University of Mumbai

No. UG/ 36 of 2019-20

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges and Directors of the recognized Institutions in Science & Technology Faculty is invited to this office Circular No. UG/95 of 2015-16, dated 5th October, 2015 relating to the revised syllabus as per (CBSGS) for the T.Y.B..Sc. Botany (Sem. V & VI).

They are hereby informed that the recommendations made by the Board of Studies in Botany at its meeting held on 18th March, 2019 have been accepted by the Academic Council at its meeting held on 10th May, 2019 **vide** item No. 4.26 and that in accordance therewith, the revised syllabus as per the (CBCS) for the T. Y .B.Sc. Botany in (Sem. V & VI) has been brought into force with effect from the academic year 2019-20, accordingly. (The same is available on the University's website www.mu.ac.in).

(Dr. Ajay Deshmukh)
REGISTRAR

MUMBAI – 400 032
03rd July, 2019

To

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

A.C./4.26/10/05/2019

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No. UG/ 36 -A of 2019 MUMBAI-400 032 3rd July, 2019

Copy forwarded with Compliments for information to:-

1) The I/c Dean, Faculty of Science & Technology,
2) The Chairman, Board of Studies in Botany,
3) The Director, Board of Examinations and Evaluation,
4) The Professor-cum-Director, Institute of Distance and Open Learning (IDOL),
5) The Director, Board of Students Development,
6) The Co-ordinator, University Computerization Centre,s

(Dr. Ajay Deshmukh)
REGISTRAR

University of Mumbai

UNIVERSITY OF MUMBAI

Syllabus for the T.Y.B.Sc.
Program: B.Sc. Course: BOTANY

(Credit Based Semester and Grading System with effect from the academic year 2019–2020)

T.Y.B.Sc. Botany Syllabus
Restructured for Credit Based and Grading System
To be implemented from the Academic year 2019-2020

SEMESTER V

Course Code	UNIT	TOPICS	Credit L	/ Weeks
USBO501	PLANT DIVERSITY III			
	I	Microbiology	2.5	1
	II	Algae		1
	III	Fungi		1
	IV	Plant Pathology		1
USBO502	PLANT DIVERSITY IV			
	I	Paleobotany	2.5	1
	II	Angiosperms I		1
	III	Anatomy I		1
	IV	Palynology		1
USBO503	FORM AND FUNCTION III			
	I	Cytology and Molecular Biology	2.5	1
	II	Plant Physiology I		1
	III	Environmental Botany		1
	IV	Plant Tissue Culture		1
USBO504	CURRENT TRENDS IN PLANT SCIENCES II			
	I	Ethnobotany and Mushroom Industry	2.5	1
	II	Plant Biotechnology I		1
	III	Instrumentation		1
	IV	Pharmacognosy and medicinal botany		1
USBOP5	Practicals based on Two Courses in Theory (501 & 502) – For 6 Units		3	8
USBOP6	Practicals based on Two Courses in Theory (503 &504) – For 6 Units		3	8
USBOP7	Practicals based on Two Courses in Theory (502 & 503) – For 3 Units		3	8
			16	32 + 8 (3 Units)

SEMESTER VI

Course Code	UNIT	TOPICS	Credit	L / Weeks
USBO601	PLANT DIVERSITY III			
	I	Bryophyta	2.5	1
	II	Pteridophyta		1
	III	Bryophyta and Pteridophyta: Applied Aspects		1
	IV	Gymnosperms		1
USBO602	PLANT DIVERSITY IV			
	I	Angiosperms II	2.5	1
	II	Anatomy II		1
	III	Embryology		1
	IV	Plant Geography		1
USBO603	FORM AND FUNCTION III			1
	I	Plant Biochemistry	2.5	1
	II	Plant Physiology II		1
	III	Genetics		1
	IV	Biostatistics		
USBO604	CURRENT TRENDS IN PLANT SCIENCES II			
	I	Plant Biotechnology II	2.5	1
	II	Bioinformatics		1
	III	Economic Botany		1
	IV	Post Harvest Technology		1
USBOP8	Practicals based on Two Courses in theory (601 & 602) – For 6 Units		3	8
USBOP9	Practicals based on Two Courses in theory (603 & 604) – For 6 Units		3	8
USBOP10	Practicals based on Two Courses in theory (602 & 603) – For 3 Units		3	8
			16	32 + 8 (3 Units)

BSc BOTANY: PROGRAM OUTCOMES

Specific core discipline knowledge

- Students can recall details and information about the evolution, anatomy, morphology, systematics, genetics, physiology, ecology, and conservation of plants and all other forms of life.
- Students can recall details of the unique ecological and evolutionary features of the local and Indian flora.

Communication skills

- Students can communicate effectively using oral and written communication skills

Problem solving and research skills

- Students can generate and test hypotheses, make observations, collect data, analyze and interpret results, derive conclusions, and evaluate their significance within a broad scientific context

BSc BOTANY: PROGRAM SPECIFIC OUTCOMES

- To recognize and identify major groups of non-vascular and vascular plants and their phylogenetic relationships. To understand the phylogeny of plants and study various
- systems of classification. To explore the morphological, anatomical, embryological details
- as well as economic importance of algae, fungi, bryophytes, pteridophytes, gymnosperms and angiosperms. To understand physiological processes and adaptations of plants. To
- provide knowledge about environmental factors and natural resources and their importance
- in sustainable development. To be able to carry out phytochemical analysis of plant extracts and application of the isolated
- compounds for treatment of diseases.
  To be able to deal with all microbes and the technologies for their effective uses in
- industry and
  mitigation of environmental concerns.
- To explain how current medicinal practices are often based on indigenous plant knowledge and to
  get introduced to different perspectives on treating ailments according to ethnomedicinal
- principles.
  To understand patterns of heredity and variation among individuals, species and
- populations and
  apply principles for improvement of quality and yield.
- To be able to apply statistical tools to gain insights into significantly different data from different
  sources.
  To acquire recently published knowledge in molecular biology, such as rDNA technology; PTC
  and bioinformatics and their applications.

SEMESTER V
THEORY

Course Code	Title	Credits
USBO501	PLANT DIVERSITY – III	2.5 Credits (60 Lectures)

Course outcomes:

The students would be able :

- To gain knowledge about microbial diversity and techniques for culturing and visualization.
- To understand the salient features of three major groups of algae, their life cycle patterns with a suitable example; to be able to identify them.
- To learn the general characteristics and classification of two major groups of fungi along with life cycles of each group; to be able to identify them.
- To understand the scope and importance of Plant Pathology and apply the concepts of various control measures of commonly widespread plant diseases.

