University of Mumbai

No. UG/12 of 2020-21

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges, the Head of the University Departments and Directors of the recognized Institutions in Science & Technology Faculty is invited to the syllabus uploaded Academic Authority Unit which was accepted by the Academic Council at its meeting held on 10th February, 2012 **vide** item No.4.18 relating to the syllabus as per the (CBSGS) for the M.Sc. (Sem. I & II) in Botany.

They are hereby informed that the recommendations made by the Board of Studies in Botany at its meeting held on 24th February, 2020 vide item No.2 and subsequently made by the Board of Deans at its meeting held on 26th June, 2020 vide item No.7 have been accepted by the Academic Council at its meeting held on 23rd July, 2020 vide item No.4.65 and that in accordance therewith, the revised syllabus as per the (CBCS) of M.Sc. (Sem. I & II) in Botany has been brought into force with effect from the academic year 2020-21, accordingly. (The same is available on the University's website www.mu.ac.in).

Vutul

MUMBAI – 400 032
11th November, 2020

(Dr. Vinod Patil)
I/c REGISTRAR

To

The Principals of the affiliated Colleges, the Head of the University Departments and Directors of the recognized Institutions in Science & Technology Faculty. (Circular No. UG/334 of 2017-18 dated 9th January, 2018.)

A.C/4.65/23/07/2020

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No. UG/12-A of 2020-21 MUMBAI-400 032 11th November, 2020

Copy forwarded with Compliments for information to:-

1) The Dean, Faculty of Science & Technology,
2) The Chairman, Board of Studies in Botany,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Co-ordinator, University Computerization Centre,

Vutul

(Dr. Vinod Patil)
I/c REGISTRAR

Copy to :-

1. **The Deputy Registrar, Academic Authorities Meetings and Services (AAMS),**
2. **The Deputy Registrar, College Affiliations & Development Department (CAD),**
3. **The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM),**
4. **The Deputy Registrar, Research Administration & Promotion Cell (RAPC),**
5. **The Deputy Registrar, Executive Authorities Section (EA),**
6. **The Deputy Registrar, PRO, Fort, (Publication Section),**
7. **The Deputy Registrar, (Special Cell),**
8. **The Deputy Registrar, Fort/ Vidyanagari Administration Department (FAD) (VAD), Record Section,**
9. **The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari,**

They are requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to in the above circular and that on separate Action Taken Report will be sent in this connection.

1. **P.A to Hon'ble Vice-Chancellor,**
2. **P.A Pro-Vice-Chancellor,**
3. **P.A to Registrar,**
4. **All Deans of all Faculties,**
5. **P.A to Finance & Account Officers, (F.& A.O),**
6. **P.A to Director, Board of Examinations and Evaluation,**
7. **P.A to Director, Innovation, Incubation and Linkages,**
8. **P.A to Director, Board of Lifelong Learning and Extension (BLLE),**
9. **The Director, Dept. of Information and Communication Technology (DICT) (CCF & UCC), Vidyanagari,**
10. **The Director of Board of Student Development,**
11. **The Director, Department of Students Walfare (DSD),**
12. **All Deputy Registrar, Examination House,**
13. **The Deputy Registrars, Finance & Accounts Section,**
14. **The Assistant Registrar, Administrative sub-Campus Thane,**
15. **The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan,**
16. **The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,**
17. **The Assistant Registrar, Constituent Colleges Unit,**
18. **BUCTU,**
19. **The Receptionist,**
20. **The Telephone Operator,**
21. **The Secretary MUASA**

for information.

AC_____
Item No. _____

UNIVERSITY OF MUMBAI

Program : M.Sc.

Course : Botany

Syllabus for Semester I and II

(Choice Based Credit System with effect from the Academic year 2020-21)

Cover Page

AC_____
Item No. _____

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	M.Sc. Botany
2	Eligibility for Admission	B.Sc. Botany
3	Passing Marks	
4	Ordinances / Regulations (if any)	
5	No. of Years / Semesters	Semester I & Semester II
6	Level	P.G. **(Strike out which is not applicable)**
7	Pattern	Semester **(Strike out which is not applicable)**
8	Status	New **(Strike out which is not applicable)**
9	To be implemented from Academic Year	From Academic Year 2020-2021

Date:

Signature :

Name of BOS Chairman / : Dr Rajendra D. Shinde

Chairman, BOS, Botany

PROGRAMME SPECIFIC OUTCOMES FOR MSc BOTANY

AT THE END OF **SEMESTER I AND II** THE STUDENTS WOULD HAVE ACQUIRED THE FOLLOWING SKILLS:

1. Students will be able to identify the major groups of organisms amongst plants and be able to classify them within a phylogenetic framework. Students will be able to compare and contrast the characteristics of Cryptogams and Phanerogams that differentiate them from each other and from other forms of life.
2. Students will be able to explain how organisms function at the level of the gene, genome, cell, tissue, organ and organ-system. Drawing upon this knowledge, they will be able to give specific examples of the physiological adaptations, development, reproduction and behaviour of different forms of life.
3. Students will be able to explicate the ecological interconnectedness of life on earth by studying ecological principles and nutrient flow through the environment. They will be able to relate the physical features of the environment to the structure of populations, communities, and ecosystems.
4. Students will be able to use the evidence of comparative biology to explain how the theory of evolution offers the only scientific explanation for the unity and diversity of life on earth. They will be able to use specific examples to explicate how descent with modification has shaped plant morphology, physiology, and life history.
5. Students will be able to carry out a thorough study of the active constituents of medicinal plants with an emphasis on the use of plant based food as medicine.
6. Students will be able to demonstrate proficiency in the experimental techniques and methods of analysis appropriate for understanding the above.

