**M. Sc. BOTANY**

**Department of Botany, Banaras Hindu University**

**PROPOSED DISTRIBUTION OF DIFFERENT COURSES AND CREDITS IN VARIOUS SEMESTERS**

**SEMESTER-I**

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| **Course Code** | **Title** | **Credits** |
| BOM101 | Phycology | 3 |
| BOM102 | Mycology | 3 |
| BOM103 | Microbiology | 3 |
| BOM104 | Angiosperms | 3 |
| BOM105 | Lab work based on Courses BOM101 & bom102 | 3 |
| BOM106 | Lab work based on Courses BOM103 & bom104 | 3 |
| BOM107 | Field Study / Tour | 2 |
| **Total** | **20** |

**SEMESTER-II**

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| **Course Code** | **Title** | **Credits** |
| BOM201 | Plant Ecology | 3 |
| BOM202 | Bryophytes, Pteridophytes and Gymnosperms | 3 |
| BOM203 | Cytology, Genetics and Genomics | 3 |
| BOM204 | Plant Physiology  | 3 |
| BOM205 | Lab work based on Courses BOM201 & bom202 | 3 |
| BOM206 | Lab work based on Courses BOM203 & bom204 | 3 |
| BOM207M | *Minor Elective: Herbal Medicine (For students of other PG Programmes. M.Sc. Botany students shall opt Minor Electives from other Programmes of the Faculty of Science)* | 2 |
|  **Total** | **20** |

**SEMESTER-III**

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| **Course Code** | **Title** | **Credits** |
| BOM301 | Plant Biochemistry  | 3 |
| BOM302 | Cell and Molecular Biology  | 3 |
| BOM303 | Biodiversity and Biostatistics | 3 |
| BOM304 | Biotechnological and Molecular Techniques and Bioinformatics  | 3 |
| BOM305 | Lab work based on Courses BOM301 & bom302 | 3 |
| BOM306 | Lab work based on Courses BOM303 & bom304 | 3 |
| BOM307M  | *Minor Elective: Biofertilizer Technology (For students of other PG Programmes. M.Sc. Botany students shall opt Minor Electives from other Programmes of the Faculty of Science)* | 2 |
| **Total** | **20** |

**SEMESTER-IV**

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| **Course Code** | **Title** | **Credits** |
| BOM401(A-C) | *Major Electives* (any one course out of BOM401A, BOM401B, BOM401C) | 3 |
| BOM402(A-C) | *Major Electives* (any one course out of BOM402A, BOM402B, BOM402C) | 3 |
| BOM403(A-C) | *Major Electives* (any one course out of BOM403A, BOM403B, BOM403C) | 3 |
| BOM404(A-C) | Lab. work based on corresponding courses of BOM401A to bom401C | 2 |
| BOM405(A-C) | Lab work based on corresponding courses of BOM402A to bom402C | 2 |
| BOM406(A-C) | Lab work based on corresponding courses of BOM403A to bom403C | 2 |
| BOM407 | Presentation of Seminar based on dissertation | 2 |
| BOM408 | Dissertation | 3 |
| **Total** | **20** |
| **Grand total** | **80** |

**Major Electives *(Special Papers)***

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| BOM401A: Air Pollution and Climate change | BOM402A: Conservation and Restoration Ecology | BOM403A: Molecular Stress Biology and Biotechnology of Cyanobacteria |
| BOM401B: Photobiology, Molecular Microbiology and Synthetic Biology | BOM402B: Environmental and Applied Microbiology | BOM403B: River Ecology and Water Management |
| BOM401C: Plant Pathology and Plant Protection | BOM402C Plant *In-vitro* Culture, Gene Expression and Genetic Manipulations | BOM403C: Microbial Genetics and Biotechnology |

\*Two external examiners of respective specializations may be appointed for each Lab. work.

**SEMESTER-I**

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| **BOM101: Phycology Credits: 3** |  |
| **Section: A**1. Algae in diverse habitats, symbiotic associations of algae
2. Algal classification, current developments, molecular phylogeny of algae
3. A general account of thallus organization and reproduction in Chloropyta, Phaeophyta and Rhodophyta.
4. Cyanobacteria: Cell structure, movement and photosynthetic pigments.
5. A brief account of Chrysophyta, bacillariophyta, Pyrrophyta, Euglenophyta, Eustigmatophyta and Prasinophyta

**Section: B**1. Role of algae in global climate regulation: carbon concentration and sequestration mechanisms including calcification; DMSP and DMS production
2. Biofuel production technology, prospects and limitations
3. Algal blooms –triggering factors, dynamics of bloom formation
4. Toxins of cyanobacteria, dinoflagellates and diatoms – mode of action and ecological significance
5. Algae and cyanobacteria as a source of bioactive molecules (antimicrobial and anticancer)
6. Regulation of heterocyst and akinete differentiation in cyanobacteria
7. Cyanobactertial biofertilizers in paddy cultivation

**Suggested readings**1. Barsanti L, Gualtieri P (2006) Algae: Anatomy, Biochemistry and Biotechnology, CRC Press, Taylor and Francis, [Boca Raton](https://www.google.co.in/search?biw=1366&bih=666&noj=1&q=Boca+Raton+Florida&stick=H4sIAAAAAAAAAOPgE-LUz9U3ME7LK09S4gAxk03LjLSMMsqt9JPzc3JSk0sy8_P084vSE_MyqxJBnGKrjNTElMLSxKKS1KJihZz8ZLAwALBfqwdLAAAA&sa=X&ved=0ahUKEwjb8qeOxIvMAhUGH5QKHQrjDH8QmxMIiAEoATAQ).
2. Bold HC, Wynne MJ (1985) Introduction to the Algae, 2nd edition, Prentice-Hall Inc, New Jersey.
3. Kumar HD (1999) Introductory Phycology, 2nd edition, Affiliated East-West Press Pvt. Ltd., New Delhi
4. Fritsch FE (1935) The Structure and Reproduction of the Algae, Vol I, Cambridge University Press, Cambridge.
5. Fritsch FE (1945) The Structure and Reproduction of the Algae, Vol II, Cambridge University Press, Cambridge.
6. Lee RE (2008) Phycology, 4th edition, Cambridge University Press, Cambridge.
7. Pandey A, Chisti Y, Lee D J, Soccol CR (2013) Biofuels from Algae, 1st edition, Elsevier Publishing Group, USA.
8. Rossini GP, (2014) Ed: Toxins and Biologically active Compounds from Microalgae, Vol 2, Biological Effects and Risk Management, CRC Press, Taylor and Francis Group, [Boca Raton](https://www.google.co.in/search?biw=1366&bih=666&q=Boca+Raton+Florida&stick=H4sIAAAAAAAAAOPgE-LUz9U3ME7LK09S4gAxk03LjLSMMsqt9JPzc3JSk0sy8_P084vSE_MyqxJBnGKrjNTElMLSxKKS1KJihZz8ZLAwALBfqwdLAAAA&sa=X&ved=0ahUKEwiXgaWq1IvMAhXFmJQKHZCbAyYQmxMIiwEoATAQ).
9. South GR, Whittick A (1998) Introduction to Phycology, Blackwell Scientific Publication, London.
10. Tebbani S, Filali R, Lopes F, Dumur D, Pareau D (2014) CO2 Biofixation by Microalgae: Modelling, Estimation and Control, Wiley-ISTE, New York.
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| **BOM 102: Mycology Credits: 3** |  |
| 1. Introduction, scope and general principles of classification of fungi
2. Myxomycotina: Plasmodiophorales and [Dictyosteliales](http://eol.org/pages/5754/overview)
3. Mastigomycotina: Chytridiales, Blastocladiales, Saprolegniales and Peronosporales
4. Zygomycotina: Mucorales and Entomophthorales
5. Evolutionary trends in conidial development and their variation in Zygomycotina
6. Ascomycotina: Endomycetales, Protomycetales, Taphrinales, Erysiphales, Eurotiales, Pezizales and Hypocreales
7. Basidiomycotina: Uredinales, Ustilaginales, Lycoperdales, Phallales, Agaricales and Aphyllophorales
8. Deuteromycotina: Sphaeropsidales, Moniliales and Mycelia sterilia, Parasexuality
9. Degeneration of sexuality in fungi
10. Lichens: Thallus structure, reproduction and economic importance

**Suggested readings**1. Webster John (1980) Introduction to fungi, Cambridge University Press, Cambridge.
2. Alexopoulos CJ, Minus CW, Blackwell M (1996) Introductory Mycology, John Wiley and Sons, Inc, New York.
3. Carlile MJ, Watkinson SC, Booday GW (2001) The Fungi, Academic Press, Cambidge.
4. Maheshwari R (2012) Fungi: Experimental Methods in Biology, CRC Press, Boca Raton, Florida.
5. Deacon JW, Blackwell M (1997) Introduction to Modern Mycology, Oxford.
6. Webster J, Roland WS (2007) Introduction to Fungi, Cambridge University Press, Cambridge.
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| **BOM103: Microbiology Credits: 3** |  |
| 1. Brief history, present status and future challenges of microbiology
2. A brief account of microbial diversity; evolution of microorganisms – RNA world hypothesis, endosymbiotic theory; a general account of Archaea
3. Isolation, purification and establishment of pure culture of microorganisms; major types of cultures – batch, continuous and synchronous
4. Nutritional types of microorganisms; symbiotic associations - *Rhizobium*-legume symbiosis and mycorrhiza
5. Anoxygenic photosynthesis with special reference to light reaction in purple bacteria; methanogenesis
6. Genetics of bacteria: Genetic recombination- an overview; mechanisms of transformation, conjugation and transduction in bacteria; role of microorganisms in genetic engineering
7. Lytic cycle in T even phages and their regulation; lysogeny and its regulation in lambda phage; a brief account of viroids and prions
8. Role of microbes in wastewater treatment with special reference to activated sludge
9. Basic design of a fermenter
10. Biosensors and their applications

