Maa Shakumbhari University, Saharanpur

Syllabus of M.Sc. Botany (CBCS)
(B.Sc. in Research- Botany)

(As per the Guidelines of U.P. Government according to National Education Policy (NEP) - 2020 w.e.f. Session 2023-2024)

Members from the Board of Studies (BOS):

S.No.	Name	Signature
1.	**Prof. Sanjeev Kumar**, Department of Botany, D.A.V. (P.G.) College, Muzaffarnagar **(Convener)**	
2.	**Prof. Ritu Agarwal**, Department of Botany, M.S. College, Saharanpur **(Member)**	
3.	**Dr. Rakesh Kumar**, Department of Botany, VSP Govt. (P.G.)College,Kairana, Shamli **(Member)**	
4.	**Dr. Yogendra Kumar**, Department of Botany, Govt. Degree College Nanauta, Saharanpur **(Member)**	
5	**Prof. Rup Narayan,** Department of Botany, CCSU, Meerut **(External Expert)**	
6	**Prof. Alok Srivastava,** Department of Plant Science, MJPRU, Bareilly **(External Expert)**	

Subject Prerequisites: Students must have passes Bachelor of Science in Botany (or Botany as one of the subjects)/Plant Sciences/Biosciences/Life Sciences from any recognized University equivalent with 55% aggregate.

Course Structure: The courses will be based on Choice Based Credit System (CBCS) structure developed by the University. There will be four compulsory or elective core courses of Botany in each semester. Apart from these, one minor elective course of other faculty is to be chosen by a student in the first year of M.Sc. (Botany). In each semester, there will be one research project of 04 credits.

Programme (M. Sc.) Objectives:

This programme has been designed to train and enable students to understand the relationship between science and society as well as logical, scientific and ethical issues related to science. In addition to this, the students will be able to think critically for the formulation of hypotheses and experimental designing based on the scientific method, which will make the students readily employable in various streams of teaching, research, civil services and in industries.

Programme Specific Outcomes (PSOs): After completing M.Sc. (with Botany), the following will be the PSOs

PSO-1: It is expected that after successfully completing M.Sc. Botany, students will develop deeper theoretical & Practical knowledge of different branches of Botany like Phytotecniques, Plant taxonomy, Anatomy, Mycology, Microbiology, Physiology, Biochemistry, Cell biology, Genetics, Molecular biology, Medicinal Botany, Pharmacognosy, Environmental issues etc, making them capable of understanding the societal, environmental issues, demands and their solutions.

PSO-2: This program has a strong theoretical basis that will help students in evolutionary relationship of lower and higher plants by using the key characters which is expected from a student of Botany to support the other branches of knowledge related to plants.

PSO-3: Many of the courses in the programme have been carefully designed that will help the students for qualifying competitive exams like IAS, IFS, CSIR NET, SET, TGT, PGT and to write research proposals for grants.

PSO-4: Continuous internal assessment provides ample opportunity to the students for improvement after every evaluation. Seminar and field visits system grooms the personality of the students and enables them to present oneself with confidence, develop a reasonably well compiled content and discuss. Assignments enable the students to compile the solutions of the given problems with optimal discussion.

PSO-5: In each semester of the programme, each student is given research project of their own choice to allow students to understand various steps of solving a research problem. Thus, this programme will help to develop research aptitude at PG level with identification of gaps in knowledge and relevance of their solutions for the society.

PSO-6: The student completing the course will be capable of executing research projects

Examination Pattern

Internal Examination

1. One written Test of 10 Marks + 5 Marks Quiz).
2. Five Marks for Class Seminar and 5 Marks of Assignment

External Examination: Written Examination of 75 Marks of 3 Hours Duration.

External Examination Pattern

Unit-I: Attempt all 10 questions. Each question carries 2 Marks.
Unit-II: Attempt any Five out of eight. Each question carries 5 Marks.
Unit-III: Attempt any Three out of Five questions. Each question carries 10 Marks.

LIST OF PAPERS IN ALL FOUR SEMESTERS

Year	Semester	Course Code	Course Title	Core Compulsory/ Elective/Value Added	Theory/ Practical/ Project	Credits	Internal Marks	External Marks (Min Marks)	Total Marks	Minimum Marks (Int+Ext)	Teaching Hours
Year-4 as per NEP-2020/ Year-I	Semester- VII as per NEP-2020/ Semester-I	0720401	Diversity of Algae & Bryophytes	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0720402	Diversity of Pteridophytes, Gymnosperms & Paleobotany	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0720403	Morphology and Taxonomy of Angiosperms	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0720404	Biology and diversity of Microbes	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0720480	Practical Lab (Based on the contents of Theory Courses)	Core Compulsory	Practical	4	25	75(25)	100	40	60
		0720460	Botanical Excursion /Research Project-I (Submission of report & Specimen)	Core Compulsory	Project	4	25	75(30)	100	40	60
		0720450 0720451	**Any One of the following:** (i)Wonders of Plants (ii)Bio-fertilizers	Minor-Elective & Value added (for other faculty)	Theory	4	25	75(25)	100	40	60
	Semester- VIII as per NEP-2020/ Semester-II	0820401	Genetics & Plant Breeding	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0820402	Cell and Molecular Biology	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0820403	Ecology and Phytogeography	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0820404	**Any One of the following:** (i) Fungi and Plant Pathology	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0820405	(ii) Anatomy and Embryology of Angiosperms		Theory	4	25	75(25)	100	40	60
		0820480	Practical Lab (Based on the contents of Theory Courses)	Core Compulsory	Practical	4	25	75(25)	100	40	60
		0820465	Industrial Training/Research Project-II	Core Compulsory	Project	4	25	75(30)	100	40	60
			Project-I + Project-II	Core Compulsory	Viva-Voce	8	50	150(60)	200	80	120
		0820450	Herbal Products	Minor-Elective & Value added (for other faculty)	Theory	4	25	75(25)	100	40	60

Year-5 as per NEP-2020/ Year-II	**Semester-IX as per NEP-2020/ Semester-III**	0920401	Plant soil water relations, Growth and Development	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0920402	Photochemistry and Metabolism	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0920403	**Any Two of the following:** (i) Stress Physiology	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0920404	(ii) Genetic Engineering		Theory	4	25	75(25)	100	40	60
		0920405	(iii) Biodiversity, conservation and Plant resources		Theory	4	25	75(25)	100	40	60
		0920406	(iv) Pharmacognosy		Theory	4	25	75(25)	100	40	60
		0920480	Practical Lab (based on the contents of Theory Courses)	Core Compulsory	Practical	4	25	75(25)	100	40	60
		0920461	Research Project-III	Core Compulsory	Project	4	25	75(30)	100	40	60
	Semester-X as per NEP-2020/ Semester-IV	1020401	**Any Four of the following:** (i)Biotechnology & Plant Tissue Culture	Elective		4	25	75(25)	100	40	60
		1020402	(ii) Bio entrepreneurship and Innovation	Elective	Theory	4	25	75(25)	100	40	60
		1020403	(iii) r-DNA Technology		Theory	4	25	75(25)	100	40	60
		1020404	(iv) Elementary Knowledge of Computes and Bioinformatics		Theory	4	25	75(25)	100	40	60
		1020405	(v) Biophysics		Theory	4	25	75(25)	100	40	60
		1020406	(vi) Industrial Microbiology		Theory	4	25	75(25)	100	40	60
		1020407	(vii) Phyto-techniques and Biostatistics		Theory	4	25	75(25)	100	40	60
		1020408	(viii) Economic Botany and Food Security		Theory	4	25	75(25)	100	40	60
		1020480	Practical Lab (Based on the contents of Theory Courses)	Core Compulsory	Practical	4	25	75(25)	100	40	60
		1020461	Research Project-IV	Core Compulsory	Project	4	25	75(30)	100	40	60
			Project-III + Project-IV	Core Compulsory	Viva-Voce	8	50	150(60)	200	80	120
		11202041 11202042 11202043	Pre PhD-Course work								

The types of paper, number of papers, credit for each semester and research project semester wise, as per guidelines of UP state govt. letter no. 401/sattar-3-2022, dated February 09,2022, as a part of NEP-2020 implementation in U.P. universities, have been prepared as above.

The maximum and minimum marks for each Theory paper, Practical papers (internal & external) and projects have been finalized according to the letter number-1032/sattar-3-2022-8(35)/2020, dated 9 February, 2022. The basic structure of the programme related to types of paper, number of papers, credit etc. have been finalized according to the letter of government dated July 13, 2021.

Core Compulsory Courses: These are main (major) courses of the subject which every student has to study who has taken admission in PG (First and Second Year).

Core Elective Courses: These are full major courses of the subject/programme.

There courses will select by the students in 1/2/3/4 (or 7/8/9/10 in case of integrated PG) Semesters. The Botany department of university/colleges will run these courses in their department/colleges according to their resources/ specialization of teacher and students may opt them according to their choice.

Minor Electives: Some of the above courses, or any other such course developed by BoS, can be taken as Minor electives by the students of other Faculty, for multi-disciplinarily.

Value added course: Some of the above courses, or any other such course developed by BoS, can be taken as Value Added course (Minimum 2 Credits/ 30 Hours) by the students of other Faculty/ Subject, for value addition, besides the courses which are not part of the curriculum/mark sheet of the Botany students are opted by the students of the Botany can be treated as an add-on to the basic requirement for compilation of a degree programme.

Marks Distribution and Teaching hours The marks distribution for each core and elective will be as Maximum marks: 100 (Internal assessment 25 marks + External Assessment 75 marks). Teaching hours for each of the course will be 60 hours. E xamination of each paper shall be of 3 Hours (Theory) and 4 Hours (Practical) The distribution of Internal Marks will be as follows

For Practical the distribution of marks will be as follow Internal Assessment	**Marks**
Practical Class Interaction	5
Viva voce	4
Two practical based exercises	7 (4+3)
Charts/model/ Collection	8
Total	25

For External practical examination the distribution of marks will be as follow External Assessment	**Marks**
Viva Voce on Practical's	10
Report of Botanical Excursion/ Lab Visits/Industrial training/ Survey/Collection/ Models with reports	10
Table work / Experiments	45
Practical Record File	10
Total	75

Research Project:

B.Sc. IV year will be equivalent to M.Sc. 1st year. At the end of the 2nd (even) semester (B.Sc. VIII semester or MSc IInd semester) & 4th/10th semester (M.Sc.), the candidate will submit a research project, which will be evaluated by an external examiner & internal supervisor along with a presentation and viva-voce examination.

In Fourth year (B.Sc.) or MSc first year and Fifth year (MSc final) the topic of the research project will be chosen from among the core compulsory courses/core elective courses of that year.

In each semester, each student will work 4 hour/ week/ semester for 4 credits. In this way a project work will be of 8 credits (i.e., 16 credits for two years).

Research project may be interdisciplinary/ multidisciplinary. It may be an industrial training/ internship/ survey work. Research project will be done under the guidance of the faculty member (s) preferably having PhD degree. For this a co-supervisor may be chosen from a university, college, industry, research institute etc.

The research project will be of 100 marks. If any student publishes a research paper from his/her research project in a UGC care listed/ Scopus indexed or Thomson Reuters, then he/she will get 25 extra marks (although maximum marks will not exceed more 100). The marks obtained in research project will be coded in grades and they will be counted in the calculation of CGPA.

Credits: MSc Programme will be run semester wise and choice-based credit system.

