observations about these functions like increasing, decreasing and, periodicity. Sequences to be introduced through the examples arising in Science beginning with finite sequences, followed by concepts of recursion and difference equations. For instance, the Fibonacci sequence arising from branching habit of trees and breeding habit of rabbits. Intuitive idea of algebraic relationships and convergence. Infinite Geometric Series. Series formulas for e^x, log (1+x), sin x, cos x. Step function. Intuitive idea of discontinuity, continuity and limits. Differentiation. Conception to be motivated through simple concrete examples as given above from Biological and Physical Sciences. Use of methods of differentiation like Chain rule, Product rule and Quotient rule. Second order derivatives of above functions. Integration as reverse process of differentiation. Integrals of the functions introduced above.

Unit 2 **(14 Periods)**

Points in plane and space and coordinate form. Examples of matrices inducing Dilation, Rotation, Reflection and System of linear equations. Examples of matrices arising in Physical, Biological Sciences and Biological networks. Sum and Produce of matrices upto order 3.

Unit 3 **(20 Periods)**

Measures of central tendency. Measures of dispersion; skewness, kurtosis. Elementary Probability and basic laws. Discrete and Continuous Random variable, Mathematical Expectation, Mean and Variance of Binomial, Poisson and Normal distribution. Sample mean and Sampling variance. Hypothesis testing using standard normal variate. Curve Fitting. Correlation and Regression. Emphasis on examples from Biological Sciences.

SUGGESTED READINGS

1. H. S. Bear: *Understanding Calculus*, John Wiley and Sons (Second Edition); 2003.

2. E. Batschelet : *Introduction to Mathematics for Life Scientists,*Springer Verlag, International Student Edition, Narosa Publishing House, New Delhi (1971, 1975)

3. A. Edmondson and D. Druce : *Advanced Biology Statistics*, Oxford University Press; 1996.

4. W. Danial : Biostatistics : *A foundation for Analysis in Health Sciences*, John Wiley and Sons Inc; 2004.

Note: It is desirable that softwares should be used for demonstrating visual, graphical and application oriented approaches.

Paper 11-CBHT 301: CELL BIOLOGY-I

THEORY **Marks: 100**

Unit 1. An Overview of Cells **(Ch 1 Cooper *et al.*/ Ch 1 Karp)**

Overview of prokaryotic and eukaryotic cells, cell size and shape, Phages, Viriods, Mycoplasma and *Escherichia coli*.

Unit 2. Tools and techniques of Cell Biology **(Ch 1 Cooper *et al.*/ Ch 18 Karp/ Ch 3 De Robertis)**

Microscopic-Principles of Light microscopy; Phase contrast microscopy; Confocal microscopy; Electron microscopy (EM)-scanning EM and scanning transmission EM (STEM); Fluorescence microscopy;

Analytical-Flow cytometry- flurochromes, fluorescent probe and working principle; Spectrophotometry; Mass spectrometry; X-ray diffraction analysis.

Separation-Sub-cellular fractionation- differential and density gradient centrifugation; Chromatography- paper, thin-layer, gel-filtration, ion-exchange, affinity and High-Performance Liquid Chromatography (HPLC).

Unit 3. Composition of Cells **(Ch 2 Cooper *et al.*)**

Molecules of cell, cell membranes and cell Proteins.

Unit 4. The Nucleus **(Ch 9 Cooper *et al.*)**

Nuclear Envelope- structure of nuclear pore complex, nuclear lamina, Transport across Nuclear Envelope, Chromatin: molecular organization, Nucleolus and rRNA Processing.

Unit 5. Protein Sorting and Transport **(Ch 10 Cooper *et al.*)**

The Endoplasmic reticulum, The Golgi Apparatus, Mechanism of Vesicular Transport, Lysosomes.

Unit 6. Mitochondria, Chloroplasts and Peroxisomes **(Ch 11 Cooper *et al.*)**

Structural organization, Function, Marker enzymes,Mitochondrial biogenesis, Protein import in mitochondria, Semiautonomous nature of mitochondria and chloroplast, chloroplast DNA, Peroxisomes'assembly

Unit 7. Cytoskeleton and Cell Movement **(Ch 12 Cooper *et al.*)**

Structure and organization of actin filaments; actin, myosin and cell movement; intermediate filaments; microtubules.

CBHP 301: CELL BIOLOGY-I

PRACTICALS **Marks: 50**

1. Separation of nucleic acid bases by paper chromatography.
2. Microscopy- Theoretical knowledge of Light and Electron microscope.
3. Study of the following techniques through electron / photo micrographs: Fluorescence microscopy, autoradiography, positive staining, negative staining, freeze fracture, freeze etching, shadow casting.
4. Study of structure of cell organelles through electron micrographs.

Permanent slide preparation:

5. Cytochemical staining of DNA-Feulgen.
6. Cytochemical staining of DNA and RNA- Methyl Green Pyronin (MGP).
7. Cytochemical staining of Polysaccharides-Periodic Acid Schiff's (PAS).
8. Cytochemical staining of Total proteins- Bromophenol blue.
9. Cytochemical staining of Histones -Fast Green.

SUGGESTED BOOKS

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

Paper 12-MBHT 301: MOLECULAR BIOLOGY-I

THEORY **Marks: 100**

Unit 1. Nucleic Acids convey Genetic Information (Ch 2 Watson)

DNA as the carrier of genetic information, Key experiments establishing-The Central Dogma, DNA Double helix, Genetic code, Direction of Protein Synthesis, Genomics.

Unit 2. The Structures of DNA and RNA / Genetic Material (Ch 6 Watson/ Ch 18 Becker)

DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves.
DNA topology-linking number, topoisomerases; Organization of DNA- Prokaryotes, Viruses, Eukaryotes.
RNA Structure
Organelle DNA -- mitochondria and chloroplast DNA.

Unit 3. Genome Structure, Chromatin and the Nucleosome (Ch 7 Watson/ Ch 18 Becker)

Genome Sequence and Chromosome Diversity, Chromosome Duplication and Segregation,
The Nucleosome
Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.
Regulation of Chromatin Structure and Nucleosome Assembly.
Organization of Chromosomes

Unit 4. The Replication of DNA (Prokaryotes and Eukaryotes) (Ch 8 Watson/ Ch 19 Becker)

Chemistry of DNA synthesis, general principles - bidirectional replication, Semi- conservative, Semi discontinuous, RNA priming, Various models of DNA replication including rolling circle, D-loop (mitochondrial), Θ (theta) mode of replication, replication of linear ds-DNA, replicating the 5'end of linear chromosome. Enzyme involved in DNA replication – DNA polymerases, DNA ligase, Primase, Telomerase and other accessory proteins

Unit 5. The Mutability and Repair of DNA (Ch 9 Watson)

Replication Errors, DNA Damage and their repair.

