JAI HIND COLLEGE
BASANTSING INSTITUTE OF SCIENCE
&
J.T.LALVANI COLLEGE OF COMMERCE
(AUTONOMOUS)

"A" Road, Churchgate, Mumbai - 400 020, India.

Affiliated to
University of Mumbai

Program: Life Sciences

Semester: VI

Credit Based Semester and Grading System (CBCS) with effect from the academic year 2019-20

T.Y.B.Sc. Life Science Syllabus

Academic year 2018-2019

Semester VI			
Course Code	**Course Title**	**Credits**	**Lectures / Week**
SLSC601	Genetics & Immunology II	4	4
SLSC602	Developmental Biology & Neurobiology II	4	4
SLSC603	Fermentation technology & Genetic engineering: A Biotechnological approach II	4	4
SLSC604	Environmental Biotechnology II	4	4
SLSC6PR1	Practical 1	4	8
SLSC6PR2	Practical 2	4	8

Semester VI – Theory

Course: SLSC601	GENETICS AND IMMUNOLOGY II (Credits: 04 Lectures/Week: 04)	
	Objectives: On completion of the course, the student must be able to: 1. Understand the concept of recombination and gene mapping in Eukaryotes 2. Understand various types of mutations and mutagenesis methods 3. Understand various tools used in molecular genetics 4. Understand the concept of recombinant DNA technology 5. Understand the relationship between malfunctions of the immune system and disorders such as autoimmunity, hypersensitivity, graft/host rejection and immunodeficiency. 6. Understand the adverse effects of immune response hypersensitivity, auto immunity 7. Understand the Principles of tumour immunology, mechanisms of transplant rejection; and immunodeficiency disorders. 8. Apply key immunologic concepts and methods to diagnose immune disorders. **Outcomes:** This course is formulated to provide knowledge of Genetics and Immunology. The genome is the blueprint of an organism and it is important to understand the mechanisms of inheritance, mutations and gene manipulation. The Immune system protects the body from possibly harmful substances by recognizing and responding to antigens with great precision. Most human diseases result from some loss of this precision. Sometimes the immune system is overwhelmed by an infection or a tumor. On other occasions the immune system aberrantly or over-exuberantly responds to innocuous environmental molecules or microbes – or to self-structures – and this results in a loss of immune regulation that results in disease. Understanding immunology has allowed the prevention of infections by the use of vaccines, has helped the medical world develop the ability to transfuse blood making modern surgery possible, has allowed transplantation to become a reality, and has led to rational treatments for allergies and autoimmune diseases**.**	
Unit I	**(A) Mechanisms of Inheritance and variation in Eukaryotes:** **Genetic recombination in Fungi:** Life Cycle, recombination in *Neurospora* and mapping by Tetrad Analysis **Genetic recombination in *Drosophila:*** Life Cycle; Recombination – Mapping the genome by two and three factor crosses, co-efficient of co-incidence and interference. **Genetic recombination in Humans:** Somatic cell Genetics: Use of cell hybrids and hybridomas for gene mapping	**15L**

	(B) Mutational Variation: i. Types of Mutations and Mutagenic agents ii. Natural biological mutagenic agents – Prokaryotic Transposable elements and their significance, Eukaryotic Transposable elements, iii. Induced mutations - Site-Directed mutagenesis using Oligomers, 'Cassette mutagenicity'; PCR-based methods of mutagenesis iv. Mutagenicity testing – Ames test, SCE Test and Mouse Specific Locus Test.	
Unit II	**(A) Tools and Techniques in Molecular Genetics:** i. DNA Sequencing – Maxam and Gilbert's method and Sanger and Coulson's method ii. DNA Fingerprinting iii. Nucleic acid in-situ hybridization (FISH) iv. The Human Genome Project and beyond: aims, major features and applications **(B) Recombinant DNA Technology:** i. Restriction enzymes and DNA joining Strategies ii. Plasmid vector (pBR322-Cloning Insulin gene) iii. Phage vectors (lambda)	**15L**
Unit III	**Hypersensitivity, Vaccines and Immunodeficiency:** **(A) Hypersensitivity:** Gell and Coombs classification- Type I: Ag-Ab reactions viz. RIST and RAST Type II: Agglutination to be included Type III: Immunoflourescence, ELISA Type IV: Tuberculin test **(B) Vaccines:** Passive immunization- i. Preformed antibodies and problems ii. Use of Chimera / humanized antibodies Active immunization- i. Whole organisms (attenuated vs. inactivated ex. Polio) ii. Purified macromolecules (Polysaccharide, toxoid and recombinant antigen vaccines) iii. Peptide Vaccines iv. DNA Vaccines **(C) Immunodeficiency:** i. B-celled- X-linked agammaglobulinimea ii. T-celled- Di George iii. Combined-SCID iv. Phagocytic- CGD v. AIDS	**15L**

