

Syllabus of Botany

SEMESTER – I

Core course I : Microbiology and Phycology

(Credits : Theory-4, Practical -2)

THEORY

Lectures: 60

Full Marks: 75

Time: 03 Hrs.

Three short and five long questions each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT 1: VIRUSES

(8 lectures)

Discovery, living & non-living characteristics: general structure with special reference to DNA virus (T-phase), lytic and lysogenic cycle; RNA virus (TMV).

UNIT 2: BACTERIA

(8 lectures)

Discovery, general characteristics, types- archaebacteria, eubacteria, wall-less forms (mycoplasma), cell structures, nutritional types, reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction).

UNIT 3: APPLIED MICROBIOLOGY

(4 lectures)

Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and medicine).

UNIT 4: ALGAE

(8 lectures)

General characteristics; Classification proposed by Fritsch, Role of Pigments in Classification of algae; range thallus organization in Algae. contribution of M.O.P Iyengar and H.D Kumar.

UNIT 5: CYANOPHYTA

(5 lectures)

General characteristics; morphology and life cycle of *Nostoc*.

UNIT 5: CHLOROPHYTA

(6 lectures)

General characteristics; morphology and life cycle of *Volvox*, *Oedogonium*.

UNIT 6: CHAROPHYTA

(2 lectures)

General characteristics; morphology and life cycle of *Chara*.

UNIT 7: XANTHOPHYTA

(3 lectures)

General characteristics; morphology and life cycle of *Vaucheria*.

UNIT 8: PHAEOPHYTA

(6 lectures)

General characteristics; morphology and life cycle of *Ectocarpus*.

UNIT 9: RHODOPHYTA

(6 lectures)

General characteristics; morphology and life cycle of *Batrachospermum*.

UNIT 10: APPLIED PHYCOLOGY

(4 lectures)

Economic importance of algae.

Suggested readings

1. Vashishishta, B.R., Singh, V.P., and Sinha A.K.(2014) Botany for Degree Students (Algae) S.Chand & Company Ltd.
2. Gangulee,H.C. and Kar, A.K. 2012, College Botany Volume-II
3. Lee, R.E. (2008), Phycology, Cambridge university Press, Cambridge. 4th edition.
4. Prescott, L.M., Harley J.P., Klein D.A. (2005), Microbiology, McGraw Hill, India. 6th edition.
5. Kumar, H.D. (1999). Introductory Phyology, affiliated East-West Press, Delhi.
6. Pelczar, M.J, (2001) Microbiology, 5th edition, Tata McGraw-hill co, New Delhi.
7. Sharma, P.D.(2014) Microbiology. Rastogi Publication, Meerut

Core Courses II : Biomolecules and cell

(Credits : Theory-4, Practical-2)

THEORY

Lectures: 60

Full Marks: 75

Time : 3hrs

Three short and five long questions each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT 1: BIOMOLECULES

(22 lectures)

Carbohydrates : Nomenclature and classification, Role of monosaccharides, Disaccharides, oligosaccharides and polysaccharides;

Proteins : Structures of amino acids; Peptide bonds; levels of proteins structure – primary, secondary, tertiary and quaternary; biological roles of proteins.

Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotide; types of nucleic acids; structure of B-DNA, Compare with Z- DNA; Types of RNA; structure of t RNA.

UNIT 2: ENZYMES

(6 lectures)

Definition, History of its discovery, Structure of enzyme: holoenzyme, apoenzyme. Prosthetic group, Cofactors, coenzymes, classification of enzymes: mechanism of action (activation energy, lock and key hypothesis, induced-fit theory). Factors affecting enzyme activity. Ribozyme.

UNIT 3: THE CELL (4 lectures)

Ultra structure of prokaryotic and eukaryotic cell.

UNIT 4: CELL WALL, PLASMA MEMBRANE & NUCLEUS (8 lectures)

Chemistry, Structure and Function of plant cell wall and Plasma Membrane and Nucleus.

UNIT 5: CELL ORGANELLES (12 lectures)

Chloroplast, Mitochondria, Peroxisome: Endoplasmic reticulum, Golgi Apparatus, Lysosomes and Ribosomes: Structure & Functions.

UNIT 6: CELL DIVISION (8 lectures)

Eukaryotic cell cycle, mitosis and meiosis, cancer.

Suggested Readings

1. Camphell, MK (2012) Biochemistry, 7th ed., published by Cengage Learning.
2. Camphell, PN and Smith AD (2011) Biochemistry illustrated, 4th ed., Published by Churchill Livingstone.
3. Tymoezko JL, Berg JM and Stryer L (2012) Biochemistry; A short course, 2nd ed. W.H.Freeman.
4. Berg JM, Tymoezko JL, and Stryer L (2011) Biochemistry, W.H.Freeman and Company.
5. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th ed. W.H. Freeman and Company.
6. Karp, G.(2010), Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
7. Hardin, J., Becker, G., Skliensmith, L.J, (2012), Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
8. Cooper, G.M, and Hausman, R.E. 2009 The Cell: A Molecular Approach, 5th edition, ASM Press & Sunderland, Washington, D.C, Sinauer Associates, MA.
9. Becker, W.M, Kleinsmith, L.J., Hardin, J. and Bertoni, G.P. 2009 The World of the cell, 7th edition, Pearson Benjamin Cummings Publishing, San Francisco.

PRACTICAL

F.M. – 40

Microbiology

1. Models of viruses – T- Phage and TMV.

2. Types of Bacteria to be observed from temporary /permanent slides/photographs.
3. Gram staining.

4

Phycology

4. Study of vegetative and reproductive structures of *Nostoc*, *Volvox*, *Oedogonium*, *Chara*, *Vaucheria*, *Ectocarpus* and *Barachospermum* through temporary preparations and permanent slides.
5. Qualitative tests for carbohydrates and proteins.
6. Study of plant cell structure with the help of epidermal peel mount of onion/ *Rhoeo*.
7. Study the phenomenon of plasmolysis and deplasmolysis.
8. Study different stages of mitosis and meiosis.