MBHP 301: MOLECULAR BIOLOGY-I

PRACTICALS **Marks: 50**

1. Preparation of Polytene chromosome from *Chironomous* larva/*Drosophila* larva
2. Demonstration of mammalian sex chromatin.
3. Preparations of temporary mount and study the different stages of Mitosis (Onion root tip).
4. Perform Southern Blot Hybridization (Restrict DNA for Southern Blot electrophoresis, perform electrophoresis of restricted DNA, perform southern transfer, hybridization and detection of gene of interest)
5. Demonstration of Northern Blotting.
6. Demonstration of Western Blotting.
7. Perform DNA amplification by PCR.
8. Study of semiconservative replication of DNA through micrographs/schematic representations.

SUGGESTED BOOKS

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
3. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.
4. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., 2008 Molecular Biology of the Gene 6th edition. Cold Spring Harbour Lab. Press, Pearson Pub.

Paper 13-BTHT 405: PLANT DEVELOPMENT AND ANATOMY

THEORY **Marks: 100**

Unit 1: Plant Sporophyte: **(Ch 16 Taiz & Zeiger)**

A bipolar structure; Onset of polarity; Cytodifferentiation and organogenesis during embryonic development; physiological and genetic aspects.

Unit 2: Introduction and scope of Plant Anatomy **(Ch 1 Fahn) (2 Periods)**

Applications in systematics, forensics and pharmacognosy.

Unit 3: Tissues and Cell Walls **(Ch 1 Dickinson) (12 Periods)**

Classification and structure of tissues; cytodifferentiation of tracheary elements and sieve elements; pits and plasmodesmata; wall ingrowths and transfer cells; adcrustation and incrustation; ergastic substances.

Unit 4: Stem **(Ch 11 Fahn) (8 Periods)**

Organization of shoot apex (apical cell theory, histogen theory, tunica corpus theory, plastochrone); shoot chimeras; types of vascular bundles; primary phloem and primary xylem; terminal, lateral and adventitious buds; primary thickening meristem.

Unit 5: Leaf **(Ch 12 Fahn) (6 Periods)**

Development of leaf, histology of C_3 and C_4 leaves; stomatal complex and diversity of stomata, scale leaves.

Unit 6: Root **(Ch 13 Fahn) (7 Periods)**

Organization of root apex (apical cell theory, histogen theory, korper-kappe theory); quiescent centre; root cap; primary root tissue: rhizodermis, cortex, endodermis, exodermis, metacutinization, lateral root apices; secondary growth in roots.

Unit 7: Vascular Cambium **(Ch 14 Fahn) (6 Periods)**

Structure and function; concept of cambial zone; cambial derivatives; seasonal activity of cambium and unusual cambial activity.

Unit 8: Secondary Growth **(Ch 4 Dickinson) (6 Periods)**

Axially and radially oriented xylary and phloic elements, cyclic aspects, juvenile adult and reaction woods; sap wood and heart wood; Phloem as a dynamic tissue.

Unit 9: Periderm **(Ch 4 Dickinson) (4 Periods)**

Development and composition of periderm, rhytidome and lenticels.

Unit 10: Adaptive and Protective Systems **(Ch 8 Dickinson) (5 Periods)**

Epidermal tissue system (cuticle, epicuticular waxes, trichomes); Anatomical adaptations in stems, leaves and roots of xerophytes, hydrophytes and halophytes.

Unit 11: Secretory and Excretory System **(4 periods)**

Hydathodes, salt glands, nectaries; cavities, lithocysts and laticifers. **(Ch 11 Dickinson)**

BTHP 405: PLANT DEVELOPMENT AND ANATOMY

PRACTICALS **Marks: 50**

1. Familiarization with techniques: double staining, maceration, peel mount, clearing.
2. Study of anatomical details through permanent slides/temporary stain mounts/macerations/ Museum specimens with the help of suitable examples.
3. Apical meristem of root and shoot, vascular cambium and intercalary meristem.
4. Distribution and types of parenchyma, collenchyma and sclerenchyma.
5. Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres; xylem parenchyma.
6. Wood: ring porous; diffuse porous; tyloses; heart-and sapwood.
7. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres.
8. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
9. Root: monocot, dicot, origin of lateral roots; secondary growth; anomalous root structure.
10. Stem: monocot, dicot - primary and secondary growth; periderm; lenticel; abnormal secondary growth in dicots and monocots;
11. Leaf: isobilateral, dorsiventral, C_4 leaves (Kranz anatomy); venation patterns.
12. Adaptive Anatomy: xerophytes, hydrophytes, parasites and epiphytes.
13. Secretory tissues: ducts and cavities, lithocytes and laticifers.

SUGGESTED READINGS

1. Dickinson, W.C. 2000 Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Fahn, A. 1974 Plant Anatomy. Pergmon Press, USA and UK.
3. Mauseth, J.D. 1988 Plant Anatomy. The Benjammin/Cummings Publisher, USA.
4. Esau, K. 1977 Anatomy of Seed Plants. Wiley Publishers.
5. Taiz, L. & Zeiger, E. 2006 Plant Physiology. (4^{th} edition) Sinauer Associates, Inc. Sunderland, M.A.

Paper 14-BTHT 406: PLANT ECOLOGY AND PHYTOGEOGRAPHY

THEORY **Marks: 100**

Unit 1: Introduction to the Biosphere **(Odum) (2 Periods)**

Inter-relationships between the living world and the environment, the components and dynamism, homeostasis.

Unit 2: Soil **(Odum)(8 Periods)**

Importance, origin, formation, composition; physical, chemical and biological components; soil profile; role of climate in soil development.

Unit 3: Water **(Odum) (4 Periods)**

Importance; states of water in the environment; atmospheric moisture; precipitation types; water in soil, water table, water bodies: aquifers, water shed.

Unit 4: The Atmosphere **(Odum) (5 Periods)**

Composition and stratification; radiation flux; role of electromagnetic radiations, UV, visible spectrum; variations in temperature; wind as a factor.

Unit 5: The Living World **(Odum) (2 Periods)**

Biotic component of environment; types of biotic interactions.

Unit 6: Fire **(Odum) (1 Period)**

As an ecological factor.

Unit 7: Levels of Organisation **(Odum) (3 Periods)**

Individual, population, community; concepts of autecology, synecology; concept of biological diversity; habitat and ecological niche.

Unit 8: Population Ecology **(Chapter 8,9, pp 122-165, Singh et al.) (3 Periods)**

Distribution and characteristics of population; population dynamics; Ecological Speciation. **Unit 9: Plant Communities** **(Chapter 11, pp 166- 219, Singh et al.) (5 Periods)**

Community characters (analytical and synthetic), ecotone and edge effect; methods of studying vegetation; dynamics of communities; plant succession, processes, types; primary and secondary succession; climax concepts.

Unit 10: Ecosystems **(Chapter 13, pp 238-252, Singh et al.) (8 Periods)**

Structure, biotic and the abiotic components; processes within ecosystem; trophic organization, basic source of energy, autotrophy, heterotrophy, parasitism; food chains and webs; ecological pyramids; biomass, standing crop.

