

SEMESTER - I

Core Paper I- PLANT DIVERSITY - I: ALGAE, FUNGI, LICHENS, BACTERIA, VIRUS AND PLANT PATHOLOGY

Instructional Hrs. : 90

Sub.Code : 15BOUC101

Max. Marks : CIA – 25; ESE - 75

Credits : 4

Objectives :To know the classification of primitive plants, vegetative and reproductive structures and economic importance of Algae, Fungi and Microorganisms.To know some specific diseases seen in plants and their control measures.

UNIT – I

18Hrs.

Algae - Classification of Algae (G.M. Smith) - Study of the Structure - Reproduction and Life cycle of *Anabaena* – *Chlamydomonas* – *Volvox* – *Oedogonium* - *Caulerpa* and *Chara*.

UNIT-II

18 Hrs.

Structure - Reproduction and Life cycle of *Diatoms* – Pennate and Centric – *Ectocarpus*-*Dictyota* and *Polysiphonia*- Economic importance of Algae.

UNIT – III

18 Hrs.

Fungi - Classification of Fungi (Alexopoulos - 1962) - Structure - Reproduction and Life cycle of *Albugo* – *Rhizopus* – *Saccharomyces* -*Aspergillus* - *Peziza* - *Puccinia* and *Agaricus*.

UNIT – IV

18 Hrs.

Structure - Reproduction and Life cycle of *Lycoperdon* - *Cercospora* – *Fusarium* and *Alternaria*- Economic importance of Fungi. Structure and Reproduction of Lichens – *Crustose* - *Foliose* and *Fruticose*.

UNIT – V

18 Hrs.

Structure and Reproduction of Bacteria and *Bacteriophage* (T4). Plant Diseases: Bunchy top of banana - Red rot of sugarcane- Blight disease of rice (symptoms - causal organisms and control measures).

Note :*Italics* denote self study Topics

PRACTICALS :

Study of the types mentioned below:

Algae - Anabaena – Chlamydomonas – Volvox – Oedogonium - Caulerpa –Chara - Diatoms – Pennate and Centric – Ectocarpus - Dictyota – Polysiphonia

Fungi - Albugo – Rhizopus – Saccharomyces -Aspergillus - Peziza - Puccinia – Agaricus - Lycoperdon- Cercospora – Fusarium – Alternaria- Lichens- Bacteria - Virus

Plant Diseases - Bunchy top of banana - Red rot of sugarcane- Blight disease of rice

TEXT BOOKS :

1. **Vashishta, B.R.**, “*Botany for Degree Students –Algae*”, S. Chand & Co., New Delhi, Revised Edition, 2004.
2. **Vashishta, B.R.**, “*Botany for Degree Students – Fungi*”, S. Chand & Co., New Delhi, Revised Edition, 2003.
3. **Pandey, B.P.**, “*Plant Pathology*”,S. Chand & Co., New Delhi, Revised Edition, 2003.

REFERENCE BOOKS :

1. **Srivastava, H.N.**, “*Fungi*”, Pradeep Publications, Jalandhar (India), New Millennium Edition, 2004.2.
2. **Sethi, I.K., and Walia, S.K.**, “*Textbook of Fungi and their Allies*”, Macmillan Publishers India Ltd. 2011.
3. **Johri, R.M., Latha, S. and Tyagi, K.** “*A Textbook of Fungi*” Dominant Publishers and Distributors Pvt. Ltd. New Delhi, 20116.
4. **Mehrotra, R.S.**, “*Plant Pathology*”, Tata Mc Graw Hill Publishing Company Ltd. , New Delhi,1996.
5. **Bilgrimi, K.S. and Dube, H.C.**,“*A text book of Modern Plant Pathology*”, Vikas Publishing House, PVT., LTD., Kanpur,1980.

SEMESTER - II

Core Paper II - PLANT DIVERSITY - II : BRYOPHYTES, PTERIDOPHYTES, GYMNOSPERMS AND PALAEOBOTANY

Instructional Hrs. : 90

Sub.Code : 15BOUC202

Max. Marks : CIA – 25; ESE - 75

Credits : 4

Objectives: To study the classification, morphology, anatomy and reproduction of some forms of Bryophytes, Pteridophytes and Gymnosperms.

To study the Geological time scale and some kinds of fossils.

UNIT – I **18 Hrs.**

Bryophytes - Classification of Bryophytes (Reimer's - Outline only) Structure and Reproduction of *Marchantia*- *Porella*- *Anthoceros* and *Funaria*.

UNIT – II **18 Hrs.**

Pteridophytes - Classification of Pteridophytes (Sporne - Outline only) Stelar evolution- Structure and Reproduction of *Psilotum*- *Lycopodium*- *Selaginella* and *Equisetum*.

UNIT – III **18 Hrs.**

Structure and Reproduction of *Ophioglossum*- *Adiantum* - *Marsilea*- Heterospory and Seed Habit.

UNIT - IV **18 Hrs.**

Gymnosperms - Classification of Gymnosperms (Sporne- Outline only) Structure and Reproduction of *Cycas*- and *Gnetum*. Angiospermic characters in *Gnetum*, *Economic Importance of Gymnosperms*.

UNIT – V **18 Hrs.**

Palaeobotany - Geological time scale- Radio carbon dating- Fossils and *kinds of fossils*-

Study of the following: *Lepidodendron* (Stem)- *Lepidophyllum* (Leaf)- *Lepidocarpon* (Fruit)- *Calamites* (Stem) and *Williamsonia*.

Note : *Italics* denote self study topics

PRACTICALS :

Study of the types mentioned below

Bryophytes - Marchantia, Porella, Anthoceros and Funaria

Pteridophytes - Lycopodium, Selaginella, Equisetum, Adiantum, Marsilea.

Gymnosperms - Cycas, Pinus and Gnetum

Palaeobotany -Lepidodendron, Lepidophyllum ,Lepidocarpon ,Calamites and Williamsonia.

TEXT BOOKS :

1. **Vashishta, B.R.,Sinha,A.K. and Adarshkumar**, “*Botany for degree students – Bryophyta*”, S. Chand & Company Ltd., New Delhi, Revised Edition, 2008.
2. **Vasishta, P.C., Sinha,A.K. and Anilkumar**, “*Botany for Degree Students – Gymnosperms*”. S.Chand& Co., New Delhi, 2006.
3. **Vashishta, P.C.,Sinha,A.K. and Anilkumar**, “*Botany for degree students - Pteridophyta*”, S. Chand & Company Ltd., New Delhi, Revised Ninth Edition, 2005.

