Learning Outcomes Based Curriculum Framework (LOCF)

For

M.Sc. (Botany)

First Year: PG Diploma in Botany
Second Year: M.Sc Botany

Department of Bio and Nano Technology

Guru Jambheshwar University of Science and Technology, Hisar 125001

2023-24

GURU JAMBHESHWAR UNIVERSITY OF SCIENCE AND TECHNOLOGY, HISAR

Scheme of Examination for M.Sc. Botany (Semester System) as per NEP-2020 to be Implemented w.e.f. session 2023-24

Sr. No.	Course Code	Course Type	Course Title	Credits	L+T+P	Total Marks (T+IA)
Semester I						
1.	BOL-101	CC 1	Biology and Diversity of Viruses, Bacteria and Fungi	4	4+0+0	70+30
2.	BOL-102	CC 2	Biology and Diversity of Algae & Bryophytes	4	4+0+0	70+30
3.	BOL-103	CC 3	Physiology and Biochemistry	4	4+0+0	70+30
4.	BOL-104	SEC 1	Biochemical and Biophysical Techniques	4	4+0+0	70+30
5.	BOP-101	CC 4	Lab – I (Biology and Diversity of Viruses, Bacteria and Fungi, Biology and Diversity of Algae & Bryophytes)	3	0+0+3	70+30
6.	BOP-102	CC 5	Lab – II (Physiology and Biochemistry)	3	0+0+3	70+30
7.	BOP-103	SEC 2	Lab – III (Biochemical and Biophysical Techniques)	3	0+0+3	70+30
8.	OES-1	OP 1	Open Elective	4	4+0+0	70+30
Total				**29**	**20+9**	**800**
Semester II						
1.	BOL-201	CC 6	Biology and Diversity of Pteridophytes & Gymnosperms	4	4+0+0	70+30
2.	BOL-202	CC 7	Cytogenetics	4	4+0+0	70+30
3.	BOL-203	CC 8	Molecular Biology	4	4+0+0	70+30
4.	BOL-204	DSC 1A	Principles of Plant Pathology	4	4+0+0	70+30
		DSC 1B	Cell and Developmental Biology			
		DSC 1C	MOOC			
5.	BOP-201	CC 9	Lab – IV (Pteridophytes, Gymnosperms & Cytogenetics))	3	0+0+3	70+30
6.	BOP-202	CC 10	Lab – V (Molecular Biology)	3	0+0+3	70+30
7.	BOP-203	DSC 2A	Lab – VI (Plant Pathology)	3	0+0+3	70+30
		DSC 2B	Lab – VI (Cell & Development Biology)			
8.	BOT-205	SEC 3	Summer Training (4-6 weeks)* (Field Visit/ Survey/ In-house Training/ Industrial Training)	4	0+4+0	70+30
Total				**25+4***	**16+4+9**	**700+100*= 800**

Semester III						
1.	BOL-301	CC 11	Plant Systematics & Biology of Reproduction	4	4+0+0	70+30
2.	BOL-302	CC 12	Plant Diversity	4	4+0+0	70+30
3.	BOL-303	CC 13	Plant Tissue Culture	4	4+0+0	70+30
4.	BOL-304	SEC 4	Biostatistics & Bioinformatics	4	4+0+0	70+30
5.	BOP-301	CC 14	Lab – VII (Plant Systematics & Biology of Reproduction)	3	0+0+3	70+30
6.	BOP-302	CC 15	Lab – VIII Plant Diversity/Plant Tissue Culture)	3	0+0+3	70+30
7.	BOP-303	SEC 5	Lab – IX (Biostatistics & Bioinformatics)	3	0+0+3	70+30
Total				**25**	**16+9**	**700**
Semester IV						
1.	BOL-401	CC 16	Plant Ecology: Principles and Concepts	4	4+0+0	70+30
2.	BOL-402	CC 17	Plant Biotechnology	4	4+0+0	70+30
3.	BOL-403	CC 18	Cardinal Principles of Academic Integrity and Research Ethics	4	4+0+0	70+30
4.	BOL-404	DSC 3A	Plant Growth and Development	4	4+0+0	70+30
		DSC 3B	Genomics			
		DSC 3C	Algae, Environment and Human Welfare			
5.	BOP-401	CC 19	Lab – X (Plant Ecology/Plant Biotechnology)	3	0+0+3	70+30
6.	BOP-402	DSC 4A	Lab – XI (Plant Growth & Development)	3	0+0+3	70+30
		DSC 4B	Lab – XI (Genomics)			
		DSC 4C	Lab – XI (Algae, Environment and Human Welfare))			
7.	BOS-410	CC 20	Credit Seminar**	2	0+2+0	50
8	BOD-411	CC 21	Project Work***	4	0+4+0	100
Total				**28**	**16+6+6**	**750**
					Grand Total= 2950+100*	

***Note: Students willing to exit the programme after second semester have to undertake the Internship/summer training**

****Evaluation will be done by a committee constituted by Chairperson**

*****Evaluation will be done by External Examiner**

Distribution of Total Credits

Name of M.Sc. Programme	Core Course (CC)	Discipline Specific Elective Course (DSC)	Skill Enhancement Course (SEC)	Open Elective (OP1)	Total Credits
Botany	**75**	**14**	**14+4***	**4**	**107+4***

Core Course-1

BOL-101: Biology and Diversity of Virus, Bacteria and Fungi

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: The aim of this course is to give the students essential knowledge pertaining to the enormous diversity that Virus, Bacteria and fungi exhibit and equip them with the understanding of their structure and biology.

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	Acquire knowledge about virus structure, steps in virus infection and role of phytoplasma in causing plant diseases.
CO2	Describe the morphological features, cell arrangement and structural components of bacterial cell in detail; will be able to differentiate between Gram-positive andGram-negative bacteria.
CO3	Enlist the characteristics of Archaea that differentiate it from Eubacteria.
CO4	Demonstrate an understanding of various fungal groups, their classification, characteristics, reproduction and economic importance.

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Viruses: Characteristics and ultrastructure of virions, Isolation and Purification, Chemical nature, Replication, Transmission and economic importance of viruses.

Phytoplasma: General characteristics and role in causing plant diseases.

UNIT- II

Archaebacteria and eubacteria: General account, Ultrastructure, nutrition and reproduction, Economic importance.

Cyanobacteria: Salient features and biological importance.

UNIT-III

A general account of fungi, their structure including ultrastructure of cell wall, majorgrowth forms and differentiation. Fungal nutrition (saprobic, biotrophic and symbiotic).

Classification of fungi by Kirk et.al (2008) - phylogeny of fungi - characters used inclassification.

General account of Chytridiomycota, Zygomycota, Glomeromycota, Ascomycota,Basidiomycota and Mitosporic fungi.

UNIT-IV

Heterokaryosis, homothallism, heterothallism, parasexuality, sex hormones, mycorrhizae and

predaceous fungi.

Lichens: Structure, Reproduction and Economic importance.

Importance of fungi in different microbiological and Biotechnological processes: role of fungi in industry (alcohol), medicine (Antibiotics and steroids) and food (edible mushrooms).

Suggested Readings:

1. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 1996. *Introductory Mycology*, JohnWiley and Sons, New York.
2. Brock, Madigan, M.T., Martinko, J.M. and Parker, J. 2015. *Biology of Microorganisms.* (14th Edition), Prentice Hall, New Jersey.
3. Deacon, J.W. 2013, *Fungal Biology*, John Wiley and Sons.
4. Sumbali, G., 2018, The Fungi (Second Edition), Alpha Science International Ltd.
5. Kirk, P.M., Canon, P.F., Minter, D.W. and Stalpers, J.A. Dictionary of the Fungi (10thEdition), CAB International, U.K, 2008.
6. Mandahar, C. L. 1978. *Introduction to Plant Viruses*. S. Chand & Co. Ltd., Delhi.
7. Mehrotra, R.S. &Aneja, K.R., 2015. *An Introduction of Mycology*, New AgeInternational Press, New Delhi.
8. Prescott, I.M., Harley, J.P.2013, *Microbiology* (9th Revised Edition), Tata McGraw Hill,USA.