Unit 11: Functional aspects of Ecosystem (Chapter 12, 14- 17, Singh et al.) (10 Periods)

Energy flow; principles, grazing and detritus food chains, models of energy flow; ecosystem productivity, measurement of productivity; ecological efficiencies and concept of energy subsidy; biogeochemical cycles; dynamics: hydrologic cycle; gaseous cycles, sedimentary cycles.

Unit 12: Diversity of Ecosystems and Biomes (Chapter 18, Singh et al.) (4 Periods)

Aquatic: fresh water (lotic and lentic), marine (pelagic and benthic), estuarine; major terrestrial biomes: tundra, temperate and tropical.

Unit 13: Phytogeogarphy (5 Periods)

Principles of phytogeography; endemism; hotspots; phytogeogarphical divisions of India: vegetation of Delhi.

BTHP 406: PLANT ECOLOGY AND PHYTOGEOGRAPHY

PRACTICALS Marks: 50

1. Study of following microclimatic variables in different habitats: soil and air temperature, wind velocity, relative humidity, rainfall and light intensity.
2. Permeability (percolation; total capacity as well as rate of movement) of different soil samples.
3. Saturation capacity and field capacity of different soil samples and rapid test for texture of soils.
4. Density and porosity and rate of infiltration of water in undisturbed soils.
5. pH and rapid field tests of soils for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency.
6. Soil organic matter in different soil samples by titration method.
7. Determination of minimal area of quadrat size by species area curve method.
8. Quantitative analysis of herbaceous vegetation for frequency; density and abundance.
9. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
10. Morphological adaptations of hydrophytes and xerophytes.

SUGGESTED READINGS

1. Singh, J.S., Singh, S.P. and Gupta, S. (2006) Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi
2. Wilkinson, D.M. (2007). Fundamental Processes in Ecology. An Earth System Approach. Oxford.
3. Daubenmier, R.F. (1970). Plants and Environment: A text book of Plant Autoecology, Wiley Eastern Private Limited
4. Daubenmier, R.F. (1970), Plant Communities, Wiley Eastern Private Limited
5. Odum, E. (2008) Ecology. Oxford and IBH Publisher.
6. Sharma, P.D. (2010) Ecology and Environment, (8^{th} Ed.) Rastogi Publications, Meerut.

Paper 15-CBHT 402: CELL BIOLOGY-II

THEORY **Marks: 100**

Unit 1. The Plasma Membrane **(Ch 13 Cooper *et al.*)**

Structure; Transport of small molecules, Endocytosis

Unit 2. Cell Wall, the Extracellular Matrix and Cell Interactions **(Ch 14 Cooper *et al.*)**

Bacterial and Eukaryotic Cell Wall; the extracellular matrix and cell matrix interactions; cell-cell interactions.

Unit 3. Cell Signaling **(Ch 15 Cooper *et al.*)**

Signaling molecules and their receptor; functions of cell surface receptors; Intracellular signal transduction pathway; signaling networks.

Unit 4. The Cell Cycle **(Ch 16 Cooper *et al.*)**

Eukaryotic Cell Cycle, Regulation of Cell cycle progression, Events of Mitotic Phase, Meiosis and Fertilization.

Unit 5. Cell Death and Cell Renewal **(Ch 17 Cooper *et al.*)**

Programmed Cell Death, Stem Cells and Maintenance of adult tissues, Embryonic Stem Cells and Therapeutic cloning.

Unit 6. Cancer **(Ch 18 Cooper *et al.*)**

Development and Causes of Cancer, Tumor Viruses, Oncogenes, Tumor Suppressor genes, Cancer Treatment- molecular approach.

CBHP 402: CELL BIOLOGY-II

PRACTICALS **Marks: 50**

1. To demonstrate the presence of mitochondria in striated muscle cells/ cheek epithelial cell using vital stain Janus Green B.
2. Study of polyploidy in Onion root tip by colchicine treatment.
3. Preparations of temporary mount of Grasshopper testis / onion flower bud anthers and study the different stages of Meiosis.
4. Study of mitosis and meiosis from permanent slides.
5. Identification and study of cancer cells- Slides/Photomicrographs.

SUGGESTED BOOKS

1. Karp, G. 2010 Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006 Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. 2009 The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009 The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

Paper 16-MBHT 402: MOLECULAR BIOLOGY-II

THEORY **Marks: 100**

Unit 1. Mechanism of Transcription **(Ch 12 Watson/ Ch 21 Becker)**
RNA Polymerase and the transcription unit
Transcription in Prokaryotes
Transcription in Eukaryotes

Unit 2. RNA Modifications **(Ch 13 Watson)**
Split genes, concept of introns and exons, removal of Introns, spliceosome machinery, splicing pathways, alternative splicing, exon shuffling, RNA editing, and mRNA transport.

Unit 3. Translation (Prokaryotes and Eukaryotes) (Ch 14 Watson/ Ch 22 Becker/ Ch 21 DeRobertis)
Assembly line of polypeptide synthesis - ribosome structure and assembly, various steps in protein synthesis. Charging of tRNA, aminoacyl tRNA synthetases. Proteins involved in initiation, elongation and termination of polypeptides. Fidelity of translation. Inhibitors of protein synthesis.
Regulation of translation
Translation-dependent regulation of mRNA and Protein Stability.

Unit 4. Transcription Regulation in Prokaryotes **(Ch 16 Watson)**
Principles of transcriptional regulation, regulation at initiation with examples from *lac* and *trp* operons

Unit 5. Transcription Regulation in Eukaryotes **(Ch 17 Watson)**
Conserved mechanism of regulation, Eukaryotic activators, Signal integration, combinatorial control, transcriptional repressors, signal transduction and control of transcriptional regulator, Gene Silencing

Unit 6. Regulatory RNAs **(Ch 18 Watson)**
Riboswitches, RNA interference, miRNA, siRNA, Regulatory RNA and X-inactivation

MBHP 402: MOLECULAR BIOLOGY-II

PRACTICALS **Marks: 50**

1. Preparation of culture medium (LB) for *E.coli (both solid and liquid)* and raise culture of *E.coli*.
2. Demonstration of antibiotic resistance. (Culture of *E.coli* containing plasmid (pUC 18/19) in LB medium with/without antibiotic pressure and interpretation of results).
3. Isolation and quantitative estimation of salmon sperm / calf thymus DNA using colorimeter (Diphenylamine reagent) or spectrophotometer (A260 measurement).
4. To perform Ames test in *Salmonella / E.coli* to study mutagenicity.

SUGGESTED BOOKS

1. Karp, G. 2010 Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006 Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
3. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009 The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.
4. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., 2008 Molecular Biology of the Gene (6th edition.). Cold Spring Harbour Lab. Press, Pearson Pub.