COURSE OUTCOMES

COURSE CODE	TITLE AND LEARNING OUTCOMES
PSBO101	**Plant Diversity-Cryptogams I (Algae and Fungi)** The students will be able to: • Classify algae into various groups, understand the importance in various fields and will be able to collect and identify them • Classify fungi into various groups, understand the role of fungi in various fields and will be able to collect and identify fungi, fungal pathogens and culture them.
PSBO102	**Plant Diversity – Spermatophyta I (Gymnosperms and Angiosperms)** Learning outcomes: The students will be able to differentiate between gymnosperms and angiosperms , study their origin and nomenclature, understand evolutionary theories for origin of Angiosperms, understand characteristics of selected Angiosperm families and learn the rules governing the code of botanical nomenclature, also learn the recent developments as in molecular systematics.
PSBO103	**Plant Physiology** Students should be able to understand how to apply the basic concepts of Plant Physiology in other fields and also to know and

	discuss the concept of physiological processes of plants.
PSBO104	**Cytogenetics, Molecular Biology and Biotechnology** Students will be able to understand the control points in a cell cycle, Study and apply principles of microbial genetics, understand recombinant DNA technology and study applications of the same for the improvement of crops.
PSBO201	**Plant Diversity- Cryptogams II (Bryophyta and Pteridophyta)** The student will be able to: Classify Bryophytes into various groups, study their importance Classify Pteridophytes into various groups, study their importance and multiplication of important ferns
PSBO202	**Plant Diversity: Spermatophyta II** **(Anatomy, Developmental Botany and Palynology)** Students will be able to understand the development of pollen, spore, fertilization and to apply palynological information to plant systematics
PSBO203	**Plant Physiology and Environmental Botany** The students should be able to: • Distinguish key physiological processes underlying the seed germination • Identify the physiological factors that regulate growth and developmental processes of plants • Demonstrate clear understanding of crop-environment interaction and its implication on crop growth and yield • Integrate and apply their knowledge of crop physiology for analytical thinking and solving practical problems experienced in agricultural systems To understand and apply ecological principles and understand legislation and measures to solve environmental problems.
PSBO204	**MEDICINAL BOTANY AND DIETETICS** Students will be able to identify medicinal plants and understand the effects of plant chemical constituents on humans and the use of plants in Dietetics and as nutraceuticals.

COURSE OUTCOMES

COURSE CODE	TITLE AND LEARNING OUTCOMES
PSBO101	**Plant Diversity-Cryptogams I (Algae and Fungi)** The students will be able to: • Classify algae into various groups, understand the importance in various fields and will be able to collect and identify them • Classify fungi into various groups, understand the role of fungi in various fields and will be able to collect and identify fungi, fungal pathogens and culture them.
PSBO102	**Plant Diversity – Spermatophyta I (Gymnosperms and Angiosperms)** Learning outcomes: The students will be able to differentiate between gymnosperms and angiosperms , study their origin and nomenclature, understand evolutionary theories for origin of Angiosperms, understand

	characteristics of selected Angiosperm families and learn the rules governing the code of botanical nomenclature, also learn the recent developments as in molecular systematics.
PSBO103	**Plant Physiology** Students should be able to understand how to apply the basic concepts of Plant Physiology in other fields and also to know and discuss the concept of physiological processes of plants.
PSBO104	**Cytogenetics, Molecular Biology and Biotechnology** Students will be able to understand the control points in a cell cycle, Study and apply principles of microbial genetics, understand recombinant DNA technology and study applications of the same for the improvement of crops.
PSBO201	**Plant Diversity- Cryptogams II (Bryophyta and Pteridophyta)** The student will be able to: Classify Bryophytes into various groups, study their importance Classify Pteridophytes into various groups, study their importance and multiplication of important ferns
PSBO202	**Plant Diversity: Spermatophyta II** **(Anatomy, Developmental Botany and Palynology)** Students will be able to understand the development of pollen, spore, fertilization and to apply palynological information to plant systematics
PSBO203	**Plant Physiology and Environmental Botany** The students should be able to: • Distinguish key physiological processes underlying the seed germination • Identify the physiological factors that regulate growth and developmental processes of plants • Demonstrate clear understanding of crop-environment interaction and its implication on crop growth and yield • Integrate and apply their knowledge of crop physiology for analytical thinking and solving practical problems experienced in agricultural systems To understand and apply ecological principles and understand legislation and measures to solve environmental problems.
PSBO204	**MEDICINAL BOTANY AND DIETETICS** Students will be able to identify medicinal plants and understand the effects of plant chemical constituents on humans and the use of plants in Dietetics and as nutraceuticals.

SYLLABUS MSc I BOTANY
SEMESTER I 2020-21

Course Code	TOPIC HEADINGS	Credits	L / Week
PSBO101	**Plant Diversity :Cryptogams I (Algae and Fungi)**	**4**	
UNIT I	**Algae**		**1**
UNIT II	**Applied Phycology**		**1**
UNIT III	**Fungi**		**1**
UNIT IV	**Plant Pathology**		**1**
PSBOP101	**Practical based on the course : Plant Diversity :Cryptogams I (Algae and Fungi)**	**2**	

Course Code	Topic	Credits: 4
PSBO101	**Plant Diversity-Cryptogams I (Algae and Fungi)**	
UNIT 1	**Algae** • Classification of Algae up to orders, according to the system proposed by G.M Smith. • General account of the chloroplasts and chromatophores in different groups of algae • Asexual and Sexual spore bearing structures in various groups of algae • Life cycle of *Scytonema, Nitella*, *Padina and Dictyota.* • *Diversity and distribution of marine algae in Maharashtra.*	1
UNIT 2	**Applied Phycology** • Culturing of algae and preservation • Contributions of Eminent Algologists in India: M. O. P. Iyengar and T. V. Desikachary. • Economic importance of algae with reference to : Food, Agriculture - Fodder, Biofuel, Biofertilizers, Industry: Agar agar, Medicine, Sewage disposal, Water pollution, Energy production. • Cultivation of algae with special reference to *Chlorella* and *Spirulina*	1
UNIT 3	**Fungi** • Classification of fungi up to orders, according to the system proposed by Alexopoulos (1962). • General account of vegetative structure of unicellular and multicellular Mycelia, Septa, Hyphal modifications in various groups of fungi • General account of spore bearing organs and their arrangements in various groups of fungi. • Spore release and dispersal – with special reference to Basidiomycotina, Deuteromycotina • Life cycle of *Stemonitis, Phytophthora*and	1

	Peziza. • Mycorrhiza: type, distribution and significance with reference to agriculture and forestry	
UNIT 4	**Plant Pathology** • Integrated management of diseases • Study of the following diseases with reference to occurrence, symptoms, causal organism, disease cycle, predisposing factors and control measures of the following diseases: a. Red rot of Sugarcane (*Colletotrichum falcatum*) b. Blast of Rice (*Pyricularia oryzae*) c. Wilt of Arhar/ Tur (*Fusarium oxysporum*) d. Green ear of Bajra (*Sclerospora graminicola*) e. Angular leaf spot of Cotton (*Xanthomonas axonopodis*)	1
Learning outcomes: The students will be able to: • Classify algae into various groups, understand the importance in various fields and will be able to collect and identify them • Classify fungi into various groups, understand the role of fungi in various fields and will be able to collect and identify fungi, fungal pathogens and culture them.		