**Suggested readings** 1. Madigan MT, Martinko JM, Bender KS, Buckley DH, Stahl DA (2014) Brock Biology of Microorganisms, 14th edition, Benjamin Cummings, New York.
2. Stanier RY, Ingraham JL, Wheelis ML, Painter PR (1987) General Microbiology, 5th edition, MacMillan, Press Ltd, New Jersey.
3. Talaro KP, Chess B (2011) Foundations in Microbiology, 8th edition, McGraw-Hill, New York.
4. Willey JM, Sherwood L, Woolverton CJ (2013) Prescott’s Microbiology, 9th edition, McGraw-Hill, New York.
5. Pelczar M.J., Chan E.C.S. and Krieg N.R. (2003) Microbiology. 5th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi.
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| **BOM104: Angiosperms Credits: 3** |  |
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| 1. Angiosperms: Apomorphies, evolutionary trends in characters, fossil angiosperms
2. Systematics: Principles and outline of classification: Takhtajan, merits and demerits
3. Botanical nomenclature: International code of botanic nomenclature; principles: rules and recommendations; priority; typification; rules of effective and valid publications; retention and choice of names
4. Taxonomic features, systematic phylogeny and economic importance of families**:** Magnoliaceae, Capparidaceae, Caryophyllaceae, Asteraceae,Apocynaceae, Boraginaceae, Convolvulaceae, Scrophulariaceae, Acanthaceae, Bignoniaceae, Lamiaceae, Verbenaceae, Polygonaceae, Euphorbiaceae, Orchidacae, Amaryllidaceae, Araceae and Arecaceae
5. Numerical taxonomy: Aims and objectives, characters and attributes, OTUs, coding, cluster analysis, merits and demerits
6. Chemotaxonomy**:** Role of phytochemicals (non-protein amino acids, alkaloids, betalins, cynogenic glucosides) in taxonomy
7. Biosystematics: Concepts; biosystematic categories; methods in experimental taxonomy
8. Embryology in relation to taxonomy
9. Molecular approaches to plant taxonomy: Application of DNA markers in angiosperm taxonomy; molecular phylogeny, angiosperm phylogeny groups
10. Experimental embryology: Haploid production; embryo culture

 **Suggested readings**1. Singh G (1999) Plant Systematics- Theory and Practices, Oxford and IBH Publishing Co, New Delhi.
2. Bhojwani SS, Bhatnagar SP (1996) Embryology of Angiosperms, Vikash Publishing House, New Delhi.
3. Judd WS, Christopher S, Campbell, Kellogg AE, Stevens PF (1999) Plant Systematics: A Phylogenetic Approach, Sinauer Associates Inc Publishers, Sunderland, Massachusetts.
4. Simpson MG (2006) Plant Systematics, Elsevier Academic Press, Amsterdam.
5. Verma BK (2011) Introduction to Taxonomy of Angiosperms, PHI Learning, New Delhi.
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**BOM 105: Lab Work Based on Courses BOM 101 and BOM 102**

**Phycology**

1. Study of representative genera of classes included in the course BOM101
2. Study of algal blooms
3. Determination of lipid in microalgae and cyanobacteria
4. Heterocyst differentiation in cyanobacteria using various nitrogen sources
5. Extraction of bioactive compounds from microalgae or cyanobacteria

**Mycology**

1. Preparation of culture media and isolation of fungi from soil, water and air
2. Isolation of chytrids through baiting technique
3. Study of following fungi of different groups
	1. Mastigomycotina: *Synchytrium, Saprolegnia, Peronospora, Phytophthora* and *Albugo*
	2. Zygomycotina: *Mucor, Rhizopus and Pilobolus*
	3. Ascomycotina: *Protomyces, Taphrina, Erysiphe, Phyllactinia, Uncinulla* and *Peziza*
	4. Basidiomycotina: *Melampsora, Uromyces, Ustilago* and *Puccinia*
	5. Deuteromycotina**:** *Aspergillus, Fusarium, Helminthosporium, Colletotrichum, Alternaria, Cercospora, Penicillium* and *Trichoderma*
4. Study of some specimens of mushrooms, fruiting bodies and lichens

**BOM 106: Lab Work Based on Courses BOM 103 and BOM 104**

**Microbiology**

1. Preparation of culture media and sterilization techniques
2. Methods for isolation and establishment of pure culture of microorganisms
3. Study of growth performance of a bacterium in batch culture and determination of specific growth rate and generation time
4. Gram staining of microbial cultures
5. Qualitative tests for microbial activities; nitrate reduction, starch hydrolysis, and urease and catalase activities
6. Counting of bacteria in environmental samples
7. Study of sensitivity of bacteria to various antibiotics
8. Detection of coliform bacteria in sewage
9. Plaque assay for bacteriophage/cyanophage
10. Demonstration of molecular tools and techniques in microbiological studies

**Angiosperms**

1. Taxonomic description of plants of families namely, Capparidaceae, Caryophyllaceae, Asteraceae, Apocynaceae, Boraginaceae, Convolvulaceae, Scrophulariaceae, Acanthaceae, Bignoniaceae, Lamiaceae, Verbenaceae, Polygonaceae, Euphorbiaceae, Amaryllidaceae, and other locally available families
2. Dissection of globular/heart- shaped embryo from suitable materials
3. Plant collection: Identification, preservation and submission of at least 30 herbarium sheets, survey of local flora and preparation of report

 **SEMESTER-II**

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| **BOM 201: Plant Ecology Credits: 3** |  |
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| 1. Definition and composition of soil, soil development, factors of soil formation, pedogenic regimes, soil properties
2. Population concepts: Characteristics, dynamics, density dependent and independent factors; population control, life history strategies (r and K selection, CAR strategy).
3. Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, prey – predator, parasitism, symbiosis
4. Community organization and characteristics: Concepts of community and continuum; community coefficients; ecological niche.
5. Ecological succession: Models and mechanisms of ecological succession; changes in ecosystem properties during succession
6. Ecosystem organization: Structure and functions; primary production (methods of measurement, global pattern, controlling factors); energy dynamics (trophic organization, energy flow pathways, ecological efficiencies); decomposition (mechanism, controlling factors); comparative account of nutrient cycles
7. Ecosystem stability: Concept (resistance and resilience); ecological perturbations (natural and anthropogenic) and their impact on ecosystems; ecology of plant invasion.
8. Environmental pollution: Kinds, sources, effects on plants and ecosystems
9. Global change: greenhouse gases, consequences of climate change; ozone layer depletion, causes and consequences

**Suggested reading**1. Odum EP, Barret GW (2005) Fundamentals of Ecology, Thomson Ed. Brooks/Cole, Cengage Learning India Pvt Ltd, New Delhi.
2. Odum EP (1983) Basic Ecology, Saunders College Pub, Philadelphia.
3. Kormondy EJ (1996) Concepts of Ecology, Prentice-Hall, [New Jersey](https://en.wikipedia.org/wiki/Upper_Saddle_River%2C_New_Jersey).
4. Singh JS, Singh SP, Gupta SR (2014) Ecology, Environmental Science and Conservation, S Chand & Co, New Delhi.
5. Pungnaire FI, Valladares F (2007) 2nd Edition, Functional Plant Ecology CRC Press/Taylor & Francis Group, Boca Raton, Florida
6. Schulze ED, Beck E, Hohenstein K (2005) Plant Ecology Springer-Verlag Berlin Heidelberg, New York
7. [Barbour, M. G.](http://www.cabdirect.org:80/search.html?q=au%3A%22Barbour%2C+M.+G.%22); [Burk, J. H.](http://www.cabdirect.org:80/search.html?q=au%3A%22Burk%2C+J.+H.%22); [Pitts, W. D.](http://www.cabdirect.org:80/search.html?q=au%3A%22Pitts%2C+W.+D.%22) (1987) 2nd Edition Terrestrial Plant Ecology. The Benzamin/Cummings Publishing Company, San Francisco

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| **BOM202: Bryophytes, Pteridophytes and Gymnosperms Credits: 3** |  |
| **Bryophytes**1. Classification of Bryophytes
2. Origin, evolution and phylogeny of Bryophytes
3. Comparative account of gametophyte structure
4. Sporophytic structure and evolution; peristome structure and its significance in the classification of mosses

 **Pteridophytes**1. Classification of Pteridophytes
2. Evolution of vascular systems in plants
3. Early vascular plants: Rhyniophyta, Trimerophytophyta and Zosterophylophyta
4. Brief account of structure and reproduction in ferns
5. Telome concept, apogamy and apospory, heterospory and seed habit