Paper 17-BTHT 507: PLANT SYSTEMATICS AND EVOLUTION

THEORY **Marks: 100**

Unit 1: Significance of Plant systematics: **(Ch 14 Simpson; Ch 4, 5,7 Judd et al.) (18 Periods)**

What is systematics; Identification, Classification and Nomenclature of plants; Field inventory, Herbarium preparation and management; important herbaria and botanical gardens of the world and India, Documentation: Flora, Monographs, Journals, Online Journals and Keys; Evidences from morphology, palyonology, cytotaxonomy, chemotaxonomy, serology, and molecular systematics.

Unit 2: Taxonomic hierarchy: **(5 Periods)**

Concept of taxa; categories and hierarchy; species concept (taxonomic, biological, evolutionary).

Unit 3: **Botanical nomenclature:** **(Ch 16 Judd et al.) (10 Periods)**

Principles and rules of nomenclature; ranks and names; type method, author citation, valid publication; rejection of names, principle of priority and its limitation; names of hybrids and cultivars.

Unit 4: Systems of classification: **(Ch 3 Judd et al., Ch 2 Simpson) (9 Periods)**

Classification by Bentham and Hooker, Engler and Prantl & Takhtajan; brief reference of Angiosperm Phylogeny Group (APG) Classification.

Unit 5: Biometrics and numerical taxonomy: **(Ch 7 Stussy) (6 Periods)**

Role of Computers in systematics; Characters and attributes; OTUs, character weighing and coding; cluster analysis, phenograms, cladistics.

Unit 6: Phylogeny of Angiosperms: **(Ch 6, 9 Judd et al.)(12 Periods)**

Terms and concepts (homology, analogy, parallelism, convergence, monophyly, polyphyly, clades); origin & evolution of angiosperms; co-evolution of angiosperms and animals; methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).

BTHP 507: PLANT SYSTEMATICS AND EVOLUTION

PRACTICALS **Marks: 50**

1. Study of vegetative and floral characters of the following families: Brassicaceae, Malvaceae, Cucurbitaceae, Fabaceae, Rubiaceae, Asteraceae, Apocynaceae, Solanaceae, Lamiaceae, Chenopodiaceae, Euphorbiaceae, Liliaceae and Poaceae (families most likely to be available during July—November).
2. Study of only characteristic morphological features of the following families: Capparaceae, Asclepiadaceae, Acanthaceae, and Cannaceae.
3. Identification of selected taxa using taxonomic keys.
4. Familiarity with local flora and herbarium techniques.
5. Use of computers/internet for data collection and identification**.**

SUGGESTED READINGS

1. Angiosperm Phylogeny Group (2003). An update of the Angiosperm Phylogeny Group classification for the orders and families of the flowering plants: APG II. Botanical Journal of the Linnaean Society 141: 399-436.
2. Crawford, D.J. (2003). Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.
3. Cronquist, A. (1981). An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.
4. Hollingsworth, P.M., Bateman, R.M. and Gornall, R.J. (1999). Molecular Systematics of Plant Evolution Taylor and Francis, London.
5. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. and Donoghue, M.J. (2008). Plant Systematics- A Phylogenetic Approach. Sinaner Associates Inc, Massachusetts, USA.
6. Simpson, M.C. (2006). Plant Systematics. Elsevier, Amsterdam.
7. Stussy, T.F. 1990. Plant Taxonomy, Columbia University Press, USA.

Paper 18-BTHT 508: PLANT PHYSIOLOGY

THEORY **Marks: 100**

Unit 1: Water balance in plant cells (Ch 4 Taiz & Zieger, Ch 2 Hopkins & Huner) (10 Periods)

Pathway of water movement; concepts of symplast and apoplast; ascent of sap; transpiration; energy exchange during transpiration; role of stomata; relationship with photosynthesis; antitranspirants; guttation; exchange of gases.

Unit 2: **Water Stress Physiology (Ch 26 Taiz & Zieger, Ch 13 Hopkins & Huner) (6 Periods)**

Characterization of stress response to water and high and low temperature response to saline soils; mechanism of response.

Unit 3: **Mineral nutrition (Ch 4 Hopkins & Huner)** (**6 Periods)**

Essential and non-essential elements; criteria for essentiality; macro and micronutrients; roles of essential elements; mineral deficiency symptoms; ion antagonism and toxicity.

Unit 4: Assimilation of Mineral Nutrients (Ch 3 Hopkins & Huner) (6 Periods)

Transport of ions across cell membranes, passive absorption, electrochemical gradient, Donnan's equilibrium, facilitated diffusion, accumulation against concentration gradient, active absorption, role of ATP, carrier systems, role of cell membrane, proton pump and ion flux.

Unit 5: **Translocation in the phloem (Ch 10 Taiz & Zeiger, Ch 9 Hopkins & Huner) (6 Periods)**

Structure-function relationship for the Translocation of photoassimilates from source to sink cells.

Unit 6: Plant growth substances: (Chs 18-21 Hopkins & Huner) (8 Periods)

Structure, biosynthesis, analysis, transport, physiological effects and mechanism of action.

Unit 7: Control of flowering (Ch 25 Taiz & Zieger, Ch 25 Hopkins & Huner) (6 Periods)

Flowering; physiological definition; role of light; photoperiodism – discovery; variation in response; long day; short day and day neutral plants; inductive and non- inductive cycles; role of dark period; role of quality and intensity of light; vernalization; mechanism; bolting in long day plants; role of growth regulators; nutrient status; nature of the flowering stimulus; diffusibility of photoperiodic and vernalization stimuli; florigen concept.

Unit 8: Physiology of fruit ripening (Ch 25 Hopkins & Huner) (4 Periods)

Physiological and biochemical changes.

Unit 9: Phytochrome and plant development (Ch 17 Taiz & Zieger, Ch 22 Hopkins & Huner) (8 Periods)

Discovery; chemical nature; mode of action; role of low energy response (LER) and high irradiance response (HIR); red (R) and far red (FR) light on photomorphogenesis.

BTHP 508: PLANT PHYSIOLOGY

PRACTICALS **Marks: 50**

1. Preparation of solutions of various concentrations of a few selected solutes.
2. Determination of osmotic potential of plant cell sap by plasmolytic method.
3. Determine water potential of given tissue by weight method and falling drop method.
4. Study of the effect of various environmental factors on transpiration in an excised twig/leaf.
5. Calculation of the stomatal index, stomatal frequency and percentage of leaf area open through stomata in a mesophyte and a xerophyte.
6. Study of the mechanism of stomatal opening and closing
7. Bolting experiment / *Avena* coleoptiles bioassay.

Projects: Students are required to perform at least one long-duration experiment as project (a suggestive list of experiments will be provided).

SUGGESTED READINGS

1. Hopkins, W.G. and Huner, P.A. 2008 Introduction to Plant Physiology. John Wiley and Sons.
2. Nelson, D.L., Cox, M.M. 2004 Lehninger Principles of Biochemistry, 4th edition, W.H. Freeman and Company, New York, USA.
3. Salisbury, F.B. and Ross, C.W. 1991 Plant Physiology, Wadsworth Publishing Co. Ltd.
4. Taiz, L. and Zeiger, E. 2006 Plant Physiology, 4th edition, Sinauer Associates Inc .MA, USA

Paper 19a-BTHT 509: ENVIRONMENTAL MANAGEMENT

THEORY **Marks: 100**

Unit 1: Introduction: **(Ch 1,2 Miller) (4 Periods)**

Man as a biological species in the ecosystem; population increase; carrying capacity, exploitation of resources due to activities like agriculture, horticulture, urbanization and industrialization.