Examination

F.M.40

- | | |
|--|----|
| 1. Prepare temporary slides of algae - | 5 |
| 2. Biochemical test – | 5 |
| 3. Mitosis & Meiosis (temporary slide) – | 5 |
| 4. Gram Staining – | 5 |
| 5. Spotting – | 5 |
| 6. Class record, collection, charts – | 10 |
| 7. Viva - Voce | 5 |

SEMESTER – II

**CORE COURSE III: Mycology and Phyto pathology
(Credits : Theory-4, Practical -2)**

THEORY
Lectures: 60

Full marks: 75

Time: 03 Hrs.

Three short and five long questions each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT 1: INTRODUCTION TO TRUE FUNGI (6 lectures)

Definition, General characteristics; Thallus organization; Cell wall composition; Nutrition, Classification by Ainsworth.

UNIT 2: MASTIGOMYCOTINA (4 lectures)

General account, Life cycle of *Synchytrium* and *Phytophthora*.

UNIT 3: ZYGOMYCOTINA (2 lectures)

General characteristics. Life Cycle of *Mucor*

UNIT 4: ASCOMYCOTINA (10 lectures)

General characteristics, life cycle of *Peziza*.

UNIT 5: BASIDIOMYCOTINA (8 lectures)

General characteristics; life cycle of *Puccinia*.

UNIT 6: ALLIED GROUP (2 lectures)

General characteristics of Slime molds.

UNIT 7: DEUTEROMYCOTINA (4 lectures)

General characteristics; Life cycle of *Alternaria*, *Cercospora*.

UNIT 8: SYMBIOTIC ASSOCIATIONS (4 lectures)

Lichen – Occurrence; General characteristics; and range of thallus organization, & Economic Importance.

UNIT 9: APPLIED MYCOLOGY (10 lectures)

Application of fungi in food industry (Fermentation, Organic acids, enzymes, antibiotics); IPM and Biopesticides.

UNIT 10: PHYTOPATHOLOGY (10 lectures)

General symptoms; etiology and control of following disease-

1. Citrus canker, ,
2. Loose smut of wheat,
3. Red rot of sugarcane,
4. Early blight of potato,
5. white rust of crucifer

Suggested Reading

1. Agrios, G.N. 1997 Plant Pathology, 4th edition, Academic Press, U.K.

2. Alexopoulos, C.J., Mims, C.W, Blackwell, M.(1996). Introductory Mycology, John Wiley & Sons (Asia) Singapore, 4th edition.
3. Webster, J. and Weber, R.(2007), Intoduction to Fungi, Cambridge University Press, Cambridge, 3rd edition.
4. Sethi, I.K. and Walia, S.K.(2011). Textbook of Fungi and their Allies, Macmillan Publishers India Ltd.
5. Sharma, P.D, (2011), Plant Pathology, Rastogi Publication, Meerut, India.

CORE COURSE IV :Archegoniate
(Credits : Theory-4, Practical -2,
THEORY
Lectures: 60

Full marks: 75

Time: 03Hrs.

Three short and five long questions each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT 1: BRYOPHYTES

(20 lectures)

General characteristics and life cycle (developmental stages not included) of

1. *Marchantia*,
2. *Anthoceros*,
3. *Sphagnum*
4. Evolution of Gametophyte and Sporophyte in Bryophytes.
5. Ecological and economic importance of bryophytes.

UNIT 2: PTERIDOPHYTA

(20 lectures)

- A) General characteristics and classification of Pteridophyta,
- B) Classification, Morphology, Anatomy and Reproduction(developmental stages not included) of
 1. *Rhynia*
 2. *Lycopodium*
 3. *Selaginella*
 4. *Equisetum*
- C) Apogamy and Apospory,
- D) Heterospory and Seed habit with reference to *Selaginella*,
- E) Stelar evolution.

UNIT 3: GYMNOSPERMS

(20 lectures)

General characteristics and classification (up to family),
Morphology, Anatomy and Reproduction (Developmental details not to be included) of

1. *Pinus* and
2. *Gnetum*

Suggested Reading

1. Vashistha, P.C., Sinha, A.K.Kumar, A.(2010), Pteridophyta. S.Chand, Delhi, India.
2. Bhatnagar, S.P. &Moitra, A.(1996), Gymnosperms, New Age International (P) Ltd Publishers, New Delhi, India.
3. Parihar, N.S, (1991), An introduction to Embryophyta : Vol. 1. Bryophyta, Cental Book Deposit, Allahabad.
4. Raven, P.H., Johnson, G.B.Losos, J.B.,Singer, S.R. (2005), Biology, Tata McGraw Hill, Delhi.
5. Vander – poorteri 2009 Introduction to Bryophyta, COP.
6. Prasad, C. (2013) An Introduction to Pteridophyta, Emkay Publication, New Delhi, India.

Practical

F.M. 40

1. *Synchytrium* ,*Phytophthora*: study of asexual stage from temporary mounts and sexual structures through permanent slides.
2. *Penicillium*: study of asexual stage from temporary mounts and sexual structures through permanent slides or photographs.
3. *Peziza*: sectioning through ascocarp.
4. *Alternaria*&*cercospora* : specimens/ photographs and temporary mounts.
5. *Puccinia* : Herbarium specimens of Black Stem Rust of Wheat. Mounts of spores.
6. Lichens : study of growth forms of lichens (crustose, foliose and fruticose)
7. Phytopathology : Herbarium specimens diseases:
 - *Citrus Canker*;
 - White rust of *crucifers*,
 - Red rot of sugarcane, ,
 - Loose smut of wheat.

8. *Marchantia* & *Anthoceros* – prepare temporary slides of V.S. of Thallus and L.S of Sporophyte (by permanent slides).
9. *Sphagnum* – Morphology of plant, whole mount of leaf (permanent slide only).
10. *Selaginella* & *Equisetum* – Prepare a temporary slide of T.S of stem and L.S of Strobilus (permanent slide).
11. *Pinus* – Prepare a temporary slide of T.S of Needle. T.S. of Stem, L.S of male and female cone (by permanent slide).