PSBOP101	**Plant Diversity :Cryptogams I (Algae and Fungi)**		**2**
• Study of following type with reference to their systematic position, thallus and reproductive structures: *Scytonema, Lyngbya, Anabaena, Volvox, Scenedesmus, Ulothrix, Enteromorpha, Pithophora, Closterium, Nitella, Padina, Gracilaria and Dictyota.* • Extraction of algal pigments and their separation by paper chromatography. • Culturing of *Chlorella* and *Spirulina* algae • Culturing of *Penicillium* by streak method • Study of the following types with reference to their systematic position, thallus and reproductive structures: *Stemonitis, Saprolegnia, Phytophthora, Penicillium, Peziza, Polyporus, Daedalea, Fusarium and Trichoderma.* • Study of the disease mentioned in the syllabus (theory) with reference to the symptoms, Causal organisms, Disease cycle and Control measures.			

M. Sc. Sem I (Practical) Examination
(09.00 AM to 2.00 PM)
BOTANY-PRACTICAL-I PSBOP101
[Plant Diversity – Cryptogams I (Algae and Fungi)]

Skeleton Question Paper

Time: 9.00 am To 2.00 pm **Max. Marks: 50**

1) Candidates should show their slides/ preparations/ results for all questions to the examiner.
2) Use of logarithm tables / simple calculator is allowed.

Q. 1. Identify, classify and describe the morphological / reproductive structures observed in specimens **A, B, C and D** **(20)**

Q.2. Identify any three algae in the given mixture **E** **(06)**

Q.3. Separate the algal pigments by paper chromatography from the given sample **F** **(05)**

Q.4. Identify and describe slides/ specimen **G, H** and **I** **(09)**

Q.5. Journal **(05)**

Q.6. *Viva-voce* **(05)**

KEY

A and B :(*Scytonema, Lyngbya, Anabaena, Volvox, Scenedesmus, Ulothrix, Enteromorpha, Pithophora, Closterium, Nitella, Padina, Gracilaria and Dictyota.)*

C and D *Stemonitis, Saprolegnia, Phytophthora, Penicillium, Peziza, Polyporus, Daedalea, Fusarium and Trichoderma*

E Mixture of six algae

F Separation of algal pigments by paper chromatography

G, H, I Red rot of sugar cane/ Blast of rice/ Wilt of tur or arhar/Green ear of bajra/ Angular leaf spot of cotton/ algae and fungi other than given above

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Course Code	Title	Credits
PSBO102	**Plant Diversity – Spermatophyta I (Gymnosperms and Angiosperms)**	4

Unit I: Gymnosperms I — 1

1. **Classification** of Gymnosperms up to orders according to the system proposed by C. J. Chamberlain.
2. Characters of Gymnosperms which resemble and differ from Pteridophytes, Angiosperms.
3. General characters; affinities and interrelationships of Cycadofilicales, Bennettitales, Cordaitales and Ginkgoales.
4. Life cycle of *Zamia* and *Araucaria*

Unit II: Origin of Angiosperms — 1

1. **Nature of probable ancestors of angiosperms**
   - Isoetes monocotyledon theory
   - Coniferales amentiferae theory
   - Gnetales angiosperm theory
   - Bennettitalean theory
   - Caytonialean theory
   - Pentoxylales theory
2. **Primitive and advanced character in angiosperms.**

Unit : III Angiosperms I — 1

1. Study of following families with reference to its systematic position, distribution, floral formula, floral diagram, affinities, morphological peculiarities, economically important plants and their uses.
   Menispermaceae, Brassicaceae, Tiliaceae, Portulacaceae, Sterculiaceae, Rutaceae, Celastraceae, Sapindaceae, Crassulaceae, Lythraceae, Gentianaceae, Boraginaceae, Chenopodiaceae, Cyperaceae.

Unit : IV Angiosperms II — 1

1. **International Code of Nomenclature for Algae, Fungi and Plants (I.C.N.)** Principles and Rules and recommendation.
2. **Systems of classification**
   a. Introduction to Artificial, Natural and Phylogenetic System of classification
   b. Bentham and Hooker's system of classification up to orders
   c. Introduction to A. P. G. systems.
3. **Taxonomy as synthetic branch**- Introduction, type function values of taxonomic characters- numerical taxonomy, Molecular systematics.

Learning outcomes:

The students will be able to differentiate between gymnosperms and angiosperms , study their origin and nomenclature, understand evolutionary theories for origin of Angiosperms, understand characteristics of selected Angiosperm families and learn the rules governing the code of botanical nomenclature, also learn the recent developments as in molecular systematics.

PSBOP102	Plant Diversity – Spermatophyta I (Gymnosperms and Angiosperms)	2

Gymnosperms: A study of following types

- *Cycadeoidea*(Fossil)
- *Williamsonia* (Fossil)
- *Zamia*
- *Cupressus*
- *Araucaria*
- *Podocarpus*

Angiosperms:

- A study of the angiosperm families mentioned in theory with reference to their morphological peculiarities and economic importance of its members.

- Identification of genus and species with the help of flora (In addition to the above mentioned families, all families studied in undergraduate classes are included)

University of Mumbai

M. Sc. Sem I (Practical) EXAMINATION

BOTANY-PRACTICAL-II PSBOP102
[Plant Diversity –Spermatophyta I (Gymnosperms & Angiosperms)]

Time: 9.00 am To 2.00 pm **Max. Marks: 50**

Skeleton Question Paper

N.B.

Candidates should show their slides/ preparations/ results for all questions to the examiner.

Q1	Identify, classify and describe specimen **A.**	**(06)**
Q2(a)	Assign specimens **B** and **C** to their respective families giving reasons. Draw the floral diagram and give the floral formulae. Sketch and label the L.S. of the flower and T.S. of ovary.	**(18)**
(b)	With the help of flora, identify the genus and species of specimen **D**	**(05)**
Q3(a)	Describe the morphological peculiarities of specimen **E**	**(05)**
(b)	Give the economic importance of specimen **F**	**(03)**
Q4	Identify and describe specimen/slide G	**(03)**
Q5	Journal	**(05)**
Q6	Field Report	**(05)**

KEY

A *Zamia, Cupressus, Araucaria and Podocarpus* - stem, male cone, female cone

B and C Menispermaceae, Brassicaceae, Tiliaceae, Portulacaceae, Sterculiaceae, Rutaceae, Celastraceae, Sapindaceae, Crassulaceae, Lythraceae, Gentianaceae, Boraginaceae, Chenopodiaceae, Cyperaceae.

D Flora- Any plant from FYBSc to MSc families can be given.

E Any plant from FYBSc to MSc families can be given.