Unit I: Microbiology **Types of Microbes:** Viruses, Bacteria, Algae, Fungi, Protozoa, Mycoplasma and Actinomycetes. **Culturing:** Sterilization, media, staining, colony characters. Pure cultures	**(15 lectures)**
Unit –II: Algae (G.M. Smith Classification System to be followed) Division Rhodophyta: Classification and General Characters: Distribution, Cell structure, pigments, reserve food, range of thallus, reproduction: asexual and sexual, Alternation of Generations, Economic Importance. Structure, life cycle and systematic position of *Polysiphonia, Batrachospermum.* Classification: Xanthophyta and General Characters of Distribution, Cell structure, pigments, reserve food, range of thallus, Reproduction: asexual and sexual, Alternation of Generations, Economic Importance. Structure, life cycle and systematic position of *Vaucheria.* Classification: Bacillariophyta and General Characters of Distribution, Cell structure, pigments, reserve food, range of thallus, Reproduction: asexual and sexual, Alternation of Generations, Economic Importance. Structure, life cycle and systematic position of *Pinnularia.*	**(15 lectures)**
Unit III: Fungi (G.M. Smith Classification System to be followed) Basidiomycetes: Classification and General characters Life cycle of *Agaricus* Life cycle of *Puccinia* Deuteromycetae: Classification and General Characters Life cycle of *Alternaria*	**(15 lectures)**

Unit IV: Plant Pathology **Study of plant diseases:** Causative organism, symptoms, predisposing factors, disease cycle and control measures of the following. White Rust –*Albugo candida* Tikka disease of ground nut: *Cercospora* Damping off disease: *Pythium* Citrus canker – *Xanthomonas axonopodis* pv. citri Leaf curl – leaf curl virus in *Papaya.* Study of Physical, chemical and biological control methods of plant diseases.	**(15 lectures)**

Course Code	Title	Credits
USBO502	PLANT DIVERSITY – IV	2.5 Credits (60 lectures)

Course outcomes:

The students would be able :

- To acquire knowledge of different fossil forms and understand their role in evolution.
- To provide plant description, describe the morphological and reproductive structures of seven families and also identify and classify according to Bentham and Hooker's system.
- To gain proficiency in the use of keys and identification manuals for identifying any unknown plants to species level.
- To relate anomalies in internal stem structure with function and appreciate the salient features of the root stem transition zone.
- To get exposure to pollen study and learn to apply it in various fields.

Unit I: Paleobotany — **(15 lectures)**

- *Lepidodendron*– All form genera root, stem, bark, leaf, male and female fructification.
- *Lyginopteris*– All form genera root, stem, leaf, male and female fructification.
- *Pentoxylon*– All form genera.
- Contribution of Birbal Sahni, Birbal Sahni Institute of Paleobotany, Lucknow

Unit II: Angiosperms I — **(15 lectures)**

- Morphology of flower – All Parts of Flower.
- Complete classification of Bentham and Hooker (only for prescribed families), Merits and demerits
- Bentham and Hooker's system of classification for flowering plants up to family with respect to the following prescribed families and economic and medicinal importance for members of the families. (Special stress on fruit morphology to be given)
  - Capparidaceae
  - Umbelliferae
  - Cucurbitaceae
  - Rubiaceae
  - Solanaceae
  - Commelinaceae
  - Graminae

Unit III: Anatomy I — **(15 lectures)**

- **Anomalous secondary growth** in the Stems of *Bignonia*, *Salvadora*, *Achyranthes*, *Dracaena*. Storage roots of Beet, Radish
- **Root stem transition**
- **Types of Stomata**– Anomocytic, Anisocytic, Diacytic, Paracytic, and Graminaceous

Unit IV: Palynology **Pollen Morphology** **Pollen viability**–storage Germination and growth of pollen Application of Palynology in honey industry, coal and oil exploration, Aerobiology and pollen allergies, forensic science	**(15 lectures)**

Course Code	Title	Credits
USBO503	FORM AND FUNCTIONS- II	2.5 Credits (60 Lectures)

Course outcomes:

The students would be able :

- To acquire knowledge about two important organelles and molecular mechanisms of translation
- To understand water relations of plants, inorganic and organic solute transport, and apply the knowledge to manage mineral nutrition and survival in challenging abiotic stresses.
- To understand succession in plant communities and study remediation technologies in order to apply knowledge acquired for cleanup of polluted sites.
- To get exposure to principles and techniques of plant tissue culture and apply these studies for improving agriculture and horticulture and to become an entrepreneur.

Unit I: Cytology and Molecular Biology **(15 lectures)**

- Structure and function of nucleus
- Structure and function of vacuole
- Structure and function of giant chromosomes
- The genetic code: Characteristics of the genetic code
- Translation in Prokaryotes and Eukaryotes.

Unit II: Plant Physiology I **(15 lectures)**

- **Water relations:** Potential, osmosis, transpiration, imbibition,
- **Solute transport:** Transport of ions across cell membranes, active and passive transport, carriers, channels and pumps.
- **Translocation of solutes:** Composition of phloem sap, girdling experiment.
- **Pressure flow model (Munch's hypothesis):**Phloem loading and unloading, anatomy of sieve tube elements and mechanisms of sieve tube translocation.
- **Mineral Nutrition:** Role of Macro and Micro nutrients, physiological functions and deficiency symptoms.

Unit III: Environmental Botany **(15 lectures)**

- **Bioremediation:** Principles, factors responsible and microbial population in bioremediation.
- **Phytoremediation**: Metals, Organic pollutants
- **Plant succession**: Hydrosere and Xerosere – Formation of Barren Space, Succession on the Land Citing Different Seres leading up to the Climax. Succession in Water, Ecesis, Poly and Mono-climax theories.