EXAMINATION

F.M. 40

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|---|----|
| 1. Preparation of temporary slide – | |
| a. Fungi – | 05 |
| b. Bryophytes – | 05 |
| c. Pteridophytes/ Gymnosperm – | 05 |
| 2. Disease identification (2 diseases). – 2 x 2 ½ = | 05 |
| 3. Spotting – | 05 |
| 4. Class records, collection & charts – | 10 |
| 5. Viva-voice - | 05 |

SEMESTER - III

Core Course V : Anatomy of Angiosperms

(Credits : Theory-4, Practical -2)

THEORY
Lectures: 60

Full marks: 75

Time:03 Hrs.

Three short and five long questions each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT 1: INTRODUCTION AND SCOPE OF PLANT ANATOMY

(2 lectures)

UNIT 2: TISSUES

(14 lectures)

Classification of tissues: Simple and complex tissues and secretory time.

UNIT 3: STEM

(8 lectures)

Types of vascular bundles: Structure of dicots and monocots stem.

UNIT 4: LEAF

(6 lectures)

Structure of dicots and monocots leaf.

UNIT 5: ROOT

(8 lectures)

Structure of dicots and monocots root.

UNIT 6: VASCULAR CAMBIUM

(10 lectures)

Structure, function and seasonal activity of cambium, Anomalous secondary growth in Boerhaavia and Dracaena.

UNIT 7: PERIDERM

(4 lectures)

Development and composition of periderm, Lenticels and rhytidome.

UNIT 8: WOOD

(2 lectures)

Sapwood, Heartwood, early & late wood, tyloses.

UNIT 9: ADAPTIVE AND PROTECTIVE SYSTEMS

(6 lectures)

Epidermal tissue system, cuticle, stomata, trichomes, Anatomical adaptation of xerophytes & hydrophytes.

Suggested Readings

1. Dickison, W.C.(2000). Integrative plant Anatomy. Harcourt Academic Press, USA.
2. Fahn. A.(1974), Plant Anatomy, Pergmon Press. USA
3. Mauseth, J.D.(1998), Plant Anatomy. The Berjammin/ Cummings Publisers, USA.
4. Esau. K.(1977). Anatomy of seed plants. John Wiley & Sons. Inc., Delhi.

Core Course VI : ECONOMIC BOTANY
(Credits : Theory-4, Practical -2)
THEORY
Lectures: 60

Full marks: 75

Time: 03 Hrs.

Three short and five long questions each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT 1: CEREALS

(6 lectures)

Wheat & Rice.

Unit 2: LEGUMES

(6 lectures)

Arhar, Pea, Gram & Moong

UNIT 3: SPICES

(8 lectures)

Fennel, saffron, clove, black pepper.

UNIT 4: BEVERAGES

(6 lectures)

Tea

UNIT 5: OIL AND FATS

(8 lectures)

Groundnut, Linseed and Brassica and coconut.

UNIT 6: DRUGS-YIELDING PLANTS(6 lectures)

Rauwolfia, Azadiracta, Ocimum, Papaver, Emblica, Aloe

UNIT 7: PLANT DRUG ABUSE

(6 lectures)

Opoids, Cannabinoid and cocaine.

UNIT 8: TIMBER PLANTS (6 lectures)

Teak, Shisham & Sal.

UNIT 9: FIBRES (6 lectures)

Cotton & Jute.

UNIT 10: SUGAR YIELDING PLANTS (2 lectures)

Sugarcane.

Suggested Readings

1. Kochhar, S.L., (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
2. Wickens, GE. (2001), Economic Botany: Principles & Practices, Kluwer Academic Publishers, The Netherlands.
3. Chrispeels. M.J. and Sadava. D.E. (2003). Plants, Genes and Agriculture, Jones & Bartlett. Publishers.

**Core Course VII : GENETICS
(Credits : Theory-4, Practical -2)**

THEORY

Lectures: 60

Full marks: 75

Time: 03 Hrs.

Three short and five long questions each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT 1: MENDELIAN GENETICS & ITS EXTENSION (18 lectures)

Mendelian; History, Principle of inheritance, chromosome theory of inheritance, autosomes and sex-chromosomes, incomplete dominance and co-dominance, Epistasis, Complementary and Duplicate genes.

UNIT 2: EXTRACHROMOSOMAL INHERITANCE (8 lectures)

Cytoplasmic inheritance: Variation in four O'clock plant, infective heredity- Kappa particles in *Paramecium*.

UNIT 3: LINKAGE AND CROSSING OVER (12 lectures)

Linkage and crossing over- cytological basis of crossing over, Interference and coincidence – color blindness and *Haemophilia*.

UNIT 4: VARIATION IN CHROMOSOME NUMBER & STRUCTURE (8 lectures)

Deletion, Duplication, Inversion, Translocation, Euploidy, Aneuploidy, origin of *Rhaphmo*, *Brassica* & *Triticale*.

UNIT 5: GENE MUTATIONS (8 lectures)

Types of mutations, Molecular basis of mutations, Mutagens – physical and chemical base analogs, deaminating, alkylating and intercalating agent, Role of mutation in crop improvement.

UNIT 6: POPULATION & EVOLUTINARY GENETICS (6 lectures)

Allele frequency, Genotype frequency, Hardy- Weinberg law, Role of natural selection, mutation, genetic drift, genetic variation & speciation.

Suggested Readings

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics. John Wiley & sons. India 8th edition.
2. Snustad, D.P. and Simmons, M.J. (2010) Principles of Genetics, John Wiley & Sons, Inc., India. 5th edition.
3. Klug, W.S., Cummings, M.R., Speneer. C.A. (2012). Concepts of Genetics. Benjamin Cummings, USA. 10th edition.
4. Griffiths, A.J.F, Wessler, S.R., Carroll, S.B., Doebley. I. (2010). Introduction to Genetic Analysis. W.H. Freeman and Co., U.S.A., 10th edition.