MSc Ist year or B.Sc. 4th year will be of 52 credits whereas MSc 2nd year will be of 48 credits.

Each semester will be of 20 credits of courses (4 theory+1 practical, each will be of 4 credits) and thus the credits of two years (4 semesters) will be 80 credits. A project work will be of 8 credits (i.e. 16 credits for two years). In other words it will be of 4 credits/semester i.e. a total of 16 credits.

A minor elective will be of 4 credits.

Thus M.Sc Programme will be of 100 credits (52+48).

DETAILED SYLLABUS

Programme/Class: M.Sc.	**Year:** First	**Semester:** First
Subject: Botany		
Course Code: : 0720401	**Course Title: Diversity of Algae, & Bryophytes**	

Objectives: To study structure, reproduction, phylogeny and inter-relationships of Algae, Bryophyta.

Course Outcomes:

1. Students will have clear idea of the characteristics of the lower plant groups (Algae and Bryophytes).
2. Concepts in the evolution of plants and application will be clear to students.

Credits: 4	**Core:** Compulsory
Max. Marks:	**Minimum Passing Marks:**

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	Important contribution of pioneer workers, research developments, opportunities, institutions and journals.	**8**
II	Classification and salient features of different classes of Algae. Algal pigments, food reserves, flagellation and their importance in classification. Thallus organization, reproduction and life cycle patterns. Economic importance of algae as food, feed, source of chemicals and drugs, Algal biofertilizers, uses in industry and Algal blooms.	**12**
III	Comparative study of classes of Chlorophyceae, Xanthophyceae and Bacillariophyceae, with reference to: a. Range of structure of plant body including ultrastructure. b. Methods of reproduction. c. Variation in life cycles.	**12**
IV	Comparative study of Phaeophyceae and Rhodophyceae with reference to: a. Range of structure of plant body. b. Range of mode of reproduction. C. Variation in life cycles.	**12**
V	Classification of Bryophytes and their distribution in India. Range of thallus structure (plant body) and anatomy in Bryophytes (with suitable examples) A general account of Marchantiales, Jungermanniales, Anthocerotales, Sphagnales, Funariales and Polytrichales.	**8**
VI	Evolutionary tendencies in sporophytes of Bryophytes (Progressive sterilization of sporogenous tissue) Reproduction, life history, Inter-relationship, affinities of various groups of Bryophytes. Ecology and economic importance of Bryophytes.	**8**

Suggested Readings:

1. Bold, H.C. and Wynne, M. J. (1985). Introduction to the algae; Structure and reproduction. Prentice Hall, Englewood cliffs, New Jersey. 16
2. Cavers, F. (1976). The inter relationships of the bryophyte. S.R. Technic, Ashok Rajpath, Patna.
3. Chapman, V.J. and Chapman D.J. (1975). The algae. 2nd Edition, Mac. Millan Publ. Inc. New York.
4. Chopra, R. N., and Kumar, P. K. (1988). Biology of Bryophytes. John Wiley and Sons, New York (NY).
5. Desikachary, T.V. (1959). Cyanophyta. ICAR, New Delhi.
6. Hoek, C. van den, Mann, D. G. and Jahns, H. M. (1995). Algae: An introduction to Phycology. Cambridge University Press, UK.
7. Kashyap, S. R. (1929). Liverworts of the Western Himalayas and the Punjab Plain. Part1, Chronica Botanica, New Delhi.
8. Kashyap, S. R. (1932). Liverworts of the western Himalayas and the panjab plain (illustrated). Part 2, the Chronica Botanica, New Delhi.
9. Parihar, N. S. (1980). Bryophytes: An introduction to Embryophyta.VolI,Bryophyta, Central Book Depot.
10. Puri, P. (1981). Bryophytes: Morphology, Growth and Differentiation. Atmaram and Sons, New Delhi.
11. Prescott, G. W. (1969). The algae: A review. Nelson, London.
12. Round, F.E. (1981). The Ecology of Algae. Cambridge University Press, Cambridge.

Programme/Class: M.Sc.	**Year:** First	**Semester:** First
Subject: Botany		
Course Code: : 0720402	**Course Title: Diversity of Pteridophytes, Gymnosperms & Palaebotany**	

Objectives: To study phylogeny and inter-relationships of Pteridophytes and Gymnosperms

Course Outcomes: 1. Students will have clear idea of the characteristics of the lower plant groups.
2. Concepts in the evolution, morphology, reproduction & application of plants will be clear to students.

Credits: 4	**Core:** Compulsory
Max. Marks: …..	**Minimum Passing Marks:** ….

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	Important contribution of pioneer workers, research developments, opportunities, institutions and journals.	**12**
II	Classification of Pteridophytes; specific characters of important classes. a. Psilopsida: Psilophytales and Psilotales. b. Lycopsida: Protolepidodendrales, Lepidodendrales, Lepidospermales and Isoetales. c. Sphenopsida: Hyeniales, Sphenophyllales and Calamitales. d. Pteropsida: Coenopteridales, Ophioglossales, Marattiales, Osmundales, Filicales, Marsileales, Salviniales and Indian Fossils.	**12**
III	Telome concept. Stelar system and evolutionary tendencies. Heterospory and evolution of seed habit. Apogamy, apospory, parthenogenesis. Soral evolution in Pteridophytes. Alternation of generations. .	**8**

IV	Classification and distribution of gymnosperms with special reference to India Study of morphology, structure and life history as illustrated by the following: Pteridospermales, Bennettitales, Cycadales, Pentoxylales,Cordaitales, Ginkgoales, Coniferales, Taxales, Ephedrales, Welwitschiales and Gnetales.	**12**
V	Evolution and Economic importance of Gymnosperms. Geological Eras and distribution of plants in geological time scale. Types of Fossils, Process of fossilization and fossil preservation methods. Techniques of study of fossils. Distribution of fossils in India	**16**

Suggested Readings:

1. Agashe, S. N. (1995). Paleobotany. Oxford and IBH Publ. Co. Pvt. Ltd., New Delhi.
2. Arnold, A. C. (2005). An Introduction to Paleobotany. Agrobios (India), Jodhpur.
3. Bhatnagar, S. P. and Moitra, A. (1996). Gymnosperms. New Age International, New Delhi.
4. Biswas, C. and Johri, B. M. (1997). Gymnosperms. 4 Narosa Publishers, NewDelhi.
5. Parihar, N.S. (1976). Biology and morphology of the Pteidophytes. Central Book Depot.
6. Rashid, A. (1999). An Introduction to Pteridophyta.Vikas Publishing House Pvt. Ltd., New Delhi.
7. Ramanujan, C.K.G. (1970). Indian Gymnosperms in time and space. Today &Tomorrow ‘s Printers & Publishers.
8. Sporne, K.R. (1965). Morphology of Gymnosperms. Hutchinson University Library.
9. Sporne, K.R. (1986). The morphology of Pteridophytes. Hutchinson University Press, London.

Programme/Class: M.Sc.	**Year:** First	**Semester:** First
Subject: Botany		
Course Code: 0720403	**Course Title**: **Morphology and Taxonomy of Angiosperms**	

Course Objectives: To acquaint the students about the morphology and taxonomy of angiosperms

Course Outcomes: On successful completion of this course, students will be able to:

- Understand the distinctive features of different angiosperms plants.
- Learn about various approaches to classify the angiosperms.
- Learn the practical applications, techniques to preserve the plants.

Credits: 4	**Core:** Compulsory
Max. Marks: 25+75	**Minimum Passing Marks:** ….

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	Morphology: Morphology of flower, Stamen and Carpel, Floral characteristics, structure of the pistil, pollen stigma interactions, Plant adaptation–physiological and their morphological nature (xerophyte, hydrophyte and halophyte)..	**12**
II	Contribution of Plant Taxonomist, Phylogeny, and research developments, opportunities, institutions and journals. e-Herbarium, Plant identifications through internet applications.	**12**

III	Need for scientific names, development of botanical code, contents of botanical code, Ranks and endings provided by the ICN, Typification (Holotype, Isotype, Paratype, Syntype, Lectotype, Neotype), Author citation, Publication of Names, Principle of Priority, PhyloCode. Outline of classification of Angiosperms as proposed by Bentham and Hooker. APG classification system: Basal living angiosperm, Monocots and Eudicots. Phylogenetic relationships of major angiosperm clades.	**12**
IV	Special features of important families: Monocots (Commelinaceae, Cyperaceae, Poaceae, Orchidaceae), Eudicots (Magnoliaceae, Ranunculaceae, Papaveraceae, Brassicaceae, Malvaceae, Oxalidaceae, Rutaceae, Fabaceae, Rosaceae, Lythraceae, Cucurbitaceae, Apiaceae, Rubiaceae, Asteraceae, Apocynaceae, Convolvulaceae, Solanaceae, Acanthaceae, Scrophulariaceae, Lamiaceae, Amaranthaceae, Euphorbiaceae, Cannabaceae, Moraceae).	**12**
V	Herbarium preparation and use, Virtual Herbarium, Roles of a Botanical Garden, Floras, Journals, Taxonomic Keys, DNA Barcoding. Chemotaxonomy, Embryology and Palynology Sieve-tube plastids in relation to taxonomy. Possible ancestors of Angiosperms.	**12**

Suggested Readings:

1. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rdedition. 29
2. Jeffrey, C. (1982). An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge.
3. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2002). Plant Systematics-A Phylogenetic Approach. Sinauer Associates Inc., U.S.A. 2nd edition.
4. Maheshwari, J.K. (1963). Flora of Delhi. CSIR, New Delhi. 5. Radford, A.E. (1986). Fundamentals of Plant Systematics. Harper and Row, New York

Programme/Class: M.Sc.	**Year:** First	**Semester:** First
Subject: Botany		
Course Code: : 0720404	**Course Title**: **Diversity of Microbes**	

Course Objectives: The objective of this course is to make students aware about microbial world and its diversity along with their skill enhancement in microbial application for human welfare and development.

Course Outcomes: By the end of the course, the students should be able to:

1. Address the concepts of microbes and their diversity.
2. Evaluate methods for isolation, purification and cultivation of microorganisms from different sources.
3. Understand classification and growth patterns of bacterial cell.
4. Differentiate between virus, viroids, virusoids and prions.

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Credits: 4	**Core:** Compulsory
Max. Marks: 25+75	**Minimum Passing Marks:** ….