**Gymnosperms**1. General features of Gymnosperms and their classification
2. Kinds of fossils, process of fossilization
3. General account of Glossopteridaceae
4. Comparative study of Coniferales (Pinaceae, Cupressaceae, Araucariaceae, Podocarpaceae, Cephalotaxaceae, Taxodiaceae), Taxales and Gnetales (Gnetaceae, Ephedraceae and Welwitschiaceae)

**Suggested readings**1. Parihar NS (1973) An Introduction to Embryophyta, Vol I (Bryophyta) and Vol II (Pteridophyta), Central Book Department, Allahabad.
2. Sambamurty AVSS (2005) A Textbook of Bryophytes, Pteridophytes, Gymnosperm and Palaeobotany, IK International Pvt Ltd, New Delhi.
3. Rashid A (2011) An Introduction to Pteridopyta, 2nd edition, Pub Vikas Publishing House Pvt Ltd, Noida.
4. Sporne KR (1967) Morphology of Gymnosperms, BI Publication, New Delhi.
5. Bhatnagar SP, Moitra A (1996) Gymnosperms, New Age international Ltd Publication, New Delhi.
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| **BOM-203: Cytology, Genetics and Genomics Credits: 3** |  |
| 1. Organization and replication of chromatin: Nucleosome and higher order organization of chromatin, conformational changes in chromatin and genetic activity, assembly/deassembly of nucleosomes during chromatin replication
2. Cytogenetics of haploids: haploidy vs. monoploidy, meiosis and breeding behaviour of haploids, uses of haploids in plant breeding and genetic studies
3. Chromosome banding patterns: Linear differentiation of chromosome segments, types of chromosome banding, uses of chromosome banding in cytogenetics
4. Chromosome engineering: transfer of gene through individual chromosome, alien addition and substitution lines; characterization and utility
5. Epigenetics : Concept and scope of epigenetics, chromatin remodelling through histone modifications, remodelling of chromatin through DNA methylation, techniques for studying epigenetic mechanisms (immunoprecipitation- ChiP, Chip-Seq)
6. Genomes and functional genomics: Genome size and C-value paradox, repetitive DNA, split genes, overlapping genes, reverse genetics, gene silencing, genome editing tools and its biology (ZFNs,TALENs,CRISPR/Cas9)
7. Plant breeding and crop improvement: Objectives and scope of plant breeding, inbreeding depression and heterosis, QTL and QTL analysis, hybrids using male sterile lines, somatic hybridization, transgenesis (Agrobacterium-mediated gene transfer) and transgenic plants, molecular farming

 **Suggested readings**1. Clark MS, Wall WJ (1996) Chromosomes: The Complex Code, Chapman & Hall, London.
2. Sharma AK, Sharma A (1985) Advances in Chromosome and Cell Genetics, Oxford & IBH Publishing Co, Kolkata.
3. [Krebs](https://www.google.co.in/search?sa=X&hl=en&biw=1366&bih=653&tbm=bks&tbm=bks&q=inauthor:%22Jocelyn+E.+Krebs%22&ved=0ahUKEwibltSLiffLAhVEcI4KHYEQDgUQ9AgIQDAE) JE, ‎ [Lewin](https://www.google.co.in/search?sa=X&hl=en&biw=1366&bih=653&tbm=bks&tbm=bks&q=inauthor:%22Benjamin+Lewin%22&ved=0ahUKEwibltSLiffLAhVEcI4KHYEQDgUQ9AgIQTAE) B, ‎ [Goldstein](https://www.google.co.in/search?sa=X&hl=en&biw=1366&bih=653&tbm=bks&tbm=bks&q=inauthor:%22Elliott+S.+Goldstein%22&ved=0ahUKEwibltSLiffLAhVEcI4KHYEQDgUQ9AgIQjAE) ES (2011) Genes X, Sudburry, Masschusetts.
4. Gupta PK (2007) Cytogenetics, Rastogi Publication, Meerut.
5. Gardner EJ, Simmons MJ, Snustad DP (2006) Principals of Genetics, 8th edition, John Wiley & Sons, Wiley India Edition, New Delhi.
6. Alberts B, Bray D, Lewis J, Ralf M, Roberts K, Watson JD (1999) Molecular Biology of the Cell, Garland Publishing Inc, New York.
7. Allard RW (1999) Principles of Plant Breeding, 2nd edition, John Wiley and Sons, New York.
8. Hartl DL, Jones EW (2007) Genetics–Analysis of Genes and Genomes, 7th edition, Jones and Barlett publishers, [Burlington](https://www.google.co.in/search?biw=1366&bih=666&q=Burlington+Massachusetts&stick=H4sIAAAAAAAAAOPgE-LSz9U3MEmpyjMwVuIEsQ1zjXILtbSyk63084vSE_MyqxJLMvPzUDhWGamJKYWliUUlqUXFAAriKyBFAAAA&sa=X&ved=0ahUKEwj9gaSzwJLMAhVBWo4KHdjkAQoQmxMIgQEoATAS).
9. David CA, et al., (2007) Epigenetics, 2nd edition, Cold Spring Harbor Laboratory Press, New York.
10. [Spillane](http://link.springer.com/search?facet-creator=%22Charles+Spillane%22) C, [McKeown](http://link.springer.com/search?facet-creator=%22Peter+C.+McKeown%22) PC (2014) Plant Epigenetics and Epigenomics: Methods and Protocol, Springer Publisher, London.

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| **BOM204: Plant Physiology Credits: 3** |  |
| 1. Water relations: Properties of water, water in tissues and cells (water potential)
2. Transport of water, solutes and translocation: Uptake, transport and translocation of water, ions, solutes from soil , across membrane (passive and active transports), through xylem and phloem; mechanisms of loading and unloading of photoassimilates
3. Photosynthesis: Basic principles of light absorption, light harvesting complexes; excitation energy transfer, mechanism of electron transport, photosynthetic quantum yield and energy conversion efficiency in different environmental conditions. A comparison of C3, C4 and CAM plants and photorespiration
4. Senescence: Physiology of senescence, senescence promoters, Programmed cell death
5. Physiological responses and acclimation of physiological processes to abiotic stresses: Light, temperature, water and salts
6. Sensory photobiology: Discovery of phytochromes; photochemical and biochemical properties of phytochromes Cellular localisation; molecular structure and photophysiology of light induced responses; mechanism of action; Signal transduction and gene expression
7. Plant growth regulators: Biosynthesis, storage and mechanism of action of plant growth hormones (auxins, gibberellins, cytokinins, abscisic acid and ethylene), hormone receptors, signal transduction and gene expression
8. The flowering process: Photoperiodism and its significance, endogenous clock and its regulation, floral induction and development

**Suggested readings**1. Buchanan BB, Gruisemm W, Jones RL (2015) Biochemistry and Molecular Biology of Plants, 2nd edition, Wiley Blackwell, New Jersey.
2. Hopkins WG, Huner NPA (2009) Introduction to Plant Physiology, 4th edition Wiley International edition, John Wiley & Sons, New York.
3. Taiz L, Zeiger E, Moller IM, Murph A (2015) Plant Physiology and Development, 6th edition, Sinurer Associates Inc Publishers, Sunderland, Massachusetts.
4. Frank B. Salisbury and Cleon W. Ross (1985) Plant Physiology Wadsworth Publishing Company, Belmont, California.
5. Robert M. Devlin (3rd edition) (1975) Plant Physiology Van Nostrand Reinhold Company, New York.
6. Walter Larcher (4th edition) (2003) Physiological Plant Ecology: Ecophysiology and Stress Physiology of Functional Groups Springer Verlag, Berlin.
7. Hans Mohr and Peter Schopfer (2010) Plant Physiology Springer Verlag, Berlin.
8. Edwin Oxlade (2007) Plant Physiology: The Structure of Plants Explained Glmp Ltd, Abergele, United Kingdom.
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**BOM 205: Lab Work Based on Courses BOM 201 and BOM 202**

**Plant Ecology**

1. Determination of the biomass distribution in different plant components of herbaceous community
2. Determination of net production in a herbaceous community
3. Analysis of distribution pattern of selected species in a grassland ecosystem
4. To compare moderately and heavily disturbed grassland stands using community coefficients (Jaccard, Sorenson)
5. Determination of dominant species for the assured stands by calculating the IVI (R-density + R frequency + R-dominance)
6. Study of the species area relationship
7. Determination of organic carbon and organic matter contents of soils collected from different habitats
8. Estimation of the dissolved oxygen content in different water samples
9. To estimate chlorophyll content in plant leaves collected from control and polluted sites
10. Estimation of the available phosphorus content in soil collected from different habitats

**Bryophytes, Pteridophytes and Gymnosperms**

1. **Bryophyta**

 Study of morphology, anatomy and reproductive structures of following Bryophytes:

 1*. Plagiochasma*

2*. Targionia*

3*. Porella*

4*. Notothylus*

5*. Sphagnum*

6*. Polytrichum .*

**B) Pteridophyta**

Study of morphology and anatomy of following Pteridophytes:

 1*. Lycopodium*

2*. Equisetum*

3*. Adiantum*

4*. Lygodium*

5*. Salvinia*

6*. Isoetes*

**C) Gymnosperms**

 Study of morphology and anatomy of following Gymnosperms:

 1. *Cedrus* 4*. Cephalotaxus*

2*. Araucaria* 5*. Taxus*

3*. Biota* 6*. Ephedra*

7*. Gnetum*

**BOM 206: Lab Work Based on Courses BOM 203 & BOM 204**

**Cytology, Genetics and Genomics**

* 1. Determination of circadian rhythms in mitotic cycle of *Allium/Vicia faba*
	2. Preparation of metaphase squashes and karyotype analysis in *Allium* and *Aloe*
	3. Feulgen staining of chromosomes
	4. Linear differentiation of chromosomes using G- banding technique in *Allium*/*Zea mays*
	5. Meiosis in *Rhoeo/Tradescantia* to study permanent translocation heterozygosity
	6. Construction of linkage map using available data
	7. To workout various steps of the process of artificial hybridization in self and cross fertilized plants
	8. Demonstration of QTLs utilizing available data

**Plant Physiology**

1. Isolation of chloroplasts from spinach leaf
2. Chromatographic separation of pigments and analysis of absorption spectra of Chl *a*, Chl *b* and carotenoids
3. Demonstration of Hill reaction using DCPIP reduction
4. Assay of guaiacol peroxidase activity in *Cyanodon dactylon*
5. To determine the chlorophyll a and b and total chlorophyll in young and senescing leaves of *Carica papaya*
6. Estimation of the concentration of ascorbic acid in green leaf samples
7. To find out the effect of temperature, organic solvent and salt on permeability behaviour of cells of beet root (*Beta vulgaris*)
8. To estimate catalase activity in stressed and unstressed plants

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| **BOM 207M: Herbal Medicine Credits: 2** 1. Diagnostic features, bioactive molecules and therapeutic values of some common medicinal plants *viz.,* Giloy, Brahmi, Safed musli, Amla, Kalmegh, Satavari, Bel, Sarpgandha, Ashwagandha, Aloe, Tulsi, Ashok, *Centella asiatica*
2. Standardisation of herbal drugs
3. Commercial cultivation of medicinal plants
4. Conservation of medicinal plants
5. Nutraceuticals and medicinal foods
6. Bioprospecting, biopiracy and protection of traditional medicinal knowledge, IPR

**Suggested readings**1. Cultivation of Selected Medicinal Plants, National Medicinal Plant Board, 36, Janpath, New Delhi.
2. Mandal SC, Mandal V, Das AK (2015) Essentials of Botanical Extraction: Principles and Applications, Academic Press, Elsevier, Amsterdam.
3. Prajati ND, Purohit SS (2006) A Hand Book of Medicinal Plants, Agrobios, Jodhpur, India.
4. Samant SS and Palini LMS (1998) Medicinal Plants of Himalaya: Diversity, Distribution and Potential Values, Gyonadra Prakashan, Nainital.
5. Singh MP (2011) Indigenous Medicinal Plants, Social, Foresting and Tribals, Daya Publishing House, New Delhi.
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**SEMESTER-III**

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| **BOM301: Plant Biochemistry Credits: 3**1. Properties of water, law of mass action, dissociation of water and its ion product (Kw), pH, ionization of weak acids and weak bases, the Henderson-Hasselbalch equation, biological buffers
2. Structure and formation of peptide bonds, Ramachandran plot
3. Biochemical energetics: General concept, laws of thermodynamics, entropy, enthalpy, free energy, redox-potential
4. Energetics of metabolic processes: Energy rich phosphorus compounds, ATP as universal currency of energy, ATP synthesis, electron transport and phosphorylation, alternate oxidase system, β-oxidation of fatty acids
5. Enzymology: General aspects, prosthetic groups and coenzymes, mechanism of catalysis, kinetics, Michaelis-Menten equation, bisubstrate reactions, active sites, factors contributing to the catalytic efficiency, enzyme inhibition, regulatory enzymes, ribozymes
6. Biological nitrogen fixation: Nitrogenase enzyme, substrates for nitrogenase, reaction mechanism, strategies to exclude oxygen and need to control hydrogen evolution, regulation of nitrogenase
7. Inorganic nitrogen metabolism: Introduction, nitrate transport, nitrate and nitrite reductases, inhibitors of nitrate and nitrite reductases, regulation of nitrate and nitrite reductases, pathways of ammonia assimilation, regulation of nitrogen assimilation
8. Sulphur and phosphorus metabolism: Sulphate uptake, activation and transfer,

assimilatory pathways of sulphate reduction, transport and assimilation of phosphate **Suggested readings** 1. Cox MM, Nelson DL (2011) Lehninger Principles of Biochemistry, 5th edition, Freeman, WH & Company, New York.
2. Berg JM, Tymoczco JL, Stryer L (2002) Biochemistry, 7th edition, Freeman, WH & Company, New York.
3. Buchanan BB, Gruisemm W, Jones RL (2015) Biochemistry and Molecular Biology of Plants, 2nd edition, Wiley Blackwell, New Jersey.
4. Voet D, Voet JG, Pratt CW (2013) Principles of Biochemistry, 4th edition, John Wiley & Sons Pvt Ltd, Singapore.
5. Weil JH (2013) General Biochemistry, 6th edition, Wiley Eastern Limited, New Delhi.
6. Devlin TM (2011) Text Book of Biochemistry, 7th edition, John Wiley & Sons, New York.
7. Zubay G (1998) Biochemistry, 2nd edition, Macmillan Publishing Company, New York.
8. Garret RH, Grishan CM (1999) Biochemistry, 2nd edition, Saunders College Publishing, New York.
9. Conn EE, Stumpf PK (1976) Outlines of Biochemistry, 5th edition, Wiley Eastern Ltd, New Delhi.
10. Campbell MK, Farrell SO (2006) Biochemistry, Cengage Learning India Pvt Ltd, New Delhi.

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| **BOM 302: Cell and Molecular Biology Credits: 3** |  |
| 1. Cell:Concept
2. Mitochondria: Structure, genome organization, protein import and mitochondrial assembly
3. Chloroplast: Structure, genome organization, import and sorting of chloroplast proteins
4. Endoplasmic reticulum: Structure, translocation of secretory proteins across ER membrane, insertion of protein into ER membrane, protein folding and processing.
5. Golgi apparatus: Organization, protein glycosylation, protein sorting and export from Golgi, the vesicular transport mechanism
6. Nucleus: Nuclear envelop, nuclear pore complex, trafficking between nucleus and cytoplasm.
7. Gene and genome: Fine structure of gene, genome organization in prokaryotes and eukaryotes
8. DNA/gene manipulating enzymes: endonuclease, exonuclease, ligase, polymerase, phosphatase, transcriptase, transferase, topoisomerase
9. DNA replication: Unit of replication, enzymes involved, origin of replication and replication fork, fidelity of replication, extrachromosomal replicons.
10. DNA damage and repair: Thymine dimer, 6-4 photoproducts, photoreactivation, excision repair
11. Genetic recombination: Homologous and non-homologous recombination, site-specific recombination
12. Programmed cell death (apoptosis): factors, molecular mechanisms, malfunctioning and significance

**Suggested readings**1. Lodish H, Berk A, Kaiser CA, et al. (2013) Molecular Cell Biology, 7th edition, WH Freeman and Comp, New York.
2. Brown TA (2006) Gene Cloning and DNA Analysis, Blackwell Publishers, Oxford.
3. Krebs JE, Goldstein E, Kilpatrick ST (2014) Lewin’s Genes XI, Jones & Bartlett Learning, Burlington.
4. Karp G (2009) [Cell and Molecular Biology: Concepts and Experiments](https://books.google.co.in/books?id=arRGYE0GxRQC&printsec=frontcover&dq=4.%09Karp+G+(....)+Cell+Biology,&hl=en&sa=X&ved=0ahUKEwjblLSck_fLAhULWY4KHRaFD-0Q6AEIHDAA), 6th edition, John Willey & Sons, New York.
5. Cooper GM, Hausman RE (2016) The Cell: A Molecular Approach, 7th edition, Sinauer Associates Inc Sunderland.
6. Alberts B, Johnson A, Lewis J et al. (2015) Molecular Biology of the Cell, 6th edition, Garland Science, New York.
7. Tropp BE (2012) Molecular Biology 4th edition, Jones and Barlett Learning, USA.
 |  |
| **BOM303: Biodiversity and Biostatistics Credits: 3** |  |
| **Section A: Biodiversity** 1. Levels of biodiversity: Genetic, species, community and ecosystem 3
2. Magnitude and distribution: Diversity gradients and related hypotheses and hot spots 2
3. Biodiversity and ecosystem functions: Concepts and hypotheses 1
4. Biodiversity and ecosystem services: Provisioning, regulating, supporting and cultural 1
5. Threats to biodiversity: Causes of biodiversity loss, species extinction, vulnerability of species to extinction, IUCN threat categories, Red data book 3
6. Strategies for biodiversity conservation: Principles of biodiversity conservation, *in-situ* and *ex-situ* conservation strategies 2