Core Course-2

BOL-102: Biology and Diversity of Algae and Bryophytes

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: The aim of this course is to give the students essential knowledgepertaining to the enormous diversity that Algae and Bryophytes exhibit and equip them with the understanding of their structure and biology.

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	Demonstrate An Understanding of various algal groups, their classification, characteristics.
CO2	Acquire knowledge about the strategies for the evolution of sex of algae and economic importance of algae.
CO3	Describe characteristic features of bryophytes and their classification; will be able to learn about the strategies for the evolution of land habit of bryophytes.
CO4	Gain knowledge about the *in vitro* reproduction of bryophytes and their economic importance.

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Algal classification: Criteria for algal classification (pigments, reserve food, flagella, chloroplasts, pyrenoids, eye spots, endoplasmic reticular membrane etc.); Comparative account of important systems of classification (Fritsch, Round, Chapmann and Lee).

Salient features of algae: Cell Structure, thallus organization, reproduction and broad classification of i) Chlorophyta ii) Phaeophyta iii) Cryptophyta and iv) Rhodophyta

UNIT-II

Reproduction in algae: Vegetative, asexual and sexual reproduction; origin andevolution of sex; life cycles.

Rhythms and bioluminescence in dinoflagellates.

Economic importance of algae: Algal biofertilizers, Algal blooms, Algae as food andfeed, uses in industries; Algae in biotechnology.

UNIT-III

General characteristics and classification: General characteristic feature of bryophytes and their classification up to order level.

Salient feature of bryophytes: General account of structure and development of gametophyte and

sporophyte of following orders: Sphagnales, Andreaeales, Takakiales, Funariales (*Funaria*, *Physcomitrium*)) and Polytrichales (*Polytrichum*).
Origin and evolution of sporophytes in bryophytes, Cytology of bryophytes, Chromosomenumber, sex chromosome, m chromosomes, accessory chromosomes.

UNIT-IV

Biology of reproduction: *in vitro* regulation of gametangia formation, effect of chemical and physical factors, Morphogenetic studies on spore germination, protonemal differentiation and bud initiation.
Economic importance of bryophytes: Medicinal uses of Bryophytes especially as a source of biologically active compounds, Ecological importance of Bryophytes, Bryophytes as a source of biologically active compounds, Role of Brypophytes in Succession.

Suggested Readings:

1. Ahluwalia, A.S., 2003, *Phycology: Principles, Processes and Applications*, Daya Publishing House, New Delhi.
2. Fritsch, F.E., 1979, *The Structure and Reproduction of Algae* (Vol. I & II), Vikas Publishing House Pvt. Ltd., New Delhi.
3. Goffinet, B. and Shaw, A.J. 2008, *Bryophyte Biology* (2nd Edn.), Cambridge University.Press, Cambridge.
4. Graham, L. E., Graham, J.M. and Wilcox, L.W. 2000, *Algae*, Prentice Hall, USA.
5. Kumar, H.D., 1999, *Introductory Phycology*, East West Press, New Delhi.
6. Lee, R. E., 2008, *Phycology*, Cambridge University Press, Cambridge, 2008.
7. Rashid, A. 1998, *An Introduction to Bryophyta.* Vikas Pub. House Pvt.Ltd., New Dehli.
8. Schofield, W.B. 1985, Introduction to Bryology, Macmillan, New York.
9. Vasishta, B. R. 1996, *Bryophyta*, S.Chand & Co. Ltd., New Delhi.

Core Course-3

BOL-103: Physiology and Biochemistry

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: The aim of this course is to give the students essential knowledge pertainingto plant physiology especially the water transport, absorption, photosynthesis, respiration and nitrogen metabolism.

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	Students will be taught about carbon fixing pathways, oxidative pathways.
CO2	Enhance knowledge of Students about nitrogen fixation and translocation of photosynthates
CO3	Structure and role of amino acids and proteins their biosynthesis and their modification into specific structure.
CO4	Will gain the knowledge on nucleic acids, their synthesis and regulation, fatty acids their types and synthesis.

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Photosynthesis: the four major complexes of thylakoids: path of carbon in photosynthesis(C_2, C_3 and CAM plants). Rubisco, structure and its association with the mechanism of carboxylation and oxygenation of RUBP. Effect of environmental factors on photosyntheticrates.

Respiration: Glycolysis, Krebs cycle, ETC and ATP synthesis, pentose phosphate pathway, glyoxylate cycle. Cyanide insensitive respiration: its mechanism and significance.

UNIT-II

Solute transport and photoassimilate translocation – uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem and phloem; transpiration; mechanisms of loading and unloading of photoassimilates.

Nitrogen Metabolism: Biological nitrogen fixation, nodule formation and nod factors, mechanism of nitrate uptake and reduction, ammonium assimilation; nitrogen transformation during plant development.

UNIT-III

Amino acids and Proteins: Classification, Structure types; Primary, Secondary, Tertiary and Quaternary structure of proteins; stability of protein structure; Classification of proteinsbased on composition, solubility function; Reverse turns and Ramachandran plot.

Enzymes: Nomenclature and Classification; Enzyme Kinetics; Mode and Mechanism of Enzyme Action,

Enzyme Regulation, Activators, Inhibitors and Isoenzymes, Allosteric enzymes.

UNIT-IV

Nucleic Acids: Structure and properties of nucleic acid bases, nucleosides and nucleotides. Biosynthesis and degradation of purines and pyrimidines, salvage pathway.

Lipid Metabolism: Structure of fatty acids, classification of lipids. Fatty acidsbiosynthesis, degradation and their regulation, Ketone bodies synthesis.

Suggested Readings:

1. Hopkins, W.G. and Hüner, N.P.A., 2009, *Introduction to Plant Physiology* (4th Ed.)Wiley & Sons. Inc. USA.
2. Buchanan, B., Gruissem, G. and Jones, R. (2000). Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA.
3. Davies P J. (2004). Plant Hormones: Biosynthesis, Signal Transduction, Action. 3rd Edition, Kluwer Academic Publisher, Dordrecht, The Netherlands.
4. Jordan, B.R. (2006). The Molecular Biology and Biotechnology of Flowering, 2nd Edition, CAB International, U.K
5. Nelson, D.L., and Cox, M.M. (2008). *Lehninger Principles of Biochemistry* (5th ed.). W.H.Freeman & Co., New York.
6. Taiz, L. and Zeiger, E. (2010) Plant Physiology. 5th Edition. Sinauer Associates, USA.
7. Heldt, H-W. and Piechulla, B. (2010). Plant Biochemistry, 4th Edition. Academic Press, NY.

Skill Enhancement Course-1

BOL-104: Biochemical and Biophysical Techniques

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: The aim of this course is to give the students essential knowledge pertainingto various tools and techniques used to gain insight into cell structure and biological processes.The focus is on studying the techniques used for isolation, purification and characterization ofbiomolecules.

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	Acquire in-depth knowledge of microscopic technology.
CO2	Understand the various methods used in separation, purification and quantification of biomolecules.
CO3	Intensive study of different structures of DNA, RNA and proteins by various techniques.
CO4	Develop ability and confidence of students by using advance techniques.

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Microscopic techniques: Introduction; Light microscope; Phase contrast microscope; Fluorescent microscope; Electron microscope (EM) – SEM, TEM and STEHM; Scanning probe microscopes-scanning tunneling microscope and atomic force microscope; Differentfixation and staining techniques.
Centrifugation: Principles of sedimentation; Types, care and safety aspects of centrifuges;Differential centrifugation; Density gradient centrifugation and their applications.