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	**Topics**	**No. of Lectures**

I	Pioneer microbiologists; golden era of microbiology. Research developments, opportunities, institutions and journals. Microbes' identifications through internet applications.	**6**
II	Introduction and general characteristics of Viruses, Classification of plant viruses. Isolation, purification and characterization of viruses. Replication, transmission of viruses, economic importance, symptomatology of plant viruses. Virus-induced cell transformation, virus-induced cancer. Cyanobacteria, Viroids, Prions. Archaebacteria and Eubacteria: General account, ultrastructure, nutrition and reproduction, economic importance. Plasmids and their characteristics. 16s r-DNA sequencing. Agricultural Microbiology: Agriculturally important microorganisms, biological nitrogen fixation, Mycorrhizae, Plant diseases and their biocontrol. Plant growth promoting rhizobacteria (PGPR). Weed and Pest Biocontrol.	**12**
III	Environmental Microbiology: Microbes and quality of environment. Microbial degradation of pesticides and hydrocarbons. Biodegradation of the agricultural residues. Bioremediation of contaminated soils and water. Microbes in nanotechnology. Biosensors, Biogas Production.	**6**
IV	Food and Industrial Microbiology: Fermentation, fermenter design and growth processes. Food spoilage. Microbes in recovery of metal (bioleaching) and oil. Cell and enzyme immobilization. Microbial enzymes of industrial interest. Single Cell Protein. Vaccines.	**7**
V	10. Host-parasite interaction: a brief idea of recognition and entry process of bacteria, viruses into animal & plant-host cells, alteration of host cell. Virus induced cancer; bacteria and plant two- component signaling systems; bacterial chemotaxis and quorum sensing. Hormones and their receptors, signaling through G–protein coupled receptors, regulation of signaling pathways.	**7**
VI	11. Innate and adaptive immune system: Types of Immunity, antigens, antigenicity, structure and function of antibody molecules, monoclonal antibodies, Antigen-antibody interactions (serology), activation & differentiation of B and T Cell, B & T cells receptors, MHC molecules compliment system, immune response during bacterial (tuberculosis), parasitic (malaria) and Viral (HIV) infections, vaccine.	**10**
VII	1Isolation, purification and cultivation of microbes. 2. Important criteria used for classifications of microorganisms (morphological, ecological, biochemical, molecular and numerical). 3. Classification of bacteria based on Bergey's manual of determinative bacteriology. 4. Archaeobacteria and Eubacteria: Characters, Ultrastructure, nutrition, genetic recombination (Transformation, Transduction, Conjugation), and economic importance. 5. Cyanobacteria: salient features and biological importance.	**12**

Suggested Readings:

1. Salyers, A. A., Whitt, D. D. (2000). Microbiology: Diversityand the Environment.1st Edition.

2. Pommerville, J. C. (2018). Fundamentals of Microbiology. 11th Edition.

3. Pelczar (Jr.), M. J., Chan, E.C.S. and Krieg, N. R. (2016). Microbiology. 5th Edition.

4. Tortora, F. (2017). Microbiology an introduction. 12th edition.

5. Willey, J., Sandman, K., Wood, D. (2020). Prescott's Microbiology. 11th Edition.

Programme/Class: M.Sc.	**Year:** First	**Semester:** First
Subject: Botany		
Course Code: : : 0727950	**Course Title**: **Wonders of Plants**	

Course Objectives: The course aims to have understanding of Plant & Religion, strange & Economic important Plants.

Course Outcomes: On successful completion of this course, students will be able to:

- Learn the basic tools of Botany and apply them in real life problems.
- Plants are wonderful in all walks of life.

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Credits: 4	**Core:** Minor-Open Elective
Max. Marks: 25+75	**Minimum Passing Marks:** ….

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	Plant & Religion: Tree worship in Vedic Period, Puranas, Buddhism & Jainism; Plant & Astrology; Sacred Groves; Venerated plants of your locality. Plants in Worship, Myths, and Plants in Epic like Mahabharata, Ramayana.	**12**
II	Plant with Unique Morphology: Welwitschia, Cacti, Orchids, Wolffia, Rafflesia, Sepria, Sequoia & it allied Taxa, Victoria amazonica, Amorphophallus, Baobab (Adansonia), Selaginella lepidophylla, Dancing Grass (*Desmodium gyrans*), *Mimosa pudica*; Insectivorous plants (*Dionaea, Nepenthes, Drosera, Utricularia* etc. Parasitic Plants.	**12**
III	Economic important Plants: Food, Ornamental, Fibers, Poisonous & Timber yielding plants of your Locality.	**8**
IV	Special pollination mechanisms (Ficus, Calotropis, Ophrys, Salvia), Signature Plants & Plants that thrills (Stimulants, Depressants etc.), Conservation of Rare, Endangered and threatened plants, Exotic & Invasive Plants.	**8**
V	Traditional knowledge and utility of some medicinal plants in India: Neem, Curry Patta, Giloe, Kachnar, Arjun, Harad, Bahera, Amla, Amaltas, Banyan, Tussi, Sadabahar and mint. Ayurvedic Products: Triphala, Chyawanprash, Ghutti, etc	**12**
VI	Introduction to Ayurvedic formulations with methods of preparation & Uses: Churna, Vati, Avleh, Asava, Arishta, Taila and Bhasma.	**8**

Suggested Readings:

1. Raven, P.H., Evert, R.F. and Eichhorn, S.E. (2005). Biology of Plants (7th ed.). New York: W. H.Freemanand Company. 49
2. Sakai, A. and Larcher, W. (1987). Frost Survival of Plants. Springer-Verlag, New YorkNY. 321pp.
3. Kochhar, S.L. (2016). Economic Botany: A Comprehensive Study. Cambridge University Press.
4. Trewavas, A. (2003). Aspects of plant Intelligence.Annals of Botany. 92 (1):1–20.
5. Prance, G.T. (2001). Discovering the plant world. Taxon,50 (2, 4): 345–359.
6.Ayurvedic formulary of India, Govt. of India
7.Pharmacopoeial standards for Ayurvedic formulations CCRAS,Delhi

Programme/Class:M.Sc.	**Year:**First	**Semester:**First
Subject: Botany		
CourseCode:::0720451	**CourseTitle**: **Biofertilizers**	

CourseObjectives: The course aims to have understanding of Sustainable practices of Agriculture

CourseOutcomes: Onsuccessfulcompletionofthiscourse,studentswillbeableto:

- LearnthebasicSustainable practices for enhancing agricultural yield.
- Concepts of Organic farming.

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Credits:4	**Core:**Minor-OpenElective
Max.Marks:25+75	**MinimumPassingMarks:**….

TotalNo.ofLectures-Tutorials-Practical(inhoursperweek):L-T-P:4-0-0

Unit	Topics	No.ofLectures
I	General account about the microbes and plants used as biofertilizer: Rhizobium (isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis).	**18**
II	Azospirillum: isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms. Azotobacter: classification, characteristics – crop response to Azotobacter inoculum, maintenance and mass multiplication.	**18**
III	Cyanobacteria (blue green algae), Azolla and Anabaena azollae association, nitrogen fixation, factors affecting growth, blue green algae and Azolla in rice cultivation. Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.	**18**
IV	Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application.	**6**

Suggested Readings:

1. Dubey, R.C., (2005). A Text book of Biotechnology S. Chand & Co, New Delhi.
2. Kumaresan, V. (2005). Biotechnology, Saras Publications, New Delhi.
3. John Jothi Prakash, E. (2004). Outlines of Plant Biotechnology. Emkay -Publication, New Delhi.
4. Sathe, T.V. (2004). Vermiculture and Organic Farming. Daya publishers.
5. Subha Rao, N.S. (2000). Soil Microbiology, Oxford & IBH Publishers, New Delhi.
6. Vayas, S.C., Vayas, S. and Modi, H.A. (1998). Bio-fertilizers and organic Farming. Akta Prakashan, Nadiad.

Programme/Class: M.Sc.	**Year:** First	**Semester:** Second
Subject: Botany		
Course Code: : 0827901	**Course Title**: **Genetics & Plant Breeding**	

Course Objectives: The paper will deal with Mendelian and non-Mendelian inheritance

Course Outcome:

1. This course will provide an understanding of - inheritance of qualitative and quantitative traits.
2. The course will provide an understanding of – fine structure of genes and biochemical genetics
3. The students will be able to learn about – mutations and extra chromosomal inheritance

Credits: 4	**Core:** Compulsory
Max. Marks: …..	**Minimum Passing Marks:** ….

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	Contribution of pioneer workers and recent developments, opportunities, institutions and journals.	**8**
II	Mendel's Laws of inheritance and modified ratios. Allelic and non-allelic interaction of genes. Multiple alleles: alleles, coat color in rodents, blood groups in Humans, self-incompatibility.	**8**
III	Linkage and crossing over: chromosome mapping, linkage groups, mechanism of chromosome pairing and synaptonemal complex. Sex determination in man, Drosophila and plants. Maternal effects and Extra- nuclear inheritance.	**8**
IV	Biochemical genetics, concept of gene. Structural changes in chromosomes: Deficiency, duplication (meiotic pairing & phenotypic effects), Inversions, translocations, (meiotic pairing, Chromosome disjunction), multiple translocations. Numerical changes in chromosomes and Haploidy: a) Euploidy/Polyploidy : Classification, production, role in evolution, utility in crop improvement. b) Aneuploidy : Trisomics, tetrasomics, monosomy, multisomy-Meiotic behaviors, breeding behavior. c) Apomixis: Cytogenetic basis and types of Apomictic reproduction	**12**
V	Mutation: Types of mutations, spontaneous and induced mutations, Physical and chemical mutagens, gene mutations, induction and detection of mutation, mutation by transposons. Concept of gene: gene structure and expression; gene fine structure, cis-trans test, introns.	**12**
VI	Methods of plant breeding. Genetic basis of inbreeding, hybridization and heterosis, exploitation of hybrid vigor. Plant breeding work done in India with special reference to potato, maize, rice, wheat, sugarcane and cotton.	**12**

Suggested Readings:

1. Gupta P K (2009). Genetics, 4/e. Rastogi Publications, Meerut.
2. Gupta P K (2007). Genetics:Classical to modern. Rastogi Publications, Meerut.
3. Griffith et *al* (2008). An introduction to Genetic Analysis. Freeman & Co.
4. Hartl DL and Jones EW (1997). Genetics: Principles and Analysis 4th Ed. Jones & Bartlett Publishers, Inc

5. Hartwell L *et al* (2000). Genetics: From genes to genomics. McGraw Hill, New Delhi.
6. Lewin B. (2007). Genes IX. Wiley Eastern Ltd., New Delhi.
7. Pierce, B. (2005). Genetics: A conceptual Approach 2nd Ed. WH Freeman
8. Snustad D P , Simmons NJ and Jenkins JB (2003). Principles of Genetics. John Wiely& Sons, New York.
9. Strickberger, N.W. (1985). Genetics 3rd Ed. Macmillan Co. New York.
10. Allard, R.W. (1960). Principles of Plant Breeding. John Wiley, New York
11. Chopra, V.L. (2000). Plant Breeding: Theory and Practice 2nd Ed. Oxford & IBH, New Delhi.
12. Frey, K. J. (1966). Plant Breeding. The Iowa State University Press, Ames.
13. Frey, K. J. (1982). Plant Breeding II. Kalyani Publishers, New Delhi.
14. Welsh, J. R. (1981). Fundamentals of Plant Genetics and Breeding. John Wiley and Sons, New York.
15. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science. Amsterdam. The Netherlands.

Programme/Class: M.Sc.	**Year:** First	**Semester:** Second

Subject: Botany	
Course Code: : 0827902	**Course Title**: **Cell and Molecular Biology**

Objectives:

1. To understand the structures and purposes of basic components of the cell.
2. To understand how these cellular components to generate and utilize energy in cells.
3. To understand the cellular components underlying mitotic and meiotic cell division.
4. To relate the cell cycle to the health, wellbeing and biology of all organisms.
5. The course further deals with plant secondary metabolites and plant-plant interaction.

Course Outcomes:

1. Students will apply their knowledge of cell biology to selected examples of changes or losses in cell function.
2. Application of the studies in accordance with responses to environmental or physiological changes.
3. Student will have better understanding of the alternation of cell function brought about by mutation.
4. Impart an insight into the various biochemical and molecular mechanism of plant biology.
5. Take students to higher levels of biochemical and molecular learning about plant system.
6. Understand the biochemical and molecular role of various biomolecules.