Section B: Biostatistics1. General concepts and terminology and Sampling methods 1
2. Concepts of central tendency, normal distribution and variability 2
3. Contingency tables and chi-square test 1
4. comparison of means: t-test, multiple range tests 2
5. Correlation and regression analyses 2
6. Simple experimental design and analysis of variance 1
7. Introduction to multivariate methods: Parametric and non-parametric ordination,

statistical packages for data analyses1. Basics of environmental modelling

 3**Suggested readings**1. [Heywood](http://www.amazon.com/s/ref%3Dntt_athr_dp_sr_1?_encoding=UTF8&sort=relevancerank&search-alias=books&field-author=Vernon%20H.%20Heywood) VH, Watson RT (1996) Global Biodiversity Assessment, Cambridge University Press, London.
2. Bryant PJ (2009) Biodiversity and Conservation, University of California, Irvine, USA.
3. Singh JS, Singh SP, Gupta SR (2014) Ecology, Environmental Science and Conservation, S Chand & Co, New Delhi.
4. Forthofer RN, Sullee E, Hernandez M (2006) Biostatistics: A guide to design, analysis & discovery, Academic Press, USA.
5. George W, Snedecor W, Cochran G (1989) Statistical Methods, Publisher Iowa State University Press, Ames, Iowa, USA.
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| **BOM 304: Biotechnological and Molecular Techniques and Bioinformatics Credits: 3**  |  |
| 1. Electrophoresis: Polyacrylamide gel electrophoresis (PAGE), Agarose gel electrophoresis (AGE), Native-PAGE, SDS-PAGE 2. Isolation and purification: (a) DNA (genomic and plasmid), (b) RNA and (c) Proteins 3. Isoelectric focusing (IEF) and 2D electrophoresis: Principle, kinds of pH gradients used in IEF-free carrier ampholytes, immobilized pH gradients 4. Blotting: Principle, transfer techniques, Southern, Northern, Western and Dot blots. 5. Gene cloning: Cloning vectors, molecular cloning and construction of DNA libraries, recombinant DNA technology, TDNA/gene transfer in plants 6. DNA amplification: Polymerase chain reaction (PCR), Reverse-trascriptase (RT- PCR), Real time-PCR 7. Genome mapping and expression analysis: RFLPs, RAPD, AFLP and FISH, Microarray and EST 8. DNA sequencing: Chemical degradation, dideoxy nucleotide sequencing, automated sequencing and next generation sequencing 9. Gene silencing: RNA interference (RNAi), mechanism of post-transcriptional gene silencing, importance of hairpin vector, Dicer, RDRP in gene silencing, applications of RNAi. 10. Plant cell and tissue culture: Concept of cellular differentiation, clonal propagation, artificial seeds, somaclones, production of secondary metabolites/natural products. 11. Databases: NCBI, EMBL, Genbank. 12. Bioinformatics tools and softwares: BLAST, ORF finder, Primer 3. **Suggested readings*** 1. Green MR, Sambrook J (2000) Molecular Cloning: a laboratory manual 4th edition, Cold Spring Harbor Laboratory Press, New York.
	2. Wilson K, Walker J (2013) Principle & techniques of biochemistry and molecular biology, 7th edition, Cambridge University Press, Cambridge.
	3. Bhojwani SS, Razdan MK (1996) Plant tissue culture: theory and practice, 1st editition, Elsevier, New Delhi.
	4. Sambrook J, Russell DW (2001) Molecular Cloning: a laboratory manual, 3rd edition, Cold Spring Harbor Laboratory Press, New York.
	5. Sohail M (2004) Gene Silencing by RNA Interference: Technology and Application, 1st edition,CRC Press, [Boca Raton](https://www.google.co.in/search?biw=1366&bih=666&q=Boca+Raton+Florida&stick=H4sIAAAAAAAAAOPgE-LUz9U3ME7LK09S4gAxk03LjLSMMsqt9JPzc3JSk0sy8_P084vSE_MyqxJBnGKrjNTElMLSxKKS1KJihZz8ZLAwALBfqwdLAAAA&sa=X&ved=0ahUKEwi6quHaxJLMAhVJC44KHbmvD_EQmxMIgAEoATAT).
	6. Hannon GJ (2003) RNAi: A Guide to Gene Silencing, 1st edition, Cold Spring Harbor Laboratory Press, New York.
	7. **Baxevanis AD, Ouellette BFF (2005) Bioinformatics: A practical Guide to the analysis of Genes and Proteins,** 3rd edition, John Wiley and Sons, New York.

**BOM 305: Lab work based on Courses BOM 301 and BOM 302** **Plant Biochemistry**1. Preparation of calibration curve of protein, extraction of protein from the plant material and its assay using Lowry *et al.* method
2. Preparation of calibration curve of DNA, extraction of DNA from the plant material and its assay using diphenylamine method
3. Preparation of calibration curve of RNA, extraction of RNA from the plant material and its assay using diphenylamine method
4. Effect of reaction time on urease activity
5. Effect of enzyme concentration on urease activity
6. Effect of various substrate concentrations on urease activity (determination of Km and Vmax using Line-weaver-Burk equation)
7. Preparation of calibration curve of nitrite using diazo-coupling method of Snell & Snell
8. Induction and assay of *in vivo* nitrate reductase (NR) activity
9. Effect of light and dark on the *in vivo* NR activity

**Cell and Molecular Biology*** 1. Estimation of protein by Bradford method
	2. Isolation of chloroplast by differential centrifugation
	3. Isolation of mitochondria by ultracentrifugation
	4. Separation and analysis of chloroplast and mitochondrial proteins by SDS-PAGE
	5. Isolation and purification of RNA from (a) prokaryotic and (b) eukaryotic organisms.
	6. Separation and analysis of RNA by Agarose gel electrophoresis
	7. Analyses of DNA damage and photorepair by spectrophotometric and PCR based methods
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| **BOM 306: Lab work based on Courses BOM 303 and BOM 304****Biodiversity and Biostatistics**1. Calculation of mean, variance, standard deviation, standard error and coefficient of variance for ecological data
2. To compare two means related to ecological data by using student’s ‘t’ test
3. Assessment of interspecific association between selected species of grassland using Chi-square approach and also to construct constellation diagram
4. Analysis of correlation coefficient between dependent and independent variables
5. Establishment of linear relationship between dependent and independent variables
6. Study of effect of independent variable on the dependent variable using ‘*F*-test’
7. To analyse best fit models between the variables and reliability of prediction
8. Assessment of species richness and species evenness of protected and unprotected grasslands
9. Analysis of ‘α-diversity’ of protected and unprotected grasslands
10. To assess β–diversity of a grassland vegetation along an environmental gradient
11. To assess γ - diversity across various habitats
12. Demonstration and handling of statistical software for data analysis: One way ANOVA, Two way ANOVA, multivariate analysis; ordination

**Biotechnological and Molecular Techniques and Bioinformatics** 1. Clean handling, sterility and reagent preparation
2. Isolation and purification of genomic and plasmid DNA from: (a) prokaryotic and (b) eukaryotic organisms
3. Separation and analysis of DNA by agarose gel electrophoresis
4. Isolation and purification of proteins from (a) prokaryotic and (b) eukaryotic organisms
5. Separation and analysis of proteins by SDS-PAGE
6. Restriction enzyme digestion and its evaluation by agarose gel electrophoresis
7. Demonstration of instruments such as PCR, real-time PCR, gel documentation system
8. Demonstration and handling of bioinformatics tools and softwares

**BOM 307M: Biofertilizer Technology Credits: 2**  |  |
| 1. Biofertilizers: Definition, types and applications in agriculture
2. Characteristics of biofertilizers: *Rhizobium, Azotobactor, Azospirillum,* phosphate-solubilizing microorganisms (PSMs), cyanobacteria, *Azolla*, mycorrhizae
3. Biological nitrogen fixation: Nitrogenase, substrates for nitrogenase, mechanism of action of nitrogenase, strategies to exclude oxygen and need to control hydrogen evolution, regulation of nitrogen fixation
4. *Rhizobium*-legume symbiosis
5. Production technology: Strain selection, sterilization, growth and fermentation, mass production of various biofertilizers
6. Application technology: Standards and quality control, application for field and tree crops, nursery plants and seedlings, agronomical significance

**Suggested readings**1. Gallon JR, Chaplin AE (1987) An Introduction to Nitrogen Fixation, Cassel Educational Limited, London.
2. Smith RJ, Lea PJ, Chaplin JR (1999) Nitrogen Fixation. In : Plant Biochemistry & Molecular Biology, 2nd edition, eds: Lea PJ, Leegood RC, John Wiley & Sons, New York, pp. 137-162.
3. Rai AN (1990) A Handbook of Symbiotic Cyanobacteria, CRC Press, Boca Raton, USA.
4. Postgate JR (1987) Nitrogen Fixation, 2nd edition, Arnold, London.
5. Stacey G, Burris RH, Evans HJ (1992) Biological Nitrogen Fixation, Chapman & Hall, New York.
6. Sprent JI, Sprent P (1990) Nitrogen Fixing Organisms: Pure and Applied Aspects. Chapman & Hall, London.
7. Kannaiyan S, Kumar K, Govindrajan K (2007) Biofertlizers Technology, Saujanya Books, New Delhi.
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**SEMESTER-IV**