Unit IV: Plant Tissue Culture **(15 lectures)**

- **Aspects of Micro-propagation with reference to Floriculture:** Detailed study of Orchid Cultivation
- **Plant cell suspension cultures for the production of secondary metabolites:** With special reference to Shikonin production.
- Somatic Embryogenesis and Artificial Seeds.
- **Protoplast Fusion and Somatic Hybridization:** i) Concept, Definition, and various methods of Protoplast Fusion ii) Applications of Somatic Hybridization in Agriculture

Course Code	Title	Credits
USBO504	CURRENT TRENDS IN PLANT SCIENCES – II	2.5 Credits (60 Lectures)

Course outcomes:

The students would be able :

- To get exposure to the technique of mushroom cultivation and explore the possibility of entrepreneurship in the same.
- To learn ethnobotanical principles, applications and utilize indigenous plant knowledge for the cure of common human diseases and improvement of agriculture.
- To gain knowledge about the latest molecular biology techniques for isolation and characterization of genes.
- To learn principles and application of commonly used techniques in instrumentation.
- To gain proficiency in the monograph study and pharmacognostic analysis of six medicinal plants.

Unit I: Ethnobotany and Mushroom Industry **(15 lectures)**

- **Ethnobotany**- Definition, history, sources of data and methods of study.
- **Applications of ethnobotany:**
  - Ethno-medicines.
  - Agriculture.
  - Edible plants.
- **Traditional medicines** used by tribals in Maharashtra towards
  - Skin ailments: *Rubia cordfolia, Sandalwood*
  - Liver ailments: *Phyllanthus, Andrographis*
  - Wound healing and ageing: *Centella, Typha, Terminalia, Tridax.*
  - Fever: *Vitex negundo, Tinospora cordifolia* leaves
  - Diabetes: *Momordica charantia, Syzygium cuminii*
- **Mushroom industry:**
  - Detail general account of production of mushrooms with respect to methods of Composting, spawning, casing, harvesting of mushroom. Cultivation of *Pleurotus, Agaricus, Volvariella* mushroom.
  - General account of mushrooms: Nutritional value, picking and packaging, economic importance.

Unit II: Plant Biotechnology I **(15 lectures)**

- Construction of genomic DNA libraries, Chromosome libraries and c- DNA libraries.
- Identification of specific cloned sequences in c-DNA libraries and Genomic libraries
- **Analysis of genes and gene transcripts –**Restriction enzyme, analysis of cloned DNA sequences. Hybridization(Southern Hybridization)

Unit III: Instrumentation **(15 lectures)**

- **Colorimetry and Spectrophotometry** (Visible, UV and IR) – Instrumentation, working, principle and applications.
- **Chromatography:** General account of Column chromatography. Principle and bedding material involved in adsorption and partition chromatography, ion exchange chromatography, molecular sieve chromatography.

Unit IV: Pharmacognosy and Medicinal Botany • Monographs of drugs with reference to biological sources, geographical distribution, common varieties, macro and microscopic characters, chemical constituents, therapeutic uses, adulterants- *Strychnos* seeds, *Senna* leaves, Clove buds, *Allium sativum, Acorus calamus* and *Curcuma longa*	**(15 lectures)**

SEMESTER V
PRACTICAL

Minimum marks for passing: 20

Semester V USBOP5 – For 6 Units	**Cr**
PRACTICAL PAPER I–PLANT DIVERSITY III – USBOP 501 (For 6 Units)	**1.5**
Microbiology • Study of aeromicrobiota by petriplate exposed method: Fungal culture, Bacterial culture. • Determination of Minimum Inhibitory Concentration (MIC) of sucrose against selected microorganism. • Study of antimicrobial activity by the disc diffusion method.	
Algae (G.M. Smith Classification System to be followed) • Study of stages in the life cycle of the following Algae from fresh / preserved material and permanent slides. ◦ *Polysiphonia* ◦ *Batrachospermum* ◦ *Vaucheria* ◦ *Pinnularia*	
Fungi (G.M. Smith Classification System to be followed) • Study of stages in the life cycle of the following Fungi from fresh / preserved material and permanent slides ◦ *Agaricus* ◦ *Puccinia* ◦ *Alternaria*	
Plant Pathology • Study of the following fungal diseases: ◦ White rust in Cruciferae (Brassicaceae) ◦ Tikka disease in Groundnut ◦ Damping off disease ◦ Citrus canker ◦ Leaf curl in *Papaya Leaf*	
Semester V USBOP7 – For 3 Units	
PRACTICAL PAPER II–PLANT DIVERSITY IV USBOP 502 (For 3 & 6 Units)	**Cr**
Paleobotany • Study of the following form genera with the help of permanent slides/ photomicrographs. ◦ *Lepidodendron* ◦ *Lyginopteris* ◦ *Pentoxylon*	**1.5**
Angiosperms I • Morphology of Flower – All Parts of Flower • Study of one plant from each of the following Angiosperm families as per Bentham and Hooker's system of classification. ◦ Capparidaceae ◦ Umbelliferae ◦ Cucurbitaceae	

- Rubiaceae
- Solanaceae
- Commelinaceae
- Graminae

- Morphological peculiarities and economic importance of the members of the above-mentioned Angiosperm families
- Identifying the genus and species of a plant with the help of Flora

Anatomy I

- Study of anomalous secondary growth in the stems of the following plants using double staining technique.
  1) Bignonia
  2) Salvadora
  3) Achyranthes
  4) Dracaena
- Study of anomalous secondary growth in the roots of
  1) Beet
  2) Radish
- Types of Stomata
  1) Anomocytic
  2) Anisocytic
  3) Diacytic
  4) Paracytic
  5) Graminaceous

Palynology I

- Study of pollen morphology (NPC Analysis) of the following by Chitale's Method
  - *Hibiscus*
  - *Datura*
  - *Ocimum*
  - *Crinum*
  - *Pancratium*
  - *Canna*
- Determination of pollen viability
- Pollen analysis from honey sample – unifloral and multifloral honey
- Effect of varying concentration of sucrose on *In vitro* Pollen germination