Unit IV	**Transplantation, Tumour Immunology, Tolerance and Autoimmunity:** **(A) Transplantation:** i. Types of grafts ii. Tissue typing (serological and MLR) iii. Mechanism of graft rejection iv. Graft vs. host disease w.r.t. bone marrow or cornea **(B) Tumour Immunology:** i. Role of the immune system, Cell mediated and humoral responses ii. NK cells and macrophages iii. Tumor specific antigens iv. Immunological surveillance v. Immunological escape and potential for therapy **(C) Tolerance:** i. Mechanism of T cell and B cell tolerance ii. Immunology of pregnancy iii. Role of T- regulatory cells **(D) Autoimmunity:** i. Mechanisms for induction (Aetiology) ii. Types of Auto immune diseases-organ specific and systemic. Example, Myasthenia gravis, Graves disease, SLE and Multiple sclerosis	**15L**
	References: 1. Snustad and Simmons. (2006). Principles of Genetics, 4th edn. John Wiley and sons. 2. Peter Russel (2006). I-Genetics; A Molecular approach, 2nd edn. Pearson. 3. Griffiths et al. (2005). Introduction to Genetic Analysis, 8th edn. Freeman and co. 4. Benjamin Lewin. (2008). Genes IX. Jones and Bartlett publishers. 5. S. B. Primrose and R. M. Twyman. (2007). Principles of Gene Manipulation and Genomics, 7th edn. Blackwell publication. 6. W. S. Klug and M. R. Cummings. (2003). Concepts of Genetics, 7th edn. Pearson. 7. W. S. Klug, M. R. Cummings, C. A. Spencer. (2006). Concepts of Genetics, 8th edn. Pearson. 8. Tom Strachan and Andrew Read. (2004). Human Molecular Genetics, 3rd edn. Garland Science pub. 9. R.A.Goldsky, T. J. Kindt, B. A. Osborne, J. Kuby. (2003) Immunology 5th edn. W.H. Freeman. 10. C. A. Janeway, P. Travers, M. Walport, M. Shlomchik. (2005). Immunology: The immune system in health and disease, 6th edn. Garland Science Pub. 11. A. K. Abbas, A. H. Litchman. (2000). Cellular and Molecular Immunology, 5th edn. Elsevier publication. 12. Roitt. (2006). Essential Immunology, 11th edn. Blackwell	

	publication. 13. D. Mole, J. Bronstoff, D. Roth, I. Roitt, Mosbey. (2006) Immunology, 7th International edn. Elsevier publication. 14. C. V. Rao. (2002). An Introduction to Immunology. Narossa Publishers.	

Semester VI – Theory

Course: SLSC602	DEVELOPMENTAL BIOLOGY AND NEUROBIOLOGY II (Credits: 04 Lectures/Week: 04)	
	Objectives: On completion of the course, the student must be able to: 1. Describe the cellular and molecular basis of development and genes involved during the early development. 2. Describe the applications of developmental biology in different fields related to treating various conditions and diseases. 3. Explain the basics of stem cell research. 4. Have a clear understanding about the human sense organs, its transduction mechanisms and pathways. 5. Understand the mechanisms of Prostaglandin inhibition for pain management. 6. Discuss the structure of reflex arc and mechanism of muscle contraction. 7. Explore neurobiological basis of certain behaviours and diseases. **Outcomes:** This course is based on Developmental biology and Neurobiology which form the fundamental aspects of Life Sciences. Development is a process by which a single cell (the zygote) gives rise to an entire multicellular organism. During the early developmental stages the cells are totipotent and as they mature they become committed to one particular type. Various genes play a role during the early development which helps decide the location of organs, anterior-posterior and dorso-ventral axis. Developmental biology gives a clear idea about the genes which plays a role during the early development. It further helps us to study the congenital abnormalities and it can be used to study and treat various conditions/diseases in humans. Neurobiology, on the other hand, is the means by which we communicate with the world. It gives us a clear idea about how senses work and the pathways and mechanisms which underlie it. This field also helps one to understand Pathophysiology of various neurobiological conditions and diseases.	
Unit I	**Cellular aspects of development:** i. Basics of stem cells Totipotency (eg. Plant cells and Animal cell Nuclei) Pluripotency (eg. Embryonic stem cells) Multipotency (Hematopoietic stem cells) Oligopotency (eg. Monocytes) ii. Stem cell niche iii. Determination e.g. Drosophila imaginal disc iv. Transdetermination e.g. Drosophila imaginal disc v. Differentiation. E.g. Neural crest cells or hematopoietic cells or as change in gene expression (beta globin gene) vi. Molecular basis of growth and differentiation vii. Genes in early development (with Drosophila as example) Maternal genes, Segmentation genes, Realiasator genes, Homeotic– Drosophila. viii. Cell cycle and its control. xi. Apoptosis	**15L**