UNIT-II

Chromatographic techniques: Theory of chromatography; Types of chromatography- Paper chromatography, thin layer chromatography, Adsorption chromatography, Partition chromatography, Affinity chromatography, Ion exchange chromatography, HPLC and Size-exclusion chromatography.
Spectrophotometry: colorimetry; UV and Visible spectrophotometry.

UNIT-III

Electrophoresis: Principle; Agarose gel electrophoresis; Polyacrylamide gel electrophoresis; 2-Dimensional gel electrophoresis; Capillary electrophoresis; Microchip electrophoresis and Isoelectric focusing.
Mass spectrometry: Introduction; Theory; Mass spectrometer; Ionization of molecules; Mass analysers-MALDI; Detectors and Applications.

UNIT-IV

Immunotechniques: Antibody generation; Detection of molecules using ELISA, RIA, Immunoprecipitation and Immunofluorescence microscopy; Detection of molecules in living cells.

Radioisotope techniques: Radioactive isotopes; Nature of radioactivity; Detection and measurement of different types of radioisotopes normally used in biology; Incorporation ofradioisotopes in biological tissues and cells; Molecular imaging of radioactive material; Disposable of radioactive wastes and safety guidelines.

Suggested Readings:

1. Hegyi, G., Kardos, J., Kovacs, M., Csizmadia, A.M., Nyitray, L., Pal, G., Radnai, L., Remenyi, A.,Venekei, I., 2013,*Introduction to Practical Biochemistry*, Eotvos Lorand University, Hungary.
2. Plummer, D.T., 1990, *An Introduction to Practical Biochemistry*, Tata Mc-Graw-Hill Publishing Company Ltd., New Delhi.
3. Prescott, L., Harley, J., Klein, D., 2005, *Microbiology* (6th Ed) Mc Graw-Hill.
4. Ranade, R. and Deshmukh, S., 2013, *Handbook of Techniques in Biotechnology*, StudiumPress (India) Pvt. Ltd. New Delhi.
5. Sawhney, S.K. and Singh, R., 2000, *Introductory Practical Biochemistry* (Ed.), NarosaPublishing House Pvt. Ltd., New Delhi.
6. Wilson, K., and Walker, J., 2010, *Principles and Techniques of Biochemistry andMolecular Biology* (7th Ed.), Cambridge University Press, New Delhi.

Core Course-6

BOL-201 Biology and Diversity of Pteridophytes and Gymnosperms

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: The aim of this course is to familiarize the students the classification of both Pteridophytes and Gymnosperms, comparative study of morphological and reproductivecharacters of Pteridophytes, brief study on family level.

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	To enhance the students' ability to perform and comparative demonstrate the difference between Pteridophytes and Gymnosperms.
CO2	Demonstrate an understanding of comparative morphology and reproduction of various Pteridophytes.
CO3	Enlist the different modern methods of propagation of gymnosperms.
CO4	Reproductive mechanism during Course of evolution Of Pteridophytes and Gymnosperms.

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

General characteristics of pteridophytes and classification.

Comparative morphology and reproduction of the following: Psilophytales (*Rhynia. Zosterophyllum*), Psilotales (*Psilotum*), Lycopodiales (*Lycopodium, Selaginella*), Lepidodendrales (*Lepidodendron*), Sphenophyllales (*Equisetum*).

UNIT-II

Comparative morphology and reproduction of the following: Ophioglossales (*Ophioglossum, Botrychium*), Marattiales (*Marattìa, Angiopteris*), Osmundales, Filicales

(*Pteris, Dryopteris*), Marsileales, Salviniales.

UNIT-III

Classification of gymnosperms and their distribution in India.

Brief account of the following families: Lyginopteridaceae, Medullosaceae, Glossopteridaceae, Caytoniaceae.

General account of the following orders: Cycadeoidales (Cycadeidea), Pentoxyalales, Cordia`tales.

Comaparative account of Structure and reproduction in the following orders: Cycadales (*Cycas*),

Ginkgoales (*Ginkgo*), Coniferales (*Pinus, Cedrus*), Ephedrales (*Ephedra),* Welwitschiales, Gnetales.

UNIT-IV

Teleome Theory, Evolution of stellar system. Apogamy, apospory, significance experimental induction, Heterospory and origin of seed habit in Pteridophytes.

Modern methods of propagation of gymnosperms: Somatic embryogenesis, haploidsprotoplast culture, Economic importance of gymnosperms.

Suggested Readings:

1. Bhatnagar, S.P. and Moitra, A.1996, *Gymnosperms*, New Age International Pvt. Ltd.,New Delhi.
2. Parihar, N.S., 1977, *The Biology and Morphology of Pteridophytes*, Central Book Depot,Allahabad.
3. Rashid, A. 1999, *An Introduction to Pteridophyta*, Vikas Publishers, New Delhi.
4. Sporne, K.R. 1965, *The Morphology of Pteridophytes*, B.I. Publications Pvt. Ltd., Delhi.
5. Sporne, K.R. 1965. *The Morphology of Gymnosperms*. B.I. Publications Pvt. Ltd., New Delhi.

Core Course-7

BOL-202 - Cytogenetics

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: The aim of this course is to give the students essential knowledge pertainingto structure and functions of a chromosome in detail. The course also explains the chromosomalvariations and their effects on biological system.

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	Acquire knowledge about the different cytogenetic and molecular techniques used for genome analysis.
CO2	Learn about role of chromosomes in sex determination and generation.
CO3	linkage and recombination frequencies in gene mapping.
CO4	Enhance knowledge and ability of students for determining the role of genetics in evolution.

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Chromatin structure and organization: Chromosome structure and DNA packaging;euchromatin and heterochromatin.

Organization of plastid and mitochondrial genomes.

Special Chromosomes: Structure, occurrence and behaviour of polytene, lampbrush, B and sex chromosomes.

Karyotype: Karyotype analysis and its evolution; FISH, GISH and flow cytometery,Chromosome banding techniques and their applications.

UNIT-II

Mendelian principles: Dominance, segregation, independent assortment.

Concept of gene: Allele, multiple alleles, pseudoallele, complementation tests.

Extension of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.

UNIT-III

Structural alterations in chromosomes: Origin, meiosis and breeding behaviour ofduplication, deficiency, inversion and translocation heterozygotes.

Variation in chromosome number: Haploids, aneuploids and euploids- origin, production, effects and uses; polyploidy and crop improvement.

Linkage and crossing over: Molecular mechanism of crossing over and role of differentenzymes; linkage groups**.**

Chromosome mapping: Two point and three-point test crosses.

UNIT-IV

Recombination: homologous and non- homologous recombination including transposition.

Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders

Population Genetics and Evolution: Allele frequencies and genotype frequencies, random mating and Hardy-Weinberg principle, inbreeding, mutation, migration, natural selection, random genetic drift, quantitative inheritance.

Suggested Readings:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., and Walter, P., 2008, *MolecularBiology of the Cell (5th Ed.)*. Garland Publishing Inc., New York.
2. Karp, G., 1999, *Cell and Molecular Biology*, John Wiley and Sons, USA
3. Lewin, B., 2010, *Gene X*, Jones and Barlett Publishers.
4. Lodish, H., Berk, A. Zipursky S. L., Matsudaira, P. Baltimore, D. Darnell, J., 2005, *Molecular Cell Biology*, W.H. Freeman & Co., U.S.A.
5. Pierce, B.A., 2012, *Genetics- A Conceptual Approach* (4th Ed.), W.H. Freeman andCompany, New York, USA
6. Russell, P.J, 2006, *Genetics (5th Ed.),* Addison Wesley Longman, California, USA.
7. Snustad, P., and Simmons, M.J, 2011, *Principles of Genetics.* (6th Ed.), John Wiley, NewYork.
8. Weaver, R.F, 2005, *Molecular Biology*, McGraw Hill International Edition.