Unit 2: Public awareness of Environment issues:

(State of the World 2003, 2006, 2009) (5 Periods)

Role of Government, NGO's, International organizations, treaties and conventions. Environmental movements.

Unit 3: Natural resources: **(4 Periods)**

Land, Water, Air, Bioresources and biodiversity.

Unit 4: Effect of human activities: **(Singh et al., MoEF Annual report, 2009) (14 Periods)**

Depletion of resources; Generation of waste; types (agricultural, municipal, industrial); management of wastes and disposal (emphasis on concepts of reduce, reuse and recycle); Pollution of air, water, soil, noise, and due to radioactive substances; causes and methods of prevention and control; Eutrophication; bioremediation; Depletion of forests; threats to biodiversity, extinction of species.

Unit 5: Sustainable Development: **(Miller) (5 Periods)**

Definition; Brundlandt Report; Threats to sustainable development, green technologies, eco-cities, Ecological footprint, National Environmental Policy.

Unit 6: Energy: **(6 Periods)**

Conventional Fuel – wood, fossil fuels; Non-conventional or alternate sources - sun, wind, bio-energy, geothermal, ocean, hydrogen, nuclear.

Unit 7: Conservation of resources **(Singh et al., Sinha, Ghosh and Singh) (10 Periods)**

Soil – Contour farming, afforestation and reforestation; Water – Rainwater harvesting, aquifers , groundwater recharge, watershed management; Biodiversity – In-situ conservation (Sanctuaries, National Parks, Biosphere Reserves, World Heritage Sites), Project Tiger and other conservation efforts. social forestry and Joint forestry Management; ex-situ conservation (botanical gardens, gene banks, cryopreservation); role of organizations like NBPGR, BSI, ZSI, WWF, IUCN and conventions like Convention on Biological diversity; Ramsar Convention, National Action Plan on Conservation of Biodiversity; Environmental laws and acts.

Unit 8: Global environment change:

(Miller, IPCC Report 2007, State of the World 2009) (8 Periods)

Greenhouse effect and global warming; climate change; shrinking of glaciers and polar ice caps and consequent effects on river and sea levels; ozone layer depletion; vegetation and biota; international efforts to control these effects (Vienna Convention, Montreal Protocol, UNFCCC, Kyoto Protocol, Copenhagen Summit, etc.); IPCC; Biosafety of GMOs and LMOs

Unit 9: Environmental impact assessment **(2 Periods)**

Concept, aim and steps.

BTHP 509: ENVIRONMENTAL MANAGEMENT

PRACTICALS **Marks: 50**

Student would be required to submit a detailed project report based on the practical work on any topic mentioned in the theory paper. Evaluation of the project will be based on the detailed report and presentation.

SUGGESTED READINGS

1. Joseph, B., Environmental studies, Tata Mc Graw Hill.
2. Mohapatra Textbook of environmental biotechnology IK publication.
3. Thakur, I S, Environmental Biotechnology, I K Publication.
4. Divan Rosencraz, Environmental laws and policies in India, Oxford Publication.
5. Michael Allabay, Basics of environmental science, Routledge Press.
6. Rana SVS, Environmenta lpollution – health and toxicology, Narosa Publication.
7. Miller, G.T. 2002. Sustaining the earth, an integrated approach. (5^{th} edition) Books/Cole, Thompson Learning, Inc.
8. Chapman, J.L., Reiss, M.J. 1999. Ecology: Principles and applications (2^{nd} edition) Cambridge University Press.
9. Ghosh, S.K., Singh, R. 2003. Social forestry and forest management. Global Vision Publishing House.
10. Sinha, S. 2010. Handbook on Wildlife Law Enforsement in India. TRAFFIC, India.

Paper 19b- LSPT 409: BIOINFORMATICS

THEORY **Marks: 100**

Unit 1. Introduction to Bioinformatics **(Ch 1 Ghosh and Mallick / Ch 1 Pevsner)**
(5 Periods)

Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics.

Unit 2. Databases in Bioinformatics **(Ch 3 Ghosh and Mallick / Ch 2 Pevsner)**
(5 Periods)

Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System.

Unit 3. Biological Sequence Databases **(Ch 4 Ghosh and Mallick / Ch 4, 5 Pevsner)**
(25 Periods)

National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database.

EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools.

DNA Data Bank of Japan (DDBJ): Introduction, Resources at DDBJ, Data Submission at DDBJ.

Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR.

Swiss-Prot: Introduction and Salient Features.

Unit 4. Sequence Alignments **(Ch 6, 8 Ghosh and Mallick / Ch 6 Pevsner)**
(10 Periods)

Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).

Unit 5. Molecular Phylogeny **(Ch 8 Ghosh and Mallick / Ch 7 Pevsner)**
(8 Periods)

Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.

Unit 6. Applications of Bioinformatics **(Ch 11 Ghosh & Mallick / Ch 20 Pevsner)**
(7 Periods)

Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.

LSPP 409: BIOINFORMATICS

PRACTICALS **Marks: 50**

1. Nucleic acid and protein databases.
2. Sequence retrieval from databases.
3. Sequence alignment.
4. Sequence homology and Gene annotation.
5. Construction of phylogenetic tree.

SUGGESTED BOOKS

1. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
3. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.

Paper 20-GGHT 501: GENETICS AND GENOMICS-I

THEORY **Marks: 100**

Unit 1. Introduction to Genetics (Ch 1 Klug and Cummings)

Mendel's work on transmission of traits, Genetic Variation, Molecular basis of Genetic Information.

Unit 2. Mitosis and Meiosis (Ch 2 Klug and Cummings)

Interrelation between the cell structure and the genetics function, Mitosis, Meiosis (explaining Mendel's ratios).

Unit 3. Mendelian Genetics and its Extension (Ch 3-4 Klug and Cummings)

Principles of Inheritance, Chromosome theory of inheritance, Laws of Probability, Pedigree analysis Incomplete dominance and codominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Environmental effects on phenotypic expression, sex linked inheritance.

Unit 4. Linkage, Crossing Over and Chromosomal Mapping (Ch 5 Klug and Cummings, Ch 7, Gardner)

Linkage and crossing over, Cytological basis of crossing over, Molecular mechanism of crossing over, Recombination frequency as a measure of linkage intensity, two factor and three factor crosses, Interference and coincidence, Somatic cell genetics – an alternative approach to gene mapping.