PRACTICAL

1. Study of anatomical details of roots, stem and leaf, through photographs/permanent.
2. Prepare a temporary slide of *Boerhaavia* stem and *Dracaena* stem for anomalous.
3. Distribution and types of parenchyma, collenchyma, sclerenchyma by photographs.
4. Xylem- Tracheary elements – tracheids, vessels and xylem fibres – by photographs

5. Phloem – Sievetubes, companion cells, phloem fibre – by photographs.
6. Adaptive anatomy- xerophytes and hydrophytes.
7. Any ten specimen from syllabus regarding economic botany for identification.
8. Testing good of fit by chi-square method.
9. Photographs/permanent slides showing translocation Rings, Laggards and inversion bridge.

PRATICAL EXAMINATION

F.M. 60

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| 1. Prepare a temporary slide of Boerhaavia stem/ Dracaena stem | -05 |
| 2. Prepare a temporary slide of xerophtes/hydrophptes | -05 |
| 3. Identification of 5 specimen & write their uses. | - 10 |
| 4. Testing goodness of fit by chi-square method. | - 08 |
| 5. Spotting (5 spots) | - 10 |
| 6. Class records, collection & charts | - 15 |
| 7. Viva-voice | - 07 |

SEMESTER - III

Core Course V : Anatomy of Angiosperms
(Credits : Theory-4, Practical -2)

THEORY
Lectures: 60

Full marks: 75

Time: 03 Hrs.

Three short and five long questions each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT 1: INTRODUCTION AND SCOPE OF PLANT ANATOMY

(2 lectures)

UNIT 2: TISSUES

(14 lectures)

Classification of tissues: Simple and complex tissues and secretory tissue.

UNIT 3: STEM

(8 lectures)

Types of vascular bundles: Structure of dicots and monocots stem.

UNIT 4: LEAF

(6 lectures)

Structure of dicots and monocots leaf.

UNIT 5: ROOT

(8 lectures)

Structure of dicots and monocots root.

UNIT 6: VASCULAR CAMBIUM

(10 lectures)

Structure, function and seasonal activity of cambium, Anomalous secondary growth in Boerhaavia and Dracaena.

UNIT 7: PERIDERM

(4 lectures)

Development and composition of periderm, Lenticels and rhytidome.

UNIT 8: WOOD

(2 lectures)

Sapwood, Heartwood, early & late wood, tyloses.

UNIT 9: ADAPTIVE AND PROTECTIVE SYSTEMS

(6 lectures)

Epidermal tissue system, cuticle, stomata, trichomes, Anatomical adaptation of xerophytes & hydrophytes.

Suggested Readings

5. Dickison, W.C.(2000). Integrative plant Anatomy. Harcourt Academic Press, USA.

6. Fahn. A.(1974), Plant Anatomy, Pergmon Press. USA
7. Mauseth, J.D.(1998), Plant Anatomy. The Berjammin/ Cummings Publisers, USA.
8. Esau. K.(1977). Anatomy of seed plants. John Wiley & Sons. Inc., Delhi.

Core Course VI : ECONOMIC BOTANY (Credits : Theory-4, Practical -2)

THEORY

Lectures: 60

Full marks: 75

Time: 03 Hrs.

Three short and five long questions each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT 1: CEREALS

(6 lectures)

Wheat & Rice.

Unit 2: LEGUMES

(6 lectures)

Arhar, Pea, Gram & Moong

UNIT 3: SPICES

(8 lectures)

Fennel, saffron, clove, black pepper.

UNIT 4: BEVERAGES

(6 lectures)

Tea

UNIT 5: OIL AND FATS

(8 lectures)

Groundnut, Linseed and Brassica and coconut.

UNIT 6: DRUGS-YIELDING PLANTS(6 lectures)

Rauwolfia, Azadiracta, Ocimum, Papaver, Emblica, Aloe

UNIT 7: PLANT DRUG ABUSE

(6 lectures)

Opoids, Cannabinoid and cocaine.

UNIT 8: TIMBER PLANTS (6 lectures)

Teak, Shisham & Sal.

UNIT 9: FIBRES (6 lectures)

Cotton & Jute.

UNIT 10: SUGAR YIELDING PLANTS (2 lectures)

Sugarcane.

Suggested Readings

4. Kochhar, S.L., (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
5. Wickens, GE. (2001), Economic Botany: Principles & Practices, Kluwer Academic Publishers, The Netherlands.
6. Chrispeels. M.J. and Sadava. D.E. (2003). Plants, Genes and Agriculture, Jones & Bartlett. Publishers.

**Core Course VII : GENETICS
(Credits : Theory-4, Practical -2)**

**THEORY
Lectures: 60**

Full marks: 75

Time: 03 Hrs.

Three short and five long questions each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT 1: MENDELIAN GENETICS & ITS EXTENSION (18 lectures)

Mendelian; History, Principle of inheritance, chromosome theory of inheritance, autosomes and sex-chromosomes, incomplete dominance and co-dominance, Epistasis, Complementary and Duplicate genes.

UNIT 2: EXTRACHROMOSOMAL INHERITANCE (8 lectures)

Cytoplasmic inheritance: Variation in four O'clock plant, infective heredity- Kappa particles in *Paramecium*.

UNIT 3: LINKAGE AND CROSSING OVER (12 lectures)

Linkage and crossing over- cytological basis of crossing over, Interference and co- incidence – color blindness and *Haemophilia*.

UNIT 4: VARIATION IN CHROMOSOME NUMBER & STRUCTURE (8 lectures)

Deletion, Duplication, Inversion, Translocation, Euploidy, Aneuploidy, origin of *Raphano*, *Brassica* & *Triticale*.