REFERENCE BOOKS :

1. **Peter George**, “ *Introduction to Palaeobotany*”, Rajat Publications, New Delhi, First Edition, 2008.
2. **Sporne, K.R.**, “ *The Morphology of Pteridophytes*”, B. I Publications, NewDelhi, 1967.
3. **Foster,A. S. and Gifford, E. M.** Comparative Morphology of Vascular Plants. W.H. Freeman and Co.,1973.
4. **Watson,E.V.**, “*Structure and life of Bryophytes,*” Hutchinson & Co Ltd, 2003.
5. **Frank Cavers**, “*The interrelationship of the Bryophyta*” S.R. Technico Book House, Patna.2003.

SEMESTER - I

ALLIED BOTANY- PAPER - I

Instructional Hrs. : 75

Sub.Code : 15BOUA101

Max. Marks : CIA – 20; ESE - 55

Credits : 4

Objectives : To know the vegetative and reproductive structures of various types of Algae, Fungi, Bryophytes, Pteridophytes and Gymnosperms. To identify the families of the plants, economically important plants, plant products and the bioprocess technology and their applications.

UNIT-I 15 Hrs.

Structure and Reproduction of Bacteria and *Bacteriophage* (T4). Plant Disease: Tikka Disease (symptoms- causal organisms and control measures).

UNIT-II 15 Hrs.

Thallophyta - Structure- Reproduction and Life cycle of the following – Nostoc – *Chlorella* - Dictyota - Albugo and Saccharomyces.

UNIT –III 15 Hrs.

Bryophyta- Pteridophyta- Gymnosperm - Structure - reproduction and life cycle of *Riccia* - Lycopodium and Cycas.

UNIT-IV 15 Hrs.

Plant Taxonomy - Study of the following families with their Systematic position- Description and Economic importance of Anonaceae – Rubiaceae – Euphorbiaceae - *Poaceae*.

UNIT –V 15 Hrs.

Applied Botany - Single cell protein - *Spirulina*. Mushroom Cultivation – Oyster - Biofertilizer – Rhizobium.

Note : *Italics* denote Self study Topics

PRACTICALS :

Study of the types mentioned above

TEXT BOOKS:

1. **Kumaresan, V.**, "*Biotechnology*", Saras Publication, Nagercoil, Kanyakumari Dt., Revised Edition, 2009.
2. **Muneeswaran, A.**, "*Text book of Botany*", Sun Publication, Madurai, 1990.
3. **Narayanaswami, R.V. & Rao, K.N.**, "*Outlines of Botany*", S. Viswanathan Printers & Publishers, Madras, New Edition, 1979.
4. **Pandey, B.P.**, "*Economic Botany*", S. Chand & Company, New Delhi, Revised Edition, 2004.
5. **Srivastava, H.N.**, "*Fungi*", Pradeep publications, Jalandhar (India), New Millennium Edition, 2004.
6. **Vashishta, B.R.**, "*Botany for Degree Students – Algae*", S. Chand & Co., New Delhi, Revised Edition, 2004.
7. **Vashishta, B.R., Sinha, A.K. and Adarshkumar**, "*Botany for Degree students – Bryophyta*", S. Chand & Company Ltd., New Delhi, Revised Edition, 2008.
8. **Vasishta, P.C., Sinha, A.K. and Anilkumar**, "*Botany for Degree Students – Gymnosperms*". S.Chand & Co., New Delhi. 2006
9. **Vashishta, P.C., Sinha, A.K. and Anilkumar**, "*Botany for Degree students - Pteridophyta*", S. Chand & Company Ltd., New Delhi, Revised Ninth Edition, 2005.

REFERENCE BOOKS:

1. **Sporne, K.R.**, "*The Morphology of Pteridophytes*", B. I Publications, New Delhi, 1967.
2. **Foster, A. S. and Gifford, E. M.** Comparative Morphology of Vascular Plants. W.H. Freeman and Co., 1973.
3. **Frank Cavers**, "*The interrelationship of the Bryophyta*" S.R. Technico Book House, Patna. 2003.

SEMESTER - II

ALLIED BOTANY - PAPER - II

Instructional Hrs. : 75

Sub.Code : 15BOUA202

Max. Marks : CIA – 20; ESE - 55

Credits : 4

Objectives : To study the histology, ecological adaptations and physiology of plants. To

study the horticultural techniques. To gain the knowledge about medicinal plants.

UNIT-I

15 Hrs.

Anatomy - Meristem –Types. Simple and Complex tissues - Primary structure of Dicot and Monocot root, Dicot and *Monocot* stem, Dicot and **Monocot leaf**.

UNIT –II

15 Hrs.

Ecology - Ecosystem – Structure (Biotic and Abiotic) and **functions** - Morphological and Anatomical adaptations of Hydrophytes and Xerophytes.

UNIT-III

15 Hrs.

Physiology - Photosynthesis- Photosynthetic apparatus- Light and Dark reactions (Calvin cycle) - Respiration- Glycolysis and *Kreb`s cycle* (outline only)

UNIT-IV

15 Hrs.

Horticulture - **Scope and importance** - Propagating methods of Horticultural Plants – *Layering*, Grafting, **Kitchen garden and flower arrangement**.

UNIT –V

15 Hrs.

Pharmacognosy - A brief account on the identifying features- medicinal properties and active principles of the following: Ginger – Vasaka – Curcuma – *Brahmi* - Cultivation and marketing of commercial medicinal plant – Vinca.

Note : *Italics* denote self study topics

PRACTICALS :

Study of the types mentioned above

TEXT BOOKS:

1. **Kumaresan, V.**, “ *Horticulture*”, Saras Publication, Nagercoil, Kanyakumari Dt., First Edition, 2008.
2. **Muneeswaran, A.**, “*Text book of Botany*”, Sun Publication, Madurai, 1990.
3. **Pandey, B.P.**, “ Plant Anatomy”, S. Chand & Company Ltd., New Delhi, Revised Edition, 2004.

REFERENCE BOOKS:

1. **Kokate, C.K, Purohit, A and Gokhal, S.R.**, “*Pharmacognosy*”, NiraliPrakashan, Pune, 43rd Edition, 2009.
2. **Handa, S.S and Kapoor, V.K.**, “*Pharmacognosy*”, Vallabh Prakashan, Delhi, Revised Edition, 1993.