Unit 5. Mutations (Ch 8 Klug and Cummings/ Ch 11 Gardner)

Chromosomal Mutations: Deletion, Duplication, Inversion, Translocation, Aneuploidy and Polyploidy; Gene mutations: Induced versus Spontaneous mutations, Back versus Suppressor mutations, Molecular basis of Mutations in relation to UV light and chemical mutagens, Detection of mutations: CLB method, Attached X method, DNA repair mechanisms.

Unit 6. Sex Determination (Ch 7 Klug and Cummings)

Chromosomal mechanisms, Environmental factors effecting sex determination, Barr bodies, Dosage compensation.

Unit 7. Extrachromosomal Inheritance (Ch 9 Klug and Cummings/ Ch 20 Gardner)

Chloroplast mutation/Variegation in Four o' clock plant and *Chlymodomonas,* Mitochondrial mutations in *Neurospora* and yeast, Maternal effects, Infective heredity- Kappa particles in *Paramecium.*

Unit 8. Quantitative Genetics (Ch 25 Klug and Cummings/ Ch 21, Gardner)

Quantitative and multifactor inheritance, Transgressive variations, Heterosis.

GGHP 501: GENETICS AND GENOMICS-I

PRACTICALS **Marks: 50**

1. Mendelian laws and gene interaction using *Drosophila* crosses.
2. Chi-square and probability.
3. Study of Linkage, recombination, gene mapping using marker based data from *Drosophila*.
4. Study of Human and *Phlox/ Allium* Karyotype (normal and abnormal).
5. Pedigree analysis of some human inherited traits.
6. Study of Hardy-Weinberg Law using simulations (seeds).

SUGGESTED BOOKS

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). VIII ed. Principles of Genetics. Wiley India.
2. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. XI Edition. Benjamin Cummings.
4. Russell, P. J. (2009). *i*Genetics- A Molecular Approach. III Edition. Benjamin Cummings.
5. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
6. Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition. John Wiley & Sons.
7. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. IX Edition. Introduction to Genetic Analysis. W. H. Freeman and Co.

ADDITIONAL READINGS

Both students as well as teachers of genetics can further benefit from knowledge of following topics as given below-

- **Epigenetics-** http://www.nature.com/nrg/focus/epigenetics/index.html
- **Tetrad Analysis in fungi**
- **Centromere Mapping**
- **Cytogenetic Mapping**

Paper 21- BTHT 610: PLANT METABOLISM AND BIOCHEMISTRY

THEORY **Marks: 100**

Unit 1: Enzymes (Ch 9 Salisbury & Ross, Ch 6 Nelson & Cox) (6 Periods)

Historical background, classification, nomenclature and importance of enzymes; role of enzymes as catalysts; physiochemical and biological properties; concept of holoenzymes; coenzyme; apoenzyme and prosthetic groups; mechanism and kinetics of enzyme action; enzyme inhibitors; isoenzymes; allosteric enzymes; industrial aspects of enzymology.

Unit 2: Carbon Assimilation (Ch 6 Hopkins & Huner, Ch 11 Salisbury & Ross) (10 Periods)

Role of chlorophylls and accessory pigments; antennae molecules and active center molecules; evidences for two photosystems; reduction of NADP; photophosphorylation; reduction of CO_2 into glucose; Benson and Calvin cycle; Hatch and Slack pathway; Crassulacean acid metabolism; energetics of CO_2 reduction; factors affecting CO_2 reduction.

Unit 3: Carbohydrate Metabolism (Ch 7 Nelson & Cox, Ch 13 Buchanan et al.) (6 Periods)

Structure, properties and importance of mono-, di- and polysaccharides; Synthesis of di - (sucrose) and polysaccharides (starch and cellulose).

Unit 4: Carbon Oxidation: (Ch 10 Hopkins & Huner, Ch 11 Salisbury & Ross) (10 Periods)

Glycolysis, anaerobic conversion of pyruvate into ethanol or lactate, energy balance, reversibility and inhibition of glycolysis, Pasteur effect, oxidative decarboxylation of pyruvate into acetyl CoA, TCA cycle, oxidative phosphorylation, oxidation of RuBP (photorespiration), factors affecting oxidative processes, regulation of TCA cycle, role of glyoxalate cycle.

Unit 5: Nitrogen and Protein Metabolism (Ch 3,4, 22 Nelson & Cox, Ch 4 Elliott) (8 Periods)

Biological nitrogen fixation and nitrogen cycle, Catabolism of amino acids, ammonia assimilation, transamination, deanimation, structure and general properties of amino acids and proteins (protein folding).

Unit 6: Lipid Metabolism (7 Periods)

Structure, properties, classification and functional significance of fatty acids, triglycerides and steroids; Synthesis and breakdown, formation of glycerides; oxidation of fatty acids, beta oxidation; energy balance. **(Ch 10 Buchanan et al, Ch 10, 21 Nelson & Cox)**

Unit 7: Intermediary Metabolism (Ch 15 Nelson & Cox), (Ch 11,12,13 Elliott) (4 Periods)

Interrelationship of carbohydrates, lipids and protein metabolism.

Unit 8: Regulation of Metabolism (Ch 6, 18 Nelson & Cox) (4 Periods)

Nature of integrated metabolism, role of acetyl CoA, control at the level of transcription and translation, control of enzyme action.

Unit 9: Secondary Metabolites and Plant Defense (Ch27 Hopkins & Huner) (5 Periods)

Introduction to alkaloids, phenolics, plant terpenes, phytoalexins, sesquiterpenes and sterols.

BTHP 610: PLANT METABOLISM AND BIOCHEMISTRY

PRACTICALS **Marks: 50**

1. Detection of the presence of plant enzymes amylase, catalase, nitrate reductase urease (*in vivo*)] in various sources.
2. To study properties (thermolability, proteinaceous nature and specificity) of any one of the enzymes (catalase/urease).
3. To study the effect of various factors (concentration, temperature, pH, inhibitor) on the activity of catalase enzyme.
4. Demonstration of dye reduction by isolated chloroplasts.
5. Study the effect of different factors on O_2 evolution during photosynthesis and demonstrate the Law of limiting factors.
6. Chemical separation of chloroplast pigments and determination of their absorption spectra.
7. To extract anthocyanin pigments and study the effect of pH on their absorption spectra.
8. Study of the rate of aerobic respiration and respiratory quotient in different plant parts/materials.
9. Identification tests for carbohydrates (Fehling's test, Benedicts test) and proteins (Ninhydrin test, Xanthoproteic test).
10. Preparation of standard curve for estimation of proteins and determination of total proteins in plant tissue extracts for example of control and GA_3 treated embryo-less wheat grains.
11. Separation and identification of amino acids by thin layer chromatography.

