AC 27/2/13
Item No. 4.2

UNIVERSITY OF MUMBAI

Syllabus for Sem V & Sem VI
Program: B.Sc.
Course : BOTANY

(Credit Based Semester and Grading System with effect from the academic year 2013–2014)

T.Y.B.Sc. Botany Syllabus
Credit Based Semester and Grading System
To be implemented from the Academic year 2013-2014

SEMESTER V

Course Code	UNIT	TOPICS	Credits	L / Week
USBO501		**PLANT DIVERSITY III**		
	I	Microbiology	2.5	1
	II	Applied Microbiology		1
	III	Fungi		1
	IV	Plant Pathology		1
USBO502		**PLANT DIVERSITY IV**		
	I	Gymnosperms	2.5	1
	II	Angiosperms		1
	III	Embryology		1
	IV	Anatomy		1
USBO503		**FORM AND FUNCTION III**		
	I	Physiology	2.5	1
	II	Cytogenetics		1
	III	Environmental Biology		1
	IV	Plant Geography		1
USBO504		**CURRENT TRENDS IN PLANT SCIENCESII**		
	I	Food as medicine and Nutrition and the Mushroom Industry	2.5	1
	II	Micropropagation		1
	III	Pharmacognosy&Medicinal Botany		1
	IV	Biotechnology		1
USBOP5	Practicals based on all the four courses in theory		6	16

SEMESTER VI

Course Code	UNIT	TOPICS	Credits	L / Week
USBO601	PLANT DIVERSITY III			
	I	Algae Life Cycle	2.5	1
	II	Algae Applications		1
	III	Bryophyta		1
	IV	Pteridophyta		1
USBO602	PLANT DIVERSITY IV			
	I	Paleobotany	2.5	1
	II	Angiosperms		1
	III	Palynology		1
	IV	Ecological Anatomy and Root Stem Transition		1
USBO603	FORM AND FUNCTION III			
	I	Physiology	2.5	1
	II	Cytogenetics and Biostatistics		1
	III	Environmental Botany		1
	IV	Forestry and Forest Products		1
USBO604	CURRENT TRENDS IN PLANT SCIENCES II			
	I	Ethnobotany and Aesthetic Botany	2.5	1
	II	Post Harvest Techniques		1
	III	Cosmetology		1
	IV	Bioinformatics		1
USBOP6	Practicals based on all the four courses in theory		6	16

SEMESTER V
THEORY

Course Code	Title	Credits
USBO501	**PLANT DIVERSITTY III**	**2.5 Credits (60 lectures)**
Unit I : Microbiology • Antibiotics and their mode of action – General. • Inhibition of cell wall synthesis – Penicillin. • Inhibition of nucleic acid and protein synthesis – Streptomycin. • Microbiological assay of antimicrobial compound • Chemical assay • Biological assay – tube dilution method and Disc plate technique.		**15 Lectures**
Unit II : Applied Microbiology • Microbial fermentation – General Process in detail • Antibiotic Production of Penicillin • Production of Glutamic acid • Production of Amylase		**15 Lectures**
Unit III : Fungi Systematic position, structure and life cycle of the following • Phycomycetes – *Albugo* • Ascomycetes – *Xylaria* • Basidiomyceyes – *Puccinia* • Deuteromycetes – *Fusarium.*		**15 Lectures**

Unit IV : Plant Pathology
• Study of plant diseases : Causative organism, symptoms, predisposing factors, disease cycle and control measures of the following.
  • Wilt of pigeon pea,
  • Tikka disease of ground nut,
• A study of physical, chemical and biological control methods of plant disease
		15 Lectures

Course Code	Title	Credits
USBO502	**PLANT DIVERSITY IV**	**2.5 Credits (60 lectures)**
Unit I : Gymnosperms Systematic position, structure and life cycle of the following • *Ephedra* • *Gnetum*		**15 Lectures**
Unit II : Angiosperms • Characters of Taxonomic Importance. • Anatomy, Palynology and Embryology in relation to Taxonomy. • Historical background of classification. • Natural system of classification – Elaboration of Bentham and Hooker system of Classification • Phylogenetic System of Classification –Hutchinson's. • Systemic Botany – • 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 • Capparidaceae • Sterculiaceae • Cucurbitaceae • Umbelliferae (Apiaceae) • Palmae • Scitaminae (Sub family – Zingiberaceae)		**15 Lectures**
Unit III : Embryology • Microsporangium – Structure and development, Microsporogenesis, role of tapetum in microsporogenesis, Development of male gametophyte. • Megasporangium - Structure and development, Megasporogenesis and Development of female gametophyte (*Polygonum* type). • Fertilization – Double fertilization and its significance. • Development of the embryo – Dicotyledonous type – *Capsella* type.		**15 Lectures**