SEMESTER – V

Core Paper – V

TAXONOMY OF ANGIOSPERMS AND ECONOMIC BOTANY

Ins. Hrs.: 75

Sub. Code : 13BOUC505

Max.Marks:CIA- 25;ESE -75 Credits:4

Objectives : To identify the families of the plants in the theory syllabus. To identify medicinally and economically important plants and plant products.

UNIT – I

15 Hrs.

Descriptive terms used in taxonomy- *stem- leaf-* inflorescence- flower fruit. Systems of classification – Natural - (Bentham and Hooker)- Modern – (Takhtajan) (outline only).

UNIT – II 15 Hrs.

Herbarium techniques and uses- Nomenclature - ICBN-Priority - Typification-Effective and Valid publication-*Author citation*.

UNIT – III

15 Hrs.

A detailed study of the following families Systematic position- Description and the *economic importance of the types* and pollination mechanisms wherever applicable. Annonaceae- Capparidaceae- Sterculiaceae-Rutaceae- **Myrtaceae**- Curcubitaceae-Apiaceae.

UNIT – IV

15 Hrs.

Rubiaceae-Asclepiadaceae-Convolvulaceae-Scrophulariaceae-Acanthaceae-Verbenaceae-*Lamiaceae*.

UNIT - V 15 Hrs.

Amarantaceae- Euphorbiaceae- Moraceae- Orchidaceae -Liliaceae-Arecaceae and *Poaceae*.

Note : Italics denote Self Study Topics

PRACTICALS:

1. Taxonomic studies of selected plant species included in the families mentioned in the theory.
2. Study of economic products of the plants belonging to the families mentioned.
3. Students should submit 20 herbarium sheets at the time of Practical examinations.
4. Field trip for 5 days to study vegetation and for specimen collection.

REFERENCE BOOKS:

1. **Lawrence- G.H.M,** “ *Taxonomy of Vascular plants*”, Oxford and IBU Publishing Co. Pvt.. Ltd., New Delhi, 1951.
2. **Pandey, B.P,** “ *Taxonomy of Angiosperms*”, S. Chand & Company Ltd. 1982, New Delhi.
3. **Pandey, B.P,** “ *Economic Botany*”, S. Chand & Company Ltd., New Delhi, 2007.
4. **Saxena, N.B. and Saxena, S,** “ *Plant Taxonomy*”, Pragati Prakashan, Revised Edition, 2001.
5. **Singh, V. and Jain, D.K,** “ *Taxonomy of Angiosperms*”, Rastogi Publications, Second Edition, 2004.

Core Paper - VI

PLANT PHYSIOLOGY

Ins. Hrs. : 75

Sub. Code : 13BOUC506

Max.Marks:CIA 25;ESE -75

Credits:4

Objectives :To understand the water relationships with Plant system.To understand the metabolic activities of plants. To understand the enzymes involved in various metabolic activities. To understand the energy relationships in various metabolic activities.

UNIT - I 15 Hrs.

Water relationships of plant – Diffusion- Osmosis – Osmotic pressure- Turgor pressure- Osmotic potential- Imbibition- Plasmolysis-absorption of water and mineral salts-Translocation of water solutes and assimilates.

UNIT - II 15 Hrs.

Transpiration- Kinds of transpiration- Mechanism of stomatal transpiration-Factors affecting stomatal movement. Plant growth regulators – Auxin- Gibberellin- Cytokinin

UNIT – III 15 Hrs.

Physiology of flowering – Photoperiodism- Phytochrome-Vernalization.Plant movements - Circadian rhythms in plants.

UNIT - IV 15 Hrs.

Phytosynthesis - Out line of chloroplast apparatus and Photosynthetic pigments- Light of dark reaction – Carbon fixation : C₄ and CAM.

UNIT - V 15 Hrs.

Respiration: Glycolysis- Kreb's cycle- Electron transport system and oxidative phosphorylation.

Note : Italics denote Self Study Topics

REFERENCE BOOKS:

1. **Arthur C. Giese** , “*Cell Physiology*”, Toppan Company Ltd. Tokyo, Japan, Fifth Edition, 1979.
2. **Frank B. Salisbury** and **Cleon W. Ross**, “*Plant Physiology*”, CBS Publisher and Distributors, New Delhi, Third Edition, 1996.
3. **Gill, P.S.**, “*Plant Physiology*”, S. Chand and Company Ltd., New Delhi, 2001.
4. **Jain, V.K.**, “*Fundamentals of Plant Physiology*”, S. Chand and Company Ltd, 1990.
5. **Jayaraman, J.**, “*Laboratory Manual in Bio-chemistry*”, New Age International (P) Ltd. Publishers, New Delhi, 2008.
6. **Ray Noggle, G.** and **George J. Fritz**, “*Introduction to Plant Physiology*”, Prentice – Hall of India Pvt Ltd., New Delhi, 1986.
7. **Rober M. Devlin**, “*Plant Physiology*”, Lifton Educational Publishing INC, New York , Third Edition, 1979.
8. **Verma, S.K.**, “*A Text book of Plant Physiology and Biochemistry*”, S. Chand and Company, New Delhi.

Core Paper -VII

PHYTOCHEMISTRY

Ins. Hrs.: 60

Sub. Code : 13BOUC507

Max.Marks : CIA 25; ESE -75

Credits: 4

Objectives : To understand structure and properties of Biomolecules, secondary metabolites and free radicals. To study the principles and working mechanism of Instruments.

UNIT- I

12 Hrs.

Atoms- Molecules- Ionic bond- Covalent bonds- Hydrogen bonds- Acids and Bases- Solutions- pH and Buffer system.

UNIT- II 12 Hrs.

Enzymes : Classification- properties- mode of action- factors affecting enzyme activity. Biomolecules- Outline of structure- classification and properties of carbohydrates.

UNIT- III

12 Hrs.

Outline of structure- Classification and properties of Amino acids- Nitrogen metabolism- Protein and Lipids.

UNIT- IV

12 Hrs.

Study of secondary metabolites – Polyphenolics - Terpenoids and Alkaloids. Free radicals – Types- Scavenging activity.

UNIT-V

12 Hrs.

Principles and working mechanism of pH - Centrifuge- Calorimetry- Spectrometry and Chromatography – Paper and Thin layer.

