

**SCIENCE COLLEGE (AUTONOMOUS)
HINJILICUT, GANJAM, ODISHA**



COURSES OF STUDIES

FOR

M. Sc. (Botany)

First Semester Examination- 2019-20

Second Semester Examination- 2019-20

Third Semester Examination- 2020-21

Fourth Semester Examination- 2020-21

The Post-Graduate (M.Sc.) curricula in Botany is of two-year duration in choice based credit system (CBCS) with total of 80 Credit and 2000 marks. The system of examination is of semester pattern. There will be four semesters each consisting of five papers with 4 credit and 100 marks each. In first and second semester there will be five core papers including four theory papers and one practical. In third semester there will be four core papers and one allied elective. Options for allied elective will be provided by other P.G. departments of the university and students have to opt for any one. Students of other departments can also opt for one allied elective provided by dept. of Botany. In fourth semester there will be three core papers and two elective papers. The three core papers include one core theory, one Seminar & field study and one practical. For each elective special paper, students have to opt for any one out of the two options in each special paper provided. For Seminar & Field Study/ Industrial Visit/Scientific Visit paper students have to present a topic of relevance as seminar presentation in the department and submit a Field Study/ Industrial Visit/Scientific Visit report, which will be evaluated by faculties of the dept. The seminar presentation carries 50 marks and field study report also carries 50 marks. For all the theory papers 20 marks is for internal evaluation and 80 marks is for end term examination.

<u>Semester</u>	<u>Paper no.</u>	<u>Type of paper</u>	<u>Credit</u>	<u>Marks</u>
First	B-101	Core	4	100
	B-102	Core	4	100
	B-103	Core	4	100
	B-104	Core	4	100
	B-105	Core	4	100
Second	B-201	Core	4	100
	B-202	Core	4	100
	B-203	Core	4	100
	B-204	Core	4	100
	B-205	Core	4	100
Third	B-301	Core	4	100
	B-302	Core	4	100
	B-303	Core	4	100
	B-304	Allied elective	4	100
	B-305	Core	4	100
Fourth	B-401	Core	4	100
	B-402	Elective	4	100
	B-403	Elective	4	100
	B-404	Core	4	100
	B-405	Core	4	100
Total			80	2000

M. Sc. Botany Syllabus (CBCS) 2015-2017

Semester	Paper No.	Paper Name	Credit	Type	Proposed marks		
					Internal	End term	Total
First	B-101	General Microbiology	4	Core	20	80	100
	B-102	Lower Plant Diversity and Paleobotany	4	Core	20	80	100
	B-103	Cell biology & Evolution	4	Core	20	80	100
	B-104	Ecology	4	Core	20	80	100
	B-105	Practical	4	Core			100
Second	B-201	Genetics and Molecular Biology	4	Core	20	80	100
	B-202	Adv. Plant Physiology & Metabolism	4	Core	20	80	100
	B-203	Adv. Plant Biochemistry and Biostatistics	4	Core	20	80	100
	B-204	Environmental Pollution	4	Core	20	80	100
	B-205	Practical	4	Core			100
Third	B-301	Systematics of Angiosperms	4	Core	20	80	100
	B-302	Natural Resources, Conservation and Utilization	4	Core	20	80	100
	B-303	Plant Embryology and plant anatomy	4	Core	20	80	100
	B-304	Environmental Biology	4	Allied Elective	20	80	100
	B-305	Practical	4	Core			100
Fourth	B-401	Plant Biotechnology and Tissue culture	4	Core	20	80	100
	B-402	(A) Microbial Physiology or (B) Environmental Biology and Ecotoxicology	4	Elective	20	80	100
	B-403	(A) Microbial Technology or (B) Environmental Management	4	Elective	20	80	100
	B-404	Seminar and Field Study/ Industrial Visit/Scientific Visit	4	Core			50 + 50 =100
	B-405	Practical	4	Core			100

Total Credit: 80 Total Marks: 2000

**FIRST SEMESTER
PAPER: B-101
GENERAL MICROBIOLOGY**

Unit- I:

Bacteria and Archaea: Classification, cell structure, nutrition, growth, reproduction, Economic importance. Bacterial genetics: plasmid and episome, conjugation, transduction and transformation.

Cyanobacteria: Classification, cell structure, nutrition, reproduction, cellular differentiation, heterocyst and its function. Economic importance of cyanobacteria,

Unit- II:

Virus: General properties, structure, purification, cultivation, principle of viral taxonomy, classification, one step growth experiment and lifecycle, Animal virus and their reproduction, Plant virus and their transmission. Economic importance of virus. Virioids and Prions.

Unit- III:

Algae: distribution (terrestrial, freshwater, marine); thallus organization; cell structure; criteria for classification of algae; pigments, reserve food, flagella, reproduction (vegetative, asexual, sexual). Salient features of Chlorophyta, Euglenophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta. Economic importance of algae. Algal blooms and toxins, algae as biofertilizer, food, feed, and uses in industry.