SUGGESTED READINGS

1. Conn, E.E., Stumpf, P.K. and Bruening, G. (2006) Outlines of Biochemistry, 4th Edition, John Wiley and Sons Inc.
2. Buchanan, B., Gruissem, W. and Jones, R. (2000) Biochemistry and Molecular Biology of Plants. American Society of Plant Biologists.
3. Elliot (2009) Biochemistry and Molecular Biology. Oxford Publishers.
4. Nelson, D.L., Cox, M.M. (2004) Lehninger Principles of Biochemistry, 4th Edition, WH Freeman and Company, New York, USA.
5. Taiz, L. and Zeiger, E. (2006) Plant Physiology, 4th Edition Sinauer Associates Inc. Publishers, Massachusetts, USA
6. Dennis, D.T., Layzell, D.B., Lefebre, D.D. and Turpin, D.H. (1997) Plant Metabolism. Addison Wesley Longman.
7. Hopkins, W.G. and Huner, P.A. (2008) Introduction to Plant Physiology. John Wiley and Sons.
8. Kaul RP (2009) Plant Metabolism. Swastik Publishers and Distributors.
9. Salisbury, F.B. and Ross, C.W. (1991) Plant Physiology, Wadsworth Publishing Co. Ltd.

Paper 22-BTHT 611: REPRODUCTIVE BIOLOGY OF ANGIOSPERMS

THEORY **Marks: 100**

Unit 1: Introduction **(Ch 1 Bhojwani & Bhatnagar) (3 Period)**

History and scope.

Unit 2: Anther **(Ch1 Shivanna) (5 Periods)**

Structure, ontogeny; tapetum; structure and functions; micro-sporogenesis; callose deposition and its significance.

Unit 3: Pollen Biology **(8 Periods)**

Microgametogenesis, pollen wall development, MGU (male germ unit) structure, NPC system, pollen wall proteins; pollen viability, storage and germination; pollen tube structure. **(Shivanna, Ch 2-4)**

Unit 4: Ovule **(8 Periods)**

Structure, ontogeny, types; special structures – endothelium, operculum, obturator, aril, arillode, caruncle, hypostase, epistase: female gametophyte – megasporogenesis and megagametogenesis: organization and ultrastructure of mature embryo sac. **(Ch 7 Bhojwani & Bhatnagar)**

Unit 5: Pollination and Fertilization **(8 Periods)**

Pollination types and significance; adaptations; pollination biology; pollen-pistil Interaction; structure of stigma and style; double fertilization. **(Ch 9,11 Raghavan)**

Unit 6: Self Incompatibility **(6 Periods)**

Basic concepts; methods to overcome self incompatibility. **(Ch 9 Shivanna, Ch Raghavan)**

Unit 7: Endosperm **(7 Periods)**

Types, development and functions; endosperm haustoria. **(Ch 11 Bhojwani & Bhatnagar)**

Unit 8: Embryogenesis **(6 Periods)**

Classification, development, organization and differentiation of crucifer and Najas embryo; embryo – endosperm relationship; physiological and genetical control. **(Raghavan)**

Units 9: Polyembryony and Apomixis **(7 periods)**

Introduction; classification; causes and applications. **(Ch 13,14 Bhojwani &Bhatnagar)**

BTHP 611: REPRODUCTIVE BIOLOGY OF ANGIOSPERMS

PRACTICALS **Marks: 50**

1. Photographs of eminent embryologists.
2. Anther: wall and its ontogeny; tapetum; microsporogenesis, stages; psuedomonads, massulae (slides and fresh material).
3. Pollen grains: fresh and acetolysed, ornamentation and aperture; pollen viability: tetrazolium test.
4. Pollen germination: in different media; calculation of percentage germination; male germ unit (MGU): through photographs.
5. Ovule: types; unitegmic, bitegmic; tenuinucellate and crassinucellate; special structures-endothelium, operculum, obturator, hypostase and epistase; caruncle and aril (permanent slides/ specimens/photographs).
6. Female gametophyte through permanent slides/ photographs: types and ultrastructure of mature embryo sac.
7. Style and stigma through suitable preparations: unpollinated and pollinated stigma and style; wet and dry stigma; hollow and solid styles; tracing and path of pollen tube.
8. Intra-ovarian pollination; test tube pollination/ fertilization: through photographs.
9. Endosperm: dissections of developing seeds for free-nuclear endosperm with haustoria; types (permanent slides).
10. Embryogenesis: study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; study of suspensor through electron micrographs.

SUGGESTED READINGS

1. Raghavan, V. 2000 Developmental Biology of Flowering plants, Springer, Netherlands.
2. Raghavan, V. 1997 Molecular embryology of flowering plants. Cambridge, University Press.
3. Shivanna, K.R. 2003 Pollen Biology and Biotechnology, Science Publishers.
4. Bhojwani, S.S. and Bhatnagar SP 2004 The Embryology of Angiosperms, Vikas Publishing House
5. Johri, B.M. l;1984 Embryology of Angiosperms, Springer-Verlag, Netherlands.

Paper 23-BTHT 612: PLANT BIOTECHNOLOGY

THEORY **Marks: 100**

Unit 1: Plant Tissue Culture (Ch 1, 3, 5-7,12, 17, 18 Bhojwani & Razdan) (12 Periods)

Historical perspective; composition of media; nutrient and hormone requirement; totipotency; organization; physic-chemical conditions for propagation of plant cells and tissues; somatic embryogenesis; protoplast isolation culture and fusion; cybrids micropropogation; androgenesis. Tissue Culture Applications

Unit 2: **Tools and Techniques of Genetic Engineering**

(Brown, Sambrook & Russel- "Introduction" section of relevant chapters) (12 periods)

Restriction Endonucleases (history, types and role); Gel Electrophoresis; PCR; Restriction Mapping; DNA Sequencing (Sanger's method); Southern, Northern and Western blotting; construction of genomic library; DNA Fingerprinting (RAPD, RFLP); FISH.

Unit 3: Plant Transformation Technology (Ch 3, 4 Slater et al.; Ch 10 Raven) (12 periods)

Obtaining gene of interest by different methods; Gene constructs; Gene transfer – prokaryotic and eukaryotic vectors; *Agrobacterium*-mediated transformation; Direct gene transfer methods– Electroporation, Microinjection, Gene-gun; Selection of transgenics - marker and reporter genes.

Unit 4: Role of Plant Biotechnology in Agriculture, Environment and Industry

(Ch 7 Chrispeel & Sadava, Ch 10 Raven) (18 periods)

Pest resistant plants (Bt-cotton); herbicide resistance; disease and stress resistant plants; transgenic crops with improved quality traits (Flavr savr tomatoes, Golden rice); Role of transgenics in degradation of pollutants (Superbug) leaching out of minerals; Application of plant biotechnology for production of quality oil, industrial enzymes, edible vaccines and planti-bodies.