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| **BOM401A: Air Pollution and Climate change Credits: 3** |  |
| 1. Atmospheric composition and climate; gaseous and particulate pollutants, indoor air pollution
2. Sulphur derivatives: Sources, effects on plants and human health, mechanism of toxicity, resistance and buffering, sulphur metabolism
3. Nitrogen derivatives: Formation and sources; uptake, metabolism, critical load; effects on plants, ecosystems and human health
4. Fluoride derivatives: Sources, bioaccumulation, effects on plants and human health.
5. Tropospheric ozone: Formation, photochemical smog; effects on plants and human health, mechanism of toxicity, induction of defense system
6. Stratospheric ozone depletion: Phenomenon, causes, effects of enhanced UV-B on terrestrial plants, microbes, marine life and human health; mechanisms of action, evolution of land plants in relation to UV radiation
7. Climate change: Greenhouse effects: process; drivers of climate change; consequences, global warming, sea level rise, agriculture, natural vegetation; human implications, effects of increased CO2 on plants, carbon sequestration in terrestrial ecosystem
8. Acid rain: Formation, deposition, trends; consequences on soil fertility, aquatic and terrestrial ecosystems; forest decline
9. Biomonitoring of air pollution: Concept, active and passive monitoring; bioindicator parameters

**Suggested Readings**1. Bell JNB, Treshow M (2002) Air Pollution and Plant Life, John Wiley and Sons Ltd, New York.
2. Omasa K, Nouchi I, De Kok LJ (2005) Plant responses to air pollution and global change, Springer Japan, Tokyo.
3. Agrawal SB, Agrawal M (1999) Environmental Pollution and Plant Responses, CRC Press, Boca Raton, USA.
4. Gurjar BR, Molina T, Ojha CSP (2010) Air Pollution Health and Environmental Impacts, CRC Press, Boca Raton, USA.
5. Vallero DA (2007) Fundamentals of Air Pollution, Elsevier Academic Press, Amsterdam.
6. Rao MN, Rao HVN (2009) Air Pollution, Mc Graw-Hill Pub Co Ltd, New Delhi.
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| **BOM 401B: Photobiology, Molecular Microbiology and Synthetic Credits: 3****Biology**  |  |
| 1. Molecular mechanisms of photodamage and photoprotection: Photo-induced damage to microbes; genetical, biochemical and molecular aspects of mycosporine-like amino acids (MAAs) and scytonemin production, ecological and economical implications.
2. Cyanobacterial toxins: Types of cyanobacterial toxins, molecular tools for the identification of toxic cyanobacteria, biochemical and molecular aspects of toxin production, ecological and economical implications
3. Light harvesting in cyanobacteria: Phycobilisomes, biochemical and molecular insight of light sensing and photomorphogenesis during complementary chromatic acclimation (CCA) in model organism *Fremyella diplosiphon*, ecological significance of CCA, model of CCA
4. Carbon concentrating mechanisms (CCM) in cyanobacteria: Components of CCM, types of carboxysome and its shell proteins, inorganic carbon uptake systems, carboxysomal enzymes, model of cyanobacterial CCM
5. Biofuels: Use of microalgae and cyanobacteria in renewable energy production, types of biofuel, cultivation systems, bioethanol production
6. Synthetic biology of cyanobacteria: Introduction of synthetic biology, Genetic modification of cyanobacteria, inducible promoters, reporters, application of cyanobacterial synthetic biology
7. Basics of antibody production: Steps involved in antibody production and purification, Innate and adaptive immune response, antigens, clonal selection theory, structure of antibody, primary and secondary antibody response, antigenic determinant (epitope), major histocompatibility complex (MHC), monoclonal and polyclonal antibodies, immunoprecipitation

**Suggested Readings**1. Herrero A, Flores E (2008) The Cyanobacteria: Molecular Biology, Genomics and Evolution, CaisterAcademic Press, Sevilla, Spain.2. Bryant DA (2004) The Molecular Biology of Cyanobacteria, Kluwer Academic Publishers, [Berlin](https://www.google.co.in/search?q=Berlin&stick=H4sIAAAAAAAAAOPgE-LUz9U3MImvKjFQ4gAxDU3NCrW0spOt9POL0hPzMqsSSzLz81A4VhmpiSmFpYlFJalFxQAaDP9DQwAAAA&sa=X&ved=0ahUKEwjZnMf_6pLMAhUNc44KHYaID0oQmxMIkwEoATAS).3. Chorus I, Bartram J (1999) Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management, WHO, Berlin.4. Singh SK, Sundaram S, Kishor K (2014) Photosynthetic Microorganisms: Mechanism for Carbon Concentration, Springer Cham Heidelberg, New York. 5. Karp G (2005) Cell and Molecular Biology, 4th edition, Willey International, New York.6. Tropp BE (2012) Molecular Biology 4th edition, Jones and Barlett Learning, USA.7. Bernard R, Glick, Jack JP (2003) Molecular Biotechnology: Principles and application of recombinant DNA, ASM Press, Washington, DC. **BOM401C: Plant Pathology and Plant Protection Credits : 3** 1. Introduction: Historical and developmental aspects of plant pathology, diseases caused by fungi, bacteria, viruses and parasitic organisms.
2. Mode of infection and role of enzymes and toxins in plant disease
3. Defense mechanisms of plants against infection: Preexisting structural and chemical defense, induced structural and chemical defense, hypersensitive reaction, role of phytoalexins and other phenolic compounds
4. Management of plant diseases: Cultural, chemical, biological, biopesticides, breeding for resistant varieties, plant quarantine, integrated pest management
5. Molecular plant pathology: Molecular aspects of host pathogen interactions; PR proteins, degradation of phytoalexins, systemic resistance mechanism; application of molecular biology to plant disease control; transgenic approach for crop protection, engineering chemicals that elicit defense response to plants
6. Study of plant diseases caused by fungi, bacteria, viruses, nematodes and mycoplasma like organisms: Wart disease of potato, blight of colocasia, downy mildew of cucurbits, stem gall of coriander, ergot of bajra, smut of sugarcane, Karnal bunt of wheat, linseed rust, Tikka disease of groundnut, red rot of sugarcane, Panama disease of banana, bacterial blight of rice, yellow vein mosaic of bhindi, mosaic of sugarcane, potato spindle tuber mosaic, ear cockles of wheat, grassy shoot of sugarcane, phylloidy of sesamum, citrus greening

**Suggested Readings**1. Agrios GN (2005) Plant Pathology, Academic Press, Burlington.
2. John AL (1998) Plant Pathology and Plant Pathogens, Wiley-Blackwell, CRC Press, [Boca Raton](https://www.google.co.in/search?biw=1366&bih=666&q=Boca+Raton+Florida&stick=H4sIAAAAAAAAAOPgE-LUz9U3ME7LK09S4gAxk03LjLSMMsqt9JPzc3JSk0sy8_P084vSE_MyqxJBnGKrjNTElMLSxKKS1KJihZz8ZLAwALBfqwdLAAAA&sa=X&ved=0ahUKEwims6mv7JLMAhUFt44KHahwAawQmxMIhgEoATAQ), USA
3. Dickinson CM (2003) Molecular Plant Pathology, Bios Scientific Publisher, Oxford.
4. Robert N, Trigiano, Windham MT, Windham AS (2003) Plant Pathology: Concepts and Laboratory Exercises, CRC Press, Boca Raton, USA.
5. Bridge PD, Clarkson JM (1998) Molecular Variability of Fungal Pathogens, CAB International, Oxfordshire.
6. Singh RS (2008) Plant Diseases, Oxford and IBH Publishing Co Pvt Ltd, New Delhi.
7. Singh RS (2008) Principles of Plant Pathology, Oxford and IBH Publishing Co Pvt Ltd, New Delhi.
8. Dhingra OD, James B, Sinclair (1995) Basic Plant Pathology Methods, CRC Publication, Boca Raton, USA.

**BOM402A: Conservation and Restoration Ecology** **Credits: 3** 1. Introduction to conservation ecology: Principles, postulates and ethics
2. Population dynamics and conservation: Genetic variation and its loss, variation in natural populations, mechanisms of population regulation, habitat specific demography, population viability analysis
3. Species and habitat conservation: Prioritizing species and habitat, protected area networks, theory of reserve design
4. Conservation strategies: Planning and management, plan process for species and site management; general principles of management; models of sustainable development
5. Ecology of disturbed ecosystems: Ecosystem dynamics and stability, disturbances, impact of disturbances on the structure and functioning of ecosystems
6. Aims and strategies of restoration: Concepts of restoration, ecosystem reconstruction, major tools used in restoration
7. Degradation and restoration of natural ecosystems

 **Suggested readings**1. Wali MK (1992) Ecosystem Rehabilitation, SPB Academic Publishing, Amsterdam.
2. Singh JS (1993) Restoration of degraded land: concepts & strategies, Rastogi Publications, Meerut.
3. [Pimm](http://www.press.uchicago.edu/presssite/author.epl?fullauthor=Stuart%20L.%20Pimm) SL (1991) The Balance of Nature? Ecological Issues in the Conservation of Species and Communities, [The University of Chicago Press](http://www.press.uchicago.edu/), Chicago.

**Smith** **RL (**2001) Ecology and Field Biology, 6th edition, Benjamin Cummings, San Francisco.1. Primack RB (2010) Essentials of Conservation Biology, 5th edition, Sinauer Associates Inc, Sunderland.