Unit- IV:

Fungi: General characters of fungi; substrate relationship in fungi; cell ultra-structure, unicellular and multicellular organization; nutrition (saprobic, biotrophic, symbiotic) reproduction (vegetative, asexual, sexual); heterothallism; heterokaryosis; parasexuality; recent trends in classification. Phylogeny of fungi. General account of Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina. Fungi in industry, medicine and food, Fungi as biocontrol agent, Mycorrhizae, Lichen.

Select text books for reading:

Prescott, L. M., Harley, J. P. and Klen, D. A. (1999). Microbiology, 7th Ed., McGraw-Hill, New York.

Pelczar, Jr., M. J., Chan E.C.S. and Krieg, N. R. (2005). Microbiology, 5th Ed, Tata McGraw-Hill, New Delhi.

Alexopoulos, C. J., Mims, C. W. and Blackwell, M. (1996). Introductory Mycology, John Wiley, New York.

Kumar, H. D. (1988). Introductory Phycology. East-West Press, New Delhi.

Maloy, S. R., Cronan, J. E. Jr. and Freifelder, D. (2008). Microbial Genetics, 2nd Ed. Norosa, New Delhi.

Mehrotra, R. S. and Aneja, R. S. (1998). An Introduction to Mycology, New Age International, New Delhi.

PAPER: B-102
LOWER PLANT DIVERSITY AND PALEOBOTANY

Unit- I:

BRYOPHYTA: Morphology, structure, reproduction and life history. Distribution, classification, general account of Marchantiales, Jungermaniales, Anthocerotales, Sphagnales, Funariales and Polytrichales. Ecological importance.

Unit- II:

PTERIDOPHYTA: Morphology, anatomy and reproduction; classification; evolution of stele; heterospory and origin of seed habit. General account of Psilopsida, Lycopsida; Sphenopsida and Pteropsida.

Unit- III:

GYMNOSPERMS: General characteristic feature of Gymnosperms, Classification of Gymnosperms and their distribution in India. General account of Cycadales, Coniferales, Ephedrales, and Gnetales.

Unit- IV:

PALEOBOTANY: Geological time scale, origin and geological evidences; evolutionary time scale (eras, periods and epoch). Types of fossils, processes of fossilization, role of fossils in evolution. Brief account of fossil Pteridophytes and Gymnosperms. Cycadeoidales, Pentoxylales, Medullosales and Glosspteriodales.

Select text books for reading:

Bhatnagar, S. P. and Moitra, A. (1996). Gymnosperms. New Age International, New Delhi.

Parihar, N. S. (1991). Bryophyta. Central Book Depot, Allahabad.

Parihar, N. S. (1991). Biology and Morphology of Pteridophytes. Central Book Depot, Allahabad.

Chamberlin, C. J. (1935). Gymnosperms: Structure and Evolution. Dover Publications, New York.

PAPER: B-103
CELL BIOLOGY & EVOLUTION

Unit- I:**Structural organization and function of intracellular organelles:**

Structural organization of the plant cell, structure and functions of cell wall, plasma membrane; ion carriers, channels and pumps; receptors. Chloroplast, mitochondria, peroxisome, endoplasmic reticulum, ribosome, lysosome, vacuole, nuclear pore and nucleolus. Cell shape and motility: cytoskeleton, organization and role of microtubules and microfilaments, implications in flagellar and other movements.

Unit- II:**Cell division, cell cycle and cell signaling:**

Cell cycle: mitosis, meiosis, DNA synthesis in cell cycle, regulation of cell cycle: role of cyclins and cyclin-dependent kinases; cytokinesis and cell plate formation; cell surface receptors, G-protein coupled receptors, signal transduction pathways, secondary messengers, regulation of signalling pathways.

Unit- III:**Structure and organisation of eukaryotic chromosomes:**

Chromatin and chromosome, heterochromatin and euchromatin, special types of chromosomes, karyotype, chromosome banding, sex chromosomes, sex determination in plants, dosage compensation, B-chromosomes, Packing of DNA, Nucleosome. Nuclear DNA content, C-value paradox, satellite DNA, cot-curve, unique and repetitive DNA.

Unit- IV:

Evolution: Theories and evidences of organic evolution, Lamarckism; Darwinism-concepts of variation, adaptation, struggle, fitness and natural selection. The evolutionary synthesis, Origin of basic biological molecules, concept of Oparin and Haldane, experiments of Miller (1953), the first cell, Evolution of prokaryotes, Origin of eukaryotic cells, Gene pool, Gene frequency; Hardy-Weinberg Law, Isolating mechanisms- speciation, Convergent evolution, sexual selection, Co-evolution, Origin of new genes and proteins; molecular evolution and polymorphism; Molecular tools in phylogeny.

Select text books for reading:

Buchachnanan, B. B., Grissem, W. and Jones, R. L. J., (2000). Biochemistry and molecular biology of plants. American Society of plant physiologists, Rockville, USA

Cooper G. M. (1997). The Cell: A molecular approach. ASM Press, Washington, D. C., USA.

Malacinski, G. M and Feidfelder, D (1998). Essentials of Molecular Biology, 3rd Ed. Jones and Bartel, London.

Lewine, B. (2004) Gene VIII, Person-Prentice Hall, London.