Credits: 4	**Core:** Compulsory
Max. Marks: 25+75	**Minimum Passing Marks:** ….

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	Introduction of Cell and molecular biologist. Research developments, opportunities, institutions and journals.	**6**
II	The Dynamic cell: Structural organization of plant cell, specialized plant cell. Microscopy: Principle, parts and functioning of electron microscopes including stereoscopic binocular, dark field illumination, confocal, phase contrast, fluorescence and polarizing microscopes, camera Lucida, SEM, TEM. STEM. Cell envelopes: Ultra-structure, chemical foundation and functions of cell wall, Biological membranes with special emphasis on plasma membrane and tonoplast membrane.	**12**

III	Plant Cell inclusions, their structure and function; Mitochondria and Chloroplast. Nucleus & Nucleolus: Structure, nuclear pores, nucleosome concept. Chromatin Organisation: Chromosome structure and composition, Centromere, Telomere, Euchromatin and Heterochromatin, Karyotypes, Polytene, Lamp brush chromosomes and Sex chromosomes.	**6**
IV	Ribosomes, Dictyosomes, Lysosomes, ER, Microbodies and Plasmodesmata. Cell cycle & Apoptosis: Biochemical and genetic mechanism– a) Mitosis, spindle formation mechanism, cytokinesis, cell plate formation, Cytoskeleton with emphasis on spindle apparatus, motor movements. b) Meiosis and its significance c) Programmed Cell Death (PCD).	**7**
V	Nucleic Acids: Nature, Structure, types of DNA (A, B, Z-DNA) and RNA, (t-RNA, micro-RNA) difference between DNA & RNA; DNA replication (Origin and fork) and its biosynthesis, extra chromosomal replications, DNA damage and repair, transposons and mechanisms of transposition. Genetic Code: Discovery, Properties and cracking of genetic code.	**12**
VI	Protein Synthesis: Basics, mechanism of protein synthesis in prokaryotes and eukaryotes, transcription, RNA processing, reverse transcription, translation and regulation of protein synthesis in prokaryotes (Structural, regulatory genes and operon model). Control of gene expression at transcription and translation level: Regulation of gene expression in phages, viruses, prokaryotes and eukaryotes, role of chromatin in regulating gene expression and gene silencing.	**17**

Suggested Readings:

1. Alberts, B., et. al. (1983). Molecular Biology of The Cell. W. W. Norton & co., 1464pp, Sixth edition, United states.
2. Cooper, G. (2000). The Cell, A molecular approach. Second edition.
3. Lodish, H., et. al. (2021). Molecular Cell Biology. Ninth edition.
4. Buchanan, B., Gruissem, G. and Jones, R. (2000). Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, USA.
5. Jordan, B.R. (2006). The Molecular Biology and Biotechnology of Flowering. 2nd Edition, CAB International, U.K.
6. Nelson, D.L., and Cox, M.M. (2008). Lehninger Principles of Biochemistry (5th ed.). W.H. Freeman & Co., New York.
7. Taiz, L. and Zeiger, E. (2010). Plant Physiology. 5th Edition. Sinauer Associates, USA.

Programme/Class: M.Sc.	**Year:** First	**Semester:** Second
Subject: Botany		
Course Code: : 0827903	**Course Title**: **Ecology and Phytogeography**	

Course Objectives: To provide the students the ability to understand the environment and distribution of plants.

Course Outcomes: On successful completion of this course the students will be able to

- Understand the concepts of ecology.
- Know about the environment and learn the way to conserve the environment.

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Credits: 4	**Core:** Compulsory
Max. Marks: 25+75	**Minimum Passing Marks:** ….

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	Introduction of ecologist, recent developments, opportunities, institutions and journals	**8**
II	Ecological factors (light, air, water, topographic, edaphic, biotic), climate change. Ecological concepts of species: Genecology and Ecological niche. Population Ecology: Basic concepts, characteristics of population and population structure. Community Ecology: Composition, characters, structure, origin and development of community: methods of study of structure of community.	**12**
III	Ecological succession: Process concept and trends. Climax. (Xerosere, hydrosere) Ecosystem Ecology: Structure and functions, with example of a natural and artificial ecosystem, Energy flow in ecosystem. Production Ecology: Measurement methods and productivity in different ecosystems.	**12**
IV	Preliminary Knowledge of I.B.P. (International Biological Programme), M.A.B (Man and Biosphere Programme). Pollution: Kinds of pollution (Air, Water, Soil and Noise) and greenhouse gases, Ozone hole, and global warming.	**8**
V	Recycling of waste: Biogas, utilization and disposal of organic wastes and inorganic wastes, Biodiversity and its conservation. Biogeochemical cycles of C, N, P, S, and Hydrological cycle, Nutrient sources, Nutrient budgets in terrestrial communities and aquatic communities. Soil erosion and conservation, rainwater harvesting, Chipko movement, Van Mahotsav, Afforestation, reforestation.	**12**
VI	Principles of phytogeography, vegetation types and Phytogeographical regions of India. Age and area hypothesis, continental drift, endemism, Hot spots, Plant exploration. Invasion and introduction. Remote sensing: Concepts, principles, processes, tools, techniques in acquisition of R.S. data. Application in ecological and meteorological research	**8**

Suggested Readings:

1. Odum, E.P. (2005). Fundamentals of ecology. Cengage Learning India Pvt. Ltd., New Delhi. 5th edition.
2. Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.
3. Ambast, R.S. & Ambast N.K. (2022). A Textbook of Plant Ecology. CBS Publisher & Distributors Pvt Ltd. 1t6th Ed.
4. Sharma, P.D. (2010). Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
5. Pratima Kapur and S. R. Govil (2004). Experimental Plant Ecology. CBS Publishers & Distributors Pvt Ltd, India
6. Govil S. R. & Tripathi, B. D. (2001). Water Pollution: An Experimental Approach. CBS Publishers & Distributors Pvt Ltd, India
7. Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach. Oxford University Press. U.S.A.
8. Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.
9. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc., U.S.A. 5th edition.

Programme/Class: M.Sc.	**Year:** First	**Semester:** Second
Subject: Botany		
Course Code: : 0827904	**Course Title**: **Fungi and Plant Pathology**	

Objectives:

1. To understand the detailed structure of fungus
2. To study the evolution of fungi.
3. To study the economic importance of fungi

Course Outcomes:

1. Students will understand every aspect of fungi.
2. Students will able to endeavour the arena of mushroom cultivation and be the future entrepreneur.
3. Students will able to use locally available strains of fungi as biocontrol agents.

Credits: 4	**Core:** Compulsory
Max. Marks: 25+75	**Minimum Passing Marks:** ….

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	Contribution of Mycologist and Plant Pathologist, Research developments, Opportunities, Institutions and journals.	**8**
II	General characters of fungi, cell structure and nutrition. Range of Thallus organization in fungi. Unique aspects of (i) fungal cells, (ii) molecular biology of fungi Types of reproduction in fungi. Classification of fungi as proposed by Ainsworth (1973) Alexopoulus, Mims& Blackwell (1996). Recognition of Fungi as a separate kingdom; splitting of the fungi (Fungi and allied organisms into three kingdoms- Protista, Chromista and Fungi. Nutrition and growth in Fungi including factors affecting fungal growth. Differentiation in fungi: control of i) Dimorphism. ii) conidiation. iii) mating (with the help of Sex hormones). Heterothallism, Heterokaryosis, parasexuality and physiological specialization in Fungi.	**12**

III	A general account and affinities of the following groups with special reference to systematic position, structure and reproduction of organisms mentioned hereunder: I. The Fungi belonging to kingdom Protozoa: a. Myxomycota (myxomycetes): Stemonites, Ceratiomyxa, b. Plasmodiophoromycota (Plasmodiophorales) Plasmodiophora. II. The Fungi belonging to Kingdom Chromista: a. Oomycota: Saprolegnia, Phythium, Phytopthora, Albugo, III. The Kingdom Fungi: a. Chytridiomycota: Synchytrium, b. Blastocladiomycota: Allomyces, Coelomomyces c. Zygomycota: Saksanaea, Pilobolus, Entomophthora d. Ascomycota : Taphrina, Phyllactinia, Erysiphae, Neurospora, Peziza e. Basidiomycota: Puccinia, Uromyces, Hemiliea, Melampsora, Tilletia, Ustilago f. Anamorphic fungi (Deuteromycotina): With reference to their telomorph, also wherever possible; Cercospora, Helminthosporium, Curvularia, Alternaria, Fusarium, Colletotrichum, Aspergillus, Penicillium.	**12**
IV	Fungal interactions: I. Role of antibiotics, hyphal interference,II. Mycoparasitism, III. Commensalism, Mycorrihizae, Lichens (Structure, types, reproduction, importance), Fungi as biocontrol agents. Symptoms of fungal, bacterial and viral plant diseases. Causes of plant diseases. Host-parasite relationship, role of enzymes and toxins in disease development. Effect of infection on physiology of host. Effect of environment on disease development-epiphytotics.	**12**
V	Disease control by Physical methods, chemical methods, crop rotation, plant quarantines, resistance Integrated pest management mechanism, its advantages, disadvantages and future prospects. Principles of biological control of air- borne and soil-borne plant diseases. Etiology and control of the following crop diseases: Paddy: Paddy blast, Bacterial leaf blight. Wheat : Black Stem rust, Bunt of wheat, Flag smut. Jowar: Grain Smut. Sugarcane: Smut, Red rot. Cotton: Wilt Grape : Downy and powdery mildew Apple : Apple scab Groundnut: Tikka disease. Fibre: Rust of Linum. Coriander: Gall of coriander.	**16**

Suggested Readings:

1. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (2007). Introductory Mycology. Fourth Edition, Wiley India Pvt. Limited.
2. Mehrotra, R.S. (2017). Plant Pathology. 3rd Edition, McGraw-Hill Education, New Delhi.
3. Okafor, N. and Okeke, B.C. (2018). Modern Industrial Microbiology and Biotechnology. 2nd Edition, CRC Press, Boca Raton
4. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi & Their Allies, Second Edition. MacMillan Publishers Pvt. Ltd., Delhi, India
5. Webster, J. and Weber, R. (2007). Introduction to Fungi. Third Edition, Cambridge University Press, Cambridge and New York.
7. Willey, J M., Sherwood, L.M. and Woolverton, C.J. (2017). Prescott's Microbiology, 10th Edition, McGraw-Hill,

USA
8. Agrios, G.N. (1997). Plant Pathology, 4th edition, Academic Press, U.K.
9. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley & Sons (Asia) Singapore. 4th edition.
10. Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press, Cambridge. 3rd edition.
11. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Publishers India Ltd.
12. Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.

Programme/Class: M.Sc.	**Year:** First	**Semester:** Second
Subject: Botany		
Course Code: : 0827905	**Course Title: Anatomy and Embryology of Angiosperms**	

Course Objectives: To study the external and internal structures of root stem and leaf.

Course Outcomes: On successful completion of this course, students will be able to:

- Understand the morphology of plants.
- Understand the basic concepts of anatomy of plants.

Credits: 4	**Core:** Compulsory
Max. Marks: 25+75	**Minimum Passing Marks:** ….