Total Credit	**3**

Semester V USBOP6 – For 6Units Semester V USBOP7 – For 3Units PRACTICAL –PAPER III FORM AND FUNCTION II USBOP 503 (For 3 & 6 Units)	Cr 1.5
Cytology and Molecular Biology • Mounting of Giant chromosomes from *Chironomous* larva • Smear preparation from *Tradescantia* buds • Predicting the sequence of amino acids in the polypeptide chain that will be formed following translation(Eukaryotic)	
Plant Physiology I • Estimation of Phosphate phosphorus (Plant acid extract) • Estimation of Iron (Plant acid extract) Note: Preparation of a standard graph and determination of the multiplication factor for Phosphate / Iron estimation using a given standard phosphate / Standard Iron solution should be done in regular practical as this will also be put as a question in practical exam	
Environmental Botany • Estimation of the following in given water sample ◦ Dissolved oxygen demand ◦ Biological oxygen demand ◦ Hardness ◦ Salinity and Chlorinity ◦	
Micropropogation • Plant Tissue culture: • Identification – Multiple shoot culture, hairy root culture, somatic embryogenesis • Preparation of stock solutions for preparation of MS medium (Note: Concept of preparation of specified molar solutions should be taught and problems based on preparation of stock solutions for tissue culture media will be given).	
Semester V USBOP6 – For 6 Units	
PRACTICAL – PAPER IV CURRENT TRENDS IN PLANT SCIENCES II USBOP 504 (For 6 Units)	**Cr**
Ethnobotany and mushroom industry • Study of plants mentioned in theory for Ethnobotany • Mushroom cultivation (To be demonstrated) • Identification of various stages involved in mushroom cultivation – spawn, pin head stage, mature/ harvest stage of *Agaricus, Pleurotus, Volvariella*	**1.5**
Biotechnology I • Growth curve of E. coli • Plasmid DNA isolation and Separation of DNA using AGE • Restriction mapping (problems), Southern blotting	
Instrumentation • Demonstration of Beer Lambert's Law • Experiment based on ion exchange chromatography for demonstration • Experiment based on separation of dyes/ plant pigments using silica gel column.	

Pharmacognosy • Macroscopic/ Microscopic characters and Chemical tests for active constituents of the following plants □ *Allium sativum* □ *Acorus calamus* □ *Curcuma longa* □ *Senna angustifolia* □ *Strychnos nux-vomica* □ *Eugenia caryophyllata*	
Total Credit	**3**

Course Code	Title	Credits
USBO601	PLANT DIVERSITY – III	2.5 Credits (60 Lectures)

Course outcomes:

The students would be able :

- To identify, describe and study in detail the life cycles of three Bryophytes.
- To and study in detail classification and general characters of three classes of Pteridophytes and identify as well as describe the life cycles of one example from each class.
- To study evolutionary aspects and economic utilization of Bryophytes and Pteridophytes.
- To identify, describe and study in detail the life cycles of three Gymnosperms.

Unit I: Bryophyta (G. M. Smith Classification system to be followed) Life cycle of *Marchantia* Life cycle of *Pelia* Life cycle of *Sphagnum*	**(15 lectures)**
Unit II: Pteridophyta (G. M. Smith Classification System to be followed) Lepidophyta – Classification, general characters; Life cycle of *Lycopodium* Calamophyta – Classification, general characters; Life cycle of *Equisetum* Pterophyta - Classification, general characters; Life cycle of *Adiantum* and *Marselia*	**(15 lectures)**
Unit III: Bryophytes and Pteridophytes: Applied aspects Ecology of Bryophytes. Economic importance of Bryophytes. Bryophytes as Indicators. Evolution of Sporophyte and Gametophyte in Bryophytes. Economic importance of Pteridophytes Diversity and distribution of Indian Pteridophytes Types of Sori and Evolution of Sori in Pteridophytes.	**(15 lectures)**
Unit IV: Gymnosperms (Chamberlain's Classification System to be followed) Life cycle of *Thuja*, Life cycle of *Gnetum* Life cycle of *Ephedra.* Economic importance of Gymnosperms	**(15 lectures)**

Course Code	Title	Credits
USBO602	PLANT DIVERSITY – IV	2.5 Credits (60 Lectures)

Course outcomes:

The students would be able :

- To study contribution of Botanical gardens, BSI to Angiosperm study and provide plant description, describe the morphological and reproductive structures of seven families.
- To gain exposure to a phylognetic system of classification.
- To gain insight into the anatomical adaptations of different ecological plant groups.
- To understand development plant of male and female gametophytes, embryonic structure and development.
- To understand the different aspects and importance of Biodiversity and utilize them for conservation of species so as to prevent further loss or extinction of Biodiversity and preserve the existing for future generations.

Unit I: Angiosperms II **Major Botanic gardens of India**– Indian Botanic Garden, Howrah; National Botanic Garden (NBRI) Lucknow; Lloyd Botanic Garden, Darjeeling; Lalbaugh Botanic Garden, Bangaluru. Botanical survey of India and regional branches of India Bentham and Hooker's system of classification for flowering plants up to family with respect to the following prescribed families and economic importance, medicinal importance and fruit morphology for members of the families **(15 lectures)** Acanthaceae Compretaceae Asclepiadaceae Labiatae Euphorbiaceae Cannaceae Hutchinson's classification system of Angiosperms Brief Introduction, Merits and Demerits of Hutchinson's Classification System	
Unit II: Anatomy II **Ecological anatomy** Hydrophytes – submerged, floating, rooted Hygrophytes -*Typha* Mesophytes Sciophytes Halophytes Epiphytes Xerophytes	**(15 lectures)**
Unit III: Embryology **Microsporogenesis** **Megasporogenesis**- Development of monosporic type, examples of all embryo sacs Types of ovules Double fertilization Development of embryo–*Capsella*	**(15 lectures)**

Unit IV: Plant Geography (Shifted from Paper – IV) **Phytogeographical regions of India**. **Biodiversity**: Definition, diversity of flora found in various forest types of India Levels of biodiversity Importance and status of biodiversity Loss of biodiversity Conservation of biodiversity Genetic diversity- Molecular characteristics	**(15 lectures)**

Course Code	Title	Credits
USBO603	FORMS AND FUNCTION – III	2.5 Credits (60 Lectures)

Course outcomes:

The students would be able :

- To study various plant biomolecular structures and appreciate the structures, role, functions and applications of enzymes.
- To gain insight into the Nitrogen and plant hormone metabolism with applications of the same in agriculture and horticulture.
- To understand principles of genetic mapping , mutations and solve problems based on them, gain knowledge of various metabolic disorders and their implications.
- To generate and test hypotheses, make observations, collect data, analyze and interpret results, derive conclusions, and evaluate their significance within a broad scientific context, using suitable statistical techniques.