F Any part of the plant from MSc part I families can be given

G Fossil

SEMESTER I
Paper III

Course Code	UNIT	TOPIC HEADINGS	Credits	L / Week
PSBO103	Title of the Paper: Plant Physiology			
	I	Photosynthesis I	4	1
	II	Photosynthesis II		1
	III	Proteins		1
	IV	Plant Hormones		1

Detailed Syllabus

Course Code	Title: Plant Physiology	Credits
PSBO103		4
Unit I: Photosynthesis I (Eukaryotes) **1.** ATP synthesis in chloroplasts (chemiosmotic hypothesis) 2. Regulation of C_3, C_4 and CAM pathways of photosynthesis: **C_3 plants:** Role of light, regulation of RUBISCO **C_4 plants:** Role of light, regulation of PEPcase, transport of metabolites, carbonic anhydrase, NADP-MDH and PPDK Regulation of CAM through transport of metabolites. 3. **Pentose Phosphate Pathway** and its importance, effect of glucose-6-phosphate dehydrogenase deficiency.		1
Unit II: Photosynthesis II (Prokaryotes) **Photosynthesis of prokaryotes**: Classification of photosynthetic bacteria**,** Pigment systems, CO_2 fixation in bacteria and cyanobacteria, Structure and mechanism of light harvesting complex, Reductive TCA cycle.		1
Unit : III Proteins Primary, secondary, tertiary and quaternary structural features and their analysis – Theoretical and experimental; protein folding – biophysical and cellular aspects, Role of chaperons in protein folding.		1
Unit : IV Plant Growth Regulators Auxins, Gibberellins, Cytokinins, Ethylene, Abscisic acid, Brassinosteroids and Jasmonic acid; Biosynthesis, storage, breakdown, transport and their physiological responses.		1
Learning outcomes: Students should be able to understand how to apply the basic concepts of Plant Physiology in other fields and also to know and discuss the concept of physiological processes of plants.		

Practical

PSBOP103	**Plant Physiology**	2	4

Major experiments

1. Enzyme kinetics: Determination of Km and Vmax of the enzyme amylase (purified amylase).
2. Extraction of cellulase from a suitable fungal culture and study of enzyme activity by DNSA method.
3. Immobilisation of yeast cells and study of invertase activity.
4. Quantitative study of diurnal fluctuation in Titratable Acid Number (TAN) in a CAM plant.
5. Extraction and estimation of GOT and GPT from suitable plant material.
6. Determine the Chl a/Chl b ratio in C_3& C_4 plants.

Minor experiment

1. Separation of organic acids by paper chromatography.
2. Separation of sugars by paper chromatography.
3. A study of the enzyme polyphenol oxidase, from potato peels.
4. Solvent extraction of chlorophyll a/b, xanthophylls and study of absorption pattern.
5. Estimation of the total nitrogen content of a plant using Kjeldahl's method.

University of Mumbai
M. Sc. Botany (Semester-I) Practical Examination
Skeleton Question Paper
Plant Physiology PSBOP103
Practical – III

Time: 9.00 am To 2.00 pm **Max. Marks: 50**

N. B. 1) Candidates should show their slides/preparations/results for all questions to the examiners.
2) Use of **logarithm tables**/simple **calculator** is **allowed**.

Q.1 Perform the given experiments **A & B (major)** and analyze the results. **(30)**

Q.2 Perform the given experiment **C (minor)** and analyze the results. **(10)**

Q.3 Journal **(05)**

Q.4 *Viva-voce* **(05)**

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MSc Sem 1 Paper IV Theory

Course Code	Title	Credits
PSBO104	**Cytogenetics, Molecular Biology and Biotechnology**	**4**
Unit I: Cytogenetics Cell division and cell cycle: Steps in cell cycle and control of cell cycle. Check points during cell cycle-G_1 to S, progression of S phase, G_2 to M phase, Anaphase check points and components involved as regulators of check points, role of cyclins and CDKs, synthesis and degradation of cyclins, structural features of CDKs and cyclins, activation and inactivation of CDKs; role of E2Fs, and DP proteins, P53, different types of Cyclin dependent CDKs, CDC25, CAKs, Wee1 proteins, nim-proteins, SCFs, Anaphase Promoting Complexes APC (cyclosomes), replication origin and replication initiation complexes. Centrosome activation- structure, duplication of centrosomes, Role of nucleophosmins, organization of mitotic apparatus, binding of tractile fibers to kinetochore complexes, molecular motors involved in movement of chromosomes to equatorial plate and in anaphase movement; cytokinesis by cleavage and phragmoplast formation- different gene products and structures involved and the mechanisms of cytokinesis.		
Unit II: Molecular Biology Microbial Genetics: Molecular basis of transformation, transduction, Conjugation; fine structure of the gene, T4 Phage, complementation analysis, deletion mapping, cis-trans tests. Tetrad analysis in *Neurospora:* Linkage detection (2 genes and centromere)		
Unit : III Recombinant DNA Technology General information onSV-40, Vaccinia, Baculovirus& retroviral vectors. Use of YAC or YEp of yeast (*Saccharomyces cervisiae*) as effective cloning vectors because of their high copy numbers in production of HBsAg vaccine Use of BAC and its advantages Strategies to create Transgenic plants with herbicide resistance: Following strategies to be studied in detail with reference to herbicide Glyphosate resistance: a) Overexpression of the target protein by using a strong promoter. b) Improved plant detoxification resulting in a more and faster conversion of toxic herbicide to non-toxic or less toxic compound. c) Detoxification of herbicide by using a foreign gene. d) Mutation of target protein Methods of modifying the Diazotrophs (N_2 fixing bacteria) by Gene alterations in *Rhizobium* sp. to a) Improve nitrogen fixing efficiency and bacterial and host		