Unit II	**Applications of developmental biology:** i. Assisted human reproduction ii. Pre and Post natal diagnosis iii. Congenital abnormalities iv. Aging – Theories of aging v. Regeneration in animal world, Regeneration of Salamander limb (dedifferentiation),Wound healing Vs. regeneration vi. Teratogenesis : Alcohol and Retinoic acid vii. Fundamentals of Stem cell Research	**15L**
Unit III	**Sensory and motor system:** i. Human Sense organs: receptors, receptor mechanisms and pathways (Introduction) ii. Visual system: Vision - structure of the eye, retina, photoreceptors (rods and cones) and colour vision, phototransduction, binocular vision, visual pathway (flow chart only– LGN to visual cortex), light & dark adaptation. iii. Auditory System: Structure of the ear, cochlea and organ of corti receptors 1, Mechanism of transduction, Auditory pathway: (MGN to audio cortex) iv. Vestibular System: Structure of the vestibular labyrinth, maculae and cristae. Mechanism of transduction. v. Chemosensory system: Olfactory and Gustatory receptors – structure vi. Skin as sense organ: somatic receptors - Types of mechano- receptors, pain reception & Pain management (example analgesic effect by prostaglandin inhibition - aspirin)` vii. Reflexes: Monosynaptic reflex arc (knee jerk reflex) and polysynaptic reflex arc (tendon reflex)	**15L**
Unit IV	**Neurobiological basis of behaviour and Diseases:** i. Associative conditioning – Overview ii. Short term memory and Long Term Memory (eg. Aplysia) iii. Addiction – narcotic drugs and their effects on CNS (eg: Opiates) v. Schizophrenia- Positive and negative symptom vi. Prions and Mad cow disease vii. Duchene's muscular Dystrophy viii. Alzheimer's disease ix. Huntington's Disease	**15L**

References:

1. Wolpert L., Tickle C., and Arias AA. (2015) Principles of Development, Oxford University Press.
2. Gilbert SF., Barresi M.J.F. (2016) Developmental Biology, Sinauer Associates, Oxford University Press.
3. R.M.Twyman. (2000) BIOS Instant Notes in Developmental Biology, Taylor & Francis.
4. Lodish H, Berk A, Zipursky SL, Matsudaira P, Baltimore D, Darnell J. Molecular Cell Biology. (2000) Molecular Cell Biology, W.H. Freeman.
5. Purves P., Augustine G., Fitzpatrick D., Hall WC., LaMantia AS., White LE. (2011) Neuroscience, Sinauer Associates, Inc.
6. Tortora GJ., Derrickson B. (2013) Principles of Anatomy and Physiology, John Wiley & Sons Inc
7. Longstaff A. (2011) BIOS Instant Notes in Neuroscience, Taylor & Francis
8. Smith C.U.M. (2002) Elements Of Molecular Neurobiology, Wiley