Unit IV : Anatomy
• Anomalous secondary growth in the
  • Stems of *Bignonia*, *Salvadora*, *Achyranthes*, *Aristolochia*, *Dracaena*.
  • Storage roots of Beet, Radish
• Types of Stomata – Anisocytic, Diacytic, Paracytic, Anomocytic and Graminaceous.
	15 Lectures

Course Code	Title	Credits
USBO503	**FORM AND FUNCTION III**	**2.5 Credits (60 lectures)**
Unit I : Physiology • **Translocation of Solutes** Transport of inorganic solutes – Active and Passive Transport, Transport of organic solutes, Shuttle systems, Anatomy of sieve tubes, Contents moving through sieve tubes, Mechanism of sieve tube translocation - Munch's Hypothesis, Electro – osmosis mechanism and Osmotic gradient, Rapid – Slow movement mechanism. • **Lipid Metabolism** Biosynthesis and Degradation of fatty acids and glycerol, Respiratory metabolism in germinating seeds, β- Oxidation, Types of lipids.		**15 Lectures**
Unit II : Cytogenetics • **Mutation – Point Mutations** • Definition • Types – somatic/germline, spontaneous/induced, gross/ point- base pair substitutions – transversion, transition; effect of substitution mutation on phenotype (Missense mutation, Nonsense mutation, Neutral mutations, Silent mutation). - Frame shift mutations (additions, deletions), - Suppression mutation. • Causes of Mutations – DNA replication errors, Induced mutations. • Mutagenic agents – Physical, Chemical (base analogs, base modifying agents). • Role of mutations in plant breeding. • **Genetic Mapping in *Neurospora*** • Linear tetrad analysis - Construction of chromosome map one gene and centromere		**15 Lectures**
Unit III : Environmental Biology • **Bioremediation-** • Bioremediation: Principles, Factors responsible and Microbial population in bioremediation. • Biomagnifications.		**15 Lectures**

• Bioaccumulation and Biotransformation. • Phytoremediation: Metals , Organic pollutants.	
Unit IV : Plant Geography • **Phytogeographical regions of India**. • **Biodiversity** : • Definition, • Biodiversity- diversity of flora found in various forest types of India, • Evolution of Biodiversity with one example of an evolutionary tree, • Levels of biodiversity, • Importance and status of biodiversity, • Loss of biodiversity, • Conservation of biodiversity, • Genetic diversity- Molecular characteristics.	**15 Lectures**

Course Code	Title	Credits
USBO504	**CURTRENT TRENDS IN BOTANY II**	**2.5 Credits (60 lectures)**
Unit I : Food as Medicine and Nutrition and Mushroom Technology • Mushroom industry – Cultivation, picking and packaging, marketing and economics of the business. • Food as medicine and nutrition – i) Dietary antioxidants ii) Food as medicine a) Anaemia b) Diabetes c) Obesity d) Skin disorders.		**15 Lectures**
Unit II : Micropropagation • Laboratory organization and techniques in plant tissue culture • Totipotency • Organogenesis • Organ Culture – Root cultures, meristem cultures, anther and pollen culture, embryo culture. • Somatic Embryogenesis and artificial seeds • Protoplast Fusion and Somatic Hybridization • Applications of tissue culture		**15 Lectures**
Unit III : Pharmacognosy, Pharmacology & Medicinal Botany • **C**ultivation practices of the following medicinal plants with respect to Soil, Propagation methods, Irrigation, Manuring (fertilizers), harvesting, processing, storage, pests and diseases, marketing and their medicinal uses – • *Allium sativum* • *Acorus calamus* • *Curcuma longa* • Monograph of drugs with respect to Biological Sources, Geographical distribution, Common Varieties, Macro and microscopic characters, Chemical constituents and therapeutic uses, adulterants of the following plants/ drugs: - *Ocimum basilicum* (Leaf) - *Strychnos nux-vomica* (Seeds)		**15 Lectures**