Unit I: Plant Biochemistry **Structure of biomolecules:** Carbohydrates (sugars, starch, cellulose, pectin, lipids (fatty acids and glycerol), proteins (amino acids) **Enzymes:** Nomenclature, classification, mode of action, Enzyme kinetics, Michaelis-Menten equation, competitive, non-competitive and un-competitive inhibitors.	**(15 lectures)**
Unit II: Plant Physiology II **Nitrogen Metabolism:** Nitrogen cycle, root nodule formation, and leghaemoglobin, nitrogenase activity, assimilation of nitrates, (NR, NiR activity), assimilation of ammonia, (amination and transamination reactions), nitrogen assimilation and carbohydrate utilization. Physiological effects and commercial applications of Auxins, Gibberillins, Cytokinins and Abscisic acid	**(15 lectures)**
Unit III: Genetics **Genetic mapping in eukaryotes:** discovery of genetic linkage, gene recombination, construction of genetic maps, three- point crosses and mapping chromosomes, problems based on the same **Gene mutations:** definition, types of mutations, causes of mutations, induced mutations, the Ame's test **Metabolic disorders**– enzymatic and non-enzymatic: Gene control of enzyme structure Garrod's hypothesis of inborn errors of metabolism, Phenyl ketone urea.	**(15 lectures)**
Unit IV: Biostatistics (Shifted from Paper – II) Test of significance student's *t*-test – Paired and Unpaired. Regression. ANOVA (one way).	**(15 lectures)**

Course Code	Title	Credits
USBO604	Current Trends in Plant Science – II	2.5 Credits (60 Lectures)

Course outcomes:

The students would be able :

- To gain insight into recent molecular biology techniques for DNA analysis and amplification and Barcoding techniques and applications therein.
- To understand and apply tools of Bioinformatics for data retrieval and phylogenetic analysis.
- To learn about the sources of economically important plants in the field of fats and oils and apply it for extraction, dealing with entrepreneurship in the field.
- To gain knowledge and proficiency in preservation of post harvest produce and explore the possibility of entrepreneurship in the field.

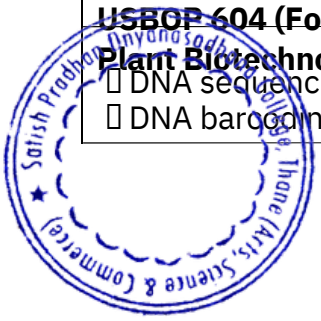
Unit I: Plant Biotechnology II **DNA sequence analysis**– Maxam – Gilbert Method and Sanger's method, Pyro Sequencing. Polymerase Chain Reaction (PCR). **DNA barcoding:** Basic features, nuclear genome sequence, chloroplast genome sequence, *rbc*L gene sequence, *mat* K gene sequence, present status of barcoding in plants.	**(15 lectures)**
Unit IV: Bioinformatics (Shifted from Paper – III) Organization of biological data, databases Exploration of data bases, retrieval of desired data, BLAST. Protein structure analysis and application Multiple sequence analysis and phylogenetic analysis	**(15 lectures)**
Unit III: Economic Botany **Essential Oils:** Extraction, perfumes, perfume oils, oil of Rose, Sandalwood, *Patchouli*, *Champaca*, grass oils: *Citronella*, Vetiver. **Fatty oils:** Drying oil (Linseed and Soyabean oil), semidrying oils (Cotton seed, Sesame oil) and non-drying oils (Olive oil and Peanut oil), **Vegetable Fats**: Coconut and Palm oil	**(15 lectures)**
Unit IV : Post Harvest Technology **Storage of Plant Produce –**Preservation of Fruits and Vegetables Drying (Dehydration) – Natural conditions – Sun drying, Artificial Drying – Hot Air Drying, Vacuum Drying, Osmotically Dried Fruits, Crystallized or Candied Fruits, Fruit Leather, Freeze Drying) Freezing (Cold Air Blast System, Liquid Immersion method, Plate Freezers, Cryogenic Freezing, Dehydro-Freezing, Freeze Drying) Canning Pickling (in Brine, in Vinegar, Indian Pickles) Sugar Concentrates (Jams, Jellies, Fruit juices) Food Preservatives Use of Antioxidants in Preservation	**(15 lectures)**

SEMEST ER VI
PRACTICAL

Minimum marks for passing: 20

SEMESTER VI USBOP8 – FOR 6 UNITS	**Cr**
PRACTICAL PAPER I–PLANT DIVERSITY III – USBOP 601(For 6 Units)	**1.5**
Bryophyta (G.M. Smith Classification System to be followed) • Study of stages in the life cycle of the following Bryophyta from fresh / preserved material and permanent slides o *Marchantia* o *Pellia* o *Sphagnum* o o	
Pteridophyta (G.M. Smith Classification System to be followed) • Study of stages in the life cycles of the following Pteridophytes from fresh / preserved material and permanent slides o *Lycopodium* o *Equisetum* o *Adiantum* o *Marsilea* o o o	
Bryophytes and Pteridophytes: Applied aspects • Economic importance of Bryophyta • Economic importance of Pteridophyta • Types of Sporophytes in Bryophyta (from Permanent slides) • Types of Sori and Soral Arrangement in Pteridophytes	
Gymnosperms (Chamberlain's Classification System to be followed) • Study of stages in the life cycles of the following Gymnosperms from fresh / preserved material and permanent slides o *Thuja* o *Gnetum* o *Ephedra* o • Economic importance of Gymnosperms	
USBOP10 – FOR 3 UNITS	
PRACTICAL PAPER II–PLANT DIVERSITY IV USBOP602 (For 3 & 6 Units)	**1.5**
Angiosperms II • Study of one plant from each of the following Angiosperm families as per Bentham and Hooker's system of classification. o Rhamnaceae o Combretaceae o Asclepiadaceae o Labiatae o Euphorbiaceae o Cannaceae o o • Morphological peculiarities and economic importance of the members of the above-mentioned Angiosperm families • Identify the genus and species with the help of flora	