Note : Italics denote Self Study Topics

PRACTICALS :

1. Determination of Osmotic Pressure of the cell sap of the given specimen (Rheo leaf).
2. Rate of respiration in flower buds/germinated seeds using simple Respiroscope (Demonstration only).
3. Separation of leaf pigments by Paper chromatography and TLC (Thin Layer Chromatography).
4. Measurement of the rate of photosynthesis under varying condition of CO₂ concentration.
5. Effect of light intensity on O₂ evolution during photosynthesis.
6. Effect of light intensity of transpiration (Demonstration only).
7. Determining the rate of transpiration using Ganong's Potometer.
8. Determination of water absorption and transpiration ratio (Demonstration only).
9. Estimation of protein and carbohydrates (Demonstration only)

REFERENCE BOOKS :

1. **Arthur C. Giese** , "*Cell Physiology*", Toppan Company Ltd., Tokyo, Japan, Fifth Edition, 1979.
2. **Jain , J.L.**, "*Fundamentals of Bio-chemistry*", S. Chand and Company Ltd., New Delhi, 2001.
3. **Jayaraman, J** , "*Laboratory Manual in Bio-chemistry*", New Age International (P) Ltd., Publishers, New Delhi, 2008.
4. **Robert M. Devlin**, "*Plant Physiology*", Lifton Educational Publishing INC, New York , Third Edition, 1979.

5. Verma, S.K., “ A Text book of Plant Physiology and Biochemistry”, S. Chand and Company, New Delhi.

Core Paper – VIII

ECOLOGY AND PHYTOGEOGRAPHY

Ins. Hrs. :60 Sub. Code : 13BOUC608

Max. Marks : CIA 25;ESE -75

Credits: 4

Objectives : To enable the students to acquire knowledge about the environment and to identify the environmental problems. To facilitate the students to find out remedial solutions.

UNIT- I 12 Hrs.

Ecological factors: Principles- Role of climatic - edaphic - Biotic factors on plants – **Kinds and Structure of Ecosystem** - Biogeochemical cycles (*Nitrogen- Carbon*).

UNIT - II 12 Hrs.

Autecology– **Ecological life history of species- Characteristics of Population**- Dispersal and migration - Synecology – Vegetation – Units of Vegetation - Methods of studying vegetation – Quadrat- *Belt and Line transect*.

UNIT – III 12 Hrs.

Ecological Adaptations - Hydrophytes – Mesophytes- Xerophytes – **Halophytes**- Morphological and Anatomical features in relation to their habitats.

UNIT –IV 12 Hrs.

Plant Distribution – **Factors affecting distribution**- Concept of Barriers - Continental drift – Endemism - **Major and Minor biomes of the world** - Plants and Plant communities as indicators.

UNIT – V 12 Hrs.

Plant geography – Principles and vegetational types of India – Tropical rain forest - Sholas and deciduous forest – Sand dunes - Scrub jungle - *Phytogeographical regions of India*.

Note : Italics denote Self Study Topics

PRACTICALS:

1. Study of morphological and anatomical adaptations of hydrophytes, xerophytes, including halophytes and mesophytes using representative samples.
2. Determination of frequency and density constituent of plant species in a terrestrial community through Quadrat and Transect (line, belt).
3. Phytogeographical regions of India.

REFERENCE BOOKS:

1. **Eugene P. Odum** , “*Fundamentals of Ecology*”, W.B Saunders company, Philadelphia and London, Third Edition, 2005.
2. **Sharma P.D.**, “*Ecology & Environment*”, Rastogi Publications, Meerut, Eleventh Edition, 2005.
3. **Shukla, R.S, Chandel,P.S.**, “*A text book of plant Ecology Including Ethnobotany and soil science*”,S.Chand& company Ltd. New Delhi, First edition,2003.
4. **Vasishta. P.C.**, “*A text book of Plant Ecology*”, Vishal Publications, NewDelhi, Second Edition, 1979.
5. **Verma, P.S. and Agarwal,V.K.**, “*Environmental Biology*”, S. Chand & Company Ltd, New Delhi, Fourth edition.1993.
6. **Subrahmanyam, N.S. andSambamurthy, A.V.S.S.** “*Ecology*”, Narosa Publishing House Pvt. Ltd. Second edition, 2006.

Core Paper – IX

GENETICS, PLANT BREEDING AND BIOSTATISTICS

Instructional Hrs. : 60

Sub. Code : 13BOUC609

Max. Marks : CIA 25; ESE -75

Credits:4

Objectives : To study the basics of Mendelian genetics. To understand the mechanism of gene expression and regulation. To understand the concept of mutation. To know the skills and methods involved in plant breeding.

UNIT- I 12 Hrs.

Mendelism and Interaction - Monohybrid - Dihybrid Cross - Back Cross - Test cross - Incomplete dominance -- Complementary – Supplementary and *Duplicate*.

UNIT- II 12 Hrs.

Classical Genetics - Linkages and Crossing over - multiple alleles - blood groups in man -- **Sex determination in plants** - *Meiosis* - Cytoplasmic inheritance (plastid only)

UNIT-III 12 Hrs.

Mutation and Gene Regulation – Types of mutation - **Somatic mutation** - **Physical and chemical mutagens** – Polyploidy - genetic code - gene regulation in prokaryotes – *Operon concept*.

UNIT-IV 12 Hrs.

Plant breeding – *Objectives* – methods of selection (Mass - Pureline and Clonal) - Hybridization methods - Hybridization techniques - Hybrid vigour.

UNIT- V 12 Hrs.

Biostatistics – Collection of data - Sampling types - Measures of Central tendency - *Arithmetic Mean* - Median. **Measures of Dispersion** - Range - Coefficient of Range - Standard deviation and Standard error (only theory).

Note : Italics denote Self Study Topics

PRACTICALS:

1. Study of Meiosis.
2. Observation of Charts for Mendelian ratios. Gene interaction and linkage. Simple problems in genetics.
3. Simple problems in Mean, Median, Mode in Biostatistics. Standard deviation, Standard error.

REFERENCE BOOKS:

1. **Allard, R.W**, "*Principles of plant breeding*", John Wiley & sons, INC. Singapore, 2000.
2. **Rama Krishnan, P**, "*Biostatistics*" Saras Publications, Nagercoil, First Edition, 2001.
3. **Sharma, J.R**, "*Principles and Practice of Plant breeding*", Tata MCG raw–Hill publishing Company Ltd., New Delhi, 1994.
4. **Singh, J. R**, "*Plant breeding principles and methods*", Kalyani Publishers, Ludiana, Seventh Edition, 2008.
5. **Verma, P. S., Agarwal, V.K**, "*Genetics*", First Edition , S. Chand & Company Ltd, New Delhi, 2002.