PAPER: B-104
ECOLOGY

Unit I:**Ecosystem organization:**

Biotic components, abiotic substances, trophic level, food chain, food web, Aquatic ecosystems, Marine ecosystems, Wetland ecosystems, Grassland ecosystems, Forest ecosystems. Ecological adaptations, Plant adaptation (morphological and anatomical)

Unit- II:

Ecosystem function: Energy flow in the ecosystem, Primary production (methods of measurement), decomposition, energy dynamics (trophic organisation, energy flow pathways, ecological efficiencies, Energy dynamics, concept of energy subsidy, universal energy flow, cybernetics, Ecological pyramids, Bio-geo-chemical cycles, The Gaia hypothesis, Geo-chemical cycles (Hydrological cycles, gaseous cycles, sedimentary cycles).

Unit- III:

Population ecology: Population interactions (population density, natality, mortality, population age structure, carrying capacity, Community ecology: Ecological communities and ecosystems, structural analysis of communities, inter- and intra-specific competitions, Mutualism and

commensalism, predation, parasitism, amensalism, competition and coexistence, Habitat and ecological niche.

Unit- IV:

Ecological regulation: System studies, Chemical transformations, Biochemical transformations, ecological succession, Mechanism of ecological succession and characters of succession, Process of succession, climax concept, Hydrosere, xerosere, ecological biodiversity.

Select text books for reading:

Panigrahi, A. K. and Alaka Sahu (2012): Text book on Environmental Studies. Giribala Publishing House, Berhampur.

Gomez, K. A. and Gomez, A. A. ((1984). Statistical Procedures for Agricultural Research, 2nd Ed. John Weley, New York.

Kormondy, E. J. (1996). Concepts of Ecology, Prentice-Hall India, New Delhi.

Odum, E. P. (1971). Fundamentals of Ecology, Saundas, Philadelphia, USA.

Misra, B. N. and Misra, M. K. (1998). Introductory Practical Biostatistics, Naya prokash, kolkata.

Smith, R. L. (1996). Ecology and Field Biology. Harper Collins, New York.

Subrahmanyam, N. S. and Sambamurty, A. V. S. S. (2000). Ecology. Narosa, New Delhi.

PAPER: B-105

PRACTICAL

Based on theory Papers B-101, B-102, B-103 and B-104

SECOND SEMESTER

PAPER: B-201

GENETICS AND MOLECULAR BIOLOGY

Unit I:

Genetics: Mendelism and deviation of Mendelian ratios, epistasis, linkage and crossing over, sex-linked inheritance, three point test cross and chromosome mapping, Extra chromosomal inheritance.

Unit- II:

Cytogenetics: Structural Chromosomal aberrations: duplication, deficiency, inversion and translocations heterozygotes; Numerical chromosome aberrations: aneuploids: trisomics and monosomics; euploids: autopolyploids, allopolyploids, role polyploidy in speciation with reference to *Triticum* and *Brassica*.

Unit- III:

Molecular Biology: Prokaryotic and eukaryotic DNA replication: DNA polymerases, replisome, replicon, primase, telomerase.

RNA transcription: mRNA, tRNA, rRNA, siRNA, miRNA, RNAi, RNA polymerases, RNA-processing, RNA splicing, spliceosome, RNA editing. Genetic code.

Protein translation, inhibitors of replication, transcription and translation, post-translational modifications, protein targeting.

Regulation of gene expression in prokaryotes and eukaryotes: role of chromatin in regulating gene expression and gene silencing.

Gene fine structure, cis-trans test; *in situ* hybridization concept and techniques, physical mapping of genes on chromosomes, FISH and GISH.

Unit- IV:

Mutagenesis, DNA damage and repair: Spontaneous and induced mutations, physical and chemical mutagens, molecular basis of mutations, transposable elements in prokaryotes and eukaryotes, mutations induced by transposons, site directed mutagenesis, DNA damage and repair mechanisms. Environmental mutagenesis and genetic toxicology.

Select text books for reading:

Lewin, B. (2004). Gene VIII. Person-Prentice Hall, London.

Pierce, B. A. (2006). Genetics: A Conceptual Approach. W. H. Freeman, New York.

PAPER: B-202

ADVANCE PLANT PHYSIOLOGY AND METABOLISM

Unit I:

Membrane transport and translocation of water and solutes: Plant water relation, mechanism of water transport through xylem, phloem loading and unloading, passive and active solute transport, membrane transport proteins.

Photosynthesis: Light harvesting complex, structure and chemistry, Photolysis of water and Hill Reaction, Photo-phosphorylation, CO₂-fixation, C₃ and C₄ and CAM pathways,

Unit II:

Respiration and lipid metabolism: Glycolysis, Fermentation, TCA cycle, pentose phosphate path ways, mitochondrial electron transport and ATP synthesis, alternate oxidase, photorespiratory pathway, Glyoxylate Cycle.

Lipid metabolism: fatty acid biosynthesis, synthesis of membrane lipids, storage lipids and their catabolism.

Unit III:

Nitrogen fixation and nitrogen metabolism: Biological nitrogen fixation, asymbiotic and symbiotic nitrogen fixation nodule formation, nod and *nif* genes their regulation and function, mechanism of nitrate uptake and reduction, ammonium transport and assimilation.