Core Course-8

BOL-203 Molecular Biology

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: The aim of this course is to give the students essential knowledge pertaining to biological processes such as DNA replication, transposition and mutations. Akey thrust of this paper is towards the molecular mechanisms involved in the control of gene expression and regulation.

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	The students will have enhanced understanding of genome structure, evolution and its replication.
CO2	This course will impart the knowledge of basics of mutations and their importance; DNA repair mechanisms.
CO3	The students will learn about the methods of genetic recombination in bacteria.
CO4	The students will gain insight into the principal mechanisms of genome expression and its regulation.

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Eukaryotic genome: Different forms of DNA, C- value paradox, unique and repetitiveDNA, gene families, hybridization kinetics and split genes.

Transposable elements: Mechanisms of transposition; transposons in bacteria, maize,Drosophila and yeast**.**

DNA Replication: Semi-conservative, bidirectional, replication origins, replicationmachinery.

UNIT-II

Mutations: types, isolation of mutants, molecular basis of mutations.

DNA damage and repair: Causes of DNA damage; Photoreactivation, excision,mismatch, post replication and error prone repair systems.

Fine structure of gene: cis-trans test, rII locus, fine structure analysis of eukaryotes.

Bacterial genetics: conjugation, transduction and transformation.

UNIT-III

Transcription: Initiation, elongation and termination in prokaryotes and eukaryotes, RNApolymerases.

RNA Processing: Processing of mRNA, rRNA and tRNA.

Genetic code: Deciphering the genetic code, characteristics.

Translation: Initiation, elongation and Termination in prokaryotes and eukaryotes.

UNIT-IV

Regulation of gene expression in prokaryotes: Operon concept, lac operon regulation bypositive and negative mechanism, trp operon, regulation by negative and attenuation.

Regulation of gene expression in eukaryotes: Transcriptional level (Regulatory sequences, nucleosome positioning, chromatin remodeling, histone modifications.); post- transcriptional level (RNA splicing, RNA stability); Translational level and post- translational level.

Suggested Readings:

1. Alberts, B., and Johnson, A., 2016, *Molecular Biology of Cell*, Gerland SciencePublisher.
2. Brown, T.A, 1999, *Genomes.* John Wiley & Sons (Asia) Pvt. Ltd., Singapore.
3. Karp, G., 2010, *Cell and Molecular Biology – Concept and Experiments*, 5th Edition.
4. Lewin, B., 2010, *Gene X*, Pearson Prentice and Hall, New Delhi.
5. Lodish, et. al., 2013, *Molecular Cell Biology*, 7th Edition, W.H. Freeman Publisher.
6. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., and Losick, R., 2008, *Molecular Biology of the Gene* (6th Ed.), CSHLP, New York.

Discipline Specific Elective Courses-1A

BOL-204: Principles of Plant Pathology

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: The aim of this course is to give the students essential knowledge pertainingto various aspects of Plant Pathology like Symptomatology, Defence mechanisms, HostParasite interactions, Role of enzymes and toxins in pathogenesis. It also aims to study the Etiology, Epidemiology and Control of different plant diseases caused by Fungi and other micro-organisms.

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	Understand the interaction between plant and pathogen in relation to the overall Environment
CO2	Demonstrate an understanding of the principles of plant pathology and the application of these principles for the control of plant disease.
CO3	Acquire physiology, photosynthesis, respiration, transpiration, translocation. Knowledge about cause of plant diseases and effect of microbial infections on plant
CO4	Demonstrate skills in laboratory and field related to plant pathology.

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Symptomatology in Fungal infections of plants.

Fundamentals of plant pathology: History of plant pathology; various levels ofparasitism; classification of plant diseases.

Pathogenesis: Penetration and entry of plant pathogens; development inside host tissue,Host – parasite Interactions: Alteration in plant physiological functions.

UNIT-II

Agents of plant diseases: General characteristics and symptoms caused by – agents of infectious diseases (fungi, bacteria, mycoplasma, virus, MLOs, Spiroplasma, Viriods, Mycoviruses and nematodes) and agents of non-infectious diseases (Air pollution, chemicals, minerals excesses, temperature)**.**

How pathogens attack plants: chemical weapons of pathogens (enzymes and toxins), Nutrition in Fungi.

UNIT-III

Etiology, Epidemiology and control of the following diseases:

a) Paddy: Paddy Blast, Brown Leaf Spot, Bacterial Blight
b) Wheat: Rusts, Bunt and Smuts, Tundu disease

c) Sugarcane: Red Rot, smut
d) Grapes: Downy and Powdery Mildews
e) Peach: Leaf Curl
f) Groundnut: Tikka disease
g) Apple: Apple Scab
h) Mustard: White Rust, Downy Mildews
i) Potato: Early and Late Blight, Wart Disease
j) Linseed: Rust
k) Damping off of the seedlings
l) Ergot of Rye

Applications of biotechnology in Plant Pathology: The use of tissue culture techniques (callus culture, apical meristem culture and protoplast fusion), Recombinant DNA technology, use of monoclonal antibodies in plant pathology.

UNIT-IV

How plants defend themselves against pathogens: structural defense and biochemical defense.
Plant disease epidemiology and plant disease forecasting: Importance of disease forecasting services, methods used in plant disease forecasting**.**

Management of plant pathogens: cultural, chemical and biological methods.

Detoxification of pathogen toxin: Application of molecular biology in diseases controlstrategies, Plant quarantine.

Suggested Readings:

1. Agrios, G.N., (2005), *Plant Pathology*, Acad. Press, Inc. California.
2. Bilgrami, K.S. and Dube, H.C., (1990), *A Text Book of Modern Plant Pathology*, VikasPublishing House, New Delhi.
3. Mehrotra, R.S. and Aggarwal, A., (2013), *Fundamentals of Plant Pathology*, Tata McGraw Hill Publ. Ltd., New Delhi.
4. Mehrotra, R.S. and Ashok Aggarwal (2017): *Plant Pathology*, Tata Mc Graw Hill Publ.Ltd., New Delhi.
5. Singh, R.S., (2018), *Plant Disease*, 9th Edition, Oxford, IBH Publ., New Delhi.
6. Singh, R.S., (2017), *Principles of Plant Pathology*, 5th Edition, Medtech.
7. Recent and important review articles from scientific journals.

Discipline Specific Elective Courses-1B

BOL-204: Cell and Developmental Biology

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: The objective of the module on cell and developmental biology is to provide a unified perspective (from historical to contemporary) of genome structure and regulatory mechanisms that are encountered during development and adaptive responses. Cellular and molecular processes that regulate of developmental cascades, including epigenetic landscape during vegetative, reproductive development, and adaptation, primarily in plants, would be discussed. The course would also overview of strategies and methods that are fundamental to understanding these concepts.

Course outcomes (CO): On successful completion of this course, the students will be able to learn about:	
CO1	Various factors such as genetic, environmental and hormones that govern developmental events
CO2	Cellular processes such as inter-cellular and intra-cellular signal transduction and cross-talksregulating development
CO3	Molecular and cellular events / processes that regulate meristem development and maintenance;vegetative and reproductive organ development
CO4	Genetic and molecular elements of epigenetic / chromatin and how chromatin re-modelling /epigenetics regulates development and adaptation

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Regulation of development: Positional information and Cell fate; morphogenetic gradient; polarity determination;commitment, differentiation, Genetic (molecular), environmental (light, temperature, gravity etc) and hormonalregulation of basic development processes, Cross talk between various growth regulators, Cell cycle regulation; Cancer v/s plant tumors; Programmed cell death and senescence, Cytoskeleton and signal transduction

UNIT-II

Vegetative organ development: Comparative account of organization of shoot and root apical meristems. Regulation of meristem size and maintenance, Lateral organ initiation from root and shoot meristems

UNIT-III

Regulation of reproductive organ development: Transition from vegetative to reproductive phase, Molecular basis of flower development and its regulation, Fruit and seed development

UNIT-IV

Chromatin organization, remodeling and development: Small RNA as regulatory molecule; Epigenetic-Role of histones and small RNA in chromatin organization; RdDM; paramutations, genomic imprinting; gene dosage, Chromatin remodelling-factors, models and processes; Chromatin state during replication and transcription, and inheritance of epigenetics, Epigenetic regulation of developmental processes (vegetative and reproductive processes; stress responses).