Core Paper –X

BIOTECHNOLOGY I – CONCEPTS AND TECHNIQUES

Ins.Hrs.: 60

Sub. Code : 13BOUC610

Max.Marks:CIA 25;ESE -75

Credits:4

Objectives : To know the outlines of genetic engineering. To develop the skill on gene transfer methods. To understand the applications and the uses of various biomolecules separation techniques. To study the extraction and separation of enzymes used in industries.

UNIT- I 12 Hrs.

Biotechnology – Biotechnology and its branches – Scope– Applications of Genetic Engineering- Enzymes used in gene cloning – DNA Polymerases- Restriction endonucleases - Ligases and *Reverse transcriptase*.

UNIT- II 12 Hrs.

Cloning vectors – Plasmids -Transposons and YAC–*CaMV* - Methods of Gene cloning – Preparation of desired genes - Isolation of DNA vector - Construction of Recombinant DNA- Introduction of Recombinant DNA into the Host cell - Selection and Multiplication of recombinant host cells - Expression of Cloned Gene.

UNIT- III 12 Hrs.

Gene Cloning Strategies -Methods of direct gene transfer – Electrophoration – *Microinjection*- Liposome fusion - Gene cloning in higher plants – use of *Agrobacterium Ti*-Plasmid as vehicle -

UNIT- IV 12 Hrs.

Techniques in biotechnology - Application and uses of PCR -DNA finger printing -Southern and Western blotting techniques - *Agarose gel electrophoresis*.

UNIT- V 12 Hrs.

Enzyme technology – Extraction- separation and purification of enzymes - Immobilization- methods -*Application of enzymes*.

Note : Italics denote Self Study Topics

REFERENCE BOOKS:

1. **Balasubramanian, P.**, Bryce, CFA., Dharmalingam, K. Green, J., Kunthala Jayaraman
“*Concepts in biotechnology*”, Universities press India Pvt. Ltd., Hyderabad, 2004.
2. **Dubey, R.C.**, “*A text book of Biotechnology*” ,S.Chand& Company Ltd, New Delhi, Third Edition, 2004.
3. **Gupta, P.K.**, “*Elements of Biotechnology*”, Rastogi publications – Meerut first edition, 2004.
4. **Joshi, P.**, “*Genetic Engineering and its Applications*”, Student Edition Jodhpur, 2000.
5. **Kumaresan, V.**, “*Biotechnology*”, Saras Publications, Nagercoil, 2009.
6. **Purohit, S.S., Mathur, S.K.**, “*Biotechnology Fundamentals & Applications*”, Agro botanical Publishers India, 1996.
7. **Purohit, S.S.**,” *Bitechnology Fundamentals & Applications*” Mrs. Saraswathi Purohit for student Edition, India, Third Edition, 2005.
8. **Razdan, M.K.**, “*Introduction to plant tissue culture*”,Oxford & IBH publishing Co. Pvt. Ltd., Second Edition, New Delhi, 2008.
9. **Trevan, M.D., Boffey, S., Goulding, K.H., Stanbury, P.**, “*Biotechnology the Biological principles*”, Tata McGraw-Hill publishing company Ltd., New Delhi, 1996.

Core Paper – XI

BIOTECHNOLOGY II –APPLIED BIOTECHNOLOGY

Ins.Hrs.: 60

Sub. Code : 13BOUC611

Max.Marks:CIA 25; ESE - 75 Credits:4

Objectives :To understand the application of genetic manipulation in Agriculture, Food, Medicines, Biopesticides.To study Bioprocess Technology and their applications.

UNIT- I 12 Hrs.

Food Technology – SCP as microbial food for future- Mass cultivation and nutritional value of Spirulina-Scenedesmus, Yeast and Bacteria (Methylophilus) - Mushroom Technology – Cultivation techniques and nutritional value of Pleurotussajor-caju – Agaricusbisporous.

UNIT- II 12 Hrs.

Biofertilizers – Advantages of mass cultivation and application technique of Rhizobium- Azospirillum- Blue Green Algae (Nitrogen Fixers)-Phosphobacteria- Azolla and VAM.

UNIT- III 12 Hrs.

Application of genetic engineering-Agriculture (transgenic plants) – *Biological control of pathogens through engineered microbes- Bacillus thuringiensis* - Medicine- Insulin- Vaccines- Gene therapy-Monoclonal antibodies and Hybridoma techniques.

UNIT - IV

12 Hrs.

Biotechnology in pollution control – Xenobiotic Compounds – Radioactive wastes- Bioremediation - Phytoremediation – Bioleaching – Biosorption – Bioplastics.

UNIT- V 12 Hrs.

Biofuels -BioEthanol- BioDiesel - Biogas production - Methane - BioHydrogen production - Petrochemical plants - Plant biomass - Types- Composition - Biomass energy.

Note : Italics denote Self Study Topics

PRACTICALS:

1. Cultivation of Pleurotus sajor-caju and Agaricus bisporous
2. Culture of Yeast and Azolla.
3. Demonstration of Biofertilizers – Azospirillum- Agrobacterium – Slides or photographs.
4. Blotting techniques –Photographs.
5. Petrochemical plants – Materials / Photographs
6. Biogas production - Photographs.

REFERENCE BOOKS:

1. **Balasubramanian, P.**, Bryce, CFA., Dharmalingam, K. Green, J., Kunthala Jayaraman, “*Concepts in biotechnology*”, Universities Press India Pvt. Ltd., Hyderabad, 2004.
2. **Dubey, R.C.**, “*A text book of Biotechnology*”, S.Chand & Company Ltd, New Delhi, Third Edition, 2004.
3. **Gupta, P.K.**, “*Elements of Biotechnology*”, Rastogi publications – Meerut first edition, 2004.
4. **Joshi, P.**, “*Genetic Engineering and its Applications*”, Student Edition Jodhpur, 2000.
5. **Kumar, H.D.**, “*Modern Concepts of Biotechnology*”, Vikas publishing house Pvt. Ltd., 2001.
6. **Kumaresan, V.**, “*Biotechnology*”, Saras Publications, Nagercoil, 2009.
7. **Purohit, S.S.**, “*Biotechnology Fundamentals & Applications*” Mrs. Saraswathi Purohit for student Edition, India, Third Edition, 2005.
8. **Trevan, M.D., Boffey, S., Goulding, K.H., Stanbury, P.**, “*Biotechnology the Biological principles*”, Tata McGraw-Hill publishing company Ltd., New Delhi, 1996.