Anatomy II • Study of Ecological Anatomy of • Hydrophytes: *Hydrilla* stem, *Nymphaea* petiole, *Eichhornia* offset • Epiphytes: Orchid • Sciophytes: *Peperomia* leaf • Xerophytes: *Nerium* leaf, *Opuntia phylloclade* • Halophytes: *Avicennia* leaf and pneumatophore, *Sesuvium* / *Sueda* leaf • Mesophytes: *Vinca* leaf	
Embryology • Study of various stages of Microsporogenesis, Megasporogenesis and Embryo Development with the help of permanent slides / photomicrographs • Mounting of Monocot (Maize) and Dicot (Castor and Gram)embryo • *In vivo* growth of pollen tube in *Portulaca /Vinca*	
Plant Geography • Study of phytogeographic regions of India • Preparation of vegetation map using Garmin's GPS Instrument • Problems based on Simpson's diversity Index	
Total Credit	**3**
SEMESTER VI USBOP9 – FOR 6 UNITS	**Cr**
SEMESTER VI USBOP10 – FOR 3 UNITS	
PRACTICAL PAPER III–FORM AND FUNCTION III USBOP603 (For 3 & 6 Units)	**1.5**
Plant Biochemistry • Estimation of proteins by Biuret method • Effect of temperature on the activity of amylase • Effect of pH on the activity of amylase • Effect of substrate variation on the activity of amylase	
Plant Physiology II • Determination of alpha-amino nitrogen • Effect of GA on seed germination • Estimation of reducing sugars by DNSA method	
Genetics • Problems based on three-point crosses, construction of chromosome maps • Identification of types of mutations from given DNA sequences • Study of mitosis using pre-treated root tips of *Allium*	
Biostatistics • *t*-test (paired and unpaired) • Problems based on regression analysis • ANOVA (One Way)	
PRACTICAL PAPER IV CURRENT TRENDS IN PLANT SCIENCES USBOP 604 (For 6 Units)	
Plant Biotechnology II • DNA sequencing by Sanger's Method and Pyro Sequencing Method • DNA barcoding of plant material by using suitable data	



Bioinformatics • BLAST: nBLAST, pBLAST • Multiple sequence alignment • Phylogenetic analysis • RASMOL/SPDBV	
Economic Botany • Demonstration: Extraction of essential oil using Clevenger • Thin layer chromatography of essential oil of *Patchouli* and *Citronella* • Saponification value of Palm oil	

Post-Harvest Technology
• Preparation of
  ▪ Squash
  ▪ Jam, Jelly
  ▪ Pickle
  ▪	

Total Credit	**3**

Scheme of Examinations:

Theory Course: Semester End Assessment	**100**	**Marks Each Theory Paper**
Practical Course	**50**	**Marks Each Practical Paper**

- **Students offering Double major (3 Units) will study Paper II and III**

Semester End Theory Examination Question Paper Pattern:

Q.1 – Four (4) Long Answer Questions on Unit – I out of which Two (2) to be solved.	**10 Marks Each**
Q.2 – Four (4) Long Answer Questions on Unit – II out of which Two (2) to be solved.	**10 Marks Each**
Q.3 – Four (4) Long Answer Questions on Unit – III out of which Two (2) to be solved.	**10 Marks Each**
Q.4 – Four (4) Long Answer Questions on Unit – IV out of which Two (2) to be solved.	**10 Marks Each**
Q.5 – Six (6) Short Answer Questions on all four (4) Units out of which Four (4) to be solved.	**05 Marks Each**

Note:

1. Minimum Marks of 20 are required in Every Practical Paper Examination in each semester.
2. A minimum of four field excursions (with at least one beyond the limits of Mumbai / Local area) for habitat studies are compulsory. Field work of not less than eight hours duration is equivalent to one period per week for a batch of fifteen students.
3. A candidate will be allowed to appear for the practical examinations only if he/she submits a certified journal of T.Y.B.Sc. Botany and the Field Report or a certificate from the Head of the Department/Institute to the effect that the candidate has completed the practical course of T.Y.B.Sc. Botany as per the minimum requirements. In case of loss of journal, a candidate must produce a certificate from the Head of the Department/ Institute that the practical for the academic year were completed by the student. However, such a candidate will be allowed to appear for the practical examination but the marks allotted for the journal will not be granted.

UNIVERSITY OF MUMBAI

T.Y.B.SC. BOTANY SEMESTER V (USBOP5)

Plant Diversity III (USBOP501)

Practical Paper – I

Duration: 9:00 am to 01:00 pm Max. Marks:50

Q.1 Perform the given Microbiological Experiment **'A'** 12

Q.2 Identify, Classify and Describe Specimens **B, C** and **D**. Sketch neat and labeled diagrams of Morphological / Microscopical structures seen in the specimens. 24

Q.3 Identify and describe slides / specimens **E, F** and **G**. 09

Q.4 Journal 05

KEY:

A– Any one experiment out of four as prescribed in syllabus.

B & **C**– Algae.

D– Fungi.

E, F & **G**– Plant Pathology, Algae or Fungi not asked above in random order.

UNIVERSITY OF MUMBAI

T.Y.B.SC. BOTANY SEMESTER V (USBOP5)

Plant Diversity IV (USBOP502)

Practical Paper – II

Duration: 9:00 am to 01:00 pm Max. Marks:50

Q. 1A. Classify specimen **'A'** up to their families giving reasons. Give floral formula. Sketch neat and labeled L. S. of flower and T.S. ovary. 10

Q. 1B. Identify genus and species of specimen **'B'** using flora. 05

Q.2 Make a temporary double stained preparation of T.S. specimen **'C'** and comment on the type of secondary growth. 06

Q.3 Perform the Palynology experiment **'D'** allotted to you. 07

Q.4 Identify and describe slide/ specimen **'E', 'F', 'G'** & **'H'**. 12

Q.5 Field report 05

Q.6 Viva voce (based on Paper I and Paper II). 05

KEY

A– Families of T.Y.B.Sc only

B– Plants from F.Y & S.Y. B. Sc Families to be included

C– Anatomy Anomalous Secondary Growth

D– As per slip

E, F, G & **H**– Fossils, Types of Stomata, Morphology of flower & Morphology of Fruits Studied in Theory – in random order

UNIVERSITY OF MUMBAI

T.Y.B.SC. BOTANY SEMESTER V (USBOP6)

FORMS AND FUNCTION III (USBOP503)

Practical Paper – III

Duration: 9:00 am to 01:00 pm Max. Marks:50

Q.1	Make a smear preparation of material **'A'** and show the slide to the Examiner. Comment on your observation / Expose the giant chromosomes from the salivary glands of *Chironomous* larva.	08
Q. 2	Perform the experiment **'B'** allotted to you (Physiology).	12
Q. 3	Perform the experiment **'C'** allotted to you (Ecology).	12
Q. 4.	Calculate the_____ of the given solution **'D'** to prepare the required solution.	07
Q. 5.	Identify and describe slide/specimen **'E'** & **'F'**.	06
Q.6.	Journal.	05

KEY

B– Physiology experiment.

C– Ecology experiment.

D– Plant Tissue Culture.

E & **F**– Multiple shoot culture, Hairy root culture, Somatic embryogenesis, Amino acid sequencing.

