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Nagpur University, Nagpur 440033

Bachelor of Science (Botany)

NEP-2020

B. Sc. Sem.-III & IV Syllabus

w.e.f. Academic Session- 2025-26

Submitted by

Board of Studies in Botany

B. Sc. Semester-III
Discipline Specific Core Course (DSC-5)- BOTANY Paper-I (BBO3T05)
Algae, Fungi, Lichens and Plant Pathology

DSC-5: Theory	Hours: 2 Hours/Week	Marks: 80+20=100	Credits: 2

Unit-I	
1. History of Phycology 2. Algology in India: M.O.P. Iyeangar, Y. Bhardwaja, T.V. Desikachary. N.D. Kamath. Habit and habitat of Algae: 1) Hydrophytes- Benthophytes, Thermophytes, Planktophytes, Halophytes, Epiphytes. 2) Edapophytes, Aerophytes – Epihalophytes, Lithophytes 3. Range of Vegetative structure of algae: Motile, Palmeloid, coccoid, Filamentous, Siphonous, Advanced	7.5 Hrs.
Unit-II	
1. Range of pigmentation in Algae (Chlorophylls, Carotenoids, Phycobilins) 2. Morphology and Reproduction of: *Volvox, Voucheria, Sargassum, Batrachospermum*	7.5 Hrs.
Unit-III	
1. Vegetative structure in fungi: Hyphae, Mycelium, Haustorium 2. Life Cycle of: *Aspergillus, Puccinia and Cercospora*	7.5 Hrs.
Unit-IV	
1. Components of Lichens: Phycobiont, mycobiont and cyanobiont 2. Occurrence: Corticolous, Lignicolous, Saxicolous, Terricolous, Marine, Freshwater 3. Nature of Association: Mutualism, Helotism and Parasitism 4. Classification of plant diseases: Endemic, Epidemic and Sporadic 5. Causal organism, symptoms, transmission and control measures of following plant diseases: Ring rot of potato, Powdery mildew of Teak, Yellow vein mosaic of Bhindi	7.5 Hrs.

DSC-5: Practical (BBO3P05)	Hours: 4 Hours/Week	Marks: 25+25=50	Credit: 1

1) Various thallus types of Algae
2) Study of vegetative and reproductive structure of *Volvax, Voucheria, Sargassum, Batrachospermum*
3) Study of *Aspergillus, Puccinia, Cercospora*
4) Identification of Lichens as per association
5) Study of some plant disease - Ring Rot of potato, Powdery mildew of Teak, Yellow vein mosaic of Bhindi

B.Sc. Semester-III Botany Practical

DSC Botany-5 (BBO3P05)

(Algae, Fungi, Lichens and Plant Pathology)

Time: 3 Hrs. **Max. Marks: 25**

Q.1. Identify the given **algal** material **(A)**, prepare temporary mount and write identifying characters **5 Marks**

Q.2. Identify the given **fungal** material **(B)**, prepare temporary mount and write identifying characters **5 Marks**

Q.3. Describe the given **lichen / plant pathology** specimen **(C)** and write comments characters **5 Marks**

Q. 4. **Spotting:** **5 Marks**

D. Algae

E. Algae

F. Fungi

G. Lichen

H. Plant pathology

Q. 5. Practical record, excursion report **5 Marks**

Suggested Readings:

1. Agrios, G.N. (1980) Plant Pathology, academic Press, INC, New York.
2. Ainsworth, G.C. and A.5.Sussman (eds). The Fungi, An advance Treatise Vol. I, II, III & IV Academic Press, New York.
3. Alexopoulos C.J., Mims C.W. and Blackwell M. 2002. Introductory Mycology (4thed.). John Wiley and Sons (Asia), Singapore.
4. Alexopoulos, C.I., Mams and Black well (1996) 4th ed. John Wiley and Sons, Inc. Wiley, New York
5. Aneja, K.R. (1993): Experimental in Microbiology, Plant Pathology & Tissue Culture, Wiswa Prakashan, New Delhi.
6. Bold H. C. and M. J. Wynne (1978): Introduction of Algae: Structure and Reproduction (Prentice Hall of India Pvt. Ltd.)
7. Gangulee H.C. and Kar A.K. 2011. College Botany (Vol. II). New Central Book Agency Calcutta
8. Mehrotra, R.S. and K.R. Aneja. (1999). An Introduction to Mycology. New Age International Publisher.
9. NY. Lee, R.E. (2018). Phycology, Fifth Edition. Cambridge University Press, Cambridge.
10. Pandey, B.P. (2014). Modem Practical Botany Vol. I. S. Chand and Company Ltd. Ramnagar, New Delhi
11. Pandey, S.N and Trivedi, P.S. (2015). A text book of Botany Vol. I Vikas publishing House Pvt Ltd, New Delhi

12. Purohit, .0, Kundra, G. K. and Singhvi, A. (2013). Practical Botany (part 1). Apex Publishing House Durga Nursery Road Udaipur, Rajasthan
13. Rangaswamy, G. and A. Mahadevan (1999) Diseases of Crop Plant in India, Prentice Hall
14. Robert Edward Lee. (2018). Phycology. Cambridge University Press, U.K. 5th edition.
15. S.K. Verma (2008). A text book of Botany Vol. 1. Silver Line Publications, Mathura Road, Faridabad
16. Sambamurty, AV.S.S. (2006). A text book of Algae. I.K International Publishing House, Pvt. Ltd.
17. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
18. Sharma O.P. (1992) Text book of thallophytes (Algae, Fungi, Bacteria, Lichen, Viruses) Tata McGraw-Hill Publishing Company Limited, New Delhi.
19. Sharma, O. P. (2011). Algae. Tata McGraw Hill Education Private Limited, U.K. 1st edition.
20. Sharma, P. D. (1991): The Fungi (Rastogi & Co. Meerut)
21. Sharma, P.D. (1993) Microbiology and plant pathology (Rastogi & Co)
22. Sunder Rajan, S. (2001): Tools and Techniques of Microbiology, Anmol Publ. New Delhi
23. Vasistha, B. R. (1990): Algae (S. Chand & Co. New Delhi)
24. Vasistha, B. R. (1990): Fungi (S. Chand & Co. New Delhi)

B. Sc. Semester-III Discipline Specific Core Course (DSC-6)- BOTANY Paper-II (BBO3T06) Fossil Angiosperms & Angiosperm Taxonomy			
DSC-6: Theory	**Hours: 2 Hours/Week**	**Marks: 80+20=100**	**Credits: 2**
Unit-I			
1. Origin of Angiosperms: (Benettitalean theory) 2. Phylogeny of Angiosperm: Homology, monophyly, polyphyly, Clads 3. Fossil angiosperms: Flower (*Sahanianthus*), Fruit (*Enigmocarpon*) 4. Angiosperm Taxonomy: Floras, Herbarium, Keys (Intended and Bracketed) 5. Botanical Nomenclature: Principles (Rank and ending of taxa, Principle of priority)			7.5 Hrs.
Unit-II			
1. Modern trends in taxonomy: Cytotaxonomy (Karyotype), Phytochemistry (Proteins, Flavonoids and Betalains), Taximetrics to taxonomy (OTUs). 2. **Classification of angiosperms**: Natural, Artificial and Phylogenetic system of classification. 3. **Systems of classification**: Bentham & Hooker and Engler & Prantl (Outline only along with merits and demerits)			7.5 Hrs.
Unit-III			
1. **Study of Families** (Dicot): Malvaceae, Brassicaceae, Fabaceae (Papilionaceae, Caesalpiniaceae, Mimosaceae) and Solanaceae (***Note: Taxonomic description along with economic importance are expected for all the families***)			7.5 Hrs.
Unit-IV			
1. **Study of Families** (Dicot): Apocynaceae, Asteraceae, Asclepiadaceae, Euphorbiaceae 2. **Study of Family** (Monocot): Poaceae (***Note: Taxonomic description along with economic importance are expected for all the families***)			7.5 Hrs.