plant interaction. b) Induce symbiotic relationship with non- leguminous plants such as wheat, rice and corn c) Transfer of gene for nitrogen fixation from *Rhizobium*sps. to other bacteria such as *Agrobacterium tumefaciens.*	
Unit : IV Applications of Recombinant DNA technology **Resistance to biotic stress:** a)Transgenic plants with insect resistance: Resistance genes from microbes: Gene from *Bacillus thuringenesis*, Cholesterol oxidase of *Streptomyces* culture filtrate, Isopentenyl transferase gene from *Agrobacterium tumefaciens* Resistance genes from higher plants: Genes for Proteinase inhibitors: eg. Cowpea trypsin inhibitor gene (CpTi), Genes for alpha amylase inhibitors. b)Transgenic plants with viral resistance: Employing virus encoded genes or virus coat proteins; e.g. Transgenic tobacco plants expressing tobacco mosaic virus coat protein gene were developed which express high level of resistance to TMV **Improvement of nutritional content and Quality:** a) Increase in sweetness and flavor in fruits and vegetables for e.g. Monellin gene from African plant (*Dioscorephylum cumminsii*)- introduction in tomato and lettuce b)Increase and change in the quality oils in *Brassica* species (increase in medium chain fatty acids and converting unsaturated fatty acid to saturated fatty acids). c)Increase in starch content (potato). **Transgenics for delayed fruit ripening and extended shelf life**- Tomato. **Transgenic plants**: Plantibodies, vaccines, Biopolymers and vitamins. **Transgenic plants in floriculture**: Increase in the shelf life of cut flowers - (Carnation flowers), Genetic engineering of Orchids, Genetic manipulation of flower pigmentation. **Genetic engineering for inducing Male Sterility in plants.** **Transgenic plants for enhancing phytoremediation.**	
Learning Outcomes: Students will be able to understand the control points in a cell cycle, Study and apply principles of microbial genetics, understand recombinant DNA technology and study applications of the same for the improvement of crops.	

MSc Sem 1 Paper IV Practical

PSBOP104	**Cytogenetics, Molecular Biology and Biotechnology**	2
	1. Preparation of cytological stains, fixatives and pre-treatment agents. 2. Squash preparation from pre-treated root tips (Colchicine/ Paradichlorobenzene/ Aesculin. 3. Squash preparation from mutagen treated root tips for study of aberrations. 4. Smear preparation from any suitable plant material. 5. Problems based on: a. Restriction map analysis and construction of restriction maps, b. Tetrad analysis in *Neurospora* – two genes and centromere. c. Deletion mapping in Bacteriophage.	

University of Mumbai
M. Sc. Botany (Semester-I) Practical Examination
Skeleton Question Paper
Cytogenetics, Molecular Biology and Biotechnology
PSBOTP 104

Time: 9.00 am To 2.00 pm **Max. Marks: 50**

N.B. 1) Candidate should show their slides preparations/results for all questions to the examiners.
2) Use of logarithm tables/simple calculator is allowed
3) Use of Mobile phones is not allowed.

Q. 1. Make a squash preparation of the pre-treated specimen A and identify the anomalies. **(10)**
Q. 2. Make a smear preparation from the anthers of specimen B to show the stages of Meiosis. Comment on the same. **(10)**
Q. 3 Construct a restriction map / deletion map for the given DNA strand from the data provided 'C'. **(08)**
Q. 4 Construct a linkage map for the chromosome of *Neurospora* from the given Data 'D' **(12)**
Q .5. Journal. **(05)**
Q. 6. *Viva-voce.* **(05)**

Key:
A – Pre-treated Onion root tips
B – *Tradescantia discolor* buds
C – Restriction map/ deletion map problem
D – *Neurospora* - tetrad analysis problem

REFERENCE BOOKS

1.Chapman, V. J. 1962. The Algae. Macmillan & Co. Ltd.

2. Fritsch, F. E. (Vol. I, II) 1977. The structure and reproduction of Algae. Cambridge University Press.

3. Gilbert M Smith.1951. Manual of Phycology. Chronica. Botanica Co.
4. Gilbert M Smith. 1971. Cryptogamic Botany (Vol. 1): Algae and Fungi. Tata McGraw Hill.

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71. Plant physiology by Lincoln Taiz and Eduardo Zeiger

72. Introduction to plant biochemistry by T W Goodwin and E I Mercer

73. Fundamentals of biochemistry by Donald Voet and Judith G Voet
Biochemistry by Zubay

M.Sc. Semester I and II Botany Syllabus
Choice Based Credit System
To be implemented from the Academic year 2020--2021

SEMESTER II

Course Code PSBO201	**Title of the Paper- Plant Diversity- Cryptogams II (Bryophyta and Pteridophyta)**			
	I	**Bryophyta I**	4	**1**
	II	**Bryophyta II**		**1**
	III	**Pteridophyta I**		**1**
	IV	**Pteridophyta II**		**1**

Course Code	**Title**	**Credits**
PSBO201	**Plant Diversity- Cryptogams II (Bryophyta and Pteridophyta)**	**4**
Unit I: Bryophyta I 1.Classification of Bryophyta, up to orders, according to the system proposed by G. M. Smith. 2. Spore bearing organs in Bryophytes. 3. Alternation of generations in Bryophyta. 4.Type study of *Targionia* and *Pogonatum.*		1
Unit II: Bryophyta II 1.Origin and evolution of Bryophyta with reference to habitat and form 2. Diversity and distribution of Indian Bryophytes. 3. Bryophytes: Applied aspects: Agriculture, medicine, Food technology and environmental aspects. 4. Contribution of Shiv Ram Kashyap and S. C. Srivastava in Bryology.		1
Unit : III: Pteridophyta I 1. Classification of Pteridophyta, up to orders, according to the system proposed by G.M.Smith. 2. Heterospory and seed habit 3. Life cycle of *Psilotum*, *Pteris* and *Azolla*		1
Unit : IV Pteridophyta II 1. The geological time scale and a study of fossil Pteridophytes Horneophyton, Cladoxylon, Sphenophyllum, Coenopteris) 2. Cultivation and maintenance of ornamental Ferns. 3.Abnormalities in the life cycle-Apogamy and Apospory 4. Ethnomedicinal uses of Pteridophytes		1

Learning outcomes: Upon successful completion of this course, the student will be able to: Classify Bryophytes into various groups, study their importance Classify Pteridophytes into various groups, study their importance and multiplication of important ferns

Practical

Course Code	Title	Credits
PSBOP201	**Plant Diversity-Cryptogams II (Bryophyta and Pterdiophyta)**	**2**
	1.Study of vegetative and reproductive structures in *Targionia, Plagiochasma, Fimbraria*, *Pellia* and *Pogonatum*. 2. Study of vegetative and reproductive structures in : *Isoetes*, *Ophioglossum*, *Pteris*, *Angiopteris*, *Lygodium* and *Azolla* 3. Study of fossils :*Horneophyton, Cladoxylon, Sphenophyllum, Coenopteris*	

University of Mumbai
M. Sc. Sem II (Practical)EXAMINATION
BOTANY-PRACTICAL- PSBOP201
[Plant Diversity – Cryptogams II (Bryophyta and Pteridophyta)

Skeleton Question Paper

Time: 9:00 am-2:00 pm **Max. Marks: 50**

N.B.

1) Candidates should show their slides/ preparations/ results for all questions to the examiner.
2) Use of logarithm tables /calculator is allowed.