Sensory Biology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins, stomatal physiology; phytohormones: ethylene, abscisic acid, brassinosteroids, polyamines, jasmonic acid.

Unit IV:

Stress Physiology: Plant responses to biotic and abiotic stress, mechanisms of biotic and abiotic stress tolerance, water deficit and drought resistance, salinity stress, metal toxicity, freezing and heat stress, oxidative stress.

Oxidative metabolism: reactive oxygen species (ROS), antioxidants, antioxidant enzymes: catalase, peroxidases, superoxide dismutase, glutathione transferase, glutathione reductase, *Halliwell–Asada cycle*.

Physiology of aging and senescence, influence of hormones and environmental factors on senescence. Programmed cell death.

Select text books for reading: Buchachnanan, B. B., Grisse, W. and Jones, R. L. J., (2000). *Biochemistry and Molecular Biology of Plants*. American Society of Plant Physiologists, Rockville, USA.

Devlin, R. N. and Witham, F. H. (1983). *Plant Physiology*. CBS Publishers, Delhi.

Salisbury, F. B. and Ross, C. W. (1991). *Plant Physiology*, Wordworth Publication California, USA.

PAPER: B-203**ADVANCE PLANT BIOCHEMISTRY AND BIOSTATISTICS****Unit I:**

Basics of Biochemistry: Structure of atoms, molecules, chemical bonds, stabilising interactions (Van der Waals, electrostatic, hydrogen bonding and hydrophobic interactions).

Principle of biophysical chemistry and bioenergetics: pH, buffer, reaction kinetics, thermodynamics, colligative properties., couples reactions, group transfer, biological energy transfer.

Unit II:

Biomolecules: Composition, structure, and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Confirmation and stability of proteins (Ramachandra plot, secondary, tertiary and quaternary structure, domains, motif, and folds). Confirmation and stability of nucleic acids (A-, B-, Z- DNA, t-RNA, mi RNA), phenols, terpenes.

Unit III:

Plant enzymes and Coenzymes: Nomenclature and classification of enzymes and coenzymes: Distribution of enzymes in plant, structure and function of Isoenzymes. Enzyme kinetics, mechanism of enzyme action and its regulation. Factors affecting enzyme action.

Antioxidants: structure and functions of ascorbic acid, glutathione, tocopherol, carotenoids etc.

Unit IV:

Biostatistics: Frequency distribution, cumulative and relative frequency. Measurement of central tendency and dispersion, mean, median and mode, mean deviations, variance and standard deviation, coefficient of variation, errors. Analysis of variance (ANOVA). Comparison of means: Students 't' test and paired 't' test. Chi-square (X^2) test, 2 x 2 contingency table and

association analysis as applied to biological experimental data. Simple correlation and linear regression analysis.

Select text books for reading:

Boyer, R. (2004). Modern Experimental Biochemistry, 3rd Ed. Pearson Educational Publication, Singapore.

Buchachnanan, B. B., Grissem, W. and Jones, R. L. J., (2000). Biochemistry and Molecular Biology of Plants. American Society of Plant physiologists, Rockville, USA

Goodwin, T. W. and Mercer, E. I. (1985). Introduction to Plant Biochemistry, 2nd ed. Pergamon, Oxford.

Mathews, C. K., Van Holde, K. E. and Ahern, K. G. (2000). Biochemistry, Addison-Wesley Publishing Company, San Francisco, USA.

PAPER: B-204
ENVIRONMENTAL POLLUTION

Unit I:

Environmental Pollution: Air pollution, water pollution, terrestrial/ soil pollution, noise pollution, and radiation pollution. Source of pollutants: natural and anthropogenic pollutants. Concept of ecotoxicology, Biological-concentration and biomagnification of pesticides and heavy metals in the ecosystem.

Unit II:

Global warming and climate change: Global warming and climate change, Greenhouse gases (GHG), Ozone layer depletion, consequences of climate change: smog, acid rain etc. Carbon and GHG management, United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol.

Unit III:

Environmental Pollution Control:

Methods of air pollution control, treatment of waste water: sewage and sewage treatment, solid waste management and recycling, municipal solid waste management, composting,

Hazardous wastes and their management: Characteristics, toxic chemicals, hospital waste and their management, treatment of hazardous waste

Unit IV:

Environmental Pollution and Legislative solution: legal remedies against pollution, Environmental Protection Act (EPA), water act, air act, environment act, Pollution Control Board, Disaster and disaster management.

Environmental education and awareness, environmental audit, environmental management, environmental crisis, environmental ethics.

Select text books for reading:

Panigrahi, A. K. and Alaka Sahu (2012): Text book on Environmental Studies. Giribala Publishing House, Berhampur.

Das, R. C., Baral, J. K., Sahu, N. C. and Misra, M. K. (1998). *The Environmental Divide: The Dilemma of Developing Countries*. A. P. H. Publication, New Delhi.

Kumar, H. D. and S.P. Adhikary (2006). *A Text Book on Environmental Engineering*. India Tech Publishing, New Delhi.