DSC-4: Practical (BBO3P06)	**Hours: 4 Hours/Week**	**Marks: 25+25=50**	**Credit: 1**
1. Study of fossil angiosperms (*Sahanianthus* and *Enigmocarpon*) from fossils, slides or pictures 2. Method of preparation of herbarium sheets 3. Preparation of Generic and specific keys (Minimum two each) 4. Study of the plants from the families mentioned in theory syllabus (at least one plant from each family)			

Suggested activities for CIE:

Seminar, quiz, debate, puzzles, assignments, collection and study of angiosperms available in local area, field work, study projects, models etc. are part of curriculum for all units in all papers

B.Sc. Semester-III Botany Practical
DSC Botany-6 (BBO3P06)
Fossil Angiosperms & Angiosperm Taxonomy

Time: 3hrs. **Max. Marks: 25**

Q.1. Describe in technical language the given angiospermic material **(A).** Classify & identify the family giving reasons	**6 Marks**
Q.2. Prepare generic key or specific key for given angiosperm material **(B)**	**4 Marks**
Q.3. Write floral formula and draw floral diagram of the given flower **(C)**	**5 Marks**
Q.4. **Spotting:**	**5 Marks**
D. Fossil Angiosperm	
E. Herbarium tools / flora	
F. Phyllotaxy	
G. Inflorescence	
H. Fruit	
Q.5. Practical record and excursion report (Submission is compulsory)	**5 Marks**

Suggested Readings

1. Cooke, T. (1958). *The Flora of the Presidency of Bombay.* Vol. I-III, (BSI reprint), Calcutta.
2. Davis, P. H. and Heywood, V. H. (1963). *Principles of Angiosperms Taxonomy,* Oliver & Boyd, Edinburgh and London.
3. Dutta, S. C. (1989). *Systematic Botany*, Wiley Eastern Co.
4. Hutchnson, J (1973) *The Families of Flowering plants*. Oxford. 3rd. Edition Clarendon Press Oxford.
5. Jeffrey, C. (1983). *An Introduction of plant Taxonomy*. Cambridge University Press, Cambridge, London
6. Lawrence, G. H. M. (1951). *Taxonomy of Vascular Plants*, Oxfd. & IBH, New Delhi.
7. Manilal, K.0S. And M.S. Muktesh Kumar [ed.] (1998), *A Handbook of Taxonomic Training*. DST, New Delhi.
8. Mitra, J.N (1974) *An introduction to systematic Botany and ecology*, The world press pvt. Ltd., Calcutta
9. Mondal, A. K. (2009), *Advanced Plant Taxonomy*, New Central Book Agency (P) Ltd.
10. Naik, V. N. (1984), *Taxonomy of Angiosperms*, Tata McGraw-Hill Publishing Company Ltd., New Delhi
11. Naik, V. N. (1998). *Flora of Marathwada*. Amrut Prakashan, Aurangabad.
12. Redford, Albert E. (1986), *Fundamentals of Plant Systematics*, Harper & Row, Publishers, New York.
13. Sambamurty, A.V.S.S. (2005), *Taxonomy of Angiosperms*, I. K. International Pvt. Ltd., New Delhi
14. Sharma, O. P. (2009) *Plant Taxonomy*, 2nd edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi

15. Shivarajan,V.V (1984) *Introduction to the Principles of Plant Taxonomy*, Oxford and IBH Publishing Co. Ltd. New Delhi
16. Simpson M.G. (2010) *Plant systematic* (Second Edition) Elsevier.
17. Singh, N. P. & Karthikeyan (eds.) (2000). *Flora of Maharashtra State (Dicotyledones)*. Vol-I, (BSI print), Calcutta.
18. Singh, N. P., Lakshinarasimhan, P. & Karthikeyan S. (2000). *Flora of Maharashtra State (Dicotyledones)*, (eds.), Vol.- II, (BSI print), Calcutta.
19. Sokal, R.R and P.H.A. Sneath (1963) *Principles of Numerical Taxonomy*, W.H. Freeman, San Francisco, London
20. Stace, C. A. (1991), *Plant taxonomy and Biosystematics*, Cambridge University Press.
21. Subrahmanyam, N. (2009), *Modern Plant Taxonomy*, Vikas Publishing House Pvt Limited, New Delhi
22. Ugemuge, N. R. 1986. *Flora of Nagpur District*. Shree Prakashan, Nagpur.
23. Woodland, DW 2009 *Contemperary Plant Systematics*, 4th edition Andrews university Press, Berrien Springs, Mich

B. Sc. Semester-III MINOR-1: BOTANY Paper-I (BBO1T01) Microorganisms-Viruses, Prokaryotes, Algae and Fungi			
MINOR-1: Theory	**Hours: 2 Hours/Week**	**Marks: 80+20=100**	**Credit: 2**
Unit-I			
1. Introduction to microorganisms. 2. Classification of microorganisms (Outline) –Carl Woese's- Domain system (1990). 3. Brief account of Bacteria- Archaebacteria, Mycoplasma, Actinomycetes 4. **Viruses-** General account, structure & multiplication of T4 Phage (Lytic, Lysogenic) 5. **Bacteria:** General characteristics, cell structure and economic importance. 6. **Cyanobacteria**: *Nostoc* (Morphology, Reproduction and importance in Agriculture)			7.5 Hrs.
Unit-II			
1. General characteristics and Economic importance of Algae. 2. **Classification of Algae:** Lee (2008) up to phylum with examples 3. **Morphology and reproduction of the following**: *Oedogonium, Chara* and *Ectocarpus*			7.5 Hrs.
Unit-III			
1. **Fungi:** General characteristics and Economic importance 2. **Classification outline:** Alexopolous and Mims, (1996) 3. **Life cycle** of *Albugo*, *Rhizopus* and *Agaricus*. 4. **Mycorrhiza:** Ectomycorrhiza and Endomycorrhiza.			7.5 Hrs.
Unit-IV			
1. **Lichens:** General account, Types of lichens, Internal Structure, Reproduction and Economic importance. 2. **Plant Pathology:** Casual organism, Symptoms, transmission and control measures of Plant diseases- Citrus Canker, Red Rot of Sugarcane, Little Leaf of Brinjal and Leaf Curl of Papaya.			7.5 Hrs.

MINOR-1: Practical (BBO1P01)	**Hours: 2 Hours/Week**	**Marks: 25+25=50**	**Credit: 1**

1. Study of Viruses from models / photographs (TMV and T4 Bacteriophage).
2. Study of Gram staining of the given Bacterial culture.
3. Study of ultrastructure of Bacteriophage from TEM photographs.
4. Study of vegetative and reproductive structure of Cyanobacteria: *Nostoc* (from temporary preparations and permanent slides)
5. Study of vegetative and reproductive structure of Algae: *Chara, Ectocarpus, and Oedogonium,* temporary preparations and from permanent slides.
6. Study of Fungal genera: *Albugo, Rhizopus, and Agaricus*.
7. Study of Lichens: Thallus structure, Types of lichens.
8. **Plant Pathology**: Study of following diseases:
   Citrus Canker, Red Rot of Sugarcane, Little Leaf of Brinjal and Leaf Curl of Papaya.
9. **Mycorrhiza:** Ectomycorrhiza and Endomycorrhiza (Photographs).
10. Instruments useful for Microbiology laboratory.