Unit IV : Biotechnology • Construction of Genomic DNA libraries, Chromosome libraries and C-DNA Libraries. • Identification of specific cloned sequences in cDNA libraries and Genomic libraries. • Analysis of genes and gene transcripts – Restriction enzyme analysis of cloned DNA sequences. • Hybridization (Southern Hybridization).	**15 Lectures**

SEMESTER V
PRACTICAL

Semester V USBOP5		Cr
PRACTICAL Paper I – PLANT DIVERSITY III		**1.5**
Microbiology		
1	Study of aeromicrobiota by petriplate exposed method • Fungal culture • Bacterial culture	
2	Determination of Minimum Inhibitory Concentration (MIC) of sucrose against selected micro organism	
3	Study of antimicrobial activity by the disc diffusion method	
Fungi and Plant Pathology		
4 To 7	Study of stages in life cycle of the following Fungi from fresh / preserved material and permanent slides i. Phycomycetes – *Albugo* ii. Ascomycetes – Yeast, *Xylaria* iii. Basiodiomycetes – *Puccinia* iv. Deuteromycetes – *Fusarium*	
8 9	Study of the following fungal diseases: i. Wilt of Pea ii. Tikka disease in Groundnut	
PRACTICAL Paper II – PLANT DIVERSITY IV		**1.5**
Gymnosperms		
1,2	Study of stages in the life cycle of the following Gymnosperms from fresh / preserved material and permanent slides i. *Ephedra* ii. *Gnetum*	
Angiosperms		
3 to 6	Study of one plant from each of the following Angiosperm families i. Capparidaceae ii. Sterculiaceae iii. Cucurbitaceae iv. Umbelliferae v. Scitaminae (Sub-family: Zingiberaceae) vi. Palmae	
	Morphological peculiarities and economic importance of the members of the above mentioned Angiosperm families	
7	Identifying the genus and species of a plant with the help of Flora	
Embryology		
8	Study of various stages of Microsporogenesis, Megasporogenesis and Embryo Development with the help of permanent slides / photomicrographs	
9	*In vivo* growth of pollen tube in *Portulaca*	
Plant Anatomy		
10to	Study of anomalous secondary growth in the stems of the following plants	

12	using double staining technique i. *Bignonia* ii. *Salvadora* iii. *Achyranthes* iv. *Aristolochia* v. *Dracaena*	
13	Types of Stomata i. Anomocytic ii. Anisocytic iii. Diacytic iv. Paracytic v. Graminaceous	
PRACTICAL - Paper III FORM AND FUNCTION III		**1.5**
Plant Physiology and Biochemistry		
1	Colorimetric estimation of fatty acids	
2	Determination of saponification value of the given oil sample	
3	Separation of fatty acids by thin layer chromatography	
Cytogenetics		
4, 5	Identification and consequences of types of point mutation i. Substitution Mutations – missense, nonsense, neutral and silent mutations ii. Frame-shift Mutations – addition, deletion (Genetic code dictionary to be provided)	
6	Study of the effect of *p*DB on Mitosis	
7	Calculation of Chiasma frequency from permanent slides / photomicrographs	
8	Tetrad analysis in *Neurospora* and construction of linkage map in *Neurospora (centromere and one gene)*	
Environmental Botany and Plant Geography		
9 to 11	Estimation of the following in / of the given water sample: i. Dissolved Oxygen Demand ii. Biological Oxygen Demand iii. Hardness iv. Salinity v. Acidity vi. Alkalinity	
12	Identification of Phytogeographical Regions of India	
PRACTICAL - Paper IV CURRENT TRENDS IN PLANT SCIENCES II		**1.5**
Entrepreneurship Development		
1	Mushroom cultivation (demonstration) – identification of various steps involved (spwan, pin head stage and mature stage)	
Micropropagation		
2 to 6	Plant Tissue Culture i. Various sterilization techniques, preparation of stock solutions, preparation of MS medium	

	ii. Seed sterilization, callus induction and regeneration iii. Encapsulation of axillary buds	
Pharmacognosy and Medicinal Botany		
7,8	Chemical tests for the active constituents of the following plants i. *Allium satinum* ii. *Acorus calamus* iii. *Curcuma longa* iv. *Oscimum basilicum* v. *Strychnos nux-vomica*	
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SEMESTER VI
THEORY