Suggested Readings:

1. Beck, C. (2010). An Introduction to Plant Structure and Development. Cambridge UniversityPress, 465pp.
2. Steeves, T.A. and Sussex, I.M. (1989). Patterns in plant development. Cambridge UniversityPress, 405pp.
3. Inz´e, D. (Ed.) (2007). Cell Cycle Control and Plant Development, Blackwell Publishing Ltd.394pp.
4. Whitelam, G.C. and Halliday, K.J. (2007). Light and Plant Development. Blackwell PublishingLtd, 350pp.
5. Meyer, P. (Ed.) (2005). Plant Epigenetic. Blackwell Publishing Ltd. 281pp.
6. Leyser, O. and Day, S. (2003). Mechanism in Plant Development. Blackwell Publishing Ltd.241pp.
7. Timmermans, M. (2010). Plant Development. Academic Press, 480pp.
8. Howell, S.J. (1998). Molecular Genetics of Plant Development. Cambridge University Press,365pp.
9. Davies, P.J. (ed.) (2010). Plant Hormones: Biosynthesis, Signal Transduction, Action. Springer,Netherlands, 802pp.
10. Karp, J.G. (2007). Cell and Molecular Biology. John Wiley & Sons, USA.
11. Buchanan, B.B., Gruissem, W. and Jones, R.L. (2015). Biochemistry and Molecular Biology ofPlants. Wiley Publisher, 1264pp.
12. Research and review articles on relevant topics

Core Course-11

BOL-301: Plant Systematics & Biology of Reproduction

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: This course aims to educate students on concept of systematics, taxonomic keys, classification of flowering plants, botanical nomenclature, plant molecular systematics, plant collection and documentation, male and female gametophyte, pollination and pollen pistilinteraction**.**

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	To acquaint students with nomenclature, systematics and taxonomic evidences
CO2	Students will be learnt about plant molecular systematics and plant documentation methods.
CO3	This course explores the reproductive biology. The students will effectively communicate scientific knowledge of how plant reproduce.
CO4	Acquire knowledge about the different interaction and apomixes.

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Systematics: Concepts and components; Plant identification: Taxonomic keys.

Classification of flowering plants: APG IV classification. Taxonomic evidence: structural and biochemical characters.

Salient Features of International Code of Nomenclature of Algae, Fungi and Plants (ICN),[Shenzhen Code (2018)].

UNIT-II

Botanical Nomenclature: Principles of nomenclature, Scientific names, Ranks, Author citation, Nomenclatural types, Valid publications, Priority of publications, Conservation ofnames, Name changes, Synonyms.

Plant Molecular Systematics: DNA sequence data, Types of sequence data, Sequence alignment, Phylogenetic analysis (parsimony, Maximum Likelihood, Bayesian approaches,Neighbour-Joining).

Plant Collecting and Documentation: Methods of collecting plants, Herbaria and data information systems, Herbarium specimens, Herbarium operations, Data Information Systems.

UNIT-III

Male gametophyte: Structure of anther, microsporogenesis, role of tapetum, Pollen development, male sterility; pollen germination, pollen tube growth and guidance; pollen allergy.

Female gametophyte: ovule development, megasporogenesis, Organisation of the embryosac, structure of

embryo sac cells

UNIT-IV

Pollination: Pollination mechanisms and vectors.

Pollen-pistil interaction and fertilization: structure of pollen; pollen – stigma interaction,sporophytic and gametophytic incompatibility, double fertilization, Endospermdevelopment, polyembryony; apomixis.

Suggested Readings:

1. Bhojwani, S.S., and Bhatnagar, S.P., 2000, *The Embryology of Angiosperms* (4th Ed.),Vikas Publishing House, New Delhi.
2. Crawford, D.J., 2003, *Plant Molecular Systematics*, Cambridge University Press,Cambridge, UK.
3. Judd, W.S., Campbell, C.S, Kellogg, E.A., Stevens, P.A. and Donoghue, M.J.,2016, *Plant Systematics: A Phylogenetic Approach*. Sinauer Associates, Inc., Massachusetts.
4. Shivanna, K.R. and Johri, B.M., 1985, *The Angiosperm Pollen: Structure and Function.* Wiley Eastern Ltd., New Delhi.
5. Simpson, M.G., 2010, *Plant Systematics*, Elsevier, Amsterdam.
6. Steussy, T.F., Crawford, D.J., Soltis, D.E. and Soltis, P.S., 2014, *Plant Systematics: The origin, interpretation, and ordering, of plant biodiversity*, Koeltz Scientific Books,Konigstein, Germany.
7. Radford, A.F.,1986, *Fundamentals of Plant Systematics*, Harper and Row Publishers, Inc.

Core Course-12

BOL-302: Plant Diversity

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: The course aims to have understanding of plant diversity, significance of diversity, need of classification, bases of classification, Plant adaptations, distribution of plants, evolutionary diversification.

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	Acquire knowledge about significance of plant diversity
CO2	Describe the morphological features, adaptations in plants in relation to habitat conditions
CO3	Understand the Plant diversity at different levels
CO4	Demonstrate an understanding of plants, their classification, characteristics, reproduction etc

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Plant diversity and Classification, Levels of biodiversity, various Phyla of Plants and theircharacteristics (Algae, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms),

UNIT-II

Ecosystem services, Human Food and Plant diversity, Bacterial diversity, Terrestrial Plant diversity, Marine Plant diversity, Inland water diversity, Rain Forest ecosystem and plant diversity, Landscape diversity

UNIT-III

Biodiversity Hotspots, Keystone species, Threats to Plant diversity, Desertification,Endangered plants, Plant invasions, Loss of Plant diversity, Plant Restoration

UNIT-IV

Indigenous people and plant diversity, Traditional plant conservation practices, Plants inIndian tradition and culture, Plant animal interactions, Use and Economic values of plant diversity, Tourism and Plant diversity, Climate changeand plant diversity

Suggested Readings:

1. Kumar, U. and Sharma, A.K. (2001). Plant biotechnology and Biodiversity conservation.Agrobios, Jodhpur.
2. Dobson, A. (1996). Conservation and Biodiversity. Palgrave MacMillan
3. Levin, S.A. (2001). Encylopedia of Biodiversity Vol 1 to 5. Academic Press New York
4. Groombridge, B. and Jenkins, M.D. (2002). World Atlas of Biodiversity, Earth living resources inthe 21st Century. University of California Press
5. Singh, J.S., Singh, S.P. and Gupta, S.R. (2008). Ecology, Environment and Resourceconservation. Anamaya Publications, New Delhi
6. Krishnamurthy, KV. (2003). Text Book of Biodiversity. Science Publishers

Core Course-13

BOL-303: Plant Tissue Culture

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: The aim of this course is to give the students essential knowledge pertaining to micropropagation, somatic embryogenesis, haploid production, somatic hybridization, cryopreservation and secondary metabolite production.