Suggested activity:

Seminar, Quiz, debate, Assignments, collection of diseased plant parts –studying symptoms and identification of pathogen, collection and study of Algae available in local area, Field work, Study Projects, Models etc. are Part of Curriculum for all units in all papers

B.Sc. Semester-III Botany Practical

MINOR-1: BOTANY Paper-I (BBO1P01)

Microorganisms-Viruses, Prokaryotes, Algae and Fungi

Time: 3hrs. **Max. Marks: 25**

Q.1.	Perform Gram staining of the given Bacterial culture / Identify giving reasons the given **Cyanobacteria (A).**	**5 Marks**
Q.2.	Identify giving reasons the given **Algae (B)**	**5 Marks**
Q.3.	Identify giving reasons the given **Fungi (C)**	**5 Marks**
Q.4.	**Spotting:**	**5 Marks**
	D. One of the instruments of Microbiology laboratory.	
	E. Whole specimen or a permanent slide of Algae.	
	F. Whole specimen or a permanent slide of Fungi.	
	G. Whole specimen or a permanent slide of Plant disease studied.	
	H. Whole specimen or a permanent slide of Lichens, Mycorrhiza.	
Q.5.	Record and excursion report (submission is compulsory)	**5 Marks**

Suggested readings

1. Agrios, G.N. (1980) Plant Pathology, academic Press, INC, New York.
2. Ainsworth, G.C. and A.S.Sussman (eds). The Fungi, An advance Treatise Vol.-I, II, III & IV Academic Press, New York.
3. Alexopoulos C.J., Mims C.W. and Blackwell M. 2002. Introductory Mycology (4thed.). John Wiley and Sons (Asia), Singapore.
4. Alexopoulos, C.J., Mims and Black well (1996) 4th ed. John Wiley and Sons, Inc. Wiley, New York
5. Aneja, K.R. (1993): Experimental in Microbiology, Plant Pathology & Tissue Culture, Wiswa Prakashan, New Delhi.
6. Barsanti, L. and Gualtieri, P. (2014). Algae: Anatomy, Biochemistry and Biotechnology, 2nd Edition. CRC/ Taylor & Francis,
7. Bergey's Manual of Systematic Bacteriology, 2nd ed., vol. 1-3, Springer Verlag, New York, NY.
8. Bold H. C. and M. J. Wynne (1978): Introduction of Algae: Structure and Reproduction (Prentice Hall of India Pvt. Ltd.)
9. Dube, R.C. and D.K.Maheshwari (2000) Practical Microbiology -S. Chand& Co. Ltd.
10. Gangulee H.C. and Kar A.K. 2011. College Botany (Vol. II). New Central Book Agency. Calcutta.
11. Gupta, V.K. and M.K.Behl (1994) Indian Plant Viruses and Mycoplasma Kalyani Publishers, 1/1, Rejinder Nagar, Ludhiana.

R.R. Atapekar

12. Marjorie, Kelly and Cowan, Heidi Smith. (2017). Microbiology: A Systems Approach. McGraw Hill New York, 5th edition.
13. Mehrotra, R.S. and K.R. Aneja, (1999). An Introduction to Mycology. New Age International Publisher.
14. NY. Lee, R.E. (2018). Phycology, Fifth Edition. Cambridge University Press, Cambridge.
15. Pandey, B.P. (2014). Modern Practical Botany Vol. I. S. Chand and Company Ltd. Ramnagar, New Delhi.
16. Pandey, S.N. and Trivedi, P.S. (2015). A text book of Botany Vol.-I Vikas publishing House Pvt./ Ltd., New Delhi
17. Pelczar M.J., Chan E.C.S and Kreig N.R. (1997). Microbiology. Tata McGraw Hill.
18. Purohit, S.D., Kundra, G. K. and Singhvi, A. (2013). Practical Botany (part I). Apex Publishing House Durga Nursery Road Udaipur, Rajasthan.
19. Rangaswamy, G. and A.Mahadevan (1999) Diseases of Crop Plant in India, Prentice Hall
20. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi, India.
21. Robert Edward Lee. (2018). Phycology. Cambridge University Press, U.K. 5th edition.
22. Sambamurty, A.V.S.S. (2006). A text book of Algae. I.K International Publishing House, Pvt. Ltd.
23. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
24. Sharma, O. P. (2011). Algae. Tata McGraw Hill Education Private Limited, U.K. 1st edition.
25. Sharma, P. D. [1991]: The Fungi (Rastogi & Co. Meerut)
26. Sharma, P.D. [1993] Microbiology and plant pathology (Rastogi & Co)
27. Smith, GM. [1971] Cryptogamic Botany, Vol 1 Algae and Fungi (TMI)
28. Smith, K. M. [1992]: Plant Viruses 6th Ed (university Book Stall New Delhi)
29. Sunder Rajan, S. (2001): Tools and Techniques of Microbiology, Anmol Publ. New Delhi
30. Tortora, G.J., Funke, B.R., Case, C.L. (2011). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 13th edition
31. Vasistha, B. R. (1990): Algae (S. Chand & Co. New Delhi)
32. Vasistha, B. R. (1990): Fungi (S. Chand & Co. New Delhi)
33. Woese CR, Fox GE (November 1977). "Phylogenetic structure of the prokaryotic domain: the primary kingdoms". Proceedings of the National Academy of Sciences of the United States of America. 74 (11): 5088 0. Bibcode: 1977PNAS... 74.5088W. doi:10.1073/pnas. 74.11.5088. PMC 432104. PMID 270744

B. Sc. Semester-III MINOR-2: BOTANY Paper-II (BBO1T02) Paleobotany, Bryophyta and Pteridophyta			
MINOR-2: Theory	**Hours: 2 Hours/Week**	**Marks: 80+20=100**	**Credit: 2**
Unit-I			
1. Palaeobotany: Concept and Importance, Geological Time Scale. 2. Contributions of Birbal Sahni 3. Types of fossils: Impression, Compression, Petrifaction, Cast, Mold and Amber. 4. Fossil plants: *Glossopteris* (Leaf, Scutum).			7.5 Hrs.
Unit-II			
1. Bryophytes – Bryophytes as amphibians of kingdom Plantae, General characteristics of Hepaticopsida, Anthocerotopsida and Bryopsida, classification (Proskauer 1957) of Bryophytes. 2. Distribution, morphology, anatomy, reproductive structures and life-cycles of *Riccia* and *Funaria* 3. Economic Importance of Bryophytes.			7.5 Hrs.
Unit-III			
1. Pteridophytes- General characteristics of Psilopsida, Lycopsida, Sphenopsida and Pteropsida 2. Classification (Smith 1955) and Economic importance 3. Alternation of generation in Pteridophytes (Homosporic and Heterosporic) 4. Stelar system in Pteridophytes			7.5 Hrs.
Unit-IV			
1. Fossil Pteridophyte: *Rhynia* 2. Morphology, anatomy, reproductive structures and life-cycle in *Selaginella*, and *Pteris* 3. Heterospory and Seed habit.			7.5 Hrs.
Note: 1. Developmental details not to be included. 2. Short Excursion tour/visit is expected to study Bryophytes and Pteridophytes or fossils in natural habitat.			