1. Identify, classify and describe the morphological / reproductive structures observed in specimens A,B,C and D. **(24)**
2. Identify and describe slides/specimens E,F,G and H. **(16)**
3. Journal **(05)**
4. *Viva-voce* **(05)**

Key:
A, B, C and D: Bryophyta and Pteridophyta
E, F, G and H: Bryophyta, Pteridophyta and Fossils (any 2)

Course Code	Title			Credits
PSBO202	**Plant Diversity: Spermatophyta II (Anatomy, Developmental Botany and Palynology)**			
	I	**Anatomy I**	4	**1**
	II	**Anatomy II**		**1**
	III	**Developmental Botany**		**1**
	IV	**Palynology**		**1**

Course Code	Title	Credits
PSBO202	**Plant Diversity- II (Anatomy, Developmental Botany and Palynology)**	**4**
Unit I: Anatomy I **1. Meristems:** Definition type of meristems, apical cell theory, histogen theory and Tunica corpus theory **2. Morphogenesis and organogenesis in plants**: Organization of shoot and root apical meristems; shoot and root development, leaf development and phyllotaxy; transition of flowering, floral meristems and floral development in *Arabidopsis* and *Antirrhinum*		1
Unit II: Anatomy II **1. Study of Tissue system:** **Sensory and tactile tissue system**: Tactile sense organs, gravitational and optical sense organs. **Secretory Tissues:** Introduction, Glands, Digestive glands, Nectaries, Resin ducts and oils ducts, Laticiferous ducts. **2. Wood Anatomy:** Coniferous and Angiosperm wood Parenchyma: Storied and non-storied wood parenchyma, Distribution of axial parenchyma Distribution of vessels Structure of rays Characters used in identification of wood.		1
Unit : III Developmental Botany 1. Male gametophyte: Pollen development and gene expression male sterility sperm dimorphism and hybrid seed production; pollen tube growth and guidance. 2. Female gametophyte; Types of embryo sacs; structure of embryo sac cells. 3. Pollination: Ultrastructural and histochemical details		1

of style and stigma, self and interspecific incompatibility, significance of pollen-pistil interaction, role of pollen wall proteins and stigma surface proteins, barriers to fertilization, methods to overcome incompatibilities, intra-ovarian pollination; in-vitro pollination. 4. Fertilization: heterospermy, differential behavior of male gametes, discharge and movement of sperms; syngamy and triple fusion, post-fertilization metabolic & structural changes in embryo-sac. 5. **Seed development and fruit growth**; endosperm development during Early Maturation and Desiccation stages; embryogenesis, ultrastructure and nucellar cytology; cell lineage during late embryo development; storage proteins of endosperm and embryo; apomixis; embryo culture; dynamics of fruit growth; biochemistry and molecular biology of fruit maturation.	
Unit : IV Palynology 1. Special relationships of pollen grain in pollen tetrads. 2. Pollen Chemistry: Introduction, Chemical constituents of pollen-Major metabolites (Carbohydrates, Mineral content, Callose, Organic acids, Amino acids, Pigments, Vitamin. s, Hormones and steroids), Chemistry of pollen wall, Pollen wall proteins. 3. Palynotaxonomy: Introduction, Systematic palynology-Palynotaxonomy of monocots (Pandanales, Glumiflorae, Principes, Liliflorae and Scitaminae) and dicots (Centospermae, Rhoeadales, Rhamnales, Malvales, Umbelliflorae), Evolutionary trends among pollen grains based on palynotaxonomical work. 4. Utilization of pollen: Pollen as health food, Pollen as medicine, Pollen allergens for diagnosis and therapy.	1
Learning outcomes: Students will be able to understand the development of pollen, spore, fertilization and to apply palynological information to plant systematics	

Practical

Course Code	Title	Credits
PSBOP202	**Spermatophyta II (Anatomy, Developmental Botany and Palynology)**	**2**
	1. Study of wood elements in *Annona, Michelia, Sterculia* and *Thuja* & *Araucaria* using the maceration technique. 2. Study of the following leaves with respect to leaf surface characters (wax, cuticle, epidermis, stomata, epidermal outgrowth): *Pistia, Ficus, Avicennia* and *Peperomia.* 3. Study of vessels, parenchyma: Axial & Ray Parenchyma – Apotracheal: Terminal, Diffuse, Banded, Reticulate; Paratracheal: Vasicentric, Aliform, Confluent, Abaxial. Ray Parenchyma &Rays: Homogenous &Heterogenous Wood Fibres from dicotyledonous wood by temporary preparation. 4. Mounting of Glands- salt glands of halophytes- *Avicennia*, *Ipomoea biloba*, *Sesuvium/Suaeda* Nectaries- Euphorbiaceae and Combretaceae (at least 3 examples from each family) Resin ducts- Pinus Oils ducts- *Citrus*, *Eucalyptus*, *Murraya* Laticiferous ducts Apocynaceae and Asclepiadaceae. Digestive glands- From permanent slides/ photomicrograph 5. Microtomy- Processing of material, Block making & staining (5 slides for submission). 6. Camera lucida sketches of parenchyma/ rays. 7. A study of types of ovules & types of embryo sacs with the help of permanent sides/photomicrographs. 8. *In vitro* germination of pollen grains, effect of temperature on pollen viability and short-*term* storage.	

	9. Detection of amino-acids, sugars and lipids by paper/ Thin layer chromatography from pollen grains. 10. Study of the morphology of the pollen (using Chitale's and acetolysis method) from the families studied in sem I & II	

M. Sc. Sem II (Practical) EXAMINATION

BOTANY-PRACTICAL- PSBOP202
[Plant Diversity –SpermatophytaII(Anatomy, Developmental Botany &Palynology)]

(Total Marks: 50)

Skeleton Question Paper

N.B.
1) Candidates should show their slides/ preparations/ results for all questions to the examiner.

1.	Macerate the given material A.	**(05)**
2.	Prepare a T.S. of leaf material B to show _____ &C to mount or show _____. Draw neat & labelled sketches.	**(10)**
3.	Prepare a block of specimen D/ cut the ribbon of material D/ double stain the slide of material D.	**(08)**
4.	Perform the palynology experiment E allotted to you.	**(06)**
5.	Identify and describe slide/ specimen/ photomicrograph of F, G & H.	**(09)**
6.a.	Journal.	**(05)**
6b.	Submission of slides of Microtomy.	**(03)**
7.	*Viva-voce*.	**(04)**

2) Use of logarithm tables /calculator is allowed.