Meffe GK, Carroll CR (2006) Principles of Conservation Biology, 3rd edition, Sinauer Associates Inc, Sunderland.**BOM402B: Environmental and Applied Microbiology Credits: 3** 1. Microbes as tools for understanding the biological processes; Yeasts, *Neurospora*, *Penicillium, E. coli*
2. Microbes and environment: pollution abatement, bioindicators, restoration of degraded ecosystems, biodegradation, bioremediation, waste management and bio-fuel production
3. Application of microbes in fermentation processes: Types, design and maintenance of bioreactors, application of fermentation technology in industry
4. Role of microbes in relation to agriculture: Nitrogen economy, microbes as tools in recombinant DNA technology for developing resistant variety of plant, mechanism of biological control, mycorrhizal association types and their application in agriculture
5. Symbiotic associations: concepts, types and applications, molecular basis of plant microbes interactions (parasitism and mutualism)
6. Microbes in food and dairy industry: mushrooms, fermented foods, microbial, spoilage of food and dairy products, toxins
7. Extremophiles: Types, mechanism of survival and their biotechnological applications
8. Microbial technology: Isolation and cultivation of microbes in pure culture from different sources, molecular identification and preservation techniques, microbial enzymes assay and isolation, bioactive molecules assay and their purification, biosensors

**Suggested Readings**1. Liu WT, Jansson JK (2010) Environmental Molecular Microbiology, Caister Academic Press, [Norfolk](https://en.wikipedia.org/wiki/Norfolk).
2. Willey JM, Sherwood L, Woolverton CJ (2013) Prescott’s Microbiology, 9th edition, McGraw-Hill, New York.
3. Hurst CJ, Crawford RL, Garland JL, Lipson DA, Mills AL, Stetzenbach LD (2007) Mannual of Environmental Microbiology, 3rd edition, American Society for Microbiology Press, Washington, D.C.
4. Kannaiyan S (2009) A Text Book of Applied Microbiology, Vols 1 to 2, Associated Publishing Company, New Delhi.
5. Mitchel R (1993) Environmental Microbiology, Wiley-Liss Publisher, New York.
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|  **BOM 402 C: Plant *In-vitro* Culture, Gene Expression and Genetic Credits: 3** **Manipulations**  1. Principles of plant tissue culture: Historical perspectives, organization of laboratory, types of cultures, media composition and preparation, role of phytohormones and aseptic manipulation
2. Cellular totipotency and differentiation: Process and molecular mechanism of totipotency and differentiation, induction and maintenance
3. Cell culture and cell cloning: Isolation of cells, preparation of pure cell culture, cell cloning techniques and its application
4. Somatic embryogenesis: Induction, controlling factors, cytological and molecular changes
5. Organogenesis: Process, inducing factors, molecular basis of organogenesis
6. Haploids: Androgenic and gynogenic haploids; obtention and promises, double haploids.
7. Parasexual hybridization: Isolation, culture and fusion of protoplasts, regeneration of hybrids and cybrids.
8. Micropropagation: General technique and stages of micropropagation, methods of micropropagation and its application.
9. Tissue culture induced variations: Somaclonal, protoclonal and gametoclonal variations, molecular basis of somaclonal variation, genetic and epigenetic changes and their selection
10. Gene structure, expression and its regulation in plants: Fine structure of gene and promoter architecture, regulatory sequences, enhancers, transcription in plants, transcription factors, RNA splicing and editing, posttranslational modifications and their importance in plants.
11. Transgenic plants: method of transformation, direct gene transfer methods, plant- *Agrobacterium* (*Ti* and *Ri* Plasmids) interactions, marker and reporter genes, marker-free transgenics, transgene silencing, molecular tools for transgenic confirmation and application.
12. Germplasm conservation: Synthetic seed technology and industrial applications; hairy root culture and bioreactors for commercial production of phytochemicals

**Suggested Readings****:**1. Bhojwani SS, Razdan M K (1996)   Plant Tissue Culture: Theory and Practice, revised edition, Elsevier Science, Amsterdam.
2. Newmann KH (2009) Plant Cell and Tissue Culture, A Tool in Biotechnology: Basics and Applications (Principles and Practice), Springer, Berlin.
3. Loyola- Vargas VM, Flota FV (2005) Plant Cell Culture Protocols, 2nd edition, Humana Press, Totowa.
4. Slater A, Scott NW, Mark R (2008) Fowler Plant Biotechnology: An Introduction to Genetic Engineering, Oxford University Press, Oxford.
5. Halford N (2006) Plant Biotechnology - Current and Future Applications of Genetically Modified Crops, John Wiley and Sons, London.
6. Jain SM, Sopory SK, Velleux RE (1996) *In Vitro* Haploid Production in Higher Plants, Vol 1-5, Kluwer Publishers, Dordrechi, Netherlands.
7. Vasil IK, Thorpe TA (1994) Plant Cell and Tissue Culture, Kluwer Academic Publishers, Netherlands.
8. Razdan MK (2003) An Introduction to Plant Tissue Culture, Oxford & IBH Publishing Co, New Delhi
9. Basset C L.  (2007) Regulation of Gene Expression in Plants: The Role of Transcript Structure and Processing.
10. Trigiano RN and Gray DJ (2011) Plant Tissue Culture, Development and Biotechnology, CRC Press, Boca Raton, USA.
 |  |
| **BOM 403A: Molecular Stress Biology and Biotechnology of Cyanobacteria Credit: 3** 1. Ecology of cyanobacteria: Molecular ecology (a) Bioinformatics tools and databases (Cyanobase) (b) Model organisms e.g., *Synechocystis* sp. PCC 6803, *Anabaena* sp. PCC 7120 (c) environmental genomics, metagenomics and phylogeny of cyanobacteria across environmental gradients
2. Cyanobacterial light harvesting complex: Phycobiliproteins, Carotenoids and xanthophylls, structure and regulation of light harvesting genes, light harvesting proteins of cyanobacteria *vis a vis* light harvesting complex of higher plants
3. Cyanobacterial responses towards abiotic stresses: Salinity, ultraviolet radiation, temperature, herbicides inhibiting PSI and PSII, desiccation and heavy metals; Signal transduction under abiotic stress (SOS pathway).
4. Functional proteomics of cyanobacteria: Applications of 2-DE/MALDI-TOF/MS and bioinformatics for characterizations of functions of abiotic stress responsive proteins in rice field cyanobacteria
5. Nutraceuticals: Cyanobacteria as source of antioxidants, biomolecules, metabolic engineering, metabolic tapping of *Spirulina platensis,* etc. as a model for desired nutraceuticals
6. Gene mining from cyanobacteria: (a) **Cyanobacteria as a source of stress tolerant genes for the development of stress tolerant crops using gene pyramiding technology** (b) Targeted genetic modifications in cyanobacteria
7. Cyanobacteria and green chemistry: Genetic engineering for production of biofuels (biodiesel, hydrogen production), bioplastics, nanomaterials (nanotechnologies)
8. Intellectual property rights and patents: Criteria for selecting a novel gene/protein for filing patents, laws of filing patents

**Suggested readings** 1. **Bryant** DA (1995) The Molecular Biology of Cyanobacteria, Kluwer Academic Publisher, Berlin.
2. **Whitton** BA, **Potts** M (2000) Ecology of Cyanobacteria - Their diversity in Time and Space, Kluwer Academic Publishers, Berlin.
3. Chavvat F, Chavvat CC (2013) Advances in Botanical Research Vol 65 Genomics of Cyanobacteria, Elsevier.
4. Sarma TA (2012) Handbook of Cyanobacteria, 1st edition, CRC press, Boca Raton, USA.
5. Larkman WD, Douglass E, Raven JA, Photosynthesis in Algae, Kluwer Academic Publishers, Berlin.
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| **BOM 403 B: River Ecology and Water Management Credits : 3****Section- A**1. Watershed hydrology, river continuum
2. Plankton and benthic communities, paradox of plankton, primary productivity,

trophic cascades, microbial loop1. Eutrophication and concept of nutrient limitation
2. Integrated river basin management, case studies related to the river Ganga

 **Section- B**1. General characteristics of water, factors influencing surface water
2. Water pollution: Sources and consequences, ground water pollution, water

quality standards1. Waste water: Flows and characteristics, collection system, waste water

treatment, drinking water processing1. Environmental management plans, Sustainability principles in water management, water use, groundwater recharge, recharging of aquifers

**Suggested readings**1. Wetzel RG (2001) Limnology- Lakes and River Ecosystem, Academic Press, California.
2. Kalff J (2002) Limnology- Inland Water Ecosystem, Prentice Hall, California.
3. Liken GE (2010) River Ecosystem Ecology- A global perspective, Academic Press, New York.
4. Gray NF (2010) Water Technology, A Butterworth-Heinemann, Oxford.
5. Vesilind PA, Morgan SM (2010) Introduction to Environmental Engineering, CL Engineering, Stamford.
6. Hammer MJ, Hammer Jr MJ (2008) Water and Waste water Technology, Prentice Hall, New Jersey.
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**BOM403 C: Microbial Genetics and Biotechnology Credits: 3**

1. Basic concepts of microbial genetics with special reference to *E. coli*, *Neurospora* and *Mu* pha
2. Microbial genome evolution
3. Genetic recombinations: Legitimate and illegitimate recombination, site specific recombination and transposition
4. Mutation: Luria-Delbrück experiment, spontaneous and induced mutagens and their effects on DNA structure and protein synthesis
5. Gene expression and regulation: *Lac operon*, tryptophan operon, regulation of virulence genes in pathogenic bacteria, heat shock regulon, SOS regulon and CpS regulon
6. Cell signaling: Communication between cell and environment with special reference to nitrogen and phosphorus
7. Plant-Microbe interaction: Perception and signalling
8. Microbial toxins: Types, biochemical and molecular basis of toxin production and mode of action
9. Gene manipulation for production of novel and commercial products: Biofuel, antibiotics and biopolymer