MINOR-2: Practical (BBO1P02)	**Hours: Hours/Week**	**Marks: 25+25=50**	**Credit: 1**
1. Study of Fossil types 2. Study of fossil plants- *Rhynia, Glsossopteris.* 3. Study of morphology, classification, reproductive structures and life-cycle of *Riccia* and *Funaria* 4. Study of morphology, classification, anatomy, reproductive structures and lifecycle of *Selaginella*, and *Pteris*			

B.Sc. Semester-III Botany Practical
MINOR-2: BOTANY Paper-II (BBO1P02)
Palaeobotany, Bryophyta and Pteridophyta

Time: 3hrs. **Max. Marks: 25**

Q. 1) Identify & give characters of the given Bryophytic material [A] and prepare a temporary Mount **5 Marks**

Q. 2) Identify & give characters of the given Pteridophytic material [B]and prepare temporary Mount. **5 Marks**

Q. 3) Describe the given fossil Type [C] **5 Marks**

Q. 4) Spotting: **5 Marks**

D- Bryophyte
E- Pteridophyte (Morphology)
F- Pteridophyte (Reproductive)
G-*Glossopteris*
H- Types of stele

Q. 5) Practical Record & Excursion Report **5 Marks**

Suggested reading

1. Agashe SN 1995. Paleobotany- Plants of the past, their evolution, paleoenvironment and Allied plants. Hutchinson & Co., Ltd., London.
2. Bhattacharya K, Hait G, and Ghosh AK 2015. A Textbook of Botany Vol II. New central Book Agency Ltd London.
3. Dhaka TS and Lalit Singh 2017. Elementary Pteridophyta. Pragati Prakashan.
4. Gangulee HC, Kar AK and Santra SC 2018. College Botany Vol II. New central Book Agency Ltd London.
5. Hait G, Bhattacharya K and Ghosh AK 2017. A Textbook of Botany Vol I. New central Book Agency Ltd London.
6. Parihar NS 1970. An Introduction to Embryophyta. Vol. I. Bryophyta. Central Book, Allahabad.
7. Parihar NS 1976. An Introduction to Pteridophytes, Central Book Depot, Allahabad.
8. Parihar NS 1995. Essential of Paleobotany. Central Book, Allahabad.
9. Parihar NS 1997. The biology and Morphology of Bryophytes. Central Book Depot, Allahabad.
10. Prasad KN 1999. An Introduction to Paleobotany. APH Publication.
11. Rashid A 2016. An Introduction to Archegoniate Plants. Vikas Publishing House.
12. Rashid A 2018. An Introduction to Bryophyta. Vikas Publishing House.
13. Rashid A 2018. An Introduction to Pteridophyta. Vikas Publication House Pvt. Ltd.
14. Santra SC 2015. Practical Botany Vol.-I NCBA London.
15. Satish Kumar 2015. Diversity of Algae, Lichen and Bryophytes. Pragati Publication.
16. Sharma OP 1990. Text Book of Pteridophyta. McMillan India Ltd. New Delhi.
17. Sharma OP 2012. Pteridophyta. Tata McGraw Hill Publishing Co. New Delhi.
18. Sharma OP 2017. Bryophyta. Tata McGraw Hill Publishing Co. New Delhi.
19. Siddiqui KA 2002. Elements of Paleobotany. Kitab Mahal Allahabad.

20. Singh V, Pande PC and Jain DK 2007. Diversity of Microbes and Cryptograms. Rastogi Publication.
21. Smith GM 1971. Cryptogamic Botany. Vol. II. Bryophytes & Pteridophytes. Tata McGraw Hill Publishing, New Delhi.
22. Sporne KR 1970. The Morphology of Pteridophytes. Hutchinson University Library London.
23. Sundara Rajan 2000. Practical Manual of Pteridophyta. Anmol Publication Pvt. Ltd. New Delhi.
24. Thakur AK and Bassi SK 2007. Diversity of Microbes and Cryptograms. S. Chand Publication, New Delhi.
25. Vanderpoorten A and Goffinet B 2009. Introduction to Bryophytes, Cambridge University Press, Cambridge.
26. Vashishtha B.R. 1992. Pteridophyta. S. Chand and Co. New Delhi.
27. Vashishtha BR 2016. Bryophyta. S. Chand Publication, New Delhi.

B. Sc. Semester-III GE/OE-5: BOTANY (BGO3T05) Nutraceuticals			
GE/OE-5: Theory	**Hours: 2 Hours/Week**	**Marks: 50+50=100**	**Credits: 2**
Unit-I			
1. Historical perspective; definition, scope and future prospects. 2. Applied aspects of the nutraceutical science. 3. Sources of nutraceuticals. 4. Nutraceutical science in relation to medicine, human physiology, genetics, food technology, chemistry and nutrition.			7.5 Hrs.
Unit-II			
1. Nutraceuticals: bridging gap between food and drugs. 2. Nutraceuticals in treatment for cognitive decline (memory, anxiety and depression). 3. Nutraceutical remedies for common disorders like arthritis, hypoglycemia, psoriasis and ulcers etc. 4. Brief idea about some nutraceutical rich supplements e.g., Bee pollen, Caffeine, Green tea, Chlorophyll (wheatgrass) and *Spirulina* etc.			7.5 Hrs.
Unit-III			
1. Functional foods and Nutraceutical (FFN): relation to foods and drugs. 2. Concept of free radicals and antioxidants. 3. Soy proteins and soy isoflavones in human health. 4. Role of nuts in cardiovascular disease prevention. 5. Functional foods from wheat and rice and their health effects. 6. Role of Dietary fibres in disease prevention.			7.5 Hrs.
Unit-IV			
1. Sources and role of isoprenoids, isoflavones, flavonoids, carotenoids, polyunsaturated fatty acids, terpenoids. 2. Vegetables, cereals, milk and dairy products as functional foods. 3. Health effects of common beans, *Capsicum annum*, mustards, ginseng, garlic, grape, citrus fruits, fish-oils, and sea foods. 4. Types of inhibitors present in various foods and inactivation of inhibitors. 5. General idea about role of Probiotics and Prebiotics as nutraceuticals.			7.5 Hrs.

B. Sc. Semester-III VSC BOTANY (BVS3P05) Plant Propagation and Tissue Culture			
VSC Practical	**Hours: 4 Hours/Week**	**Marks: 50+50=100**	**Credits: 2**
Unit-I			
1. Prepare media (soil mix) for propagation of plants in nursery beds and pots. 2. Preparation of plant material for potting and repotting. 3. Preparation of nursery beds and sowing of seeds in nursery 4. Study the methods of breaking seed dormancy. 5. Study the seed viability using TTZ method.			15 Hrs.
Unit-II			
1. Study the percentage of seed germination by paper slot method. 2. Study of methods of vegetative propagation (Cutting, budding, layering and grafting). 3. Study the operation of autoclave, hot-air oven and laminar air flow 4. Study calibration of pH meter. 5. Surface sterilization of seeds for the development of explants			15 Hrs.
Unit-III			
1. Preparation of stocks solutions for MS media. 2. Preparation of MS media. 3. Surface sterilization of explants for culturing. 4. Culturing of explants for callus induction. 5. Study the method of sub-culturing.			15 Hrs.
Unit-IV			
1. Culturing of explants for root and shoot induction. 2. Study the regeneration efficiency of various explants on micropropagation 3. Study the stepwise process of hardening of regenerated plants. 4. To isolate protoplast from spinach leaves by enzymatic method. 5. To demonstrate the process of protoplast culture.			15 Hrs.