Hill, M. K. (1997). *Understanding Environmental Pollution*. Cambridge University Press, UK.

Mason, C. F. (1991). *Biology of Freshwater Pollution*. Longman, New York.

PAPER: B-204

PRACTICAL

Based on Theory Papers B-201, B-202, B-203 and B-204

THIRD SEMESTER

PAPER: B-301

SYSTEMATICS OF ANGIOSPERMS

Unit I:

Taxonomic Structure: Taxonomic hierarchy; Concept of species, genus and family, Plant Nomenclature: Salient features of International Code of Botanical Nomenclature (ICBN), Major rules: priority, effective and valid publications and author citation. Type concept, Taxonomic Tools: Field and Herbarium techniques; Floras and Botanic Gardens, Computer and Taxonomy.

Unit II:

Systems of Angiosperm Classification: Artificial, natural and phylogenetic systems, relative merits and demerits of major systems of classification (Bentham and Hooker, Engler and Prantle, Hutchinson and Takhtajan).

Unit III:

Angiosperm Families: Floral structure and phylogenetic relationship among the taxa under the following orders: Liliiflorales, Scitaminae, Orchidales, Ranales, Rosales, Tubiflorae, Malvales, Asterales and Rubiales.

Unit IV:

Taxonomic Evidences: Morphology, anatomy, palynology, embryology, cytology, phytochemistry and serology.

Concept of Phytogeography: Climate and Vegetation pattern of the World; Endemism, Floristic regions of India; vegetational pattern of India.

Select text books for reading:

Davis, P. H. and Heywood, V. H. (1973). *Principles of Angiosperms Taxonomy*. Robert E. Kreiger, New York.

Panigrahi, AK and Sahu Alaka (2002): *Glossary of Economically important plants*. New Central Book Agency, Calcutta.

Heywood, V. H. and Moore, D. M. (1984). *Current Concepts in Plant Taxonomy*. Academic press, London.

- Solbrig, O. T. (1970). Principles and Methods Plant Biosystematics. MacMillan, London.
- Stace, C. A. (1989). Plant taxonomy and Biosystematics. Edward Arnold, London.
- Takhtajan, A. L. (1997). Diversity and Classification of Flowering Plants. Columbia University Press, NY.
- Woodland, D. W. (1991). Contemporary Plant Systematics. Prentice-Hall, New Jersey, USA.

PAPER: B-302

NATURAL RESOURCES, CONSERVATION AND UTILIZATION

Unit I:

Natural resources and management: Conservation of natural resources, Non-renewable energy resources, Alternative sources of energy, new concepts for alternative energy. Renewable energy resources: Water resources, soil resources, Soil conservation and management. Water resources and conservation: rain water harvesting, water shed management, uses of water, Forest as a renewable resource, deforestation, afforestation, conservation, social forestry, wild-life conservation

Unit II:

World Centres of Primary Diversity of Domesticated Plants: Basic concepts, origin of agriculture and plant introduction. Origin, evolution, botany, cultivation and uses of (i) Food crops, (ii) fibre crops, (iii) medicinal and aromatic plants, and (iv) vegetable and oil-yielding crops with special reference to local plants. Plants, plant parts and plant products used in homeopathy medicines, Plants, plant parts and plant products used in ayurvedic medicines, Important timber-yielding plants, Important poisonous plants of India.

Unit III:

***In situ* conservation:** International efforts and Indian initiatives; protected areas in India – Sanctuaries, national parks, biosphere reserves, wetlands and mangroves for conservation of wild biodiversity.

Unit IV:

***Ex situ* conservation:** Principles and practices; botanical gardens, field gene banks, seed banks, cryobanks, general account of the activities of Botanical Survey of India (BSI), National Bureau of Plant Genetic Resources (NBPGR). Principles of conservation; extinction; environmental status of plants based on IUCN (Now World Conservation Union). Salient features of Biodiversity Act and rules.

Select text books for reading:

- Panigrahi, A. K. and Alaka Sahu (2012): Text book on Environmental Studies. Giribala Publishing House, Berhampur.
- Conway, G. and Barbier, E. (1994). Plants, Genes and Agriculture. Jones and Bartlett, Boston, USA.
- Heywood, V. H. and Wyse Jackson, P. S. (1991). Tropical Botanical Gardens, Their role in Conservation and Development. Academic press, San Diego, USA.

Kothari, A. (1997). Understanding Biodiversity: Life sustainability and Equity. Orient Longman, New York.

Negi, S. S. (1993). Biodiversity and its Conservation in India. Indus Publishing Company, New Delhi.

Simmonds, N. W. (1979). Evolution of Crop Plants. Longman, New York.

PAPER: B-303

PLANT EMBRYOLOGY AND PLANT ANATOMY

Unit I:

Male and female gametophyte: Structure of anthers, microsporogenesis, role of tapetum, pollen development and gene expression; male sterility, sperm dimorphism and hybrid seed production, pollen germination, pollen tube growth and guidance, pollen storage, pollen allergy, pollen embryos. Female gametophyte: Ovule development, megasporogenesis; organization of the embryo sac, structure of the embryo sac cell.