UNIVERSITY OF MUMBAI

T.Y.B.SC. BOTANY SEMESTER V (USBOP6)

CURRENT TRENDS IN PLANT SCIENCE II (USBOP504)

Practical Paper – IV

Duration: 9:00 am to 01:00 pm Max. Marks:50

Q.1. Perform the experiment **A**– growth curve of *E.coli* / Isolate plasmid DNA and separate using AGE. 12

Q.2. Perform the experiment **'B'** allotted to you. 10

Q.3. Describe macroscopical /microscopical character with the help of neat and labelled sketches of specimens **'C'** and **'D'**. Perform the chemical test / TLC to identify the active constituents. 14

Q. 4 Identify and explain the specimens/ photographs **'E', 'F'** and **'G'**. 09

Q. 5. Journal. 05

KEY

B– Experiment based on Beer- Lambert's Law Experiment on separation of dyes/pigments using silica gel column chromatography

C & **D**–*Allium sativum, Acorus calamus, Curcuma longa, Senna angustifolia, Strychnos nux-vomica Eugenia caryophyllata*

E, F & **G**– any stage of mushroom cultivation, any Plant from ethnobotany, problems on restriction mapping

UNIVERSITY OF MUMBAI

T.Y.B.SC. BOTANY SEMESTER V (USBOP7)

Plant Diversity IV (USBOP502) (For 3 Units)

Practical Paper – II

Duration: 9:00 am to 01:00 pm Max. Marks:50

Q. 1A. Classify specimen **'A'** up to their families giving reasons. Give floral formula. Sketch neat and labelled L.S. of flower and T.S. of ovary. 10

Q. 1B. Identify genus and species of specimen **'B'** using flora. 05

Q.2 Make a temporary double stained preparation of T.S. specimen **'C'** and comment on the type of secondary growth. 06

Q.3 Perform the Palynology experiment **'D'** allotted to you. 07

Q.4 Identify and describe slide/ specimen **'E', 'F', 'G' & 'H'**. 12

Q.5 Field report 05

Q.6 Journal. 05

KEY

A– Families of T.Y.B.Sc only

B– Plants from F.Y & S.Y. B. Sc Families to be included

C– Anatomy Anomalous Secondary Growth

D– As per slip

E, F, G & **H**– Fossils, Types of Stomata, Morphology of flower & Morphology of Fruits Studied in Theory – in random order

UNIVERSITY OF MUMBAI

T.Y.B.SC. BOTANY SEMESTER V (USBOP7)

FORMS AND FUNCTION III (USBOP503) (For 3 Units)

Practical Paper – III

Duration: 9:00 am to 01:00 pm Max. Marks:50

Q.1	Make a smear preparation of material **'A'** and show the slide to the Examiner. Comment on your observation / Expose the giant Chromosomes from the salivary glands of *Chironomous* larva.	08
Q. 2	Perform the experiment **'B'** allotted to you (Physiology).	12
Q. 3	Perform the experiment **'C'** allotted to you (Ecology).	12
Q. 4	Calculate the_____ of the given solution **'D'** to prepare the required solution.	07
Q. 5	Identify and describe slide/specimen **'E'**& **'F'**.	06
Q.6.	Viva voce (based on Paper II and Paper III).	05

KEY

B– Physiology experiment.

C– Ecology experiment.

D– Plant Tissue Culture.

E & **F**– Multiple shoot culture, Hairy root culture, Somatic embryogenesis, Amino acid sequencing.

UNIVERSITY OF MUMBAI

T.Y.B.SC. BOTANY SEMESTER VI

(USBOP8)

Plant Diversity III (USBOP601)

Practical Paper – I

Duration: 9:00 am to 01:00 pm Max. Marks:50

1	Identify, classify and describe specimen **'A'** and **'B'**. Sketch neat and labelled diagrams of Morphological/Microscopical structures seen in the specimens.	12
2	Identify, classify and describe specimen **'C'** and **'D'**. Sketch neat and labeled diagrams of Morphological/Microscopical structures seen in the specimens.	12
Q.3	Identify, classify and describe specimen **'E'**. Sketch neat and labeled diagrams of Morphological/Microscopical structures seen in the specimens.	06
Q.4	Identify and describe slides/specimen **'F', 'G' 'H', 'I'** & **'J'**.	15
Q.5	Journal.	05

KEY

A & **B**– Bryophytes: *Marchantia, Pellia & Sphagnum*

C & **D**– Pteridophytes: *Lycopodium, Equisetum, Adiantum* & *Marsilea*

E– Gymnosperm: *Thuja, Gnetum & Ephedra*

F, G, H, I & **J**– Economic importance of Bryophytes, Economic importance of Pteridophytes Types of Sporophytes in Bryophyta, Types of Sori in Pteridophytes, Soral arrangement in Pteridophytes, Economic importance of Gymnosperms. (In random order)

UNIVERSITY OF MUMBAI

T.Y.B.SC. BOTANY SEMESTER VI

(USBOP8)

Plant Diversity IV (USBOP602)

Practical Paper – II

Duration: 9:00 am to 01:00 pm Max. Marks:50

Q. 1 A.	Classify specimen **'A'** up to its family giving reasons. Give floral formula. Sketch neat and labeled L.S. of flower and T.S. ovary.	08
Q. 1.B.	Identify genus and species of specimen **'B'** using flora.	04
Q. 2	Make a stained preparation of specimen **'C'** and comment on its ecological anatomy.	06
Q.3.A	Calculate Simpson's Diversity Index from the given data **'D'**.	08
Q.3.B	Mark the Phytogeographic region **'E'** in the map of India and Comment on the same.	05
Q.4	Identify and describe slide/specimen **'F', 'G' & 'H'**.	09
Q.5	Field Report.	05
Q.6	Viva voce (based on Paper I and Paper II)	05

KEY

A– Families of T.Y.B.Sc Sem – VI only

B– Plants from F.Y., S.Y. & T.Y. B. Sc**.**(Sem – V Families to be included**)**.

C– Ecological anatomy.

F, G & **H**– Economic importance of specimen from prescribe families (Sem VI only)**,** Morphological Peculiarities of prescribed families (Sem – VI only), Embryology. (In random order)

UNIVERSITY OF MUMBAI

T.Y.B.Sc. BOTANY SEMESTER VI (USBOP9)

FORM AND FUNCTION III (USBOP603)

PRACTICAL III

Duration: 9:00 am to 01:00 pm Max. Marks:50

Q.1 Perform the experiment **'A'** allotted to you.