UNIT 5: GENE MUTATIONS (8 lectures)

Types of mutations, Molecular basis of mutations, Mutagens – physical and chemical base analogs, deaminating, alkylating and intercalating agent, Role of mutation in crop improvement.

UNIT 6: POPULATION & EVOLUTIONARY GENETICS (6 lectures)

Allele frequency, Genotype frequency, Hardy- Weinberg law, Role of natural selection, mutation, genetic drift, genetic variation & speciation.

Suggested Readings

5. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics. John Wiley & sons. India 8th edition.
6. Snustad, D.P. and Simmons, M.J. (2010) Principles of Genetics, John Wiley & Sons, Inc., India. 5th edition.
7. Klug, W.S., Cummings, M.R., Spener. C.A. (2012). Concepts of Genetics. Benjamin Cummings, USA. 10th edition.
8. Griffiths, A.J.F, Wessler, S.R., Carroll, S.B., Doebley. I. (2010). Introduction to Genetic Analysis. W.H. Freeman and Co., U.S.A., 10th edition.

PRACTICAL

10. Study of anatomical details of roots, stem and leaf, through photographs/permanent.
11. Prepare a temporary slide of *Boerhaavia* stem and *Dracaena* stem for anomalous.
12. Distribution and types of parenchyma, collenchyma, sclerenchyma by photographs.

13. Xylem- Tracheary elements – tracheids, vessels and xylem fibres – by photographs
14. Phloem – Sievetubes, companion cells, phloem fibre – by photographs.
15. Adaptive anatomy- xerophytes and hydrophytes.
16. Any ten specimen from syllabus regarding economic botany for identification.
17. Testing good of fit by chi-square method.
18. Photographs/permanent slides showing translocation Rings, Laggards and inversion bridge.

PRATICAL EXAMINATION

F.M. 60

- | | | |
|--|-----|------|
| 8. Prepare a temporary slide of Boerhaavia stem/ Dracaena stem | -05 | |
| 9. Prepare a temporary slide of xerophtes/hydrophtes | -05 | |
| 10. Identification of 5 specimen & write their uses. | | - 10 |
| 11. Testing goodness of fit by chi-square method. | | - 08 |
| 12. Spotting (5 spots) | | - 10 |
| 13. Class records, collection & charts | | - 15 |
| 14. Viva-voice | | - 07 |

SEMESTER- V

Core Course XI: Reproductive Biology Of Angiosperms

(Credits : Theory-4, Practical -2)

THEORY

Lectures: 60

Full Marks: 75

Time : 03 Hrs.

Three short and five long questions each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT 1: ANTHER

(4 lectures)

Anther wall: structure and function, microsporogenesis.

UNIT 2: POLLEN BIOLOGY

(8 lectures)

Microgametogenesis & Palynology and scope (a brief account).

UNIT 3: OVULE

(10 lectures)

Structure; Types; Female gametophyte- megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of *Polygonum* type; organization and structure of mature embryo sac.

UNIT 4: POLLINATION AND FERTILIZATION

(8 lectures)

Pollination types and significance; adaptation; structure of stigma and style; path of pollen tube in pistil; double fertilization.

UNIT 5: ENDOSPERM

(6 lectures)

Types, development, structure and functions.

UNIT 6: EMBRYO

(6 lectures)

Development of dicot embryo (*crucifertype*) and monocot embryo (*Luzulattype*)

UNIT 7: SEED

(4 lectures)

Structure, importance and dispersal mechanisms.

UNIT 8: POLYEMBRYONY & APOMIXES

(6 lectures)

Introduction, classification; causes & application.

Suggested Readings

1. Bhojwani, S.S and Bhatnagar, S.P.(2011). The Embryology of Angiosperms, Vikas Publishing House. Delhi 5th edition.
2. Shivanna, K.R. (2013). Pollen Biology and Biotechnology, Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
3. Raghavan, V.(2000). Development Biology of Flowering plants, Springer, Netherlands.
4. Johri, B.M. I(1984), Embryology of Angiosperms, Springer- Verlag, Netherlands.

Core Course XII: PLANT PHYSIOLOGY **(Credits : Theory-4, Practical -2)**

THEORY

Lectures: 60

Full Marks: 75

Time:03 Hrs.

Three short and five long questions each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT 1: PLANT WATER RELATIONSHIP (14 lectures)

Water Potential, water absorption by roots, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap-cohesion-tension theory. Transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement.

UNIT 2: MINERAL NUTRITION (10 lectures)

Essential and beneficial elements macro and micronutrients, methods criteria for essentiality, mineral deficiency symptoms, roles of essential elements, Hydroponics.

UNIT 3: TRANSLOCATION IN THE PHLOEM (10 lectures)

Mass flow hypothesis of Munch.

UNIT 4: PLANT GROWTH REGULATORS (16 lectures)

Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene.

UNIT 5: PHYSIOLOGY OF FLOWERING

(10 lectures)

Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy.

Suggested Readings

1. Hopkins, W.G. and Huner, A.(2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., Møller, I.M and Murphy, A (2015). Plant Physiology and development. Sinauer Associates Inc. USA 6th edition.
3. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual, Narosa Publishing House, New Delhi.

PRATICAL

1. Anther: Wall and its ontogeny; Tapetum; MMC, spore tetrads, through photographs.
2. Pollinia (slides/photographs, fresh material).
3. Ovule: types-anatropous, orthotropous, amphitropous/camphylotropous, circinotropous, unitegmic, bitegmic; Tenuninucellate and crassinucellate; (permanent slides/ specimens/ photographs).
4. Female gametophyte through permanent slides/ photographs
5. Embryogenesis: Study of Development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages.
6. Study of Plasmolysis.
7. Determination of water potential of given tissue (potato tuber) by weight method.
8. Calculation of stomatal frequency from the two surfaces of leaves of a mesophyte and xerophytes.
9. To study the phenomenon of seed germination (effect of light).
10. To demonstrate suction due to transpiration.