KEY:

A- *Annona, Michelia, Sterculia* and *Thuja* and*Araucaria*

B& C- *Pistia, Ficus, Avicennia* and *Peperomia.*

Salt glands of halophytes- *Avicennia*, *Ipomoeabiloba*, *Sesuvium/Suaeda*
Nectaries- Euphorbiaceae and Combretaceae (at least 3 examples from each family)Resin ducts- *Pinus*
Oils ducts- *Citrus*, *Eucalyptus*, *Murraya*
Laticiferous ducts- Apocynaceae and Asclepiadaceae.

D- Microtomy- Block making and trimming of block OR Ribbon cutting and mounting of ribbon on slide OR Double Staining of mounted ribbon on slide and preparing a permanent slide

E- Palynology experiment: *In vitro* germination of pollen grains, effect of temperature on pollen viability and short-*term* storage

Detection of amino-acids, sugars and lipids by paper/ Thin layer chromatography from pollen grains.

F, G & H- Types of ovules and types of embryo sacs, Digestive glands, pollen grains, Anatomy not asked above.

Course Code PSBO203	Title of the Paper- Plant Physiology and Environmental Botany			
	I	Seed Physiology	4	1
	II	Stress Physiology		1
	III	The Environment, Biogeography and Population Ecology:		1
	IV	Climate Change		1

Course Code	Title	Credits
PSBO203	Plant Physiology and Environmental Botany	4

UNIT I: **Seed physiology:** 1. Physiology and Biochemistry of seed germination, Mobilization of food reserves, Germination and growth factors. 2. Seed dormancy, Control and release of seed dormancy. 3. Factors in control for the long term storage of seeds, seed proteins.	1
UNIT II: **Stress Physiology:** 1. Biotic and abiotic stress, Response of plants to Biotic (pathogenic and insects) stress, Adaptations to eliminate and tolerate the infection, Hypersensitive reaction. 2. Response of plants to abiotic stress - Drought stress, Heat stress - Heat shock proteins, Chilling, and freezing, Salinity stress 3. Signaling pathways activated during stress.	1
UNIT III: **The Environment, Biogeography and Population Ecology**: 1. Environment: Components, Major components of physical environment, biotic and abiotic interactions, 2. Biogeography: Major terrestrial biomes, Theory of island bio-geography, Bio-geographical zones of India. 3. Population Ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection).	1
UNIT IV **Climate Change:** 1. Global warming, carbon credits, Kyoto mechanism. 2. Factors responsible for climate change, Climate	1

change in relation to the changes in patterns of temperature, precipitation and sea level rise, Impacts of Climate Change on various sectors – Agriculture, Forestry and Ecosystem. The Montreal Protocol, Paris Agreement, UNFCCC, IPCC. 3. Adaptation Strategy/ Mitigation Measures, Blue carbon initiative.	
Learning outcomes: On completion of the course students should be able to: • Distinguish key physiological processes underlying the seed germination • Identify the physiological factors that regulate growth and developmental processes of plants • Demonstrate clear understanding of crop-environment interaction and its implication on crop growth and yield • Integrate and apply their knowledge of crop physiology for analytical thinking and solving practical problems experienced in agricultural systems To understand and apply ecological principles and understand legislation and measures to solve environmental problems.	

Practical

PSBOP203	**Plant Physiology and Environmental Botany**	**2**
	1. Assessing seed viability by TTC method 2. Determination of Nygard index of algae in a water body. 3. Determination of dust load on lives of roadside plant. 4. Comparison of two population of a species collected from two areas. 5. Determination of primary production of an area by harvest method. 6. Determination of primary production of an area by chlorophyll method. 7. Effect of water and salinity stress on chlorophyll content of leaves. 8. Effect of water and salinity stress on Proline content of leaves 9. Determination of Stomatal Index of leaves. 10. Determination of LAI of different types of trees. 11. Assessment of pollution in ambient air, on	

	the basis of injured leaf area. Field exercises: • Assessment of erosion status of land along a 'stream' on a slope or on flat land • Assessment of status of waste land, on the basis of its appearance and visible plant growth. • Assessment of degradation of a forest on the basis of its canopy cover and height, strata and species diversity	

University of Mumbai

M. Sc. Sem II (Practical) EXAMINATION

BOTANY-PRACTICAL-IV PSBOP203
Plant Physiology and Environmental Botany

Time: 9:00 am-2:00 pm **Max. Marks : 50**

Skeleton Question Paper

N.B.

1) Candidates should show their slides/ preparations/ results for all questions to the examiner.
2) Use of logarithm tables /calculator is allowed.

Q.1. PHYSIOLOGY EXPERIMENT..... **(15)**
Q.2. ECOLOGY EXPERIMENT... **(15)**
Q.3 PHYSIOLOGY EXPI./ MINOR ECOLOGY EXPI .... **(10)**
Q.4. JOURNAL... **(05)**
Q.5. *VIVA VOCE*.... **(05)**

M.Sc – I
SEMESTER – II, PAPER – IV

PSBO204	**Title of the Paper: MEDICINAL BOTANY AND DIETETICS**			
	I	**Medicinal Botany I**	4	**1**
	II	**Medicinal Botany II**		**1**
	III	**Dietetics I**		**1**
	IV	**Dietetics II**		**1**

Course Code	**Title**	**Credits**
PSBO204	**Medicinal Botany and Dietetics**	4
Unit I: Medicinal Botany I Monograph of drugs with respect to Biological source, Geographical distribution, macro and microscopic characters, chemical constituents and therapeutic uses of the following drugs: Root: .....*Withania somnifera* (Ashwagandha) Rhizome:.....*Zingiber officinale*(Ginger) Stem bark:..*Cinnamom zeylanicum* (Cinnamon) and *Holarrhena antidysenterica* (Kurchi) Leaf: .....*Azadirachta indica* (Neem) *Fruit:*.....*Foeniculum vulgare* (Fennel) Seed: .....*Plantago ovata* (Isabgol)		1
Unit II: Medicinal Botany II **Introduction to Pharmacopeia:** Indian pharmacopeia and Ayurvedic pharmacopeia **Quality control of crude drugs:** • Morphological examination – Exomorphic characters • Microscopical evaluation – Anatomical characters • Preliminary phytochemical tests. • Development of standardization parameters – Moisture content, Ash values, Solvent extraction value, bitterness value, foaming index, swelling index and heavy metal.		1
Unit III: Dietetics I Nutraceuticals: • Definition and Introduction, classification (Dietary supplements, functional foods, Medicinal food, Pharmaceuticals) • Role of plant nutraceuticals in health benefits (onion, garlic, tomato, carrot, beet, turmeric). • Current trends and future prospective of nutraceuticals.		1
Unit IV: Dietetics II **Plant Food as medicine** Plant food in the treatment of diseases – arthritis, constipation, diarrhoea,		1

diabetes, , hypertension, cancer, jaundice, memory and piles Concept of Antioxidants, their significance, Plants as a source of antioxidants.	
Learning outcomes: Students will be able to identify medicinal plants and understand the effects of plant chemical constituents on humans and the use of plants in Dietetics and as nutraceuticals.	