Unit II:

Pollination, Pollen-pistil interaction and fertilization: Floral characteristics, pollination mechanisms and vectors, breeding system; commercial considerations, structure of the pistil, pollen stigma interactions, sporophytic and gametophytic self incompatibility (cytological, biochemical and molecular aspects), double fertilization *in vitro* fertilization.

Unit III:

Seed development and fruit ripening: Endosperm development during early, maturation and desiccation stages, embryogenesis, ultra-structure; cell lineages during late embryo development; storage proteins of endosperm and embryo; polyembryony, apomixis; embryo culture, dynamics of fruit growth and ripening; Latent life-dormancy; Importance and types of dormancy, seed dormancy, overcoming seed dormancy, bud dormancy.

Unit IV:

Plant Anatomy:

Tissue and tissue system: Meristematic tissue, distribution of mechanical tissues, apical meristem, Anomalous secondary growth (adaptive and non-adaptive), Root-shoot transition, shoot-root development, leaf development and phylotaxy, transition to flowering.

Select text books for reading:

Bewley, J. D. and Black, M. (1994). Seed: physiology of Development and Germination. Plenum, New York.

Bhojwani, S. S. and Bhatnagar, S. P. (2008). The Embryology of Angiosperms. Vikas Publishing House, New Delhi.

Raghavan, V (1997). Molecular Embryology of Flowering Plant. Cambridge University Press, Cambridge.

Raghavan, V. (1999). Developmental Biology of Flowering Plants. Springer-Verlag, New York.

PAPER: B-304
ALLIED ELECTIVE
ENVIRONMENTAL BIOLOGY

Unit I:

Ecosystem: Biotic components, abiotic substances, trophic level, food chain, food web, Energy flow in the ecosystem, Ecological pyramids, Bio-geo-chemical cycles. Ecological communities and ecosystems, inter- and intra-specific competitions, Mutualism and commensalism, predation, parasitism, amensalism, competition and coexistence.

Unit II:

Natural resources, conservation and management: Conservation of natural resources, Non-renewable energy resources, Alternative sources of energy, new concepts for alternative energy. Renewable energy resources: Water resources, uses of water, rain water harvesting, water shed management. Soil resources: Soil conservation and management. Biodiversity and its conservation.

Unit III:

Environmental Pollution: Concept of pollution, Air pollution, water pollution, terrestrial/ soil pollution, noise pollution, and radiation pollution. Source of pollutants: natural and anthropogenic pollutants.

Global warming and climate change: Global warming and climate change, Greenhouse gases (GHG), Ozone layer depletion, consequences of climate change: smog, acid rain etc.

Unit IV:

Environmental Pollution and Legislative solution: Legal remedies against pollution, Environmental Protection Act (EPA), water act, air act, environment act, Pollution Control Board, Disaster and disaster management. Environmental education and awareness, environmental audit, environmental management, environmental crisis, environmental ethics.

Select text books for reading:

Panigrahi, A. K. and Alaka Sahu (2012): Text book on Environmental Studies. Giribala Publishing House, Berhampur.

Das, R. C., Baral. J. K., Sahu, N. C. and Misra, M. K. (1998). The Environmental Divide: The Dilemma of Developing Countries. A. P. H. Publication, New Delhi.

Kumar, H. D. and S.P. Adhikary (2006). A Text Book on Environmental Engineering. India Tech Publishing, New Delhi.

Das, M.C. (2000). Fundamental of Ecology, 2nd Ed, Tata McGraw-Hill, New Delhi.

Kothari, A. (1997). Understanding Biodiversity: Life sustainability and Equity. Orient Longman, New york.

Negi, S. S. (1993). Biodiversity and its Conseravation in India. Indus Publishing Company, New Delhi.

PAPER: B-305
PRACTICAL

Based on Theory Papers B-301, B-302 and B-303

FOURTH SEMESTER
PAPER: B-401
PLANT BIOTECHNOLOGY AND TISSUE CULTURE

Unit I:

Plant nutrition, plant cell and tissue culture: Plant micro and macronutrients, vitamins and growth hormones (auxins, gibberellins, cytokinins): physiological effects and mechanism of action, Media for plant tissue culture. General introduction, history, scope, concept of cellular differentiation, totipotency. Organogenesis and adaptive embryogenesis fundamental aspects of morphogenesis, somatic embryogenesis, androgenesis, micropropagation techniques.

Unit II:

Protoplast culture: Somatic hybridization, protoplast isolation, fusion and culture, hybrid selection and regeneration. Possibilities, achievements and limitations of protoplast research. Applications of plant tissue culture: clonal propagation, artificial seed production of hybrids, somaclones, production of secondary metabolites/natural products, cryopreservation and germplasm storage.

Unit III:

Plant genomics: Introduction to plant genomics, functional genomics, transcriptomics and proteomics, comparative genomics, organelle genomes (Mitochondria and Chloroplast). Studying genomes: shotgun approach, clone contig approach, chromosome walking and jumping. Polymerase chain reaction (PCR), RT-PCR.

Analysis of genome through application of DNA fingerprinting techniques: RFLP, RAPD, AFLP, SSR, DNA micro array. Physical maps, expressed sequence tags (ESTs).