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	Recent Research developments, Opportunities, Institutions and journals. Shoot development: organization of shoot apical meristem (SAM), Cytological and molecular analysis, Leaf (Marginal meristem). Root development: organization of root apical meristem (RAM), Cell fates and lineage differentiation of vascular tissue, regulation of root growth. Epidermal structures, ontogeny and classification of stomata, trichomes and secretory glands Phloem: Structure and development of sieve elements, P-Proteins Xylem: Structure and development of tracheary elements Vascular cambium: normal and abnormal functioning Nodal Anatomy: evolution of nodal vasculature	**12**
II	Plant Tissues: Classification; Simple and complex tissues; cytodifferentiation of tracheary elements and sieve elements; Pits and plasmodesmata; Wall ingrowths and transfer cells, adcrustation and incrustation, Ergastic substances.	**8**
III	Stem: Organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cytohistological zonation); Types of vascular bundles; Structure of dicot and monocot stem. Leaf: Structure of dicot and monocot leaf, Kranz anatomy. Root: Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent center; Root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin of lateral root.	**8**
IV	Vascular Cambium: Structure, function and seasonal activity of cambium; Secondary growth in root and stem. Wood: Axially and radially oriented elements; Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; dendrochronology. Periderm: Development and composition of periderm, rhytidome and lenticels.	**12**

VI	Adaptive and Protective Systems: Epidermal tissue system, cuticle, epicuticular waxes, trichomes (uni-and multicellular, glandular and nonglandular, two examples of each), stomata (classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes. Secretory System: Hydathodes, cavities, lithocysts and laticifers.	**8**
VII	Stamen and Carpel evolution. Microsporogenesis and Megasporogenesis. Embryo sac and its types. Pollination and Fertilization. Embryo and Endosperm development. Placentation and its types. Types of fruits. Seed germination. Dormancy.	**12**

Suggested Readings:

1. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
3. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.
4. Esau, K. (1977). Anatomy of Seed Plants. John Wiley & Sons, Inc., Delhi.
5. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, Vikas Publishing House. Delhi. 5th edition.
6. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
7. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.
8. Johri, B.M. (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.

Programme/Class: M.Sc.	**Year:** First	**Semester:** Second
Subject: Botany		
Course Code: : : 0827950	**Course Title: Herbal Products**	

Objectives: To study preparation herbal medicinal product and herbal cosmetics

Course outcomes: Upon completion of the course, the students shall be able to understand following

1. Key ingredients used in herbal products and cosmetics
2. Key building blocks for various herbal formulations.
3. Various key ingredients and basic science to develop aromatherapy, cosmetics, Cosmeceuticals.
4. Scientific knowledge to develop cosmetics and cosmeceuticals with desired Safety, stability, and efficacy.

Credits: 4	**Core:** Minor-Open Elective
Max. Marks: 25+75	**Minimum Passing Marks:** ….

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	Pioneer workers of Ayurveda, Research developments, Opportunities, Institutions and journals.	**12**
II	Herbs as raw materials: Definition of herb, herbal medicine, herbal medicinal product, herbal drug preparation. Source of Herbs. Selection, identification and authentication of herbal materials. Processing of herbal raw material. Preparations of Decoction, Infusion, Fluid extract, Tincture, Aromatic water, Hair care Botanicals, Herbal Cream, Herbal Shampoo, Herbal Syrup	**12**
III	Herbal Cosmetics: Scope, Formulation development and quality control of Herbal cosmetics used in: Hair care, skin care, anti-wrinkles & antiaging.	**12**
IV	Herbs in cosmetics: A brief account of following herbals or herb extracts or herbal products of cosmetic importance such as Acacia concinna pods, Aloe Vera, Almond oil, Neem, Citrus aurantium peels, Henna, Turmeric, Liquorices, Olive oil, tea tree oil and wheat germ oil with special emphasis on their source, active principles and cosmetic properties.	**12**

V	Herbal formulations: Conventional herbal formulations like syrups, mixtures and tablets and Novel dosage forms like phytosome. Aromatherapy: Various essentials oils used in Aromatherapy with their Significance. Evaluation of Drugs: WHO & ICH guidelines for the assessment of herbal drugs Stability testing of herbal drugs.	**12**

Suggested Readings:

1. Sharma, P. P. (2008). Cosmetics - Formulation, Manufacture and quality control, 4th edition, Vandana publication, Delhi.

2. Skaria,B. P. et al. (2021). Aromatic Plants. Horticulture Science Series, New India Publishing Agency, New Delhi.
3. Keville, K. and Green, M. (2008).Aromatheraphy (A Complete Guide to the Healing Art). Sri Satguru Publications, New Delhi.
4. Chattopadhyay, P. K. (2018). Herbal Cosmetics & Ayurvedic Medicines (EOU). National Institute of Industrial Research, Delhi.
5. Balsam, M. S. and Sagarin, E. (1972-1974). Cosmetics Science and Technology. Wiley Inter-science, New York.
6. Barel, A. O., Paye, M. and Maibach, H. I. (2009). Handbook of cosmetic science and Technology. 3rd edition.

Programme/Class: M.Sc.	**Year:** Second	**Semester:** Third
Subject: Botany		
Course Code: : : 0927901	**Course Title**: **Plant soil water relations, Growth and Development (Plant Physiology)**	
Course Objectives: To study the plant soil and water interaction. How the factors influence the growth and development of plants		
Course Outcomes: On successful completion of this course, students will be able to: • Have an understanding of Physiological behavior of plants. • Learn the basic concepts of soil water plant interaction.		
Credits: 4	**Core:** Compulsory	
Max. Marks: 25+75	**Minimum Passing Marks:** ….	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Unit	**Topics**	**No. of Lectures**
I	Pioneer workers of Plant Physiology, Research developments, Opportunities, Institutions and journals. Functional aspects of plant cell structure: colloidal systems, Water as a universal solvent, pressures and potentials. Active and passive absorption of water. Factors affecting water absorption Role of micro and macro mineral nutrients, their physiological functions and deficiency symptoms, Hydroponics. Mechanism of ion (mineral) absorption. Factors affecting mineral absorption.	**20**
II	Driving forces and resistances in transpiration; stomatal movement mechanism. Ascent of sap, Translocation of solutes in plants; sensor-regulator system, sucrose sensing mechanism. Stress Physiology: Plant response to biotic and abiotic stress, mechanism of stress tolerance, HR and SAR, water deficit and drought resistance mechanism of salinity, metal toxicity, freezing heat and oxidative stress resistance,	**12**
III	Discovery, chemical structure, physiological role, mechanism of action, bioassay and practical applications of following plants hormones: Auxins, Gibberellins, Cytokinin. Hormone receptors, cell signaling and Signal transduction	**8**

IV	Elementary idea of structure and functions of ABA, Ethylene, Ascorbic Acid, Brassinosteroids, Polyamines, Jasmonic acid and Salicylic acid. 11.Sensory photobiology: detection structure, chemistry, physiology, function and mechanism of action of phytochromes, cryptochromes and phytotropins. Photoperiodism; Photoinduction and vernalization, Role of florigen, vernalin, phytochrome and C/N ratio in flowering.	**12**
V	Dormancy: Dormancy of seeds and buds, gene expression during dormancy. Seed germination and seedling growth, metabolism of nucleic acid, mobilization of reserved food material, hormonal control of seedling growth, gene expression during seedling growth. Endogenous rhythms. Plant movements. Ageing and Senescence	**8**

Suggested Readings:

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U. S.A. 4th edition.

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

3. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.

Programme/Class: M.Sc.	**Year:** Second	**Semester:** Third
Subject: Botany		
Course Code: : : 0927902	**Course Title**: **Phytochemistry and Metabolism**	

Course Objectives: To study the phytochemical logics of plant life.

To understand the metabolism involved in plant life

How the reactions make possible the plant life.

Course Outcomes: On successful completion of this course the students will be able to

Learn and understand mechanism involved in respiration and photosynthesis, metabolism.

Basics of proteins, lipids and carbohydrate.

Credits: 4	**Core:** Compulsory
Max. Marks: 25+75	**Minimum Passing Marks:** ….

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	Contribution of pioneer workers of biochemistry, Research developments, Opportunities, Institutions and journals. Fundamentals of thermodynamics and bioenergetics, Buffers, pH Scale, redox potential, Structure and functions of ATP; Forces stabilizing macromolecules.	**16**
II	Classification, mechanism of enzyme action and catalysis, Allosteric mechanism, active sites, isoenzymes, Coenzymes, steady state enzyme kinetics, Michaelis - Menten equation and its significance. Conformation of proteins: secondary, tertiary and quaternary structure; domains; motif and fold, Ram Chandran's Plot, Protein catabolism: Lysosomal and ubiquitin targeted proteolysis.	**12**
III	General concept, Photosynthetic apparatus, Photosynthetic cycle, pigments, light harvesting and non-cyclic complexes, Photo-oxidation of water, electron and proton transport, Photophosphorylation. Carbon assimilation – the calvin cycle (C3 cycle), Photorespiration and its significance, the C4 cycle, the CAM pathway, biosynthesis of starch and sucrose, physiological and ecological considerations.	**12**

IV	Overview of plant respiration, glycolysis, the TCA cycle, electron transport and ATP synthesis, oxidative phosphorylation; coupled reaction group transfer biological energy transducers, Pentose phosphate pathway, glyoxylate cycle, alternative oxidase system; Structure and function of fatty acids, biosynthesis and their catabolism.	**12**
V	Overview of biological nitrogen fixation, nodule formation and nod factors, mechanism of nitrate uptake and reduction, ammonium assimilation, nucleotide metabolism. Sulphur uptake, transport and assimilation. Elementary idea of secondary metabolites like alkaloids, lignin and phenolics (terpenes, phenols) with emphasis on flavonoids.	**8**

Suggested Readings:

1. Campbell, M.K. (2012). Biochemistry, 7th ed., Published by Cengage Learning.
2. Campbell, P.N. and Smith, A.D. (2011). Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone.
3. Tymoczko, J.L., Berg, J.M. and Stryer, L. (2012). Biochemistry: A short course, 2nd ed., W. H. Freeman.
4. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2011). Biochemistry, W.H. Freeman and Company.
5. Nelson, D.L. and Cox M.M. (2008). Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company.
6. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
7. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
8. Cooper, G.M. and Hausman, R.E. 2009 The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
9. 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.

Programme/Class: M.Sc.	**Year:** Second	**Semester:** Third
Subject: Botany		
Course Code: : : 0927903	**Course Title**: **Stress Physiology**	

Objective: Objective: This course aims to educate student on concepts of various types of stresses in crop production and strategies to overcome them.

Learning Outcome:

1. The students will understand various aspects of stress physiology such as physiological and molecular basis of abiotic and biotic stress tolerance in plants.
2. The knowledge in stress physiology will be useful for developing climate resilient genotypes for sustainable crop production.
3. Student also able to explain what basic processes and/or traits are affected by each one of the stresses.
4. Explain how the plant tissue responds at the biochemical and molecular level to each one of the stresses.

Credits: 4	**Core:** Compulsory
Max. Marks: …..	**Minimum Passing Marks:** ….