PRATICAL EXAMINATION

1. Embryo dissection. -05
2. Determination of water potential of given tissue (potato tuber) by weight method. - 10

3. Calculation of stomatal frequency from the two surfaces of leaves of a mesophytes and xerophytes. - 05
4. Spotting - 05
5. Class records, charts, models. - 10
6. Viva-voice - 05.

SEMESTER- VI

**Core Course XIII: PLANT METABOLISM
(Credits : Theory-4, Practical -2)**

THEORY

Lectures: 60

Full Marks: 75

Time:03 Hrs.

Three short and five long questions each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT 1: CONCEPTS OF METABOLISM (6 lectures)

Introduction, anabolic, catabolic and amphibolic pathway.

UNIT 2: CARBON ASSIMILATION (14 lectures)

Historical background, photosynthetic pigments, role of photosynthetic pigments (chlorophylls and accessory pigments), photochemical reactions, photosynthetic electron transport, PSI, PSII, CO₂ reduction, red drop Emerson effect, Quantum Yield, Quantum Requirement & C₃, C₄ Cycle, photorespiration, photophosphorylation.

UNIT 3: CARBON OXIDATION (10 lectures)

Glycolysis, fate of pyruvate, oxidative pentose phosphaste pathway, oxidative decarboxylation of pyruvate, TCA Cycle, amphibolic role, anaerobic reactions, mitochondrial electron transport, oxidative phosphorylation, factors affecting respiration.

UNIT 4: ATP- SYNTHESIS (8 lectures)

Mechanism of ATP synthesis, substrate level phosphorylation, (oxidative and photophosphorylation).

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UNIT 5: LIPIDS METABOLISM (8 lectures)

Introduction, saturated & unsaturated fatty acid, β -oxidation.

UNIT 6: NITROGEN METABOLISM (8 lectures)

Biological nitrogen fixation (examples of legumes and non-legumes); Reductive amination& Transamination.

Suggested Readings

1. Hopkins, W.G. and Huner, A.(2008). Introduction to Plant Physiology. John Wiley and Sons.
2. Taiz, L., Zeiger, E., Møller, I.M and Murphy, A (2015). Plant Physiology and development. Sinauer Associates Inc. USA 6th edition.
3. Harborne, J.B. (1973). Phytochemical Methods. John Wiley & Sons. New York.

Core Course XIV : Plant Biotechnology

(Credits : Theory – 4, Practical -2)

THEORY

Lectures : 60

Full Marks : 75

Time : 03 Hrs.

Three short and five long questions, each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

1. Plant Tissue Culture

History : Basic requirement of tissue culture, Technique, Prospect and application , Totipotency, Organogenesis, Embryogenesis, Protoplast Isolation , micropropagation, Somatic hybridization, anther culture, pollen culture, Cryopreservation , Germplasm Conservation.

(20 Lectures)

2. Recombinant DNA Technology

Tools, Restriction endonucleases Eco-RI Bam H1, Sal-1, Plasmid, Cloning Vectors; Properties, (pBR-322, Cosmid, Lambda phage, Shuttle vector YEP), Ti- Plasmid, Process and application of r-DNA technology, genomic and c-DNA library, PCR technology, Blotting – Northern and southern, DNA – finger printing .

(25 Lectures)

3. Application of Bio- technology

Pest resistant (Bt-cotton), Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice, Genetically Engineered products- Humulin, Gene therapy – ADA Deficiency (SCID)

(15 Lectures)

Practical

Full Marks : 40

Time : 03 Hrs.

1. Separation of Pigments by Chromatography method.
2. Experiment Showing O₂ is evolved during photo synthesis
3. Experiment Showing that light is essential for photo synthesis. - 10
4. Effect of carbon dioxide on photo synthesis
5. Demonstration of in vitro sterilization and inoculation methods using shoot tip, anther,
6. pollen or explant. - 10
7. Study of anther embryo and endosperm culture, micro propagation, somatic embryogenesis & artificial seeds through photographs.
8. Photographs from biotechnology - 5
9. Spotting - 5
10. Class records - 10
11. Viva- voce - 5

SUGGESTED READINGS

1. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture : Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
2. Gilick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology – Principles and Applications of recombinant DNA. ASM Press, Washington.
3. Bhojwani, S.S. and Bhatnagar, S.P. (2011)., The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd., New Delhi, 5th edition.
4. Snustad, D.P. and Simmons, M.J (2010). Principles of Genetics. John Wiley and Sons, U.K. 5th edition.
5. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics : Principles, Techniques and Applications. John Willey & Sons Inc. U.S.A.

Discipline Specific Elective

PAPER – I Plant Breeding

(Credits : Theory – 4, Practical -2)

THEORY

Lectures : 60

Full Marks : 75

Time : 03 Hrs.

Three short and five long questions, each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

1. Introduction and Objectives

- 10

2. Methods of Crop Improvement, introduction, Selection, Hybridization

- 22

3. Inbreeding, Inbreeding Depression, Heterosis

- 14

4. Role of mutation, Polyploidy, distant hybridization, role of Biotechnology in crop improvement

- 14

SUGGESTED READINGS

1. Singh, B.D (2005), Plant Breeding ; Principles and Methods, Kalyani Publishers. 7th edition.
2. Chaudhari. H.K. (1984). Elementary Principles of Plant Breeding Oxford – IBH.2nd edition.
3. Acquaah, G. (2007) Principles of Plant Generics & Breeding Blackwell Publishing.

Discipline Specific Elective

PAPER – II Natural Resource Management
(Credits : Theory – 4, Practical -2)

THEORY
Lectures : 60

Full Marks : 75

Time : 03 Hrs.