SEMESTER – V

Core Paper – V

TAXONOMY OF ANGIOSPERMS AND ECONOMIC BOTANY

Ins. Hrs. : 75

Sub. Code : 13BOUC505

Max. Marks : CIA- 25; ESE -75

Credits: 4

Objectives : To identify the families of the plants in the theory syllabus. To identify medicinally and economically important plants and plant products.

UNIT – I

15 Hrs.

Descriptive terms used in taxonomy - *stem- leaf- inflorescence- flower fruit*. Systems of classification – Natural - (Bentham and Hooker)- Modern – (Takhtajan) (outline only).

UNIT – II

15 Hrs.

Herbarium techniques and uses- Nomenclature - ICBN-Priority - Typification- Effective and Valid publication- *Author citation*.

UNIT – III

15 Hrs.

A detailed study of the following families Systematic position- Description and the *economic importance of the types* and pollination mechanisms wherever applicable. Annonaceae- Capparidaceae- Sterculiaceae- Rutaceae- **Myrtaceae**- Curcubitaceae- Apiaceae.

UNIT – IV

15 Hrs.

Rubiaceae-Asclepiadaceae-Convulvulaceae-Scrophulariaceae-Acanthaceae-Verbenaceae-*Lamiaceae*.

UNIT - V

15 Hrs.

Amarantaceae- Euphorbiaceae- Moraceae- Orchidaceae -Liliaceae- Arecaceae and *Poaceae*.

Note : Italics denote Self Study Topics

PRACTICALS:

1. Taxonomic studies of selected plant species included in the families mentioned in the theory.
2. Study of economic products of the plants belonging to the families mentioned.
3. Students should submit 20 herbarium sheets at the time of Practical examinations.
4. Field trip for 5 days to study vegetation and for specimen collection.

REFERENCE BOOKS:

1. **Lawrence- G.H.M**, “ *Taxonomy of Vascular plants*”, Oxford and IBU Publishing Co. Pvt.. Ltd., New Delhi, 1951.
2. **Pandey, B.P**, “ *Taxonomy of Angiosperms*”, S. Chand & Company Ltd. 1982, New Delhi.
3. **Pandey, B.P**, “ *Economic Botany*”, S. Chand & Company Ltd., New Delhi, 2007.
4. **Saxena, N.B.** and **Saxena, S**, “ *Plant Taxonomy*”, Pragati Prakashan, Revised Edition, 2001.
5. **Singh, V.** and **Jain, D.K**, “ *Taxonomy of Angiosperms*”, Rastogi Publications, Second Edition, 2004.

Core Paper - VI

PLANT PHYSIOLOGY

Ins. Hrs. : 75

Sub. Code : 13BOUC506

Max. Marks : CIA 25; ESE -75

Credits:4

Objectives : To understand the water relationships with Plant system. To understand the metabolic activities of plants. To understand the enzymes involved in various metabolic activities. To understand the energy relationships in various metabolic activities.

UNIT - I

15 Hrs.

Water relationships of plant – Diffusion- Osmosis – Osmotic pressure- Turgor pressure- Osmotic potential- Imbibition- Plasmolysis -absorption of water and mineral salts- Translocation of water solutes and assimilates.

UNIT - II

15 Hrs.

Transpiration- Kinds of transpiration- Mechanism of stomatal transpiration- Factors affecting stomatal movement. Plant growth regulators – Auxin- Gibberellin- Cytokinin

UNIT – III

15 Hrs.

Physiology of flowering – Photoperiodism- Phytochrome- Vernalization. Plant movements - *Circadian rhythms in plants.*

UNIT - IV

15 Hrs.

Phytosynthesis - Out line of chloroplast apparatus and *Photosynthetic pigments*- Light of dark reaction – Carbon fixation : C₄ and CAM.

UNIT - V

15 Hrs.

Respiration: Glycolysis- *Kreb's cycle*- Electron transport system and *oxidative phosphorylation.*

Note : Italics denote Self Study Topics

REFERENCE BOOKS:

1. **Arthur C. Giese** , “*Cell Physiology*’’, Toppan Company Ltd.Tokyo, Japan, Fifth Edition, 1979.
2. **Frank B. Salisbury** and **Cleon W. Ross**, “*Plant Physiology*”, CBS Publisher and Distributors, New Delhi, Third Edition, 1996.
3. **Gill, P.S.**, “*Plant Physiology*”, S. Chand and Company Ltd., New Delhi, 2001.
4. **Jain, V.K.**, “*Fundamentals of Plant Physiology*”, S. Chand and Company Ltd, 1990.
5. **Jayaraman, J**, “*Laboratory Manual in Bio-chemistry*”, New Age International (P) Ltd. Publishers, New Delhi, 2008.
6. **Ray Noggle, G.** and **George J. Fritz**, “*Introduction to Plant Physiology*”, Prentice – Hall of India Pvt Ltd., New Delhi, 1986.
7. **Rober M. Devlin**, “*Plant Physiology*”, Lifton Educational Publishing INC, New York , Third Edition, 1979.
8. **Verma, S.K.**, “*A Text book of Plant Physiology and Biochemistry*”, S. Chand and Company, New Delhi.

Core Paper - VII

PHYTOCHEMISTRY

Ins. Hrs. : 60

Sub. Code : 13BOUC507

Max. Marks : CIA 25; ESE - 75

Credits: 4

Objectives : To understand structure and properties of Biomolecules, secondary metabolites and free radicals. To study the principles and working mechanism of Instruments.

UNIT- I

12 Hrs.

Atoms- Molecules- Ionic bond- Covalent bonds- Hydrogen bonds- Acids and Bases- Solutions- pH and *Buffer system*.

UNIT- II

12 Hrs.

Enzymes : *Classification*- properties- mode of action- factors affecting enzyme activity. Bio molecules - Outline of structure- classification and properties of carbohydrates.

UNIT- III

12 Hrs.

Outline of structure- Classification and properties of Amino acids- Nitrogen metabolism- Protein and *Lipids*.

UNIT- IV

12 Hrs.

Study of secondary metabolites – Polyphenolics - Terpenoids and Alkaloids. Free radicals – Types- Scavenging activity.

UNIT-V

12 Hrs.

Principles and working mechanism of pH - Centrifuge- Calorimetry- Spectrometry and Chromatography – Paper and Thin layer.