Course Code	Title	Credits
USBO601	**PLANT DIVERSITY III**	**2.5 Credits (60 lectures)**

Unit I : Algae Life Cycle
• **Systematic position, structure and life cycle of the following**
  • Cyanophyta : *Rivularia*,
  • Chlorophyta : *Oedogonium*, *Chara*,
  • Chrysophyta : Diatoms,
  • Rhodophyta : *Polysiphonia*.
		15 Lectures

Unit II : Algae Applications
• Applications
  • Biofuel &
  • Food
• Origin and evolution of sex in Algae**.**
		15 Lectures

Unit III : Bryophyta
• **Systematic position, structure and life cycle of the following**
  ➢ *Marchantia*
  ➢ *Pellia*
• Evolution of the sporophyte in Bryophyta
• Economic importance of Bryophytes
		15 Lectures

Unit III : Pteridophyta
• **Systematic position, structure and life cycle of the following**
  ➢ *Lycopodium*
  ➢ *Marsilea*
• **Evolution of sorus in Pterophyta**
		15 Lectures

Course Code	Title	Credits
USBO602	**PLANT DIVERSITY IV**	**2.5 Credits (60 lectures)**
Unit I : Paleobotany • **Systematic position, structure and life cycle of the following form genera** ➢ *Lepidodendron* ➢ *Lyginopteris* ➢ *Pentoxylon* • Fossil records, Location/collection spots • Contributions of Birbal Sahani to Paleobotany • BSIP – Projects and Goals.		**15 Lectures**
Unit II : Angiospermae • Tools of Angiosperm Taxonomy – Library, Floras, Monographs, Dictionary, Periodicals, Index and Journals • Study of following plant families • Rutaceae • Asclepiadaceae • Scrophulariaceae • Labiatae (Lamiaceae) • Amaranthaceae • Polygonaceae • Graminae		**15 Lectures**
Unit III : Palynology • Pollen and Spore Morphology – size and shape, polarity, apertures (NPC), exine stratification, exine excrescences, construction of a palynogram. • Application of Palynology in honey industry, coal and oil exploration and forensic science. Aeropalynology and pollen allergy. • Pollen viability and storage – Causes for loss of pollen viability, Tests for pollen viability, Pollen storage. • Germination and growth of the pollen tube, factors affecting pollen tube growth.		**15 Lectures**

Unit IV : Ecological Anatomy and root Stem transition
• Root - Stem Transition
• Ecological Anatomy
  • Hydrophytes
  • Epiphytes
  • Sciophytes
  • Halophytes
  • Xerophytes
  • Mesophytes	

Course Code	Title	Credits
USBO603	**FORM AND FUNCTION III**	**2.5 Credits (60 lectures)**
Unit I : Physiology • **Vegetative Growth** **General** phases of growth, Growth Curves, Factors affecting growth – External (environmental) and internal (genetic, hormonal, nutritional); Role of plant growth regulating substances – Auxins, Cytokinins and Gibberellins and their commercial applications. • **Nitrogen Metabolism** **Nitrogen** Cycle, Root nodule formation and Leg- haemoglobin, Nitrogenase activity, Assimilation of nitrates (NR – NiR activity), Assimilation of Ammonia (Amination and Transamination reactions), Nitrogen Assimilation and Carbohydrate utilization.		**15 Lectures**
Unit II : Cytogenetics And Biostatistics • **Regulation of gene expression in prokaryotes** • Gene regulation of lactose utilization in *E. coli*, *lac* operon. • **Biostatistics** • Coefficient of Correlation . • Student's t test (paired and unpaired)		**15 Lectures**
Unit III : Environmental Botany • **Toxicology**: • Pesticides: Use in agriculture and public health programme. • Basic principles of toxicology including LD_{50} and $LC_{50,}$ Absorption, distribution and physiological effects- Lead and Parathion. • **Global environmental issues:** **Global environmental problem and remedial measures-** • Climate change: Global warming and Greenhouse effect. • Ozone depletion. • Acid Rain. • GMO- Biosafety measures. • Consequences of the use of pesticides and fertilizers. • Surface water and industrial pollution: e.g. Ganga river water. • Air pollution in metro cities. • Waste management including e-waste.		**15 Lectures**