Three short and five long questions, each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

1. Natural resources – Definition and types
- 02
2. Sustainable utilization - Concept, approaches (Economical Socio cultural, Ecological)
- 08
3. Land - Soil degradation and management
- 08
4. Water – fresh water, marine, estuaries, wetlands, threats and management strategies
- 08
5. Biological resource – Bio diversity – Definition and types, significance, threat and management.
- 14
6. Forest – Definition, importance, management
- 06
7. Energy - Renewable & Non renewable sources
- 08
8. National & international efforts in resource management
- 06

Practical

Full Marks : 40
Hrs.

Time :

1. To, study hybridization experiments & its products.
2. Roles of Bio-technology in crop improvement Photograph -
10
3. Photographs & news of solid waste generated by domestic system – Bio
degradable and non bio degradable & its impacts
4. Collection of data of local forest area -
10
5. Emasculation -
10
6. Viva Voce -
10

SUGGESTED READINGS

1. Vasudevan, N. (2006) Essentials of Environmental Science. Narosa Publishing House, New Delhi.
2. Singh, J.S. Singh, S.P. and Gupta, S. (2006) Ecology, Environment and Resource Conservation, Anamaya Publications, New Delhi.
3. Rogers, P.P., Jalal, K.F and Boyd, J.A (2008). An Introduction to Sustainable Development Prentice Hall of India Private Limited, New Delhi.,

Discipline Specific Elective

PAPER – III Environmental Education & Waste Management

(Credits : Theory – 4, Practical -2)

THEORY

Lectures : 60

Full Marks : 75

Time : 03 Hrs.

Three short and five long questions, each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

1. Under standing Ecosystems, population, Community, Ecosystems, and its components, Biosphere,
2. Destruction of Ecosystem due to changing pattern of land use
Migration, Transportation, Urbanization, Sprawl, Industrialization
3. Environmental Impact assessment
4. Sources & Classification of waste
5. Impact of waste accumulation
6. Need for management of waste
7. safe disposal of waste
8. Legal provision for waste management
9. Swakchh Bharat Abhiyan – Your Suggestions.

Discipline Specific Elective

PAPER – IV Industrial Environmental Microbiology

(Credits : Theory – 4, Practical -2)

THEORY

Lectures : 60

Full Marks : 75

Time : 03 Hrs.

Three short and five long questions, each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

1. Biogas – Process & Importance - 05
2. a) Bio remediation - 20
Role of Microbes in waste Management
b) Bio remediation of Hydrocarbons
Bio remediation of Industrial waste
Bio remediation of xenobiotics
c) Bio minning
Bio reactirs
3. Microbial Flora of Water - 10
Water pollution, Sewage , algal bloom,
BOD, COD, Eutrophication.
4. Microbes in agriculture - 10
Biological fixation, mycorrhiza, isolation of root nodule bacteria
5. Microbial products of Industrial value - 15
Organic acids, Alcohol,. Antibiotics, Down stream processing & uses

Practical

Full Marks : 40

Time :

Hrs.

1. Study of Plant community in college campus.
2. Project of waste management for clean green campus.
-10
3. Principles and functioning of instruments in microbiology laboratory
4. Hands on sterilization techniques and preparation of culture media.
-10

5. Spotting
- 5
6. Record
- 10
7. Viva voce
- 5

SUGGESTED READINGS

1. Pelzar, M.J. JR., Chen E.C.S., Krieg. N.R. (2010) Microbiology : An application based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi
2. Tortora, G.J., Funke, B.R., Case C.L. (2007) Microbiology, Pearson Benjamin Cummings, San Francisco, U.S.A 9TH edition.

GENERIC ELECTIVE

**PAPER – I Biodiversity (Microbes, Algae, Fungi and Archegoniate)
(Credits : Theory – 4, Practical -2)**

THEORY

Lectures : 60

Full Marks : 75

Time : 03 Hrs.

Three short and five long questions, each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT 1 : MICROBES

- 10

Viruses – Discovery, general structure, & nature

Bacteria - Discovery, general characteristics, cell structure, and Economic Importance.

UNIT 2 : ALGAE

- 10

General characteristics, Morphology and life cycles of Nostoc , chlamydomonas , chara, Batrachospermum

UNIT 3 : FUNGI

- 10

General characteristics, Morphology and life cycles of albugo, puccinia, alternatia. Lichens- General account.

UNIT 4 : BRYOPHYTES

- 10

General characteristics, Morphology, anatomy and reproduction of Marchantia and Funaria.

UNIT 5 : PTERIDOPHYTES

- 10

General characteristics, Morphology, anatomy and reproduction of Selaginella, Pteris.

Stealer evolution.

UNIT 6 : GYMNOSPERMS

- 10

General characteristics, Morphology, anatomy and reproduction of Pinus. & its Economic Importance

PRACTICAL

Full Marks : 20

1. Models of Viruses
2. Types of Bacteria from slides/ photographs/Slides
3. Study of vegetative and reproductive structures by preparation of temporary slides from 2 to 6 units .

4. Spotting
- 5
5. Record
- 4
6. Viva voce
- 2

GENERIC ELECTIVE

PAPER – II PLANT ECOLOGY AND TAXONOMY (Credits : Theory – 4, Practical -2)

THEORY

Lectures : 60

Full Marks : 75

Time : 03 Hrs.

Three short and five long questions, each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT - I ECOLOGY

25

1. Introduction –
2. Ecological adaptation - Hydrophytes Xerophytes
3. Plant communities - succession – process & types
4. Eco-system Structure ,types, - pond, Grassland, Energy flow, Trophic organisation, Food chain, Food web, Ecological pyramid.
5. Pollution - Air & Water – Cause & Control.

UNIT - II TAXONOMY

- 35

1. Introduction, Identification, classification, nomenclature.
2. Taxonomic aids – herbarium & Botanical Gardens.
3. Taxonomic hierarchy
4. Principles & rules of ICBN
5. Classification - Bentham & Hooker And Hutchinson's System

6. Study of following families
Apocynaceae, Solanaceae, Poacea

PRACTICAL

Full Marks : 20

1. Study of morphological adaptations of hydrophytes and xerophytes.
- 3
2. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method.
- 6
3. Study of vegetative and floral characters of the families included in syllabus with floral diagram, floral formula and systematic position.
4. Spotting
- 5
5. Record
- 4
6. Viva voce
- 2

GENERIC ELECTIVE

**PAPER – III PLANT Anatomy Embryology, Economic Botany
(Credits : Theory – 4, Practical -2)**

THEORY

Lectures : 60

Full Marks : 75

Time : 03 Hrs.