B. Sc. Semester-III Botany Practical

VSC -5 (BVS3P05)

Plant Propagation and Tissue Culture

Time: 5 Hrs. **Max. Mark:** 50

Q. 1 To perform the experiment on Plant propagation **(A)** and report the findings. **10 Marks**

Q. 2 Write a note on working of Autoclave/ Laboratory oven / Laminar Air flow **(B)**. **10 Marks**

Q. 3 Surface sterilization of seeds for the development of explants **(C)**. **10 Marks**

Q. 4 Spotting: **10 Marks**

(D) Plant propagation
(E) Plant propagation
(F) Plant Tissue Culture
(G) Plant Tissue Culture
(H) Plant Tissue Culture

Q. 5 Practical record, viva-voce and excursion report **10 Marks**

Suggested Readings:

1. Anjana R, Joy PP (2014) A Plant Biotechnology Laboratory manual. Kerala Agriculture University
2. Annu Verma, Hemant Kumar Panigrahi and Abhay Bisen (2013) Plant Propagation and Nursery management. IGKV, Rajnandgaon, Chattisgarh.
3. BK Singh, Nidhika Thakur, Om Prakash, Anand singh Practical Manual of Plant Propagation and Nursery Management. Banda University of Agriculture and Technology Banda, Uttar Pradesh.
4. Cell Growth and Division: A Practical Approach edited by Basega R, IRL Press.
5. Dixon, R.A. and Gonzales, R. A. (Eds.) 1994. Plant Cell Culture - A Practical Approach. Oxford University Press, New York.
6. Robert N. Trigiano and Dennis J. Gray. 2000. Plant Tissue Culture Concepts and Laboratory Exercises. 2nd edit., CRC Press LLC.

B. Sc. Semester-IV

Discipline Specific Core Course (DSC-7)- BOTANY Paper-I (BBO4T07)

Genetics, Plant breeding, Biostatistics & Evolution

DSC-7: Theory	Hours: 2 Hours/Week	Marks: 80+20=100	Credits: 2

Unit-I	
1. Gene Interaction: Allelic gene interaction (Incomplete dominance 1:2:1); non-allelic gene; interaction (Complementary genes 9:7, Dominant epistasis 12:3:1) 2. Multiple alleles and Polygenic inheritance 3. Linkage: Definition, theories of linkage (Coupling and Repulsion); Types of linkage (Complete and incomplete); significance. 4. Crossing over: Definition; Breakage and reunion theory; significance.	7.5 Hrs.

Unit-II	
1. Variation in chromosome number and its significance: Euploidy (Auto- and Allo-polyploidy); Aneuploidy (Nullisomic, monosomic, trisomic and tetrasomic) 2. Structural changes in chromosomes and its significance: Deficiency, Duplication, Inversion and Translocation 3. Gene mutation: Spontaneous and Induced mutations; Types (Frame shift and substitution), physical and chemical mutagens; Applications of induced mutation in crop improvement.	7.5 Hrs.

Unit-III	
1. Fine structure of gene: Classical concept- cistron, muton and recon 2. Extra-chromosomal Inheritance: Cytoplasmic inheritance, male sterility in higher plants. 3. Population Genetics: Gene pool, genetic drift, gene frequencies, Hardy-Weinberg Law. 4. Evolutionary genetics: Role of natural selection; Genetic variation and Speciation.	7.5 Hrs.

Unit-IV	
1. Plant Breeding: Definition, objective and domestication of crop plants. 2. Methods of Plant Breeding: Pure line selection; Technique of hybridization; Heterosis 3. Biostatistics: Mean, Mode, Median, Standard deviation, Standard error, and Student's 't' test. 4. Evolution: Origin of life and organic evolution (Miller's theory).	7.5 Hrs.

DSC-7: Practical (BBO4P07)	Hours: 4 Hours/Week	Marks: 25+25=50	Credit: 1

1) Work out the types of gene interaction mentioned in theory syllabus.
2) Study of aneuploidy through idiogram.
3) Study of chromosomal aberrations (structural and numerical changes)
4) Problems based on Population genetics.
5) Demonstration of hybridization technique
6) Compute mean, median and mode from the given data
7) Compute standard deviation and standard error from the given data.
8) Apply Student's 't' test to analyze the data.

B. Sc. Semester-IV Botany Practical

DSC Botany-7 (BBO4P07)

Genetics, Plant breeding, Biostatistics & Evolution

Time: 3 Hrs. **Max. Mark: 25**

Q. 1 To work out the type of gene interaction **(A)** from the given data. **4 Marks**

Q. 2 Identify and comment on the chromosomal changes (structural & numerical) in given photograph **(B)** **4 Marks**

Q. 3 To solve the given problem on population genetics **(C).** **4 Marks**

Q. 4 To solve the problem on Biostatistics **(D)** from the given data. **4 Marks**

Q. 5 Spotting **4 Marks**

(E) Gene interaction/Linkage/ Crossing over
(F) Variation in chromosome number
(G) Variation in chromosome structure
(H) Plant Breeding

Q. 6 Practical Record and Excursion report **5 Marks**

Suggested Readings:

1. Ahluwalia Karvita (2010) Genetics, New Age International (P) Ltd Publishe, New Delhi.
2. Alberts BD, Bray J, Lewis M, Raff K, Roberts, and Watson JD (1999) Molecular Biology of the Cell Garland Publishing Co. Inc. N.Y.
3. Arora Mohan P, Sandhu GS (2009) Genetics, Himalaya Publishing House, Mumbai.
4. Arora PN Malhan PK (1996) Biostatistics, Himalaya publishing House.
5. Arora PN, Malhan PK (2006) Biostatistics. Himalaya Publishing House. Mumbai.
6. Cooper GM (1997) The Cell: A Molecular Approach, Oxford Univ. Press.
7. Genetics by Russel Peter Adison Wesley Longman Inc. (5thedition)
8. Gupta PK (1999) A Text Book of cell and Molecular Biology, Rastogi Publications, Meerut India.

9. Gupta PK (2007) Genetics: Classical to Modern. Rastogi Publications, Meerut
10. Gupta PK (2013) Genetics: Classical to Modern, Rastogi Publication, Meerat.
11. Kar Dipak Kumar, Haldar Soma (2017) Plant Breeding, Biometry Biotechnology, New Central Book Agency Ltd. London.
12. Kar DK, Halder S (2015) Cell Biology, Genetics, Molecular Biology, New Central Book Agency Pvt. Ltd, London.
13. Karp G (2019): Cell and Mol Biology- Concepts and Experiments. John Wiley & Sons Inc.
14. Kathamba Rajan (2007) Biostatistics- Theroy and Problems. Himalaya Publishing House. Mumbai.
15. Kumar HD (1991) A text book of Cytology, Genetics and Evolution, Kalyani Publisher, New Delhi.
16. Lewin G (2000) Gene VII John Wiley and Sons, New York.
17. Padmini E. (2015) Biochemical Calculation and Biostatistics. Books and Allied (P) Ltd Kolkata.
18. Powar CB (2007) Genetics Vol I and II. Himalaya Publishing House. Mumbai.
19. Prasad S. (2008) Elements of Biostatistics. Rastogi Publication, Meerat.
20. Rastogi Veer Bala (2021) Genetics, Medtech Science Press.
21. Russel PJ (1998) Genetics, The Benjamin/ Cummings publishing Con. Inc. USA.
22. Satish Kumar, Harjinder Singh and Vikas Tyagi (2018) Modern Phytotechniques and Biostatistics. Pragati Publication, Meerat.
23. Shukla RS and Chandel PS (2004) Cytogenetics, Evolution and Plant Breeding, S Chand and Company, New Delhi.
24. Singh BD (2018) Fundamentals of Genetics, Kalyani Publications, New Delhi.
25. Singh BD (2018) Plant Breeding Principle and Method, Kalyani Publication, New Delhi.
26. Singh MP and Sunil Kumar (2009) Genetics and Plant Breeding, APH Publishing Corporation, New Delhi.
27. Snustad DP and Simmons MJ (2000) Principles of Genetics, John Wiley and sons, USA.
28. Strickberger MW (2022) Genetics, Pearson.
29. Tomar BS and Singh N (2019) Cell Biology and Genetics, Pragati Prakashan, New Delhi.
30. Verma PS and Agarwal VK (2005) Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. S. Chand and Co. Ltd, New Delhi.
31. Vyas SP and Mehta A (2011) Cell and Molecular Biology. CBS Publ. and Dist. Pvt. Ltd., New Delhi.
32. Xu Yunbi (2010) Molecular Plant Breeding, CABI International