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	Important contribution of pioneer workers of Stress Physiology, Research developments, Opportunities, Institutions and journals.	**8**
II	Biological stress vs. Physical Stress, Types of stresses and general methods of measurement of stress response (Strain), Stress physiology in crop improvement, Response to UV stress: Injury and resistance mechanism	**12**
III	Response to low temperature stress: Chilling, freezing, frost injury and mechanism of resistance, Adaptations, Response to high temperature stress: Injury and mechanism of resistance, Heat shock proteins, Adaptations	**12**

IV	Response to nutrient deficiency stress, Heavy metal stress, injury and mechanism of resistance, adaptations, Salinity stress, Ionic and salt stress injury, mechanism of resistance.	**12**
V	Response to water deficit: Desiccation, Dehydration injury; Mechanism of resistance, Adaptations. Response to water excess: Flooding, hypoxia, Mechanism of resistance, Adaptations, Causative agents for Biotic Stresses	**8**
VI	Mechanism of Resistance against Fungal, Bacterial and viral pathogens. Fire stress to forests. Mechanism involved to save the plant forests fire.	**10**

Suggested Readings:

1. Levitt, J. (1981). Plant responses to environmental stresses (vol. I &II). Academic Press, New York & London.
2. Dwivedi & Dwivedi, (2005). Physiology of abotic stress in plants. Agro bios, India.
3. Kramer, P. J. (1983). Water relations of Plants. Academic Press.
4. Panda S.K. (2002). Advances in Stress Physiology of Plants. Scientific Publishers, Jodhpur.

Programme/Class: M.Sc.	**Year:** Second	**Semester:** Third
Subject: Botany		
Course Code: : : 0927904	**Course Title**: **Genetic Engineering**	
Course Objectives: The aim of this course is to provide a profound knowledge on the methods used in Genetic Engineering allows students to apply these in basic and applied fields of biological research in an innovative way.		
Course Outcomes: : Upon successfully completing this course, the students could be able to: 1. Outline the basic steps in genetic engineering. Describe the mechanism of action and use of restriction enzymes. 2. Describe the techniques used to probe DNA for specific gene of interest and also the technique used to study gene expression. 3. Conceptualize the basics and applications of genomics, proteomics and bioinformatics. 4. Discuss the methods of protein sequencing, protein and metabolic engineering and their future prospects. 5. Explain the usefulness of RNA interference and its potential for crop improvement. 6. Outline the fundamentals of genome editing.		
Credits: 4	**Core:** Compulsory	
Max. Marks: …..	**Minimum Passing Marks:** ….	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Unit	Topics	No. of Lectures
I	Important contribution of pioneer workers of Genetic engineering, Research developments, Opportunities, Institutions and journals.	**12**
II	Genetic Engineering (General), Restriction mapping, Restriction of Chimeric DNA- staggered cleavage, addition of oligopolymer tailing & linkers, blunt end ligation. Gene sequencing (principle & different techniques), c-DNA & genomic libraries.	**12**
III	DNA analysis: Labelling of DNA & RNA probes, southern & florescence in-situ hybridization, DNA fingerprinting, chromosome walking. Techniques for gene expression: Northern & western blotting, gel retardation technique, DNA footprinting, primer extension, S1 mapping, reporter assays.	**12**
IV	Proteomics as a tool for plant genetics, breeding & diversity studies. Protein extraction/ purification techniques viz electrophoresis & column chromatography. Protein sequencing methods, detection of post translational modifications of proteins, methods of analysis of gene expression at RNA and protein level, large scale expression such as Microarray based techniques. Protein Engineering and metabolic engineering- definition and explanation, Steps, Achievements and future prospects	**12**
V	RNA interference- Introduction, RNAi as tool for gene expression. RNAi as a potential therapy. Use of transposons in genetic analysis: Transposons & T-DNA tagging & its use in identification & isolation of genes. Introduction to genome editing with reference to CRISPR/Cas system.	**12**

Suggested Readings:

1. Howe, C. (2007). Gene Cloning and Manipulation (2nd Edition).
2. Clark, D., Pazdernik, N. and McGehee, M. (2018). Molecular biology (3rd Edition).
3. Primrose, S. B. and Twyman, R. (2006). Principles of Gene Manipulation and Genomics (7th Edition).
4. Brown, T. A. (2020). Gene Cloning and DNA Analysis: An Introduction (8th Edition).
5. Thieman, (2020). Introduction to Biotechnology (4th Edition).

Programme/Class: M.Sc.	**Year:** Second	**Semester:** Third
Subject: Botany		
Course Code: : : 0927906	**Course Title**: **Biodiversity, conservation and Plant resources**	
Course Objectives: To provide the knowledge of the biodiversity conservation of plants and sustainable use of plant resources. **Course Outcomes: :** On successful completion of this course the students will be able to • Lean about diversity of life. • Know how to conserve the plants • Sustainable use of plant resources.		
Credits: 4	**Core:** Compulsory	
Max. Marks: 25+75	**Minimum Passing Marks:** ….	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Unit	**Topics**	**No. of Lectures**
I	Important contribution of pioneer workers of this field, Research developments, Opportunities, Institutions and journals.	**8**
II	Biodiversity: Definition; factors responsible for determination of Biodiversity; Global concern over climate change. Levels of Biodiversity: Genetic, Species, Ecological, Evolutionary and Agrobiodiversity. Diversity Measures: (Diversity Indices)- Alpha(α), Beta (β), Gamma(γ) Diversity.	**8**
III	Biodiversity Conservation Initiatives a) In situ Stratagy: National parks, Wild life sanctuaries, biosphere reserves and world heritage sites. b) Ex-situ Stratagy: By seeds, reclamation, Afforestation, tree Plantation, seed banks, gene banks, cryobanks c) General account of activities of BSI, NBPGR for conservation and non-formal conservation efforts d) Restoration or Rehabilitation of Endangered species.	**12**
IV	Biodiversity at world level: Biodiversity at global and country level, wild plant wealth. Ecosystem diversity in India: Desert, forest, Grassland ecosystem, wetland, Mangroves. Species Diversity: Endemic species, cultivated plants/Agro- diversity, Endangered plants.	**12**
V	Loss of Biodiversity: a) Causal factors – Developmental pressure, encroachment, exploitation, human induced and natural floods, earthquake, cyclone, landslides, Disaster management. b) Threat to Ecosystem, species and genetic Diversity. Categories of threats: Endangered, Vulnerable, Rare and Threatened	**12**
VI	Plant resources, Concept, Status and Concern Basic concepts of local plant diversity and its economic importance World centers of primary diversity of domesticated plants Biodiversity protection laws and policies, management of natural resources.	**8**

Suggested Readings:

1. Primack, (2014). Essentials of Conservation Biology, 6th ed. Sinauer.
2. Groom, (2005). Principles of Conservation Biology, 3rd ed. Sinauer.
3. van Dyke (2008). Conservation Biology, 2nd ed. Springer.
4. Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.

Programme/Class: M.Sc.	**Year:** Second	**Semester:** Fourth
Subject: Botany		
Course Code: : : 1027901	**Course Title**: **Pharmacognosy**	
Course Objectives: To study the fundamentals of Pharmacognosy like scope, classification of crude drugs, their identification and evaluation, phytochemicals present in them and their medicinal properties. **Course Outcomes: :** Upon completion of the course, the student shall be able 1. to know the techniques in the cultivation and production of crude drugs 2. to know the crude drugs, their uses and chemical nature 3. know the evaluation techniques for the herbal drugs 4. to carry out the microscopic and morphological evaluation of crude drug		
Credits: 4	**Core:** Compulsory	
Max. Marks: 25+75	**Minimum Passing Marks:** ….	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Unit	Topics	No. of Lectures
I	Definition, history, scope and development of Pharmacognosy. Phytochemical and Pharmacological literature review of Azadirahcta indica, Asparagus Ocimum sanctum, Shankapushpi etc	**12**
II	Types of Plant drugs from vegetative parts and their Pharmacognostic study a) Root drugs; Glycyrrhiza and Asparagus, Coleus, Withania, Catharanthus b) Rhizome drugs, Zingiber c) Leaf drugs, Andrographis, Clitoria d) Bark drugs: Terminalia arjuna, Holorrhena	**16**
III	Types of Plant drugs from Reproductive parts and their Pharmacognostic study a) Flower drugs: Crocus, Carthamus, Spilanthes b) Seed drugs: Piper longum, Mucuna c) Fruit drugs: Carum cuminum, Emblica, Cassia.	**16**
IV	Evaluation of the drugs; Organoleptic, Microscopic, Physical, Chemical and Biological methods of evaluation A brief account of various drug constituents: Carbohydrates, Cardiac glycosides, alkaloids, flavinoids, Tannins volatile oils, resins quinines and steroids with particular reference to Acacia gum, Phyllanthus, Coleus, Asparagus, Rauvolfia	**16**

Suggested Readings:

Evans, W. C. (2009). Trease and Evans Pharmacognosy. 16th edition, W.B. Sounders & Co., London.
2. Ali, M. (2020). Pharmacognosy and Phytochemistry, CBS Publishers & Distribution, New Delhi.
3. Kolkata, C. K., Gokhlae, P. (2007). Text book of Pharmacognosy. 37th Edition, Nirali Prakashan, New Delhi.
4. Choudhary, R. D. (1996). Herbal drug industry. IstEdn, Eastern Publisher, New Delhi.
5. Ansari, S. H. (2007). Essentials of Pharmacognosy. IInd edition, Birla publications, New Delhi.
6. Pande, H. (2015). Herbal Cosmetics. Asia Pacific Business press, Inc, New Delhi.
7. Kalia, A. N. (2005). Textbook of Industrial Pharmacognosy. CBS Publishers, New Delhi.
8. Endress, R. (1994). Plant cell Biotechnology, Springer-Verlag, Berlin.
9. Bobbers, J., Marilyn K. S., VE Tylor. (1996). Pharmacognosy& Pharmaco biotechnology

Programme/Class: M.Sc.	**Year:** Second	**Semester:** Fourth
Subject: Botany		
Course Code: : : 1020401	**Course Title: Biotechnology & Plant Tissue Culture**	

Course Objectives: This course aims to help the students to attain an advanced understanding of the components of plant biotechnology and will provide an overview of genetic manipulation, its applications, GM crops, etc.

Learning Outcomes: Upon successfully completing this course, the students could be able to:

1. Conceptualize plant transformation and selection of desirable genes for crop improvement.
2. Learn the procedure for generating GM crops.
3. GM crops and products are in the market, their contributions towards food security, sustainable environment and medicine.

Credits: 4	**Core:** Elective
Max. Marks: 25+75	**Minimum Passing Marks:** ….

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	Pioneer workers of Biotechnology, Research developments, Opportunities, Institutions and journals. Recombinant DNA technology, basic concept in genetic engineering, tool and techniques of recombinant DNA technology. Enzymes in genetic engineering. Restriction enzymes, DNA ligase, Polymerase, exonucleases, endonucleases, restriction endonucleases, S I nucleases, DNA ligases, reverse transcriptase and alkaline phosphatase. etc. Cloning vehicles: Plasmids, Cosmids, Lambda phage, Charon phage, shuttle vectors, 2µ DNA plasmids, yeast plasmids, M13 vector. Transposons, Primary vectors and plasmids - expression vectors.	**24**
II	Selection of genes, Gene libraries, Genomic and cDNA library - Gene transfer methods, Genetic organization of Ti plasmids, Ti plasmid mediated transfer - Agrobacterium tumefaciens, DNA mediated transfer. Calcium phosphate, PEG, DEAE, via liposomes - Microinjection - Macroinjection, microprojectile, and electroporation, - Selection of clones, marker and reporter genes in screening methods. Hybridizations - colony, Southern, Northern, Western Blotting. Elementary Knowledge of next generation sequencing.	**12**
III	Introduction to Plant Tissue culture, Terms and definitions, Tools and techniques of plant tissue culture. Culture media, culture media preparation and sterilization, callus and suspension cultures. Organ Culture and Protoplast culture. Protoplast-Isolation regeneration and Viability test, Somatic hybridization and methods of protoplast fusion- chemical. Techniques and applications of somatic embryogenesis and regeneration of plants, anther, pollen, ovule, endosperm, hairy root cultures.	**12**
IV	Cell/callus line selection for resistance to herbicide, stress and diseases. Role of tissue culture in rapid clonal propagation, production of pathogen - free plants and synthetic seeds. Plant transformation: Methods of gene transfer in plants. Agrobacterium and CaMV mediated gene transfer; direct gene transfer using PEG, micro injection,	**12**

	electroporation, microprojectile (biolistics) method, liposome mediated DNA delivery. Transgenic plants for crop improvement: Maize, Rice, Wheat, Cotton, Brinjal and Tomato.	