Unit IV : Forestry and Forest Products
• **Forest Products**:
  • Major and Minor Forest products,
  • Timber industry,
  • Paper industry,
• Fodder yielding plants
	15 Lectures

Course Code	Title	Credits
USBO604	**CURRENT TRENDS IN PLANT SCIENCES II**	**2.5 Credits (60 lectures)**
Unit I : Ethnobotany and Aesthetic Botany • Ethnobotany – -Definition, History, Sources of data and methods of study. Aesthetic Botany – -Bonsai – Definition, Types, Methods & Tools, Plants. -Ikebana : Types of arrangements -Fresh Flower arrangement in Indian Ceremonies – Rangoli, Garland etc. -Dry Flower arrangement.		**15 Lectures**

Unit II : 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, Dehydrofreezing, Freeze drying),
  • Canning-
  • Pickling - (in Brine, in vinegar, Indian Pickles)
  • Sugar Concentrates (Jams, Preserves, Jellies, Fruit juices)
  • Food Preservatives
  • Use of Anti-oxidants in preservation.
		15 Lectures

Unit III : Cosmetology
• **Introduction to Herbal Cosmetics:**
  • Definition,
  • Collection and processing of herbal material,
  • Natural and artificial drying of herbal material.
• **Standardization of raw material –**
  • Importance of standardization,
		15 Lectures

• Physical and chemical methods of standardization, • Quantitative and qualitative estimation of phytoconstitutes • **Application of herbs in the following herbal cosmetics** • Herbal Shampoo**,** • Herbal Hair Dye/ Herbal Hair Oil/Hair Cream/Hair Gel, • Herbal Face Mask, • Herbal Bath Oil. • Current status of Herbal Cosmetic Industry in India, Problems and Future prospects of Herbal Cosmetic Industry in India.	
Unit III : Bioinformatics • Organization of biological data, databases, • Exploration of data bases, retrieval of desired data, BLAST etc. • Protein structure analysis and application, • Multiple sequence analysis and phylogenetic analysis	**15 Lectures**

SEMESTER VI
PRACTICAL

Semester VI USBOP6		Cr
PRACTICAL PAPER I – PLANT DIVERSITYIII		**1.5**
Algae		
1 to 4	Study of stages in the life cycle of the following Algae from fresh / preserved material and permanent slides i. Cyanophyta – *Rivularis* ii. Chlorophyta – *Oedogonium*, *Chara* iii. Chrysophyta – *Diatoms* iv. Phaeophyta – *Polysiphonia*	
5	Utilization of Algae as i. Biofuel ii. Food	
Bryophyte		
6 , 7	Study of stages in the life cycles of the following Bryophytes from fresh / preserved material and permanent slides i. *Marchantia* ii. *Pelia*	
Pteridophyta		
8 to 10	Study of stages in the life cycle of the following Pteridophytes from fresh / preserved material and permanent slides i. *Lycopodium* ii. *Marsilea*	
11	Study of the soral structure of i. *Ophioglossum* ii. *Osmunda* iii. *Lygodium* iv. *Pleopeltis* v. *Pteris* vi. *Asplenium* vii. *Nephrolepis*	
PRACTICALS PAPER II – PLANT DIVERSITY IV		**1.5**
Paleobotany		
1	Study of the following form genera with the help of permanent slides / photomicrographs i. *Lepidodendron* ii. *Lyginopteris* iii. *Pentoxylon*	
Angiosperms		
2 to 4	Study of one plant from each of the following Angiosperm families i. Rutaceae ii. Asclepiadaceae iii. Scrophulariaceae iv. Labiatae v. Amaranthaceae vi. Polygonaceae	

	vii. Graminae	
5	Morphological peculiarities and economic importance of the members of the above mentioned Angiosperm families	
6	Identify the genus and species with the help of flora	
Palynology		
7	Study of pollen morphology (NPC Analysis) of the following by Chitley's Method i. *Hibiscus* ii. *Datura* iii. Labiatae iv. *Crinum* v. *Pancratium* vi. *Canna*	
8	Determination of pollen viability	
9	Pollen analysis from honey sample – unifloral and multifloral honey	
Ecological Plant Anatomy		
10 to 14	Study of Ecological Anatomy of i. Hydrophytes ii. Epiphytes iii. Sciophytes iv. Xerophytes v. Halophytes vi. Mesophytes	