B. Sc. Semester-IV Discipline Specific Core Course (DSC-8)- BOTANY Paper-II (BBO4T08) Plant Development, Anatomy and Embryology			
DSC-8: Theory	**Hours: 2 Hours/Week**	**Marks: 80+20=100**	**Credits: 2**
Unit-I			
1. **Tissue:** Definition, Characteristics of Meristematic tissue; Classification of meristems based on position. 2. **Simple Permanent Tissue-** Structure and Role of Parenchyma, Collenchyma, and Sclerenchyma 3. **Complex Permanent Tissue-** Structure and Role of Xylem and Phloem 4. **Apical meristem of shoot and root:** Histogen theory, Tunica-Corpus theory, Newman's theory 5. **Cambium:** Types and functions.			7.5 Hrs.
Unit-II			
1. **Types of vascular bundles:** Radial, Conjoint and Concentric. 2. **Normal Primary structure of root:** Dicot (*Sunflower*) and Monocot (*Maize*) 3. **Normal Primary structure of stem:** Dicot (*Sunflower*) and Monocot (*Maize*) 4. **Normal secondary growth in dicot stem:** *Sunflower* 5. **Anomalous Secondary growth in stem:** Dicot (*Bignonia,*) and Monocot (*Dracaena*)			7.5 Hrs.
Unit-III			
1. **Periderm:** Composition, functions, Lenticel, Bark and Commercial cork 2. **Secondary structures:** Growth rings, Sap wood, Heart wood and Tyloses 3. **Anatomy of leaf:** Dicot (*Nerium*) and Monocot (*Maize*) 4. **Nodal anatomy:** Leaf trace, leaf gap, branch trace and branch gap.			7.5 Hrs.
Unit-IV			
1. **Pollination:** Types and Significance. 2. **Anther:** T. S. of mature anther, microsporogenesis; structure of pollen grain and development of male gametophyte. 3. **Ovule:** Types of ovule, Structure of anatropous ovule, megasporogenesis, Development of female gametophyte (*Polygonum* type) 4. **Fertilization:** Double fertilization and triple fusion, endosperm and its types, structure of dicot embryo (Onagrad type) and monocot embryo.			7.5 Hrs.

DSC-8: Practical (BBO4P08)	Hours: 4 Hours/Week	Marks: 25+25=50	Credit: 1

1. Study of simple and complex tissue from permanent micro-preparations.
2. Study of different types of vascular bundles.
3. Study of internal structure of dicot and monocot roots with the help of temporary micro-preparations.
4. Anatomy of normal primary dicot and monocot stem
5. Anatomy of normal and anomalous secondary growth in stem with the help of double stained permanent micro-preparation.
6. Study of secondary structures with the help of specimen (e.g. Bark, Growth ring, heart wood, sap wood)
7. Study of internal structure of dicot (*Nerium*) and monocot leaf (Maize) with the help of temporary micro-preparation.
8. To calculate germination percentage of pollen grains in the given material.
9. Study of structure of anther and pollen grains.
10. Study of different types of ovule.
11. Study of dicot and monocot embryos from permanent micro-preparation.

(Note: Developmental stages are not expected)

B. Sc. Semester-IV Botany Practical
DSC Botany-8 (BBO4P08)
(Plant Development, Anatomy and Embryology)

Time: 3 Hrs. **Max. Marks: 25**

Q. 1: Prepare temporary mount of the given **root/leaf** material **(A)** and identify giving diagnostic characters. **5 Marks**

Q. 2: Prepare double stained permanent mount of the given **stem** material **(B)** and identify giving diagnostic characters. **6 Marks**

Q. 3: Calculate germination percentage of **pollen grains** in given material **(C)**. **5 Marks**

Q. 4: **Spotting:** **4 Marks**

(D) Tissue
(E) Vascular bundle
(F) Secondary structure
(G) Embryology

Q. 5: Practical Record and Excursion report. **5 Marks**

Suggested Readings:

1. Bhojwani, S. S. and Bhatnagar, S. P. (2000): The Embryology of Angiosperms, Vikas Publishing House, Delhi.

2. Cutter, E. G. (1971): Plant Anatomy: Experiment and Interpretation. Part II. Organs. Edward Arnold, London.
3. Esau, K. (1979): Anatomy of seed Plants, 2nd Edn. John Wiley and Sons New York Fahn, A. Plant Anatomy, 2nd Edn. Pergamon Press, Oxford.
4. Fageri, K. and Van der Pol, L. (1979): The Principles of Pollination Ecology. Pergamon Press, Oxford.
5. Fahn, A. (1982): Plant Anatomy, (3rd edition). Pergamon Press, Oxford.
6. Heslop-Harrison, J. (1971): (Editor). Pollen: Development & Physiology. Butterworths, London,
7. Nair, P.K.K. (1970): Pollen morphology of Angiosperms. Scholar Publ. House, Lucknow,
8. Pandey B. P. (Fourth Revised Edition 2001): A Text Book of Botany- Angiosperms; S. Chand Publisers.
9. Pandey S. N. & Chadha Ajanta (1996 Reprint 2008): Plant Anatomy and Embryology, Vikas publishing House Pvt Ltd.
10. Raghavan, V. (1986): Embryogenesis in Angiosperms: A Developmental and Experimental Study. Cambridge University Press, Cambridge.
11. Singh, H. (1978): Embryology of Gymnosperms, Encyclopedia of Plant Anatomy X, Gebryder, Bortragear, Berlin.
12. Singh, Pandey and Jain (Third Revised Edition 2018): Anatomy and Embryology of Angiosperms; Rastogi Publications.