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	Acquire knowledge about the non - conventional methods of plant propagation.
CO2	Learn about regeneration of complete plants from plant organs/cell other than seeds
CO3	Apply knowledge regarding in vitro techniques in Agriculture and forestry.
CO4	Attain practical knowledge of preparing artificial seeds. Develop curiosity about use of non - conventional methods in storage and conservation of germplasm.

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Plant Tissue Culture: History of Plant Tissue Culture, Basic concept, principles and scopeof plant cell and tissue culture, concepts of cellular differentiation; Totipotency; basic techniques of plant tissue culture; callus formation, organogenesis and embryogenesis.

Protoplast isolation, fusion and culture, somatic hybridization, hybrid selection and regeneration. Cybrids and their application.

UNIT-II

In vitro haploid production and its significance, Anther/Pollen culture and ovary culture; Embryo and ovule culture Production of triploids through endosperm culture.

Micropropagation: meristem culture and virus-free plants; Cryopreservation of plant celland tissue cultures and establishment of gene banks

Somaclonal variations and isolation of useful mutants; mechanisms and applications in genotype improvement.

UNIT-III

Plant Secondary Metabolites: Sources and production of secondary metabolites; criteria for cell selection, factors affecting the culture of cells; different bioreactors and their use in secondary metabolite production; biochemical pathways for the production of different secondary metabolites; biotransformation.

UNIT-IV

Somatic embryogenesis, production of synthetic seeds, importance, limitation and theirutilization.

Application of tissue culture in forestry and agriculture; status of tissue and cell culturetechnology in India edible vaccines, and their prospects.

Suggested Readings:

1. Bhojwani, S.S. and Razdan, M.K., 1996, *Plant Tissue Culture: Theory and Practice* (Arevised Edition), Elsevier Science Pub., New York, USA.
2. Chawla, H.S., 2020, *Introduction to Plant Biotechnology* (3rdEdition), Oxford and IBHPub. Co., New Delhi.
3. Collins, H.A. and Edwards, S. 1998, *Plant Cell Culture*, Bios Scientific Pub., Oxford,U.K.
4. Glick, B.R., and Pasternak, J.J., 1998, *Molecular Biotechnology: Principles andApplications*, ASM Press, Washington, DC.
5. Razadan, M.K., 1993, *An introduction to Plant Culture*, Oxford & IBH Pub., Co., NewDelhi, India.

SEC 4

BOL-304: Biostatistics & Bioinformatics

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: This course has a strong interdisciplinary component and is designed to equip students with essential skills in bioinformatics (at basic level). It will introduce applications of computational biology in diverse areas of biological sciences and provide training in the use of statistics in biological sciences.

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	Get introduced to basic tools and concepts of Bioinformatics and their significance in applied and basic biology. They will also learn application of various bioinformaticstools, biodiversity databases and biological resources.
CO2	Learn about various biological databases and bioinformatics tools.
CO3	Get conceptual understanding of Statistic and Statistics.
CO4	Learn about the various types of estimations and tests used in biostatistics.

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Introduction to Bioinformatics: Definition, history, role and applications of bioinformatics.
Biodiversity databases: IUCN, Species 2000, Fish Base, IPNI, ICTV, ITIS, Tree of life.
Biological materials resources: ATCC, MTCC, NCCS.

UNIT-II

Biological databases: Primary, secondary and structural Protein and Gene Information Resources–PIR, SWISSPROT, PDB, Gene bank, DDBJ, EMBL-EBI, Specialized genomicresources.
Bioinformatics Tools: homology and similarity tools (BLAST, FASTA, SSEARCH, or HMMER search), protein functional analysis tools (Pfam Scan, HMMER3 phmmer, Phobius, Pratt RADAR), sequence analysis tools.

UNIT-III

Biostatistics: Conceptual understanding of Statistic and Statistics; Parameters; Variable; Population, Finite and Infinite Populations; Sample; Discrete and Continuous Variable;
Sample: Simple random sample, Stratified Sample, Clustered Samples, Judgement Sample, Countable and Uncountable Sample; Variable and Attributes; Dichotomous attributes.

UNIT-IV

Estimation: Point Estimation; Interval estimation; Confidence Interval, Arithmetic mean,Median, Mode, Merits and demerits of Mean, Median and Mode; Range; Roles of t – statistic; when and where do we use it, Independent t – statistic, Paired t – statistic, Two samples t – statistic, One sample t – statistic, F –

statistic; Chi-square test and its uses; "testing" in statistic, Hypothesis, Null hypothesis, Two-sided hypothesis, One-sided hypothesis; Critical region; Level of significance, P – value; Standard deviation; Variance.

Suggested Readings:

1. Attwood, T.K. and Parry-Smith, D.J., 2004, *Introduction to Bioinformatics*, PearsonEducation, Singapore, Pvt. Ltd.
2. Dwyer, R.A., 2004, *Genomic Perl: From Bioinformatics Basics to Working Code*,Cambridge University Press, 1st south Asian edition.
3. Edwards, D., 2007, *Plant Bioinformatics: Methods and Protocols*, Humana Press, newJersey, USA.
4. Kulas, J.T., 2008, *SPSS Essential: Managing and Analyzing Social Science Data*, JohnWiley and Sons, New York.
5. Rosenkrantz, W.A., 2009, *Introduction to Probability and Statistics for Science*,*Engineering and Finance*, CRC Press, Boca Raton.
6. Schwartz, R., Phoenix, T. and d Foy, B., (2005), *Learning Perl* (4th edition), O'Reiley andAssociates, ISBN: 0-596-10105-8.

Core Course-16

BOL-401: Plant Ecology: Principles and Concepts

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: The aim of this course is to give the students essential knowledge about basic concepts of plant ecology especially of structure of ecosystem, different niches, community, different energy flow pathways, biogeochemical cycles, population properties andecological succession.

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	Understand mechanisms by which organisms interact with other organisms and with their physical environment.
CO2	Develop insights about the concepts of populations, community and ecosystems and can use in management of natural resources for sustainable development.
CO3	Acquire knowledge about limiting factors controlling distribution and growth of organisms. Comprehend interactions among components of ecosystems for betterstability.
CO4	Describe biotic and abiotic factors that influence the dynamics of populations.

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Concept and structure of ecosystem: Cybernetic nature and stability (resistance and resilience) of ecosystems; structure and function of some Indian ecosystems: forest,grassland, freshwater, marine and eustarine. Brief idea of microcosms, spacecraft and cityas ecosystems.

Concept of Habitat and ecological niche; fundamental and realized niche; resource portioning: ecological equivalents, natural selection, allopatric and sympatric speciation. Artificial section and domestication.

UNIT-II

Concept of community: intra-community classification, analysis of communities (analyticand synthetic characters), species diversity, ecotones and edge effect.

Concept related to energy: primary productivity and its measurements, global pattern andcontrolling factors; food chain, food web, trophic levels, energy flow pathways, ecologicalenergetics, energy budgets, ecological efficiencies.

UNIT-III

Concept of limiting factors; Liebig's law of minimum, Shelford's law of tolerance, factorcompensation and ecotypes, ecads, ecological indicators.

Pattern and basic types of biogeochemical cycles (C, N, P and S), sedimentary cycle, cycling of non-essential elements and organic nutrients; nutrient cycling in the tropics, recycle index.

UNIT-IV

Population group properties: life history strategies (r and k selection), carrying capacity, population

regulation, types of interactions, concept of metapopulation – demes anddispersal, interdemic extinctions. **Ecological succession and its types,** relay floristics and initial floristics composition, bioenergetics, models (facilitation, tolerance and inhibition), causes, changes in ecosystemproperties during succession, concept of climax; its unit's theories and forms.