PRACTICALS - Paper III –FORM AND FUNCTION III		**1.5**
Plant Physiology and Biochemistry		
1	Determination of alpha-amino nitrogen	
2	Estimation of proteins by Lowry's method	
3	Determination of NR activity in leaf discs	
4	Quantitative analysis of amylase in GA treated and non-treated seeds	
Biostatistics		
5	Calculation of coefficient of correlation	
6, 7	Student's t test (paired and unpaired)	
Environmental Botany and Forestry		
8 to 10	Estimation of the following in the given water sample: i. Sulphate ii. Phosphate iii. Copper, Lead	
11	Calculation of LD_{50} of Phenol / $CuSO_4$ or any heavy metal	
12	Forest Products i. Timber ii. Paper iii. Fibre iv. Fodder yielding plants	

PRACTICALS - PAPER IV – CURRENT TRENTS IN PLANT SCIENCES IV		**1.5**
Plant Products		
1 to 3	Identification of plant products based on exomorphic and endomorphic features, and	

	chemical tests for the active constituents i. Alkaloids – *Vinca*, *Datura*, *Adathoda* ii. Glycosides – *Aloe*, *Senna* iii. Tannins – *Terminalia belerica* / *T. chebula*	
	Identification of dye-yielding plant products based on exomorphic and endomorphic features and study of the absorption spectrum of the dye i. *Curcuma longa* ii. *Bixa orellana* iii. Henna	
Horticulture		
4, 6	Preparation of i. Squash ii. Jam iii. Jelly iv. Pickle	
7 to 11	Aesthetic Botany i. Bonsai (Demonstration) ii. Types of floral arrangements • Flower rangoli • Ikebana • Bouquet • Garland • Dry flower arrangement	
Cosmetology		
12	Preparation of the following herbal products i. Face mask ii. Bath oil iii. Hair wash powder	
Bioinformatics		
13,14	• BLAST: nBLAST, pBLAST • Multiple Sequence Alignment • Phylogenetic Analysis • RASMOL / spdbv	
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Scheme of Examinations:

Theory Course:

Recommendations for Internal Assessment for	**40 marks**
One periodical test on class instructions	20 marks
One assignments	10 marks
Active Participation (attentiveness/ability to answer questions)	05 marks
Leadership qualities in organizing or participation in academic or Co-curricular activities /mannerism and articulation etc.	05 marks
External Assessment	60 Marks

Practical Course: 50 marks external.

Note:

1. A minimum of four field excursions(with at least one beyond the limits of Mumbai) 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.
2. A candidate will be allowed to appear for the practical examinations only if he/she submits a certified journal of TYBSC 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 practicals 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.

Reference Books

1. A handbook of Ethnobotany by S.K. Jain, V. Mudgal – Chapter – 1 & 3; Relevance of Ethnobotany .
2. Plants in folk religion and mythology (Contribution to Ethnobotany by S.K.Jain 3rd Rev. Ed.).
3. Introduction to Plant Physiology Noggle and Fritz, Prentice Hall Publishers (2002)
4. Plant Physiology Salisbury and Ross CBS Publishers
5. Plant Physiology Taiz and Zeiger Sinauer Associates Inc.Publishers,2002
6. Genetics Russel Peter Adison Wesley Longman Inc. (fifth edition)
7. An introduction to Genetic analysis Griffith Freeman and Company (2000)
8. Fundamentals of Biostatics Rastogi Ane Books Pvt Ltd (2009)_
9. College Botany Vol I and II Gangulee Das and Dutta Central Education enterprises.
10. Cryptogamic Botany Vol I and II Mcg raw Hill
11. Industrial Microbiology Casida New Age Internationa, New Delhi
12. Industrial Microbiology Mac Millan Publications, New Delhi
13. Physiological Plant Anatomy Haberlandt Mac Millan and Company
14. Ayurveda Ahar P H Kulkarni
15. Pharmacognosy Kokate, Purohit and Gokhale Nirali Publications
16. Bioinformatics Sunder rajan Himalaya Publications
17. Instant Notes on Bioinformatics Westhead (2002) Taylor Francis Publications.