B. Sc. Semester-IV MINOR-3: BOTANY Paper-I (BBO2T03) Spermatophyte: Gymnosperm and Angiosperm Morphology			
MINOR-3: Theory	**Hours: 2 Hours/Week**	**Marks: 80+20=100**	**Credit: 2**

Unit-I	
Gymosperms: 1. **Gymnosperms:** General characteristics, Classification (Stewart, 1982) and Economic Importance 2. **Fossil Gymnosperm:** *Cycadeoidea* (Morphology and Reproductive structure) 3. **Life cycle of:** *Cycas* (Morphology, Anatomy and Reproductive structures)	7.5 Hrs.
Unit-II	
Vegetative Morphology: 1. **Root:** Tap root and adventitious root, modification of root for storage and respiration. 2. **Stem:** Branching (Monopodial and Sympodial), Modification of stem (Runner, Suckers, Rhizomes, Tuber, Bulb) 3. **Leaf:** Typical leaf, Types (Simple and Compound), Types of phyllotaxy, Venation, Modification of leaf (Tendril, Phyllode)	7.5 Hrs.
Unit-III	
Reproductive Morphology: 1. **Inflorescence:** Definition, Racemose, Cymose and Special types. 2. **Flower:** Structure of Typical flower, insertion of floral whorls, Variation in thalamus (Androphore, Gynophore and Gynandrophore) 3. **Calyx and Corolla:** Cohesion, Forms of corolla and Aestivation. 4. **Androecium:** Parts, Cohesion, Adhesion and Fixation.	7.5 Hrs.
Unit-IV	
Carpel and Fruit: 1. **Gynoecium:** Parts, Cohesion, Adhesion and Placentation. 2. **Fruit:** Definition, Pericarp, Types of fruits: Simple (Dehiscent, Schizocarpic, Dry Indehiscent, Fleshy Indehiscent); Aggregate (Etaerio) fruits, Composite Fruits (Sorosis and Syconus).	7.5 Hrs.

DSC-3: Practical (BBO2P03)	**Hours: 2Hours/Week**	**Marks: 25+25=50**	**Credit: 1**

1. Study of Gymnosperms:
   a) Fossil gymnosperm- *Cycadeoidea*
   b) Cycas
2. Study of different root modifications
3. Study of branching pattern of stem
4. Modifications of stem
5. Study of leaf: Types (Simple & Compound), Phyllotaxy, Venation and Modifications.
6. Inflorescence: Types mentioned in theory.

7. Flower: Parts, calyx, corolla, androecium, gynoecium, Insertion of Floral whorls, variation in thalamus.
8. Fruits: Study of different types of fruits

B.Sc. Semester-IV Botany Practical
MINOR-3: BOTANY Paper-I (BBO2P03)
Spermatophyte: Gymnosperms and Angiosperm Morphology

Time: 5 Hrs. **Max. Marks: 25**

Q. 1:	Identify the given **Gymnospermic** material **(A)**. Prepare temporary mount and write identifying characters.	**5 Marks**
Q. 2:	Describe the given **leaf** material **(B)**.	**5 Marks**
Q. 3:	Describe the given **flower (C)**	**5 Marks**
Q. 4:	**Spotting**:	**5 Marks**
	(D) Gymnosperm **(E)** Fossil gymnosperm **(F)** Modified root/Stem	
	(G) Inflorescence **(H)** Fruit	
Q. 5:	Practical Record and Excursion report.	**5 Marks**

Suggested Readings:

1. Bhatnagar, S. P. and Moitra A. (1996): Gymnosperms. New Age International Limited, New Delhi.
2. Bierhorst, D. W. [1971]: Morphology of Vascular Plants. McMillon & Co. N. R.
3. Chamberlain, C. J. (1986) Gymnosperms-Structure and Evolution. CBS Publishers & Distributors.
4. Cronquist A. (1961) Introductory Botany. Harper and Brothers, Publishers, New York.
5. Datta A. C. [1971] A Class-book of Botany, Oxford University Press.
6. Galbraith D (1989) Understanding Biology. John Wiley & Sons Inc.
7. Gangulee H. C. and Kar A. K (1970) College Botany Vol. I & II, New Central Book Agency, Calcutta
8. Moore, R, Clark W. D, Vodopich D. S. (1998) Botany. Second Edition. WCB/McGraw-Hill,
9. Sambamurty A.V.S.S. (2013) A Textbook of Bryophytes, Pteridophytes, Gymnosperms and Paleobotany. I K International Publishing House Pvt. Ltd.
10. Saxena A. K. and Sarabhai R. P. (1962) A Textbook of Botany Vol.-II. Ratan Prakashan Mandir, Agra.
11. Sharma, O. P. (2004). Gymnosperms. McMillan India Ltd.
12. Singh M. P, Sharma A K (2002) Textbook of Botany. Anmol Publications Pvt. Ltd.
13. Sporne, K. R. (1965): The Morphology of Gymnosperms. Hutchinson University Library Press, London.
14. Vashishtha, B. R. [1992]: Gymnosperm. S. Chand & Co. New Delhi.
15. Vashistha, P.C (1978) Botany for Degree Students- Gymnosperms Vol. V. S. Chand and Co. New Delhi.
16. Vashistha, P.C, Sinha A. K. and Kumar A (1976) Botany for Degree Students-Gymnosperms S. Chand Publishing.
17. Verma, V. (2010) Botany. Ane Books Pvt. Ltd.

B. Sc. Semester-IV
MINOR-4: BOTANY Paper-II (BBO2T04)
Cell Biology and Genetics (Mendelism)

MINOR-4: Theory	Hours: 2 Hours/Week	Marks: 80+20=100	Credit: 2

Unit-I	
1. Definition of cell, brief account of Cell theory proposed by Schleiden and Schwann. 2. Comparison between prokaryotic and eukaryotic cell 3. Ultra-structure of typical plant cell 4. Ultra-Structure and functions of: a. Cell wall b. Cell membrane (Fluid Mosaic model) c. Endoplasmic reticulum	7.5 Hrs.
Unit-II	
Ultra- Structure and functions of: Continued d. Golgi complex e. Ribosomes f. Mitochondria g. Chloroplast h. Lysosome i. Vacuole j. Peroxisomes and Glyoxysomes	7.5 Hrs.
Unit-III	
Ultra-Structure and functions of: Continued k. Nucleus 5. Morphology of typical eukaryotic chromosome 6. Karyotype and idiogram 7. Molecular organization of chromosome- **Nucleosome model** 8. Sex chromosomes in ***Melandrium album*** (XY-type)	7.5 Hrs.
Unit-IV	
9. Cell cycle 10. Mitosis in plants 11. Meiosis in plants 12. Significance of Mitosis and Meiosis 13. Mendelism: Monohybrid and dihybrid cross, Laws of inheritance: Law of segregation and Law of independent assortment	7.5 Hrs.

DSC-4: Practical (BBO2P04)	Hours: 2Hours/Week	Marks: 25+25=50	Credit: 1

1. Study of cell organelles with the help of photographs and slides.
2. Study of Mitosis with suitable plant materials.
3. Study of Meiosis with suitable plant materials.
4. To work out Numerical problems based on monohybrid and dihybrid ratio.