Suggested Readings:

1. Chapman, J.L. and Reiss, M.J. 1998, *Ecology Principles and Applications* (2nd Edition), Cambridge University Press, U.K.
2. Odum, E.P. and Barrett, G.W., 2005, *Fundamentals of Ecology*, Thomson Books/Cole, U.S.A.
3. Sharma, P.D., 2011, *Ecology and Environment*, Rastogi Publ. Meerut.
4. Singh, J.S., Singh, S.P. and Gupta, S.R., 2006, *Ecology, Environment and ResourceConservation*, Anamaya Publishers, New Delhi.
5. Stiling, P., 1999, *Ecology: Theories and Applications*, Prentice Hall Inc., London.
6. Tiwari, S.C. 2005, *Concept of Modern Ecology*, Bishan Singh Mahendra Pal Singh,Dehra Dun.

Core Course-17

BOL-402: Plant Biotechnology

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: The aim of this course is to give the students essential knowledge pertainingto Recombinant DNA Technology, DNA cloning, gene amplification, genetic transformation methods and IPRs

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	Understand various tools and techniques used in genetic engineering.
CO2	Demonstrate the strategies and measures for manipulation of genome by incorporating desirable genes pertaining to specific traits.
CO3	Acquire knowledge about different methods for genetic transformation of plants
CO4	Understand patent, copyright and trademark, the acts and policies in India and abroad.

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Techniques used in DNA technology: Gel electrophoresis, PFGE, Southern and westernblotting, Dot blots, Chemical synthesis of genes, DNA chip technology.

Isolation of genes, Sequencing of genes: Maxam & Gilbert's method, Sanger's methodand next generation sequencing technologies.

Brief account of proteomics and genomics

UNIT-II

DNA cloning methods: using vectors (Plasmids, phages, cosmids, phagemids, transposons, artificial chromosomes, BAC, YAC, MAC), cloning in bacteria and eukaryotes, genomic and C-DNA libraries.

Gene amplification by PCR: different types, DNA fingerprinting, molecular probes:General features and applications.

UNIT-III

Genetic engineering: Principles, methods and applications in agriculture. Methods for genetic transformation and transgenic plants production through *Agrobacterium tumefaciens* and *A. rhizogenes*, Gene transfer methods in plants; viral vectors and their applications, Bt cotton and Golden rice (A brief introduction).

Chloroplast transformation: its success with tobacco and potato.

UNIT-IV

Intellectual Property Rights: Patents, trade secrets, copyright, trademarks; GeographicalIndicators (GI); Registration, subject matter and ownership of IPRs.

Plant genetic resources; GATT & TRIPPS; Patenting of biological material; Plant breeder'srights (PBRs) and farmer's rights. Infringement, passing off action and remedies availableto IPR holder. Some legal cases related to trademarks, copyrights and patents.

Suggested Readings:

1. Brown, T.A., 1999, *Genomes*, John Wiley & Sons (Asia) Pvt. Ltd., Singapore
2. Chawla, H.S., *Introduction to Plant Biotechnology* (2nd edition), Oxford and IBHPublishing, Co. Pvt. Ltd., New Delhi.
3. Glick, B.R. and Pasternak, J.J., 1998, *Molecular Biotechnology: Principles andApplications*, ASM Press, Washington DC.
4. Gupta, P.K. 1996, *Elements of Biotechnology*, Rastogi & Co., Pub., New Pub., Meerut,India.
5. Henry, R.J. 1998. Practical Applications of Plant Molecular Biology, Chapman &Hall, London, UK.
6. Lewin, B. 2005. Genes VIII, Oxford University Press, Oxford, UK.
7. Singh, B.D., 2007, *Biotechnology: Prospects and Applications*. Springer, Germany.
8. Snustad, D.P. and Simmons, M.J. 2000. Principles of Genetics (2nd Ed.) John Wiley &Sons. Inc., New York, USA

Core Course-18

BOL-403: Cardinal Principles of Academic Integrity and Research Ethics

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: The aim of this course is to give the students essential knowledge about academic integrity values**,** writing skills, UGC policy for academic integrity and prevention, identification of publications misconduct, complains and appeals, conflicts of interest, predatory publisher and journals.

Course outcomes: At the end of the course, the students will know:	
CO1	Academic Integrity, Plagiarism (prevention and detection) and UGC regulations
CO2	Research and Publications ethics and best practices

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Academic Integrity: Introduction, Academic Integrity Values- Honesty and Trust, Fairness and Respect, Responsibility and Courage, Violations of Academic Integrity- typesand consequences.

UNIT-II

Plagiarism -definition, Plagiarism arising out of misrepresentation- contract cheating, collusion, copying and pasting, recycling, Avoiding Plagiarism through referencing and writing skills, UGC Policy for Academic Integrity and prevention, Some Plagiarism detection tools.

UNIT-III

Research and Publication ethics: Scientific misconducts- Falsifications, Fabrication and Plagiarism (FFP), Publication ethics- definition, introduction and importance, Best practices/standard setting initiatives and guidelines-COPE, WAME etc.,

UNIT-IV

Violation ofpublication ethics, authorship and contributor-ship, Identification of publications misconduct, complains and appeals, Conflicts of Interest, Predatory publisher and journals.

Suggested Readings:

1. Beall, J., 2012, *Predatory publishers are corrupting open access*, Nature, 489 (7415),179.
2. Chaddah, P., 2018, *Ethics in Competitive Research: Do not get scooped; do not getplagiarized*, ISBN: 978-9387480865.
3. Indian National Science Academy (INSA), 2019, *Ethics in Science Education, Researchand Governance*, ISBN: 978-81-939482-1-7.

4. MacIntyre, A., 1967, *A short History of Ethics*, London.
5. National Academy of Sciences, National Academy of Engineering and Institute of Medicine, 2009, *On being a Scientist: A guide to Responsible Conduct in research*, (ThirdEdition), National Academics press.
6. Resnik D. B., 2011, *What is ethics in research & why is it important*, National Institute of Environmental Health Sciences, 1-10.s

DSC 3A

BOL-404: Plant Growth and Development

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: The aim of this course is to give the students essential knowledge differentaspects of plant growth and development especially germination and dormancy of seeds, plantgrowth regulators, senescence and abscission, photomorphogenesis and response of plant to different abiotic stresses.

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	Understand the basic concepts of plant growth and development.
CO2	Acquire in depth knowledge about various plant growth regulators and their role in physiology of growth and development.
CO3	Describe metabolic changes associated with the senescence and abscission and their hormonal control.
CO4	Demonstrate an understanding of physiology of flowering and sensory biology.

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Plant Growth: Growth concepts, Growth curves, Growth analysis. Germination andDormancy of seeds; factors affecting dormancy and its regulation by plant growth regulators and environmental factors.

Stress Physiology: Response of plants to abiotic stresses: abiotic stress affecting plant productivity. Basic principles of crop improvement programme under stress.

UNIT-II

Plant Growth Regulators: Discovery, biosynthetic pathways, transport, influence onplant growth and mechanism of action of: Auxins, Gibberellins, Cytokinins, Ethylene, Abscisic acid.

Senescence and Abscission: Physiological and biochemical changes associated with senescence and abscission.

UNIT-III

Tropism: Phototropism, nature of receptors, role of hormones, Geotropism and nastism.

Secondary metabolites and chemical defence: Natural products (secondary metabolites),their range and ecophysiological functions. Overview of terpenoidal, alkaloidal, and phenolic metabolites and their biosynthesis. Biochemical mechanisms of plants' chemical war against other plants and animals.

UNIT-IV

Phytochromes: mechanism of phytochrome action, photomorphogenesis and cryptochromes.

The Flowering Process: Photoperiodism and its significance, importance of dark periods, role of vernalization. Nature and events during flowering, florigen concept, chemical control of flowering.