Note : Italics denote Self Study Topics

PRACTICALS :

1. Determination of Osmotic Pressure of the cell sap of the given specimen (Rheo leaf).
2. Rate of respiration in flower buds/germinated seeds using simple Respiroscope (Demonstration only).
3. Separation of leaf pigments by Paper chromatography and TLC (Thin Layer Chromatography).
4. Measurement of the rate of photosynthesis under varying condition of CO₂ concentration.
5. Effect of light intensity on O₂ evolution during photosynthesis.
6. Effect of light intensity of transpiration (Demonstration only).
7. Determining the rate of transpiration using Ganong's Potometer.
8. Determination of water absorption and transpiration ratio (Demonstration only).
9. Estimation of protein and carbohydrates (Demonstration only)

REFERENCE BOOKS :

1. **Arthur C. Giese** , "*Cell Physiology*", Toppan Company Ltd., Tokyo, Japan, Fifth Edition, 1979.
2. **Jain , J.L.**, "*Fundamentals of Bio-chemistry*", S. Chand and Company Ltd., New Delhi, 2001.
3. **Jayaraman, J.** , "*Laboratory Manual in Bio-chemistry*", New Age International (P) Ltd., Publishers, New Delhi, 2008.
4. **Robert M. Devlin**, "*Plant Physiology*", Lifton Educational Publishing INC, New York , Third Edition, 1979.
5. **Verma, S.K.**, "*A Text book of Plant Physiology and Biochemistry*", S. Chand and Company, New Delhi.

Core Paper – VIII

ECOLOGY AND PHYTOGEOGRAPHY

Ins. Hrs. : 60

Sub. Code : 13BOUC608

Max. Marks : CIA 25;ESE - 75

Credits: 4

Objectives : To enable the students to acquire knowledge about the environment and to identify the environmental problems. To facilitate the students to find out remedial solutions.

UNIT- I

12 Hrs.

Ecological factors: Principles - Role of climatic - edaphic - Biotic factors on plants – **Kinds and Structure of Ecosystem** - Biogeochemical cycles (*Nitrogen* - Carbon).

UNIT - II

12 Hrs.

Autecology – **Ecological life history of species- Characteristics of Population-** Dispersal and migration - Synecology – Vegetation – Units of Vegetation - Methods of studying vegetation – Quadrat- *Belt and Line transect*.

UNIT – III

12 Hrs.

Ecological Adaptations - Hydrophytes – Mesophytes - Xerophytes – **Halophytes-** Morphological and Anatomical features in relation to their habitats.

UNIT – IV

12 Hrs.

Plant Distribution – **Factors affecting distribution-** Concept of Barriers - Continental drift – Endemism - **Major and Minor biomes of the world** - Plants and Plant communities as indicators.

UNIT – V

12 Hrs.

Plant geography – Principles and vegetational types of India – Tropical rain forest - Sholas and deciduous forest – Sand dunes - Scrub jungle - *Phytogeographical regions of India*.

Note : *Italics denote Self Study Topics*

PRACTICALS:

1. Study of morphological and anatomical adaptations of hydrophytes, xerophytes, including halophytes and mesophytes using representative samples.
2. Determination of frequency and density constituent of plant species in a terrestrial community through Quadrat and Transect (line, belt).
3. Phytogeographical regions of India.

REFERENCE BOOKS:

1. **Eugene P. Odum** , “*Fundamentals of Ecology*”, W.B Saunders company, Philadelphia and London, Third Edition, 2005.
2. **Sharma P.D.**, “*Ecology & Environment*”, Rastogi Publications, Meerut, Eleventh Edition, 2005.
3. **Shukla, R.S, Chandel,P.S.**, “*A text book of plant Ecology Including Ethnobotany and soil science*”,S.Chand & company Ltd. New Delhi, First edition, 2003.
4. **Vasishta. P.C.**, “*A text book of Plant Ecology*”, Vishal Publications, NewDelhi, Second Edition, 1979.
5. **Verma, P.S. and Agarwal,V.K.**, “*Environmental Biology*”, S. Chand & Company Ltd, New Delhi, Fourth edition. 1993.
6. **Subrahmanyam, N.S. and Sambamurthy, A.V.S.S.** “*Ecology*”, Narosa Publishing House Pvt. Ltd. Second edition, 2006.

Core Paper – IX

GENETICS, PLANT BREEDING AND BIOSTATISTICS

Instructional Hrs. : 60

Sub. Code : 13BOUC609

Max. Marks : CIA 25; ESE - 75

Credits: 4

Objectives : To study the basics of Mendelian genetics. To understand the mechanism of gene expression and regulation. To understand the concept of mutation. To know the skills and methods involved in plant breeding.

UNIT- I

12 Hrs.

Mendelism and Interaction - Monohybrid - Dihybrid Cross - Back Cross - Test cross - Incomplete dominance - Complementary – Supplementary and *Duplicate*.

UNIT- II

12 Hrs.

Classical Genetics - Linkages and Crossing over - multiple alleles - blood groups in man -- **Sex determination in plants** - *Meiosis* - Cytoplasmic inheritance (plastid only)

UNIT-III

12 Hrs.

Mutation and Gene Regulation – Types of mutation - **Somatic mutation- Physical and chemical mutagens** – Polyploidy - genetic code - gene regulation in prokaryotes – *Operon concept*.

UNIT-IV

12 Hrs.

Plant breeding – *Objectives* – methods of selection (Mass - Pureline and Clonal) - Hybridization methods- Hybridization techniques - Hybrid vigour.

UNIT- V

12 Hrs.

Biostatistics – Collection of data - Sampling types - Measures of Central tendency - *Arithmetic Mean*- Median. **Measures of Dispersion- Range- Coefficient of Range-** Standard deviation and Standard error (only theory).

Note : Italics denote Self Study Topics

PRACTICALS:

1. Study of Meiosis.
2. Observation of Charts for Mendelian ratios. Gene interaction and linkage. Simple problems in genetics.
3. Simple problems in Mean, Median, Mode in Biostatistics. Standard deviation, Standard error.

REFERENCE BOOKS:

1. **Allard, R.W**, "*Principles of plant breeding*", John Wiley & sons, INC. Singapore, 2000.
2. **Rama Krishnan, P**, "*Biostatistics*" Saras Publications, Nagercoil, First Edition, 2001.
3. **Sharma, J.R**, "*Principles and Practice of Plant breeding*", Tata MCG raw–Hill publishing Company Ltd., New Delhi, 1994.
4. **Singh, J. R**, "*Plant breeding principles and methods*", Kalyani Publishers, Ludiana, Seventh Edition, 2008.
5. **Verma, P. S., Agarwal, V.K**, "*Genetics*", First Edition , S. Chand & Company Ltd, New Delhi, 2002.