5.	To prove Mendel's law of segregation by applying Chi-square test with the help of coloured beads.
6.	To prove Mendel's law of independent assortment by applying Chi-square test with the help of coloured beads.
7.	To demonstrate monohybrid cross by using coloured beads.
8.	To study the morphology of typical eukaryotic Chromosome (by using photographs)
	Note: **Botanical excursion and visits are compulsory**

B.Sc. Semester-IV Botany Practical
MINOR-4: BOTANY Paper-II (BBO2P04)
Cell Biology and Genetics (Mendelism)

Time: 5 Hrs. **Max. Marks: 25**

Q. 1: To prepare semi-permanent smear/squash of the given plant material (A), identify stage/ Stages of Cell division. **5 Marks**

Q. 2: To prove Mendel's law of segregation by using coloured beads (B) and apply Chi-square test **5 Marks**

Q. 3: To prove Mendel's law of independent assortment by using coloured beads (C) and apply *Chi-square* test **5 Marks**

Q. 4: **Spotting:** **5 Marks**

(D) Types of cell **(E)** Cell organelle **(F) Cell organelle**

(G) Mitosis/ Meiosis **(H)** Chromosome morphology

Q. 5: Practical Record and Excursion report. **5 Marks**

Suggested reading:

1. De. Robertis and E.M. De. Robertis (1980): Cell and Molecular Biology, 7th Ed. Saunders College/Holt Rinehart and Winston, Philadelphia.
2. Dnyansagar, V. R. (1986): Cytology and Genetics, Tata McGraw Hill.
3. Ganesh Prasad (1998): Introduction to Cytogenetics, Kalyani Publishers, New-Delhi.
4. Gardner E.J.; Simmons M.S. and D. Peter Snustad, (2006): Principles of Genetics, Wiley India Pvt. Ltd., New Delhi.
5. Gerald Karp (2013): Cell Biology, 7th Ed., Wiley India Pvt. Ltd., New Delhi.
6. Powar, C. B. (2010): Cell Biology, Himalaya Publishing House, Mumbai.
7. Sarin, C. (1985) Genetics, Tata Mc Graw Hill.
8. Singh, B. D., (2023): Fundamental of Genetics, 6th Ed.; MedTech Science Press, Scientific International Pvt. Ltd., New Delhi.
9. Strickberger M.W. (1976): Genetics 2nd Ed., Mac Millan Publising Co. Inc., New York.
10. William Hexter; Henry t. Yost Jr, (1977): The Science of Genetics, Printice-Hall of India Pvt. Ltd, New-Delhi.

B. Sc. Semester-IV GE/OE-6- BOTANY (BGO4T06) Biofuels Technology, IPR			
GE/OE-6: Theory	**Hours: 2 Hours/Week**	**Marks: 80+20=100**	**Credits: 2**
Unit-I			
1. **Introduction:** Biofuel an overview 2. Conventional biomass, Aquatic biomass. 3. **Microbial Biofuels Production process:** Various microbes involved, Different biochemical routes for the Biofuels production. 4. Molecular biological approaches for the improvement of Biofuels production, Effect of physico-chemical parameters on the Biofuels production.			7.5 Hrs.
Unit-II			
1. **Bioethanol and biogas production:** By fermentation of vegetable wastes. 2. Methane from anaerobic digestion: metabolic processes, practical aspects. 3. **Biodiesel production:** current perspective. 4. Biodiesel production by microalgae.			7.5 Hrs.
Unit-III			
1. **Introduction:** Origin, Nature, Meaning of Intellectual Property Rights. 2. IPR- Types, Ethical issues related to publishing, Plagiarism and Self-Plagiarism, Software for detection of Plagiarism. 3. **Intellectual Properties:** Intellectual property rights (IPR) and protection (IPP), 4. Patents, trade secrets, copyrights, trademarks, GATT and TRIPS.			7.5 Hrs.
Unit-IV			
1. **Geographical Indication (GI):** Meaning and difference between GI and trademarks- Procedure for registration, effect of registration and term of protection. 2. **Plant Variety Protection:** Meaning and benefit sharing and farmers' rights- Procedure for registration, effect of registration and term of protection. 3. **Layout Design Protection:** Meaning- Procedure for registration, effect of registration and term of protection.			7.5 Hrs.

Suggested Readings:

1. Bouchoux, D. (2012). Intellectual property right, Cengage learning.
2. Cave Drapcho, John Nghiem, and Terry Walker, Biofuels Engineering Process Technology, McGraw Hill Publications.
3. Donald Klass, Biomass for Renewable Energy, Fuels, and Chemicals, Academic Press Publications.
4. Dr. B. L. Wadehra, Law relating to Intellectual Property, Universal Law Publishing Co.
5. Dr. G.B. Reddy, Intellectual Property Rights and the Law, Gogia Law Agency.

6. Dr. S. R. Myneni, Law of Intellectual Property, Asian Law House.
7. Ganguli, Prabuddha. (2017). Intellectual property right - Unleashing the knowledge economy, Tata McGraw Hill Publishing Company Ltd.
8. J. D. Wall, Bioenergy, ASM Press, Washington DC, 2008.
9. Johnson, M, (2021). Intellectual Property Law: Basics and Beyond. Coursera.
10. Mousdale, D. M. (2008), Biofuels: Biotechnology, Chemistry and Sustainable Development, CRC Press, Boca Raton.
11. P. David, Biofuels, Solar and Wind as Renewable Energy Systems, Springer, Colorado, 2008.
12. Ram B. Gupta and Ayhan Demirbas, Gasoline, Diesel and Ethanol Biofuels from Grasses and Plants, Cambridge University Press.
13. Robert C. Brown, Biorenewable Resources: Engineering New Products from Agriculture, Wiley-Blackwell.
14. Vaidhyanathan, Siva. (2017)."Intellectual Property: A Very Short Introduction". Oxford University Press.
15. W. Institute, Biofuels for Transport: Global Potential and Implications for Sustainable Energy and Agriculture, Earthscan, London, 2007.

B. Sc. Semester-IV SEC BOTANY (BVS4P06) Nursery and Greenhouse Management			
SEC Practical	**Hours: 2 Hours/Week**	**Marks: 50+50=100**	**Credits: 2**
Unit-I			
1. Different types of nursery bed preparation. 2. Preparation of potting mixture for nursery 3. To study methods of soil sterilization for plant nursery 4. To study natural methods of vegetative propagation (Cutting, Layering, Suckers, Bulb, Corm)			15 Hrs.
Unit-II			
1. To study artificial methods of vegetative propagation (Budding, grafting) 2. Garden Implements used in nursery preparation. 3. To study different growth hormones used in plant propagation. 4. Routine garden operations in plant nursery management (Direct seeding, planting, transplanting, pricking, shading, pinching, defoliation, mulching)			15 Hrs.
Unit-III			
1. Common diseases of nursery plants and their management 2. Different chemical fertilizers and insecticides used in nursery. 3. Preparation and uses of different biofertilizers, organic manures, vermicompost 4. Method of preparation of bio-compost.			15 Hrs.
Unit-IV			
1. Biopesticides used in nursery 2. Study of Greenhouse infrastructure and requirements. 3. Visit to agriculture/horticulture/forest/medicinal plant nursery. 4. Practicing nursery techniques by raising annuals/ forest trees / vegetables / medicinal plants.			15 Hrs.

B. Sc. Semester-IV Botany Practical
SEC BOTANY (BVS4P06)
Nursery and Greenhouse Management
(BVS4PO6)

Time: 5 Hrs. **Max. Marks: 50**

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1. Comment on different methods of soil sterilization or to study different natural methods of vegetative propagation **10 Marks**
2. Comment on different artificial methods of vegetative propagation or study of garden implements (Any two) **10 Marks**
3. Comment on preparation and uses of different biofertilizers or organic manures or vermicompost **10 Marks**
4. Comment on preparation and uses of given biopesticide **10 Marks**
5. Practical record, viva-voce and excursion report **10 Marks**

Suggested Readings:

1. Arun Kumar Singh and Abhinav Kumar (2020). Propagation and nursery management.
2. B. S. Chundawat (2017). Plant propagation and nursery management.
3. G. S. Randhawa and A. Mukhopadhyay (2004). Floriculture in India. Allied Publishers, New Delhi.
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