Suggested Readings:

1. Tropp, B. E. (2012). Molecular Biology. Fourth Edition, Jones and Bartlett India Pvt. Ltd, New Delhi.
2. Howe, C., (2007). Gene Cloning and Manipulation. 2nd Edition.
3. Watson, D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., and Losick, R. (2008). Molecular Biology of Gene. 6th Edition, Cold Spring HarborLaboratory Press Cold Spring Harbor, New York, U.S.A.
4. Clark, D., Pazdernik, N., McGehee, M. (2018). Molecular biology. 3rd Edition.
5. Freifelder, D. (1990). Molecular Biology. 2nd Edition, Narosa Publishing HouseNew Delhi.
6. Nicholl, D. S. T. (2008). An Introduction to Genetic Engineering. 3rd Edition.
7. Plant Molecular Biology - Genetic Analysis of Plant Development and Metabolism. Springer-Verlag, New York, London.
8. Grierson, D. and Covey, S. (1984). Plant Molecular Biology, Practical Approach. IRL Press, Oxford, Washington DC.
9. Henry, R. J. (2005). Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK.
10. Shaw, C. H. and Brown. T.A. (1988, 2020). Gene Cloning and DNA Analysis: An Introduction. 8th Edition.
11. Primrose, S. B. and Twyman, R. (2006). Principles of Gene Manipulation and Genomics. 7th Edition.
12. Tewari, K. K. and Singhal, G. S. (1997). Plant Molecular Biology and Biotechnology. Narosa Publishing House, New Delhi.

Programme/Class: M.Sc.	**Year:** Second	**Semester:** Fourth
Subject: Botany		
Course Code: : : 1020402	**Course Title: Bio entrepreneurship and Innovation**	

Course Objectives: Impart knowledge and work experience based/case study-based training to students in the field of innovation and uses of various biology/ biotechnology-based products, goods, services employed in bio entrepreneurship.

Course Outcomes: On successful completion of this course the students will be able to:

1. To be able to prepare a business plan and launch career as bio- entrepreneur.
2. Being able to get employment in a bioindustry or a bioconsultancy

Credits: 4	**Core:** Elective
Max. Marks: 25+75	**Minimum Passing Marks:** ….

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	Important contribution of pioneer workers of this field, Research developments, Opportunities, Institutions and journals.	**12**
II	Entrepreneurship in the Life Sciences. Development of Products in the Biomedical Industry.	**8**
III	Integration of science, technology and business. From Lab to land: scope in agro/food processing industry	**12**
IV	Industrial management. Market analysis.	**12**

V	Business development. Regulatory mechanisms.	**8**
VI	Indian bioentrepreneurial scenario. Case studies of successful bioentrepreneurs.	**8**

Suggested Readings:

1. Rhonda, A. (2010). Six-Week Start-Up: A Step-by-Step Program for Starting Your Business, Making Money and Achieving Your Goals! Redwood City: The Planning Shop.
2. Byrne, J. A. (2011). World Changers: 25 Entrepreneurs Who Changed Business as We Knew it. New York: Penguin.
3. Edwards, S. and Edwards. (1999). Working from Home: Everything you need to Know about Living and Working under the Same Roof. New York: Penguin Putman.

Programme/Class: M.Sc.	**Year:** Second	**Semester:** Fourth
Subject: Botany		
Course Code: : : 1020403	**Course Title: r-DNA Technology**	
Course Objectives: To introduce the students with the application of DNA Technology. **Course Outcomes: :** On successful completion of this course the students will be able to: • Know the techniques to transfer the DNA in biological systems. • Understand the basic principles of r-DNA Technology.		
Credits: 4	**Core:** Elective	
Max. Marks: 25+75	**Minimum Passing Marks:** ….	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Unit	**Topics**	**No. of Lectures**
I	Important contribution of pioneer workers in this field, Research developments, Opportunities, Institutions and journals.	**8**
II	Genetic Engineering – Definition and explanation, restriction enzymes and restriction modification system. Cloning and expression vectors – Definition and explanation: plasmids, cosmids, and phagemids, fd, fl, and M13 vectors, transposons vectors. Artificial chromosomes as vector. Expression vectors; Use of promotors and expression cassettes, Virus expression vectors, binary and shuttle vectors.	**12**
III	Reconstruction of chimeric DNA – staggered cleavage, addition of Oligopolymer tailing, blunt end ligation. Cloning in bacteria vs. cloning in Eukaryotic cells. Preparation of molecular probes and their uses; labeling of probes, radioactive vs non-radioactive. Techniques used in probing DNA, RNA & Protein electrophoresis, Southern, Northern and Western blotting. Techniques of restriction mapping.	**12**
IV	Polymerase chain reaction – Principles, techniques and modification, gene cloning vs. PCR, application and uses of PCR. Chromosome walking, Chromosome jumping, Chromosome landing, map-based cloning. Compliment DNA, its cloning and cDNA library.	**12**

V	RFLPs & RAPD and their applications. Gene sequencing.	**8**
VI	Protein Engineering- definition and explanation, Steps involved, methods used, Achievements and future prospectus. Drug designing – methods used, blocking enzyme activity, blocking hormones receptors, inhibition of DNA/RNA synthesis. Chemical synthesis vs recombinant DNA technology in protein engineering and drug designing.	**8**

Suggested Readings:

1. Altman, D.G. (2006). Practical Botany for Medical Research. London: Chapman and Hall.
2. Rosner, B. (2006). Fundamentals of BioBotany.
3. Bonita, R., R. Beaglehole and T. Kjellstrom (2006). Basic Epidemiology, 2nd Edition. World Health Organization.
4. Gordis, L. (2004). Epidemiology, 3rd Edition. Philadelphia.
5. Dunn, G. and B. Everitt (1995). Clinical BioBotany: An Introduction to Evidence-based Medicine. Edward Arnold.
6. Daniel, W.W. and C.L. Cross (2012). BioBotany: A Foundation for Analysis in the Health Sciences, 10th Edition. Wiley.

Programme/Class: M.Sc.	**Year:** Second	**Semester:** Fourth
Subject: Botany		
Course Code: 1020404	**Course Title: Elementary Knowledge of Computes and Bioinformatics**	

Course Objectives: To give students a firm foundation in the advanced optimization techniques for the solution of the problems covered in course contents.

Course Outcomes: On successful completion of this course, the students will be able to:

- Develop the ability to formulate fairly complex optimization problems in the context of practical problems.
- Learn the use of software computer applications.
- Use the DNA, RNA, Database for further applications

Credits: 4	**Core:** Elective
Max. Marks: 25+75	**Minimum Passing Marks:** ….

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	Important contribution of pioneer workers in this field, Research developments, Opportunities, Institutions and journals.	**8**
II	Computer System- Definition; Components (Input/output unit, Control Unit., Primary Storage Unit, Arithmetic and Logic Unit); Types of Memory, Generation of Computers Number System & Logic Gates- Application of Number Systems (Decimal Number System, Binary Number System, Hexadecimal Number System) & Conversions (Decimal to Binary, Binary to Decimal, Decimal to Hexadecimal, Hexadecimal to Binary); Addition operation in Binary Number System; Introduction to Logic Gates(AND, OR, NOT, NAND, NOR, XOR XNOR); Introduction to Software.	**12**
III	Bioinformatics - Introduction; Definition & Concept, Role of Bioinformatics, Introduction of Internet in Biology & objectivity, Services of Internet used for Biological Data, Human Genome Project.	**12**

IV	Database System- Definition; Purpose of Database System; Advantages of Database System, Relational Database- Definition; Relational Data Model, Database- Primary Databases & Secondary Databases, Sequence Databases(EMBL, GenBank, DDBJ, SWISS-PROT, PIR, TrEMBL), Protein Family/Domain Databases (PROSITE, Pfam, PRINTS & SMART)	**12**
V	Sequence comparison algorithm, Dynamic programming, Dot plot matrix, sequence scoring schemes (weight matrix as Identify scoring, genetic code scoring scheme chemical scoring, observed Substitution matrix and Gap penalties),Sequence database similarity searching algorithms, local alignment, global alignment, FAST A, BLAST (BLASTP, BLASTN, BLASTX, TBLASTN, TBLASTX) and similarity searching scores and their statistical interpretation	**8**
VI	Motifs and Domains, algorithm for multiple alignments, Biological motifs, micro array, Phylogenetic prediction: Relationship of Phylogenetic analysis to sequence alignment, Genome complexity and phylogenetic analysis, concept of evolutionary trees. Maximum parsimony method, distance method, maximum likelihood method	**8**

Suggested Readings:

1. Y.Wang.Z.wang.(2023) Squence Analysis and Paralled Computing Tsinghua University press .
2. K.Stephen (2009) Bionformatics for system biology Springr.Press
3. Sharma.Vinay (2016) Text book of Bionformatics Rastogi Publication Meerut
4. R.Sundralingan and V.kumaresan (2000) Bionformatics Saras Publication T.N.
5. Ruchi Singh (2014) Bionformatics Vikas Publication .
6. Orpita Basu (2007) Bionformatics Oxford University Press
7. Pradeep.K.Sinha and Priti Sinha (2004) Computer fundamentals B.P.B Publication.

Programme/Class: M.Sc.	**Year:** Second	**Semester:** Fourth
Subject: Botany		
Course Code: 1020405	**Course Title:** (iv) **Biophysics**	

Course Objectives: To introduce students with biophysical concepts.

Course Outcomes: On successful completion of this course the students will be able to:

- Understand the basic ideas of biophysics.
- Learn theoretical methods and practicable techniques used in plant cell.
- Understand how cell works and effect of X-ray, Ultrasound on a living cell.
- Ability to develop the models of biomolecules.

Credits: 4	**Core:** Elective
Max. Marks: 25+75	**Minimum Passing Marks:** ….