Core Paper –X

BIOTECHNOLOGY I – CONCEPTS AND TECHNIQUES

Ins. Hrs. : 60

Sub. Code : 13BOUC610

Max. Marks : CIA 25; ESE - 75

Credits: 4

Objectives : To know the outlines of genetic engineering. To develop the skill on gene transfer methods. To understand the applications and the uses of various bio molecules separation techniques. To study the extraction and separation of enzymes used in industries.

UNIT- I

12 Hrs.

Biotechnology – Biotechnology and its branches – Scope – Applications of Genetic Engineering- Enzymes used in gene cloning – DNA Polymerases- Restriction endonucleases - Ligases and *Reverse transcriptase*.

UNIT- II

12 Hrs.

Cloning vectors – Plasmids - Transposons and YAC – *CaMV* - Methods of Gene cloning – Preparation of desired genes - Isolation of DNA vector - Construction of Recombinant DNA- Introduction of Recombinant DNA into the Host cell - Selection and Multiplication of recombinant host cells - Expression of Cloned Gene.

UNIT- III

12 Hrs.

Gene Cloning Strategies -Methods of direct gene transfer – Electrophoration – *Microinjection*- Liposome fusion - Gene cloning in higher plants – use of *Agrobacterium Ti-Plasmid* as vehicle -

UNIT - IV

12 Hrs.

Techniques in biotechnology - Application and uses of PCR - DNA finger printing - Southern and Western blotting techniques - *Agarose gel electrophoresis*.

UNIT - V

12 Hrs.

Enzyme technology – Extraction- separation and purification of enzymes - Immobilization- methods - *Application of enzymes*.

Note : Italics denote Self Study Topics

REFERENCE BOOKS:

1. **Balasubramanian, P.**, Bryce, CFA., Dharmalingam, K. Green,J., Kunthala Jayaraman “*Concepts in biotechnology*”, Universities press India Pvt. Ltd., Hyderabad, 2004.
2. **Dubey, R.C.**, “*A text book of Biotechnology*” , S.Chand & Company Ltd, New Delhi, Third Edition, 2004.
3. **Gupta, P.K.**, “*Elements of Biotechnology*”, Rastogi publications – Meerut first edition, 2004.
4. **Joshi, P.**, “*Genetic Engineering and its Applications*”, Student Edition Jodhpur, 2000.
5. **Kumaresan, V.**, “*Biotechnology*”, Saras Publications, Nagercoil, 2009.
6. **Purohit, S.S., Mathur, S.K.**, “*Biotechnology Fundamentals & Applications*”, Agro botanical Publishers India, 1996.
7. **Purohit, S.S.**,” *Bitechnology Fundamentals & Applications*” Mrs. Saraswathi Purohit for student Edition, India, Third Edition, 2005.
8. **Razdan, M.K.**, “*Introduction to plant tissue culture*” , Oxford & IBH publishing Co. Pvt. Ltd., Second Edition, New Delhi, 2008.
9. **Trevan, M.D., Boffey, S., Goulding, K.H., Stanbury, P.**, “*Biotechnology the Biological principles*”, Tata McGraw-Hill publishing company Ltd., New Delhi, 1996.

Core Paper – XI

BIOTECHNOLOGY II –APPLIED BIOTECHNOLOGY

Ins. Hrs. : 60

Sub. Code : 13BOUC611

Max. Marks : CIA 25; ESE - 75

Credits: 4

Objectives : To understand the application of genetic manipulation in Agriculture, Food, Medicines, Biopesticides. To study Bioprocess Technology and their applications.

UNIT - I

12 Hrs.

Food Technology – SCP as microbial food for future - Mass cultivation and nutritional value of Spirulina- *Scenedesmus*, *Yeast* and **Bacteria (Methylophilus)** - Mushroom Technology – Cultivation techniques and nutritional value of *Pleurotus sajor-caju* – **Agaricus bisporous**.

UNIT - II

12 Hrs.

Biofertilizers – Advantages of mass cultivation and application technique of *Rhizobium*- *Azospirillum*- Blue Green Algae (Nitrogen Fixers)- *Phosphobacteria*- *Azolla* and VAM.

UNIT - III

12 Hrs.

Application of genetic engineering - Agriculture (transgenic plants) – **Biological control of pathogens through engineered microbes- *Bacillus thuringiensis*** - Medicine - Insulin- Vaccines- Gene therapy - Monoclonal antibodies and Hybridoma techniques.

UNIT - IV

12 Hrs.

Biotechnology in pollution control – Xenobiotic Compounds – Radioactive wastes- Bioremediation - Phytoremediation – Bioleaching – Biosorption – Bioplastics.

UNIT - V

12 Hrs.

Biofuels - BioEthanol- BioDiesel - Biogas production - **Methane** - BioHydrogen production - *Petrochemical plants* - **Plant biomass - Types- Composition - Biomass energy.**

Note : Italics denote Self Study Topics

PRACTICALS:

1. Cultivation of *Pleurotus sajor-caju* and *Agaricus bisporus*
2. Culture of Yeast and *Azolla*.
3. Demonstration of Biofertilizers – *Azospirillum*- *Agrobacterium* – Slides or photographs.
4. Blotting techniques –Photographs.
5. Petrochemical plants – Materials / Photographs
6. Biogas production - Photographs.

REFERENCE BOOKS:

1. **Balasubramanian, P.**, Bryce, CFA., Dharmalingam, K. Green,J., Kunthala Jayaraman , “*Concepts in biotechnology*”, Universities Press India Pvt. Ltd., Hyderabad, 2004.
2. **Dubey, R.C.**, “*A text book of Biotechnology*” , S.Chand & Company Ltd, New Delhi, Third Edition, 2004.
3. **Gupta, P.K.**, “*Elements of Biotechnology*”, Rastogi publications – Meerut first edition, 2004.
4. **Joshi, P.**, “*Genetic Engineering and its Applications*”, Student Edition Jodhpur, 2000.
5. **Kumar, H.D.**, “*Modern Concepts of Biotechnology*”, Vikas publishing house Pvt. Ltd., 2001.
6. **Kumaresan, V.**, “*Biotechnology*”, Saras Publications, Nagercoil, 2009.
7. **Purohit, S.S.**,” *Bitechnology Fundamentals & Applications*” Mrs. Saraswathi Purohit for student Edition, India, Third Edition, 2005.
8. **Trevan, M.D., Boffey, S., Goulding, K.H., Stanbury, P.**, “*Biotechnology the Biological principles*”, Tata McGraw-Hill publishing company Ltd., New Delhi, 1996.