Unit IV:

Transgenic plants: Insect-, pathogen- and herbicide-resistant plants, stress and senescence tolerant plant. Genetic manipulation of flowering pigmentation and plant nutrient content, Plant as bioreactors. Edible vaccines and plant yield.

Select text books for Reading:

Glick, B. R. and Pasternak (2003). Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press, Washington, D. C., USA.

Kyte, L. and Kleyn, J. (1996). Plants From Test Tube to: an Introduction to Micropropagation, 3rd Ed. Timber press, Portland, USA.

Pollard, W. J. and Walker (1990). Plant Cell and Tissue Culture Vol VI. Humana press Clifton, USA.

PAPER: B-402 (A)
(ELECTIVE)
MICROBIAL PHYSIOLOGY

Unit I:

Microbial Growth: Microbial growth curve, Phases of growth, Mathematical expression of growth, generation time, specific growth rate. Isolation and purification of microbes, maintenance, and preservation, cultural characteristics of microbes; Synchronous and asynchronous culture, continuous culture and chemostat principle.

Unit II:

Microbial Metabolism: Heterotrophic generation of ATP, Fermentation versus respiration, Respiratory metabolism, Oxidative phosphorylation, autotrophic generation of ATP, Chemolithotrophy, Anoxic bacterial photosynthesis. Fermentation pathways (ethanol, homo and hetero lactic fermentation, mixed acid fermentation, butandiol and propanic acid, amino acid fermentation).

Unit III:

Microbes in extreme environments: Extremophiles-their nature and application, thermophilic bacteria and archaea, properties of thermophiles and thermo-enzymes, deep-sea extremophiles, halophiles, acidophiles, basophile and psychrophilic.

Unit IV:

Plant microbe interaction: Microbial interaction with plants (Rhizosphere, Mycorrhiza and root-nodule bacteria). Plant and disease: Concept, parasitism and pathogenicity, host range of pathogens, development of diseases in plants, stages of development of disease.

Select text books for Reading:

Prescott, L. M., Harley, J. P. and Klen, D. A. (1999). Microbiology, 7th Ed., McGraw-Hill, New York.

Pelczar, Jr., M. J., Chan E.C.S. and Krieg, N. R. (2005). Microbiology, 5th Ed, Tata McGraw-Hill, New Delhi.

Agrios, G. N. (2005). Plant Pathology, 5th Ed, Elsevier Academic press, USA.

**PAPER: B-402 (B)
(ELECTIVE)**

ENVIRONMENTAL SCIENCE AND ECOTOXICOLOGY

Unit-I. Scope of Environmental science; Origin of biosphere, Hunting gathering society, Physico-chemical and biological factors in the environment; Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere; Chemical transformations and biochemical transformations operating in the environment. Organizational hierarchy in the ecosystem,

Unit-II. Concept, dynamics and structure of ecosystem, interactions, energy trapping mechanism and transfer of energy; Technoecosystems. Man and bio-geo-chemical cycles, atmospheric stability, inversions and mixing heights, windroses. The Gaia hypothesis.

Unit-III. Chemical composition of air, Thermochemical and photochemical reactions in the atmosphere, Chemistry of water, Soil chemistry- inorganic and organic components of soil, nitrogen pathways and NPK in soils.

Unit-IV. Toxic chemicals in the environment, Industrial wastes in the environment, Impact of heavy metals (Hg, cadmium, arsenic and lead) in the environment, Impact of pesticides in the environment, Impact of toxicants on plants and animals - Toxicity studies, Physiological and

biochemical changes in plants and animals. Environmental impact analysis, Environmental public hearing, Environmental and ecological consequences of population growth, Human, environment and health.

Select text books for reading:

Panigrahi, A. K. and Alaka Sahu (2012): Text book on Environmental Studies. Giribala Publishing House, Berhampur.

Das, R. C., Baral. J. K., Sahu, N. C. and Misra, M. K. (1998). The Environmental Divide: The Dilemma of Developing Countries. A. P. H. Publication, New Delhi.

Kumar, H. D. and S.P. Adhikary (2006). A Text Book on Environmental Engineering. India Tech Publishing, New Delhi.

Das, M.C. (2000). Fundamental of Ecology, 2nd Ed, Tata McGraw-Hill, New Delhi.

Kothari, A. (1997). Understanding Biodiversity: Life sustainability and Equity. Orient Longman, New York.

Negi, S. S. (1993). Biodiversity and its Conseravation in India. Indus Publishing Company, New Delhi.

**PAPER: B-403 (A)
(ELECTIVE)**

MICROBIAL TECHNOLOGY

Unit I:

Microbes in recombinant DNA technology and genetic Engineering: Restriction endonucleases, Isolation, identification and purification of DNA and mRNA, synthesis of cDNA, cloning of cDNA. Vectors for cloning: plasmids, pBR 322 and derivatives, bactriophage λ and derivatives, cosmids, construction of genome and DNA libraries.