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	Important contribution of pioneer workers in this field, Research developments, Opportunities, Institutions and journals. Flow of energy in biological cells, production of green energy and its application.	**6**
II	Thermodynamics: Concept of temperature, laws of thermodynamics, enthalpy and thermo chemistry: exothermic and endothermic reactions, free energy, entropy, Gibb's equation, and kinetic theory of gases.	**12**

III	Nature and propagation of light, reflection, refraction, interference, diffraction, polarization, quantum theory of light. Depletion of Oxygen Pressure with altitude, Pollutants and Ozone layer depletion, Toxicity and its effect on Bio-macromolecular Structure and Function, Physiological effects of environmental stress.	**10**
IV	Introduction to Probabilistic Models, Stochastic Models of Diffusion and other Biological Applications, Markov chains with Biological Applications.	**12**
V	Basic principles; Different types of immunoglobulin's and antigens; Antigen-antibody interactions; complements, mechanism of generation of diverse antibodies in the same host, synthesis of antibodies; major disorders of the immune system, auto-immune diseases. Protein-DNA and Drug-DNA interaction.	**8**
VI	(a) X-Ray: Effects on Bio-macromolecules. (b) Gamma Radiation: Molecular effects of Gamma Radiation, Radiation Chemistry of Water, Free Radicals, Effects on Biomolecules & Molecular Structures: Radiation Effects on Proteins, Radiation Effects on Nucleic Acids, Radiation Effects on Membranes. Effects on Cells and Organelles (c) Ultraviolet Radiation: Effects on Bio-macromolecules & Molecular Structures, UV Radiation Effects on Proteins, Nucleic Acids, Cells and Organelles. (d) Alpha & Beta Radiations: Effects on Cells and Organelle's, human body. (e) Radiation Hazards & Protection: Radiation Effects and Genetics, Methods to combat ionizing, non-ionizing and particle radiations, use of radiations in cancer & other diseases.	**12**

Suggested Readings:

1. Biological Effects of Radiation by Coggle J.E.. (Taylor & Francis).
2. Molecular Theory of Radiation Biology by Chadwick K.H. &Leenbouts H.P. (Springer Verlag)
3. Introduction to Radiological Physics and Radiation Dosimetry by Atlik F.H. (John Wiley)
4. An Introduction to Environmental Biophysics by Campbell, Gaylon S., Norman, John M. (Springer)
5. Textbook of Biochemistry with Clinical Correlations By Thomas M. Devlin (Wiley)
6. Biochemistry By Jeremy M. Berg, John L. Tymoczko & LubertStryer (W.H. Freeman)
7. Lehninger Principles of Biochemistry, David Lee Nelson, Michael M. Cox. (W.H. Freeman)
8. Principles of Biochemistry by Donald Voet, Charl, Judith G. Voet – (Wiley)
9. Molecular Cell Biology by Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, HiddePloegh, Angelika Amon, Matthew P. Scott, (W.H. Freeman),
10. G. B. Arfken, Mathematical methods for physicists: a comprehensive guide, 7th ed. Amsterdam ; Boston: Elsevier, 2013.
11. B.Rosner, Fundamentals of biostatistics,7thed. Boston: Brooks/Cole, Cengage Learning, 20 Introductory Physics, Building Understanding by Jerold Touger (Wiley)
12. Physics in Biology and Medicine by Paul Davidovits (Academic Press) iii. Introduction to Biological Physics for the Health and Life Sciences by Kirsten Franklin, Paul Muir, Terry Scott, Lara Wilcocks, Paul Yates
13. Intermediate Physics for Medicine and Biology by Russell K Hobbie, Bradley J Roth (Springer)
14. Essentials of Chemical Biology: Structure and Dynamics of Biological Macromolecules by Andrew D. Miller, Julian Tanner (Wiley)
15. An Introduction to Chemistry for Biology Students by George I. Sackheim (Pearson)

Programme/Class: M.Sc.	**Year:** Second	**Semester:** Fourth
Subject: Botany		
Course Code: 1020406	**Course Title**: Industrial Microbiology	
Course Objectives: To give students a firm foundation for industrial use of microbes. **Course Outcomes** On successful completion of this course, the students will be able to: • Develop the ability to work in microbial industry.		
Credits: 4	**Core:** Elective	
Max. Marks: 25+75	**Minimum Passing Marks:** ….	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Unit	Topics	No. of Lectures
I	Important contribution of pioneer workers in this field, Research developments, Opportunities, Institutions and journals.	**12**
II	Exploitation of microorganisms and their products, screening, strain development strategies, immobilization methods, fermentation media, raw material used in media production, antifoaming agents, buffers, downstream processing.	**12**
III	Fermentation equipment and its uses, fermenter design, Types of fermenters and fermentations- single, batch, continuous, multiple, surface, submerged and solid state. Production of green energy from microbes and its application. Waste (solid/liquid) recycling by the microbes. Bio- accumulators (microbes)/Scavengers of metals (microbes)	**12**
IV	Industrial products from microorganisms- antibiotics: production of penicillin, streptomycin. Interferons, vaccines, hormones, vitamins.	**12**
V	Enzymes from microbes: amylase, protease. Organic acids: citric acid, acetic acid, amino acids: glutamic acid, lysine. Production of alcoholic beverages: bear and wine, biofuels: ethanol, methane, and biogas.	**12**

Suggested Readings:

1. Pelzar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). Microbiology: An application-based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.
2. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. Pearson Benjamin Cummings, San Francisco, U.S.A. 9th edition.
3. Frazier, W.C. (1988) Food Microbiology, McGraw Hill Inc. 4th Edition.
4. Prescott, L.M., Harley J.P., Klein D. A. (2005). Microbiology, McGraw Hill, India. 6th edition.

Subject: Botany		
CourseCode:1020407	**CourseTitle**:Phyto-techniques and Biostatistics	
CourseObjectives: Togivestudentsafirmfoundationfor various Phytotechniques. To understand basic elementary knowledge and application of Statistics in field of Biological Sciences **CourseOutcomes** On successful completion of this course, the students will be able to: • Develop the ability to work in industry. • Analyze the data • Conduct the experiments • Help to progress the science		
Credits:4	**Core:** Elective	
Max.Marks:25+75	**MinimumPassingMarks:**….	
TotalNo.ofLectures-Tutorials-Practical(inhoursperweek):L-T-P:4-0-0		
Unit	**Topics**	**No.ofLectures**
I	Different types of stains, their preparation and uses: Safranin, fast green, hematoxylin, iodine, cotton blue, crystal violet, ruthenium red, Janus green, Gram's stains, Acetocarmine. Microtomy: dehydration, clearing and embedding of material, section cutting, dewaxing.Collection and preparation of herbarium sheets; preservation and storage of plant materials	**12**
II	4Instrumentation, principle and Methods of fractionation- Cell sorting, Chromatography, Electrophoresis, Centrifugation, X- ray diffraction. Spectrophotometry, MS, NMR, ESR, ORD/CD spectrometers, Radioisotopic methods: Geiger Muller & Liquid Scintillation Counters. Immunological methods: immunodiffusion, immuno- electrophoresis, crossed immuno- electrophoresis, counter- RIA, ELISA, Immunoblotting	**12**
III	Introduction of Biostatistics. Collection and Classification of data: Sampling and types of sampling methods. Presentation of Data: Tabular, Graphical, Line Diagrams, Frequency Polygon, Frequency Curve, Scatter or Dot Diagram, Bar Diagrams, Pie Chart. Measures of central tendency - Mean, median, mode. Measures of dispersion: Range, standard error, standard deviation, co-efficient of variations.	**12**
IV	Analysis of variance (ANOVA): Summary of steps involved in ANOVA. Test of hypothesis and tests of significance: Student's t-Test, Chi-square test, F-test. Introduction to life table. Parametric and Non-parametric test.	**12**
V	Probability: Sum rule, Product rule and Binomial expansion. Probability distribution: Normal, Binomial and Poisson. Kurtosis. Correlation and Regression: Types of correlation (linear, non-linear, positive and negative), difference between correlation and regression.	**12**

SuggestedReadings:

1. Plummer, D.T. (1996). An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd. New Delhi. 3rd edition.
2. Ruzin, S.E. (1999). Plant Microtechnique and Microscopy, Oxford University Press, New York. U.S.A.
3. Ausubel, F., Brent, R., Kingston, R. E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. (1995). Short Protocols in Molecular Biology. John Wiley & Sons. 3rd edition.
4. Zar, J.H. (2012). Biostatistical Analysis. Pearson Publication. U.S.A. 4th edition
5. Danniel, W.W., (1987). Biostatistics. New York, John Wiley Sons.
6. Sundarrao, P.S.S and Richards, J. (2012). An introduction to Biostatistics, 5th edition.
7. Selvin, S., (1991). Statistical Analysis of epidemiological data, New York University Press.
8. Bishop, O.N. (1966). The Principles of Modern Biology: Statistics for Biology. Houghton Mifflin Company, Boston.
9. Freedman, P. (2017). The Principles of scientific research. New York, Pergamon Press.
10. Campbell, R.C. (1998). Statistics for Biologists. Cambridge University Press.

Programme/Class: M.Sc.	**Year:** Second	**Semester:** Fourth
Subject: Botany		
Course Code: : : 1020408	**Course Title**: **Economic Botany and Food Security**	
Course Objectives: The aim of this course is to provide a profound knowledge about the products of economically important plants which are of various uses.		
Course Outcomes: : Upon successfully completing this course, the students could be able to know: 1. Scope of economic botany, study of economically important plants and plant products. 2. The tropical, subtropical and temperate crops that are sources of food, beverages, spices, medicines, timber and essential oil. 3. The genetic and evolutionary aspects of different plants and their health benefits. 4. The need to increase the food production to meet the demand of increasing population		
Credits: 4	**Core:** Elective	
Max. Marks: 25+75	**Minimum Passing Marks:** ….	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Unit	Topics	No. of Lectures
I	Origin of Cultivated Plants. The work of Vavilov. The future role of Plants in relation to mankind. Cereal Crops- Wheat, Rice, Maize, Barley, Oat, Sorghum, Millets and Pseudocereals . research center, journals and contribution of Indian Scientists.	**12**
II	Legumes or Pulses-Pea, Gram, Pigeon pea, Lentil, Black and Green gram. Fibres and Fibre yielding plants- Classification of fibres. Cotton, Flex, Hemp, Jute, Sann or Sunn hemp, Coir, Kapok.	**12**
III	Oil yielding plants- Classification of vegetable oil. Methods of oil extraction. Groundnut, Mustard, Common olive, Coconut, Castor, Cottonseed, Soya bean, Sesame. Petro-crops: our future fuel.	**12**
IV	Spices, Condiments and other flavourings- Classification of Spices Ginger, Turmeric, Cinnamon, Clove, Black pepper, Coriander, Cumin, Chillies, Fennel, Cardamom, Saffron. Medicinal Plants- Drug plants, Drugs obtained from Roots, Stems, Barks, Leaves, Flowers, Fruits and Seeds, Alkaloids and Cancer.	**12**
V	Food Safety and Security- Functions of FSSAI, Sanitary Parameters for food service premises. Challenges and Future plan of FSSAI. Food Security in India, Schemes of Central govt for Food security. Role of cooperatives in food security. Challenges and Future prospectives.	**12**

Suggested Readings:

1. Economic Botany-A Comprehensive Study by S. L. Kochhar. 5th Edition, Cambridge University Press, 4843/24,2nd Floor, Ansari Road, Daryaganj, Delhi – 110002, India
2. Plants and Human Welfare by O. P. Sharma, Pragati Prakashan, Meerut.
3. Economic botany : principles and praetiees / edited by Gerald E. Wickens. SPRINGER SCIENCE+BUSINESSMEDIA, LLC.
4. DEV, S. MAHENDRA, KANNAN, K.P. AND RAMCHANDRAN, NEERA (EdS.). 2003. Towards a Food
5. SecureIndia: Issues and Policies. Institute for Human Development, New Delhi.
6. Anil Chandy Ittyerah, Food Security in India: issues and suggestions for effectiveness, IIPA, Delhi.