PRACTICAL

Course Code	Title	Credits
PSBOP204	**Medicinal Botany and Dietetics**	2

Medicinal Botany –I

1. A study of the macroscopic and microscopic characters and identification of active ingredients of drugs mentioned in the syllabus for theory by means of chemical tests.

- Root:..... *Withania somnifera* (Ashwagandha)
- Rhizome:.....*Zingiber officinale*(Ginger)
- Stem bark: ...*Cinnamom zeylanicum* (Cinnamon) and *Holarrhena antidysenterica* (Kurchi)
- Leaf:.....*Azadirachta indica*(Neem)
- *Fruit*:.....*Foeniculum vulgare* (Fennel)
- Seed: .....*Plantago ovata* (Isabgol*)*

Medicinal Botany -II

2. Determination of Moisture content, Ash values, Solvent extraction value of the given sample.

3. Determination of foaming index of the given sample.

4. Determination of swelling index of the given sample.

NUTRACEUTICALS

- Extraction and detection of lycopene by TLC
- Amino acid profile of a plant/plant product

6. Identification of plants Nutraceuticals for health benefits (As per theory topics)

University of Mumbai
M. Sc. Sem II (Practical) EXAMINATION

BOTANY-PRACTICAL- PSBOP204
[Medicinal Botany and dietetics]

Time: 9:00 am-2:00 pm **Max. Marks : 50**

Skeleton Question Paper

N.B.

1) Candidates should show their slides/ preparations/ results for all questions to the examiner.
2) Use of logarithm tables /calculator is allowed.

Q 1. Identify and describe Macroscopic and Microscopic characters of specimen A and B. Identify the active ingredients from the same using chemical tests/TLC. **(16)**

Q 2. Estimate the Fresh Weight and Dry Weight ratio and total ash content/foaming index/swelling index of the given plant material C. **(08)**

Q3. Extract and detect lycopene from given material D

OR

Q3. Perform TLC to show the amino acid profile of the plant material D **(08)**

Q4. Identify and describe botanical source and uses of the specimens E and F **(08)**

Q 5. Journal**.** **(05)**

Q 6. *Viva-voce.* **(05)**

KEY:

A and B

Withania somnifera (Ashwagandha)
Zingiber officinale(Ginger)
Cinnamom zeylanicum (Cinnamon) and
Holarrhena antidysenterica (Kurchi)
Azadirachta indica (Neem)
Foeniculum vulgare (Fennel)
Plantago ovata (Isabgol*)*

C and D

Any plant material

E and F

Nutraceuticals as per theory topics

Reference books:

1. Trease D. & Evans W. C.: Text Book of Pharmacognosy: W. B. Saunders.

2. Tyler V.E., Brady L.R. & Robbers J. E.: Pharmacognosy; Lea Feibger, USA.

3. Wallis T. E.; Text Book of Pharmacognosy; CBS Publishers, Delhi.

4. Kokate C.K., Purohit A. P. &Gokhale S. B.: Pharmacognosy; Nirali Publications, Pune.

5. Harbone J. B.: Phytochemical Methods: A guide to modern techniques Analysis: Chapman& Hall, London.

6. Bruneton J.: Pharmacognosy, Phytochemistry, Medicinal Plants: Intercept Limited.

7. Vasudevan T.N. & Laddha K.S.: A Textbook of Pharmacognosy, Vrinda Publication House, Jalgaon.

8. The Indian Pharmacopeia: The Controller of Publication; Delhi.

9. Brain K.R. & Turner T. D.: The Practical Evaluation of Phytopharmaceuticals: Wright, Scientica, Bristol.

10. Iyengar M. A. &Nayak S. G.: Anatomy of Crude Drugs: Manipal Power Press Manipal.

11. Iyengar M. A.: Pharmacognosy of Powdered Drugs; Manipal Power Press, Manipal.

12. Kokate C. K.: Practical Pharmacognosy; Vallabh Prakashan.

13. Wagner, Bladt & Zgainski; Plant Drug Analysis; Springer Verlag.

14. Khandelwal K. R.: Practical Pharmacognosy Techniques and Experiments; Nirali Prakashan, Pune.

15. Vasudevan T. N. and Laddha K. S.: Practical Pharmacognosy; New Vrinda Publishing House, Jalgaon

16. Pulok Mukeerjee, Quality control Advanced Plant Physiology – Noggle & Fritz – Prantice – Hall of India.

18. Introductory Plant Physiology – Malcom Wilkins, Pitman Publication Ltd, 1984.
19. Plant Physiology – Pandey and Sinha, Vikas Publishing House, 1987.

20. Outlines of Biochemistry – Conn &Stumpf, John Willey and Co., 1987.

21. Plant Physiology, Biochemistry and Molecular Biology – Dennis and Turnip, Longman Scientific and Technical, 1990.

22. Plant Physiology – Taiz and Zeiger, Sinauer association Inc.

23. E. P. Odum (1996) Fundamentals of Ecology, Natraj Publisher, Dehra Dun.

24. K.M.M. Dakshini (1999) Principle and Practices in Plant Ecology, CRC, Boston.

25. M.C. Dash (1994) Fundamentals of Ecology, Tata McGraw Hill, New Delhi.

26. M.C. Molles Jr. (1999) Ecology- Concepts and Application, McGraw Hill, New Delhi.

27. V. Ingegnoli (2002) Landscape Ecology: a widening foundation, Springer, Bonn.

28. E.J. Kormondi (1999) Concepts of Ecology, Prentice Hall of India, New Delhi.

29. Chapman, J.L. and Reiss M.J. (2005) Ecology Principles and Applications, Cambridge University Press, London.

30. E.P. Odum and G. W. Barrett (2005) Fundamentals of Ecology, Thomson Asia Pvt. Ltd., Singapore.

31. S.V.S. Rana (2005) Essentials of Ecology and Environmental Sciences, Prentice Hall of India, New Delhi.

32. Environment and Ecology-EAS105/EAS 205-R.Rajagopalan

33. Environmental Studies from Crisis To Cure-2nd Edition-R. Rajagopalan

34. Smith, R.L (1996). Ecology and field biology, Harper Collins, New York

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