Q.2 Perform the experiment **'B'** allotted to you.

Q.3 Make a squash preparation to show the stage of mitosis from the pre-treated root tips **'C'**. 05

Q.4 Construct a chromosome map from the given data **'D'** / Identify the type of mutation and comment on them (any two types of mutations) 10

Q.5 From the given data/ material **'E'** determine test of significance using students t-test/ Regression Analysis /ANOVA 10

Q.6 Journal. 05

KEY

A– Plant Biochemistry Experiment.

B– Plant Physiology Experiment.

UNIVERSITY OF MUMBAI

T.Y.B.Sc. BOTANY SEMESTER VI (USBOP9)

CURRENT TRENDS IN PLANT SCIENCE II (USBOP604)

PRACTICAL IV

Duration: 9:00 am to 01:00 pm Max. Marks:50

Q.1	Perform the DNA barcoding of plant material using given data **'A'**.	12
	OR	
	Perform DNA sequencing by Sanger's method of the given sequence **'A'**.	12
Q.3	Perform the experiment **'B'** allotted to you.	12
Q.4	Perform the given analysis of data **'C'** using computer(Bioinformatics).	08
Q.5	Prepare the squash/Jam/jelly/pickle from the given material **'D'**.	12
Q.6	Viva voce. (Based on Paper III and Paper IV)	06

KEY

B– TLC of *Patchouli* or *Citronella* / Saponification value

C– BLAST / Multiple Sequence Alignment (MSA) / Phylogenetic Analysis / RASMOL / SPDBV

UNIVERSITY OF MUMBAI

T.Y.B.SC. BOTANY SEMESTER V (USBOP10)

Plant Diversity IV (USBOP602) (For 3 Units)

Practical Paper – II

Duration: 9:00 am to 01:00 pm Max. Marks:50

Q. 1A.	Classify specimen **'A'** up to its family giving reasons. Give floral formula. Sketch neat and labeled L.S. of flower and T.S. ovary.	08
Q. 1.B.	Identify genus and species of specimen **'B'** using flora.	04
Q. 2	Make a stained preparation of specimen **'C'** and comment on its ecological anatomy.	06
Q.3.A	Calculate Simpson's Diversity Index from the given data **'D'**.	08
Q.3.B	Mark the Phytogeographic region **'E'** in the map of India and Comment on the same.	05
Q.4	Identify and describe slide/specimen **'F', 'G'** & **'H'.**	09
Q.5	Field Report.	05
Q.6	Journal	05

KEY

A– Families of T.Y.B.Sc Sem – VI only

B– Plants from F.Y., S.Y. & T.Y. B. Sc.(Sem – V Families to be included).

C– Ecological anatomy.

F, G & **H**– Economic importance of specimen from prescribe families (Sem VI only), Morphological Peculiarities of prescribed families (Sem – VI only), Embryology. (In random order)

UNIVERSITY OF MUMBAI

T.Y.B.Sc. BOTANY SEMESTER VI(USBOP10)

FORM AND FUNCTION III (USBOP603) (For 3 units)

PRACTICAL III

Duration: 9:00 am to 01:00 pm Max. Marks:50

Q.1 Perform the experiment **'A'** allotted to you.

Q.2 Perform the experiment **'B'** allotted to you.

Q.3 Make a squash preparation to show the stage of mitosis from the pre-treated root tips **'C'**. 06

Q.4 Construct a chromosome map from the given data **'D'**/ Identify the type of mutation and comment on them (any two types of mutations) 10

Q.5 From the given data/ material **'E'** determine test of significance using students t-test/ Regression Analysis /ANOVA 09

Q.6 Viva-voce. (based on Paper II and Paper III) 05

KEY

A– Plant Biochemistry Experiment.

B– Plant Physiology Experiment.

ReferenceBooks

1. A handbook of Ethnobotany by S.K. Jain, V. Mudgal
2. rdPlants in folk religion and mythology (Contribution to Ethnobotany by S.K.Jain3Rev.Ed.).
3. Introduction to Plant Physiology by Noggle and Fritz, Prentice Hall Publishers(2002)
4. Plant Physiology by Salisbury and Ross CBS Publishers
5. Plant Physiology by Taiz and Zeiger Sinauer Associates Inc. Publishers,2002
6. thGenetics by Russel Peter Adison Wesley Longman Inc. (5edition)
7. An introduction to Genetic analysis Griffith Freeman and Company(2000)
8. Fundamentals of Biostatics by Rastogi, Ane Books Pvt. Ltd.(2009).
9. College Botany Vol I and II by Gangulee Das and Dutta Central Education enterprises.
10. Cryptogamic Botany Vol I and II by G M Smith, Mcg raw Hill
11. Industrial Microbiology by Cassida, New Age International, New Delhi
12. Industrial Microbiology Mac Millan Publications, New Delhi
13. Physiological Plant Anatomy by Haberlandt, Mac Millan and Company
14. Ayurveda Ahar by P H Kulkarni
15. Pharmacognosy by Kokate, Purohit and Gokhale, Nirali Publications
16. Bioinformatics by Sunder Rajan
17. Instant Notes on Bioinformatics by Westhead (2002), Taylor Francis Publications.
18. Bioinformatics by Ignasimuthu
19. DNA barcoding plants: taxonomy in a new perspective 2010. K Vijayan and C H Tsou, Current Science, 1530 –1541.
20. Introduction to Biostatistics by P K Banerjee, Chand Publication.
21. Plant Biotechnology by K. Ramawat
22. Practical Biochemistry by David Plummer, McGraw Hill Publ.
23. Economic Botany by A F Hill, TATA McGRAW-HILL Publishing Co. Ltd.
24. Post-Harvest Technology by Verma and Joshi, Indus Publication
25. Embryology of Plants by Bhojwani and Bhatnagar
26. Pollen Morphology and Plant Taxonomy by G. Erdtman, Hafner Publ. Co., N.Y.
27. A text Book of Palynology by K Bhattacharya, New Central Book Agency Pvt. Ltd., London
28. An introduction to Embryology of Angiosperms by P Maheshwari, McGraw Hill Book Co.
29. Plant Systematics by Gurcharan Singh, Oxford and IBH Publ.
30. Taxonomy of Vascular Plants by Lawrence George, H M, Oxford and IBH Publ.