**Suggested Readings**

* 1. Snyder L, Champnees W (2007) Molecular Genetics of Bacteria, ASM Press Washington, DC.
	2. Jermy WD, Park SF (2013) Molecular Genetics of Bacteria, 4th edition, John Wiley and Sons Ltd, New York.
	3. Joseph WL, Gerhart D, Hans GS (1999) Biology of the Prokaryotes, Blackwell Science Ltd, Oxford.
	4. Krebs JE, ‎ **Lewin B, ‎** Goldstein ES (2011) Genes X, Publishers Sudburry, Masschusetts.
	5. James DW, Tania AB, Stephen PB, Alexander G, Michael L, Richard L (2008) Molecular Biology of the Gene, 6th edition, Cold Spring, New York.
	6. Stanly R, Maloy JC, David F (1994) Microbial Genetics, Narosa Publisher, New Delhi
	7. Bernard R, Glick, Jack JP (2003) Molecular Biotechnology: Principles and application of recombinant DNA, ASM Press, Washington, DC.
	8. Brown TA (2007) Genomes, Garland Science, Taylor & Francis Group, New York & London.
	9. Alberts B (2014) Molecular Biology of the Cell, 6th edition, Martin, Roberts Keith and Walter Peter- Garland Science (Taylor & Francis Group), New York & London.
1. Lodish H, Berk A, Zipursky SL, paul M, Baltimore D, Darnell JE (2008) Molecular Cell Biology, WH Freeman Company, New York.
2. Tropp BE (2012) Molecular Biology 4th edition, Jones and Barlett Learning, USA.

**BOM 404: Lab work based on Courses BOM401A to BOM401C**

**BOM404A: Air Pollution and Climate Change**

1. Estimation of the ambient levels of SO2 by improved West and Gaeke method
2. To estimate the ambient levels of NO2 by modified Jacob and Hochheiser method
3. Estimation of the ambient levels of TSP and PM10 by high volume sampler
4. Determination of the air pollution tolerance index (APTI) of selected tree species
5. To determine the total phenolic content in leaves of selected plant species collected from differently polluted sites
6. Determination of the ascorbic acid content in leaves of selected plant species collected from differently polluted sites
7. To determine the protein content in leaves of selected plant species collected from differently polluted sites
8. To estimate the sulphate-S contents in soil collected from differently polluted sites.
9. Estimation of the sulphate-S contents in leaves of selected plant species collected from differently polluted sites
10. Quantification of selected heavy metals in dust deposited on leaf surfaces of selected plant species

**BOM 404 B: Photobiology, Molecular Microbiology and Synthetic Biology**

1. Extraction and purification of mycosporine-like amino acids (MAAs) from cyanobacteria
2. Spectrophotometric and HPLC analyses of MAAs
3. Extraction and purification of scytonemin from cyanobacteria
4. Spectrophotometric and HPLC analyses of scytonemin
5. Study of complementary chromatic acclimation (CCA) in cyanobacteria and extraction of photosynthetic pigments (chlorophyll, carotenoids and phycobiliproteins)
6. Spectrophotometric, FPLC and SDS-PAGE analyses of phycobiliproteins
7. Test for genomic and plasmid DNA damage and repair in cyanobacteria
8. Analysis of nucleotide sequence and encoding protein using bioinformatics tools

**BOM404 C: Plant Pathology and Plant Protection**

1. Study of plant diseases, namely wart of potato, blight of colocassia, downy mildew of cucurbits, wart of sesame, stem gall on coriander, ergot of bajra, smut of sugarcane, linseed rust, tikka disease of groundnut, red rot of sugarcane, bacterial blight of rice, yellow vein mosaic of bhindi, mosaic of sugarcane, grassy shoot of sugarcane and other local diseases on crops
2. Preparation of media and slants for isolation
3. To Study antagonism between fungi in culture medium
4. Quantitative estimation of mycotoxins secreted by toxigenic strains of fungi
5. Estimation of rotting on fruits inoculated by fungi

**BOM 405: Lab work based on Courses BOM402A to BOM402C**

**BOM405A: Conservation and Restoration Ecology**

1. Impact of disturbance on grassland community in terms of water holding capacity of soil
2. Study of the impact of disturbance on grassland community in terms of bulk density and porosity across soil profile
3. Impact of disturbance on grassland community in terms of carbon stock across soil profile
4. Study of the impact of disturbance on grassland community in terms of available nitrogen stock across soil profile
5. Analysis of the coefficients of species area relationships across the disturbance gradient in grassland community
6. Study of the effect of grazing on herbaceous cover in grassland community
7. Study of the structural components of herbaceous community at pre- and post-disturbed stages of grassland community
8. To study the recovery in species composition after protection of a disturbed (fire) herbaceous community
9. Analysis of the recovery in species diversity after protection of a disturbed (clipping and digging) herbaceous community
10. Analysis of the recovery in herbaceous biomass after protection of a disturbed (clipping and digging) community

**BOM405B: Environmental and Applied Microbiology**

1. Preparation of different culture media and isolation of fungi, bacteria and actinomycetes from waste materials
2. Isolation and culture of vesicular arbuscular mycorrhizal (VAM) fungi from soil/root
3. Isolation and study of biocontrol agents (BCAs): *Trichoderma, Bacillus, Pseudomonas*
4. Study the fermentation of different types of substrate
5. Study the biological activities of microbes; enzymatic, antibacterial, antifungal activities
6. Extraction of secondary metabolites from the broth culture of fungi
7. Determination of minimum inhibitory concentration (MIC) of antimicrobial compounds
8. Quantitative enzymatic assay of amylase and cellulase produced by microbes

**BOM 405 C:**  **Plant *In-vitro* Culture, Gene Expression and Genetic Manipulations**

1. Aseptic manipulation; washing, capping, packing & sterilization, laminar flow operation & general precautions, stock solutions & media preparation.
2. Preparation of different types of standard tissue culture media such as M S medium.
3. Callus induction from leaf tissues by using 2-4D as growth regulator.
4. Induction of shooting/multiple shoots from nodal explants of *Spilanthus acmella.*
5. *In vitro* regeneration of *Bryophyllum* plants from leaf segments.
6. Shoot-tip meristem culture for raising virus-free plants.
7. Induction of embryogenesis in anther culture of *Datura innoxia.*
8. Preparation of synthetic seeds by using different micropropagules for germplasm conservation.
9. To study cyto-differentiation in different types of callus.

**BOM 406: Lab work based on Courses BOM403A to BOM403C**

**BOM 406A: Molecular Stress Biology and Biotechnology of Cyanobacteria**

# Demonstration of CYANOBASE, and retrieving of gene sequences for multiple sequence alignment for candidate gene for making phylogenetic tree using (MEGA 5.0, CLUSTAL X etc)

# Determination of LC50 doses of selected abiotic stresses in cyanobacterium *Anabaena* sp PCC 7120

# Determination of lipid peroxidation and hydrogen peroxide content in stressed and non-stressed cyanobacterium

# SDS-PAGE profiling of controlled and selected abiotic stress exposed model cyanobacterium in order to monitor stressed induced proteins

# Demonstration of two dimentional gel electrophoresis (2-DE), PD-Quest (software), MALDI-TOF

# DNA isolation, primer designing and PCR amplification of 16S rDNA sequences from *Anabaena* sp PCC 7120

# Demonstration of bioreactor for mass cultivation for biofuel and other fine chemicals

# Lipid profiling from stressed model cyanobacterium

# Study of fluorescence spectra of control and stressed model cyanobacterium

**BOM 406B: River Ecology and Water Management**

1. Determination of chloride in given water samples
2. Determination of hardness in given water samples
3. Estimation of dissolved oxygen in water samples by Winkler method
4. Estimation of primary productivity in water samples by light and dark bottles method
5. Estimation of biological oxygen demand (BOD) in given water samples
6. Estimation of nitrate in given water samples
7. Estimation of phosphate in given water samples
8. Estimation of total and faecal coliforms in given water samples

**BOM 406C: Microbial Genetics and Biotechnology**

1. Understanding the regulation of expression of *Lac Operon* in the *E. coli* grown in different sugar sources and estimation of β-galactosidase activity, a key enzyme product of *Lac Operon* using ONPG (o-nitrophenyl β -galactoside) as substrate
2. Determining the antibiotic resistance pattern against different antibiotics in *E. coli* and calculating the LC50
3. Ultraviolet radiation-induced damage and photorepair system in bacteria
4. Csaky, Arnow and Neilands Assay: Siderophore production and regulation of metal ion acquisition in bacterial system
5. Filter mating experiment: Transposon based mutagenesis of cyanobacterial strain by triparental conjugation (using three strains i.e. DH5α (cargo plasmid), J53 (conjugal plasmid) and HB101 (helper plasmid)) and isolation of auxotrophic mutants
6. Quantitative determination of alkaline phosphatase activity in bacterial strains in response to different levels of phosphate

**END**