Suggested Readings:

1. Garrett, R.H. and Grisham, C.M., 1999, *Biochemistry* (Second edition), Saunders CollegePublishing, Philadelphia.
2. Huner, N. and Hopkins, W., 2013, *Introduction to Plant Physiology*, (4th ed.), John Wiley& Sons, Inc.
3. Krishnamoorthy, H.N, (1993), *Physiology of Plant Growth and Development*, Atma Ramand Sons, Delhi.
4. Kumar, H.D. and Singh, H.N. (1993), *Plant Metabolism* (Second edition), Affiliated East-West Press Pvt Ltd. New Delhi.
5. Salisbury, F.B. and Ross, C.W. (1992). Plant Physiology. Fourth edition, WadsworthPublishing Co. Belmont, California, USA.
6. Srivastava, L.M. (2006). Plant Growth and Development: Hormones and Environment.Academic Press. Published by Elsevier India Pvt. Ltd., New Delhi.
7. Taiz, L., Zeiger, P. E. E., Mller, P. E. I. M., & Murphy, P. A. C. A., 2018, *Fundamentalsof plant physiology*, Sinauer Associates.

DSC 3B

BOL-404: Genomics

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: The aim of this course is to give the students detailed knowledge of basic methods involved in genome studies, their organization and function.

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	Enhance knowledge about human genome project, genome sequencing projects formicrobes, plants and animals, accessing and retrieving genome project information from web
CO2	Develops ability to use genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs, different methods of gene annotation and approachesof gene expression.
CO3	Spread awareness about the concept of forward and reverse genetics, gene tagging.
CO4	To acquaint students with RNAi, gene silencing, genome imprinting different method of genome engineering

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

UNIT-I

Genomics: Human Genome Project- methodology, outcomes and lessons learnt, Genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from web, Annotation of genome/gene sequence, Synthetic genomes- current status and future prospects

Comparative Genomics: Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; use of genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in genome sequence.

UNIT-II

Methods of gene annotation: Principle of analyzing genome wide gene expression and itsutility.

Approaches to analyze differential expression of genes - ESTs, SAGE, microarrays andtheir applications. Use of high throughput RNA sequence data for differential expression analysis using various new approaches.

UNIT-III

Concept of forward and reverse genetics as applied to designing genome wide screensfor deciphering gene function.

Gene tagging: gene and promoter trapping, knockout and knockdown mutants.

Introduction to comparative genomics of model plants and related crop species.

UNIT- IV

Introduction to RNAi and gene silencing.

Genome imprinting: small RNAs and their biogenesis, role of small RNAs inheterochromatin formation and gene silencing.

Introduction of genome engineering: a comparative study of genome engineering methods.

Suggested Readings:

1. Birren, B., Green, E.D., Klapholz, S., Myers, R.M. and Roskams, J., 1997, *GenomeAnalysis*, CSHL Press.
2. Brown, T.A., 2007, *Genomes 3*, Garland Science Publishing New York, London.
3. Chawla, H.S., 2009, *Introduction to Plant Biotechnology* (3rd Ed.), Oxford & IBHPublishing Co. Pvt. Ltd., New Delhi.
4. Hartl, D.L. and Ruvolo, M., 2011, *Genetics- Analysis of Genes and Genomes* (8th Ed.),Jones and Bartlett Publishers, Inc., USA.
5. Hunt, S.P. and Livesey, F.J., 2000, *Functional Genomics*, Oxford University Press, NewYork. London.
6. Lewin, B., 2005, *Genes VIII*, Oxford University Press, Oxford, UK
7. Singer, M., and Berg, P., 1991, *Genes and Genomes: A Changing Perspective*; UniversityScience Books, CA, US.

DSC 3C

BOL-404: Algae, Environment and Human Welfare

Credit: 4 (Lectures: 60) **Marks: 100**

Exam duration: 3 Hrs. **Theory: 70; IA: 30**

Course Objective: This course aims to educate students towards advance topics involving algae for Industrial/environmental application and for human welfare. The course also deals with photosynthesis, lipid metabolism, Nitrogen fixation and assimilation in algae.

Course outcomes (CO): On successful completion of this course, the students will be able to:	
CO1	The student will learn about organization of the photosynthesis apparatus from blue green algae to red algae, photosynthetic pigments and light harvesting, light absorption: PSI and PSII, electron transport chain which is important for production of ATP with the help of ATP synthase.
CO2	The students will learn about uptake mechanism(s) of HMs through various transporters present on plasma membrane.
CO3	The course teaches about various beneficial products from algae and their industrial production. These include various algae utilized for food, as neutraceuticals or as fuel
CO4	They will also learn about how algal cells have various strategy to counterthe HMs induced oxidative stress and their negative consequences on vital metabolic occurrences like photosynthesis and nitrogen metabolism

Note: Examiner will set nine questions in all, selecting two questions from each unit and one question of short answer/objective type covering the entire syllabus, which will be compulsory. Students will have to attempt five questions in all selecting one from each unit and the compulsory question. All questions will carry equal marks.

Unit I

Photosynthesis advancement in various class of algae

Organization of the photosynthesis apparatus from blue green algae to red algae,photosynthetic pigments and light harvesting, light absorption: PSI and PSII, electrontransport chain, proton transport and ATP synthesis, CO_2 assimilation under dark reaction,RUBISCO activity and its interaction with light and oxygen.

Unit II

Nitrogen fixation and assimilation in algae: GS-GOGAT cycle, GDH cycle, Nitrogenase, Heterocyst differentiation, structural significance, physiological and biochemical adaptation for Nitrogen fixation, NR, NiR, GS, GOGAT, and AspAT enzymes biosynthesis, structure and their functions, nitrogen fixation and photosynthesis-relationship, nitrate reduction and assimilation in algae, assimilation of organic nitrogen in algae: urea, amino acids and amides.

Unit III

Tolerance and detoxification mechanisms of HMs in algae: Effective methods of culturing the potent algae for efficient phycoremediation of HMs, various methods implied by algae for efficient accumulation of HMs, uptake of HMs by various cell membrane associated transporters, reactive oxygen species, oxidative stress, carbonylation of proteins during HMs stress, metallothionein, antoxidative

enzymes: SOD, CAT, APX, GR, DHAR, MDHAR and non enzymatic antioxidants: GSH, AsA, proline, and polyamines.

Unit IV

Algal application for human welfare: Algae for food, pigments, antioxidants, proteins and carbohydrate. Algal Lipids, biodiesel and biofuel production: Fatty acid biosynthesis, Polyunsaturated fatty acid accumulation, Biodiesel production,Biohydrogen, Bioethanol production. Research hurdles and possible solutions.

Biotechnological advancements in algal research: Genetic engineering in algae, Mutagenesis for strain improvement, engineering efforts for advancement in culturing techniques, Integrated multitrophic aquaculture.

Suggested Readings:

1. egyankosh.ac.in/bitstream/123456789/16683/1/Unit-7.pdf
2. Carmichael, W.W. (ed.) (2013). The Water Environment: Algal Toxins and Health. Plenum Press,NY. ISBN 13: 978-1-4613-3269-5. 490pp
3. Mihir Kumar Das. 2010. Algal Biotechnology. Daya Publishing House, New Delhi.
4. Vashishta, P.C. 2014. S.Chand & Company Ltd, New Delhi.
5. Ian Morris. 1977. An introduction to the algae. Hutchinson & Co (Publishers) Ltd. London.
6. Kumar, H.D. 1999. Introductory Phycology. Affiliated East-West Press, Delhi.
7. Hoek, C. Van, D. 1999. An Introduction to Phycology. Cambridge University Press.
8. Bold, H.C and Wynne, M.J. 1985. Introduction to the Algae. Prentice Hall of India, New Delhi
9. Fritsch, F.E. 1945. Structure and reproduction of Algae. Cambridge University press.
10. Round, FE. 1984.The Ecology of Algae. Cambridge University Press.
11. Lee, R.D. 2008.Phycology 4th Edition, Cambridge University Press, New York