BTHP 612: PLANT BIOTECHNOLOGY

PRACTICALS **Marks: 50**

1. Preparation of media MS (1962), Nistch (1969) and White's medium
2. Aseptic culture of different explants, methods of *in vitro* sterilization, inoculation and subculture methods
3. Construction of Restriction Map from the data provided.
4. Study of Genetic engineering Techniques (photographs): FISH , DNA Fingerprinting, DNA Sequencing , Gene gun, Ti plasmid.
5. Calculation of percentage similarity between different cultivars of a species using RAPD profile (by binary method) and study of Dendrogram.
6. Demonstration of Southern, Northern and Western Blotting
7. Study of steps of genetic engineering techniques from photographs (Bt cotton, Golden rice, Flavr savr tomatoes)

SUGGESTED READINGS

1. Slater, A., Scott, N.W. & Fowler, M.R. 2008 Plant Biotechnology: The Genetic Manipulation of Plants, Oxford University Press.
2. Bhojwani, S.S. and Razdan 2004 Plant Tissue Culture and Practice.
3. Chrispeel, M.J. and Sadava, D.E. 1994 Plants, Genes and Agriculture. Jones and Barlett Publishers.
4. Reinert, J. and Bajaj, Y.P.S. 1997 Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture. Narosa Publishing House.
5. Smith, R. 2000 Plant Tissue Culture: Techniques and Experiments, 2nd edition, Academic
6. Gardner, E.J. Simmonns, M.J. Snustad, D.P. 2008 8th edition Principles of Genetics. Wiley India.
7. Russell, P.J. 2009 Genetics – A Molecular Approach. 3rd edition. Benjamin Co.
8. Raven, P.H., Johnson, GB., Losos, J.B. and Singer, S.R. 2005 Biology. Tata MC Graw Hill.
9. Brown, T. A. Gene cloning and DNA analysis: An Introduction. Blackwell Publication.
10. Sambrook & Russel. Molecular Cloning: A laboratory manual. (3rd edition)

Paper 24- GGHT 602: GENETICS AND GENOMICS II

THEORY **Marks: 100**

Unit 1. Genetic Analysis and Mapping in Bacteria and Bacteriophages (Ch 6, Klug and Cummings/ Ch 5, Griffith *et al.*)

Conjugation; Transformation; Transduction, Recombination.

Unit 2. Genome Dynamics-Transposable genetic elements, Eukaryotic Viruses (Ch 22, Klug and Cummings/ Ch 14, Griffith *et al.*)

Prokaryotic transposable elements- IS elements, Composite transposons, Tn-3 elements; Eukaryotic transposable elements- Ac-Ds system in maize and P elements in *Drosophila*; Uses of transposons; Eukaryotic Viruses.

Unit 3. Developmental Genetics and Model System (Ch 19, Klug and Cummings*)*

Study of model systems in developmental genetics- *Drosophila melanogaster Sachharomyces cerevisiae, Caenorhabditis elegans, Arabidopsis thaliana,* and *Xenopus laevis*.

Unit 4. Genomics, Bioinformatics and Proteomics (Ch 21, Klug and Cummings/Ch 8-9, Russell/ Ch2, 3, 4 Ghosh, Z. and Mallick,V.)

Genomes of bacteria, *Drosophila* and Humans*;* Human genome project; Evolution and Comparative Genomics.

Introduction to Bioinformatics, Gene and protein databases; Sequence similarity and alignment; Gene feature identification.

Gene Annotation and analysis of transcription and translation; Post-translational analysis- Protein interaction.

Unit 5. Genomic Analysis- Dissection of Gene Function (Ch 23, Klug and Cummings)

Genetic analysis using mutations, forward genetics, genomics, reverse genetics, RNAi, functional genomics and system biology.

Unit 6. Population Genetics (Ch 27, Klug and Cummings)

Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift.

Unit 7. Evolutionary Genetics (Ch 28, Klug and Cummings)

Genetic variation and Speciation.

GGHP 602: GENETICS AND GENOMICS II

PRACTICALS **Marks: 50**

1. Genomic DNA isolation from *E.coli* (without plasmid*)*.
2. Restriction enzyme digestion of genomic DNA from *E.coli*.
3. Isolation of plasmid DNA and genomic DNA together from *E.coli*. and restriction enzyme digestion.
4. Restriction enzyme digestion (*EcoR*I) of genomic and plasmid DNA (obtained from Expt.3).
5. Estimation of size of a DNA fragment after electrophoresis using DNA markers.
6. Construction of Restriction digestion maps from data provided.
7. Demonstration of DNA fingerprinting.

SUGGESTED BOOKS

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. 2006 Principles of Genetics. 8th edition John Wiley & Sons.
2. Snustad, D.P., Simmons, M.J. 2009 Principles of Genetics. 5th edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. 2009 Concepts of Genetics. 9th Edition. Benjamin Cummings.
4. Russell, P. J. 2009 Genetics- A Molecular Approach. 3rd edition. Benjamin Cummings.
5. Glick, B.R., Pasternak, J.J. 2003 Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
6. Pevsner, J. 2009 Bioinformatics and Functional Genomics. 2nd edition. John Wiley & Sons.
7. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. 9th Edition. Introduction to Genetic Analysis.
8. Ghosh, Z. and Mallick,V. 2008 Bioinformatics-Principles and Applications. Oxford Univ. Press

SEMESTER SYSTEM AT THE UNDERGRADUATE LEVEL

Course of Study **B.Sc (Honours) Botany** **Total number of papers: 24**

Semester I

- Paper 1 — Biology-I (Introduction to Biology) — **LSPT - 101**
- Paper 2 — Biodiversity-I Algae & Microbiology — **BTHT - 101**
- Paper 3 — Chemistry-I — **CHCT - 301**
- Paper4 — Technical writing & Communication in English/Computational Skills — **ENAT-101/ CSAT - 101**

Semester II

- Paper 5 — Biodiversity- II Mycology & Phytopathology — **BTHT - 202**
- Paper 6 — Biodiversity-III Archegoniatae — **BTHT - 203**
- Paper 7 — Chemistry-II — **CHCT - 402**
- Paper 8 — Technical writing & Communication in English/Computational Skills — **ENAT-201/ CSAT - 201**

Semester III

- Paper 9 — Plant Resource Utilization — **BTHT - 304**
- Paper 10 — Mathematics and Statistics — **MACT - 303**
- Paper 11 — CELL BIOLOGY I — **CBHT - 301**
- Paper 12 — MOLECULAR BIOLOGY I — **MBHT - 301**

Semester IV

- Paper 13 — Plant Development & Anatomy — **BTHT-405**
- Paper 14 — Plant Ecology & Phytogeography — **BTHT -406**
- Paper 15 — CELL BIOLOGY II — **CBHT - 402**
- Paper 16 — MOLECULAR BIOLOGY-II — **MBHT-402**

Semester V

- Paper 17 — Plant Systematics and Evolution — **BTHT-507**
- Paper 18 — Plant Physiology — **BTHT-508**
- Paper 19 — Environmental Management/ Bioinformatics — **BTHT-509/ LSPT-409**
- Paper 20 — GENETICS & GENOMICS-I — **GGHT-501**

Semester V

- Paper 21 — Plant Metabolism & Biochemistry — **BTHT-610**
- Paper 22 — Reproductive Biology of Angiosperms — **BTHT-611**
- Paper 23 — Plant Biotechnology — **BTHT-612**
- Paper 24 — GENETICS & GENOMICS-II — **GGHT-602**