Three short and five long questions, each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT – 1 ANATOMY

- 20

1. Meristematic Tissues - apical, lateral, Intercalary Meristem & simple complex tissues
2. Anomalous secondary growth in Boerhaavia & Dracaena

UNIT – 2 EMBRYOLOGY

- 22

1. Outlines of life cycle of an angiospermic plant
2. Types of ovules
3. Types of Embryo Sacs, Development of Polygonum type
4. Double Fertilization
5. Endosperm & Polyembryony

UNIT – 3 ECONOMIC & BOTANY

- 18

Morphology & uses of following

1. Cereal – Wheat
2. Legumes – Gram
3. Fibre - Cotton
4. Timber – Seeshum, Teak
5. Oil – Mustard, Sunflower
6. Medicinal – Tulsi, Neem & Amla

PRACTICAL

Full Marks : 20

1. Identification of Tissues (parenchyma, collenchymas and sclerenchyma)

2. Temporary mounts of section of anatomical specimens
- 4
3. Embryo dissection / Photograph of ovules
- 2
4. Plant identification & uses
- 3
5. Spotting
- 5
6. Record
- 4
7. Viva voce
- 2

GENERIC ELECTIVE

PAPER – IV PLANT PHYSIOLOGY , CYTOLOGY & GENETICS, BIO- TECHNOLOGY (Credits : Theory – 4, Practical -2)

THEORY

Lectures : 60

Full Marks : 75

Time : 03 Hrs.

Three short and five long questions, each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT – I

- 25

1. Transpiration - Mechanism & significance
2. Ascent of Sap – Root Pressure transpiration pull, theory
3. Photosynthesis – Photophosphorylation , C₃,C₄ Cycle
4. Respiration – Glycolysis , TCA Cycle.
5. Growth Hormone – Auxin, Gibbrelline

UNIT – II

- 25

1. Structure of Cytoplasmic Cell Organelles – Mitochondria , Chloroplast, Ribosome
2. Cell Division – Mitosis, Meiosis,
3. Principles of inheritance , Mendel’s Law
4. Complimentary Genes & epistasis
5. Gene – Mutation & Polyploidy

UNIT – III

- 5

1. Plant Tissue Culture – History, Requirement, Technique & Application

PRACTICAL

Full Marks : 20

1. To perform physiological Experiment of syllabus
- 4
2. Cytological Slide preparation
- 3
3. Photographs from Bio- technology
- 2
4. Spotting
- 5
5. Record
- 4
6. Viva voce
- 2

Core Course XIII : PLANT – METABOLISM (Credits : Theory – 4, Practical -2)

THEORY

Lectures : 60

Full Marks : 75

Time : 03 Hrs

UNIT – I

Introduction – Anabolic, Catabolic, Amphibiotic, Pathways

- 05

UNIT – II

Carbon, Assimilation

History, Role of photosynthetic pigments, Photo chemical reactions, PSI, PSII, Photophosphorylation, Red drop, Emerson effect, Quantum Requirement & yield, C₃,C₄ Cycle, Photo Respiration

- 15

UNIT – III

Carbon Oxidation

Glycolysis, Fate of pyruvate , oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, TCA cycle, Mitochondrial electro transport, Anaerobic respiration, Factors affecting respiration .

- 15

UNIT – IV

Mechanism of ATP Synthesis

Substrate level phosphorylation, oxidative phosphorylation, photo phosphorylation.

12

UNIT – V

Lipid Metabolism

Introduction, Saturated and un saturated fatty acid, B-oxidation of fat.

UNIT – VI

- 05

Nitrogen Metabolism

Nitrate assimilation, Biological Nitrogen fixation, reductive amination, Transamination

08

SKILL ENHANCEMENT COURSE

Biofertilizers

(Credits2)

Lectures : 30

Full Marks - 50

Time :

Three short and five long questions, each carrying 20 marks, are to be set covering the whole syllabus out of which four questions are to be answered.

UNIT – 1 (4 lectures)

General account about the microbes used as biofertilizer – Rhizobium – isolation, identification , mass multiplication, earrier based inoculants Actinorrhizal symbiosis.

UNIT – 2 (8 lectures)

Azospirillum : isolation and mass multiplication – carrier based inoculants, associative effect of different microorganisms. Azotobacter : classification, characteristics – crop response to Azotobacter inoculums, maintenance and mass multiplication.

UNIT – 3 (4 lectures)

Cyanobacteria (blue green algae), Azolla and Anabaena azollae association, nitrogen fixation factors affecting growth, blue green algae and Azolla in rice cultivation.

UNIT – 4 (8 lectures)

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculums production of VAM, and its influence on growth and yield of crop plants.

UNIT – 5 (6 lectures)

Organic farming – Green manuring and organic fertilizers, Recycling of bio-degradable municipal, agricultural and industrial wastes – biocompost making methods, types and method of vermicomposting – field Application.

Suggested Readings

1. Dubey, R.C.,2005 A Text book of Biotechnology S.chad & Co., New Delhi.
2. Kumaresan, V.2005, Biotechnology, Saras Publications, New Delhi.
3. John Jothi Prakash, E. 2004. Outline of Plant Biotechnology. Publication New Delhi
4. Sathe, T.V.2004 Vermiculture and Organic Farming. Daya Publishers.
5. Subha Rao, N.S.2000, Soil Microbiology, Oxford & IBH Publishers, New Delhi.
6. Vayas, S.C.Vayas, S. and Modi, H.A. 1998 Bio-fertilizers and organic Farmng Akta Prakashan, Nadiad.