Identification of recombinant DNA, hybridization technique, blotting techniques. Gene addition and gene subtraction (antisense) techniques. DNA synthesis and sequencing. *Agrobacterium* - the natural genetic engineer of Ti and Ri plasmid, mechanism T-DNA transfer to plant

Unit II:

Microbes as Biofertilisers and Biocontrol agents: Biofertilisers and their application: *Rhizobium*, *Azotobactor*, *Azospirillum*, PGPR, Mycorrhizae, Cyanobacteria (BGA) and *Azolla*. Microbes used in control of pest and diseases, biopesticides, BT (*Bacillus thuringensis*), *Trichoderma*

Unit III:

Use of Microbes in food, feed and industry: Single cell protein: Algal protein (*Chlorella*, *Spirulina*); Fungal protein-Yeast, Mushroom cultivation; sunscreen pigments from microbes and their use: Commercial production of microbial enzymes, industrial chemicals (alkanes, butanol, ethanol, amino acid, hydrogen, organic acids), antibiotics, sterols and algal-biofuel.

Unit IV:

Microbes in environmental management: Microbes as important component of environment, role of microbes in organic composting, Microbes as indicator of water pollution, remediation of

water pollutants using biofilms, microbial soil remediation and xenobiotic degradation, microbial leaching.

Select text books for reading

- 1) Industrial Microbiology, G. Reed (editor), CBS Publishers (AVI Publishing Company), Biology of industrial microorganisms. A.L. Demain
- 2) Brown T. A. Gene Cloning and DNA Analysis. Blackwell Science, London.
- 3) Glick, B. R. and Pasternak (2003). Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press, Washington, D. C., USA.
- 4) Winnacker E - L, (2003). From Genes to Clones. Panima, New Delhi.
- 5) Callow, J. A., Ford-Lloyed, B. V. and Newbury, H. J. 1997. Biotechnology and Plant Genetic Resources: Conservation and Use, CAB International, Oxon UK.
- 6) Glazer, A. N. and Nikaido, H. 1995. Microbial Biotechnology. W. H. Freeman & Company, New York, USA.
- 7) Gustafson, R. J. 2000. Genomes. Kluwer Academic Plenum Publishers, New York, USA.
- 8) Henry, R. J. 1997. Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK.
- 9) Jolles, O. and Jornvall, H. (eds) 2000. Proteomics in Functional Genomics. Birkhauser Verlag, Basel, Switzerland.
- 10) Old, R. W. and Primrose, S. B. 1989. Principles of Genome Analysis. Blackwell Scientific Publications. Oxford, UK.
- 11) Primrose, S. B. 1995. Principles of Genome Analysis. Blackwell Scientific Ltd., Oxford, UK.
- 12) Watson, J. , Tooze and Kurtz Recombinant DNA: A short course

PAPER: B-403 (B) (ELECTIVE)

ENVIRONMENTAL MANAGEMENT

Unit-I. Environmental pollution and management. Cause, sources and impact of air pollution, water pollution and land pollution, Radiation pollution, Thermal pollution. Industrial pollution and its waste (Effluent and solid waste) management in South Odisha..

Unit-II. Ozone layer depletion, Green house effect and global warming and its management, Nature and effect and treatment of chemical wastes, sewage and sewage treatment, Abatement of pollution, Environmental pollution and legislative solutions, constitutional remedies, Legal remedies against pollution. Environmental act. Environmental education and awareness, Environmental audit, Environmental crisis, Forest and forest management.

Unit-III. Disaster management, environmental management, Sustainability and economic development. Strategies for conservation of biodiversity, loss of biodiversity, Threat to biodiversity loss & habitat loss, poaching of wild life, water resource conservation and management of water resources. Water conservation measures, conservation of fresh water resources, Use and overuse of waters, Land resource and desertification.

Unit-IV. Natural resources and conservation: Kinds of natural resources, Non-renewable energy resources, renewable energy resources, Mainstream forms of renewable energy-wind power, hydropower, solar energy, tidal power, biomass, biogas, biodiesel, geothermal energy, artificial photosynthesis. Alternative sources of energy, Coal to wood, petroleum to whole oil, alcohol to fossil fuel, coal gas to petroleum, Relatively new concepts of alternative energy (algal fuel, biodiesel from algae, photo bioreactors, biomass briquettes, biological hydrogen production.

Select text books for reading:

Panigrahi, A. K. and Alaka Sahu (2012): Text book on Environmental Studies. Giribala Publishing House, Berhampur.

Kumar, A. Water pollution, Daya Publishing House, New-Delhi

Das, M.C. (2000). Fundamental of Ecology, 2nd Ed, Tata McGraw-Hill, New Delhi.

Kothari, A. (1997). Understanding Biodiversity: Life sustainability and Equity. Orient Longman, New york.

Negi, S. S. (1993). Biodiversity and its Conseravation in India. Indus Publishing Company, New Delhi.

PAPER: B-404

Seminar and Field Study/ Industrial Visit/Scientific Visit

[Each student will deliver two seminar presentations per year and at-least one seminar per semester. In first three semesters, the presentation of students will be evaluated by staff members and will be purely internal. The final semester seminar presentation along with field study report will be evaluated by an external examiner in presence of staff members.]

PAPER: B-405 (A / B)

PRACTICAL

Based on Theory Papers B-402 and B-403 (Specialization Based A / B)