Semester VI – Theory

Course: SLSC603	FERMENTATION TECHNOLOGY & GENETIC ENGINEERING: A BIOTECHNOLOGICAL APPROACH II (Credits: 04 Lectures/Week: 04)	
	Objectives: On completion of the course, the student must be able to: 1. Understand the enzyme technology ., the various methods of immobilization of enzymes 2. Understand how the fermentation technology can be applied in medicine 3. Basic Knowledge of plant and animal tissue culture and production of secondary metabolites 4. Provide examples of current applications of biotechnology and advances in the different areas like medical, microbial, agricultural, plant and animal tissue culture 5. Understand cloning in eukaryotes and applications of recombinant DNA technology and related ethical issues 6. Understand important recent tools used in genetic engineering 7. Understand basic Bioinformatics **Outcomes:** This course emphasizes the practical use of microbial organisms in the production of enzymes, the knowledge of fermentative processes used in the industrial production of vaccines, vitamins, secondary metabolites like penicillin and other biopharmaceuticals. This course also introduces the student to the theory of plant and animal tissue culture Students study media, sterilisation, explants, micro propagation, callus culture, organogenesis, somatic embryogenesis, Protoplast isolation and fusion in plant tissue culture. The course also introduces the practice and process of culturing animal cells and cell lines in a laboratory. Focuses on media preparation, cryopreservation and maintenance of cell lines. This course also focuses on applications in recombinant DNA technology and Bioinformatics.	
Unit I	**Enzyme and Pharmaceuticals Production:** **(A) EnzymeTechnology-** i. Enzyme production; example Amylase (bacterial & fungal) ii. Immobilized Biocatalyst (method of immobilization, applications – biosensors) **(B) Application of fermentation technology in medicine:** Production of i. Antibiotics (Penicillin) ii. Vitamins (Vit. B12) iii. Vaccines (Polio, HbsAg) iv. Monoclonal antibodies v. Biopharmaceuticals (Insulin / IFN)	**15L**

Unit II	**Tissue Culture biotechnology:** **(A) Application of fermentation technology Agriculture:** i. Secondary metabolites from plant tissue culture ii. Biopesticides – Bacteria (*B. thuringiensis*), Virus (Polyhedrosis virus) and fungal (*Trichoderma*) **(B) Plant and Animal Tissue Culture:** i. Animal – Laboratory setup, Media, Basic techniques (Disaggregation of tissue and primary culture, maintenance of cell lines. ii. Plant – Media, Basic techniques (callus and suspension culture, organogenesis, & somatic embryogenesis, Protoplast isolation and fusion)	**15L**
Unit III	**Genetic Engineering:** **(A) Cloning in Eukaryotes** i. Cloning vectors in yeast ii. Cloning vectors in animal: SV 40, Baculovirus iii. Cloning in plants: Ti plasmid based vectors (binary and Co-integrative vectors), Microinjection method **(B) Applications of recombinant DNA Technology:** i. In animals: - Transgenic animals - Knock-in, Knockouts and Knock-down systems - Giant mouse (MMT promoter growth hormone fusion gene) - Xenopus oocyte as expression system ii. Transgenic plants: Bt cotton and weedicide resistant gene, Genetically modified food iii. Gene therapy (Parkinson disease or SCID) **(C) Ethical, legal and social implications of recombinant DNA technology and consumer awareness (labelling of GM foods)**	**15L**
Unit IV	**(A) Tools in genetic engineering** i. PCR: Polymerase chain reaction Method, Limitations and applications, Types of Primers – Universal, Nested, Poison primers, Types of PCR – Q-PCR, RT-PCR ii. Electrophoresis: Agarose gel electrophoresis (Principle, methodology and applications), PAGE, Two-Dimensional Gel Electrophioresis ii. Blotting techniques: Southern blotting, Nothern blotting, Western blotting iii. Microarrays iv. Cre-Lox system v. CRISPR **(B) Bioinformatics:** i. Biological databases (Formats: FASTA and GenBank) ii. Sequence annotation iii. Drug designing and Docking (basic concept) iv. Sequence alignment: Pairwise alignment Eg. BLAST, Multiple	**15L**

	alignment Eg. ClustalW v. Phylogenetic trees and concept of bootstrapping vi. Primer designing	
	References: 1. Michael L Shuler and Fikret Kargi. (2008). Bioprocess Engineering*:* Basic Concepts., Prentice-Hall of India Pvt Ltd. 2. Stanbury P.F.,Whitaker A. and Hall S.J. (2007). Principles of Fermentation Technology. Elsevier India Pvt Ltd. 3. Prescott And Dunn. (2004). Industrial Microbiology. Chapman & Hall. 4. Casida, L.E. (2003) Industrial Microbiology. New Age International (P) Ltd. 5. S.B. Primrose and Twyman. (2006). Principles of gene manipulation, 7th Ed. Blackwell. 6. R.W. Old and S.B. Primrose. (2004). Principles of gene manipulation, 6th edition, Blackwell. 7. Watson. (20010), Recombinant DNA, 3rd ed. ASM Press. 8. T.A. Brown. (2009). Gene cloning and DNA analysis, 2nd ed. Wiley-Blackwell. 9. B. Glick et al. (2010). Molecular Biotechnology- Principles and application of recombinant DNA, 4th ed. ASM Press. 10. D. Clark, N. Pazdernik. (2009) Biotechnology- Applying the genetics to revolution. Academic Press.	

Semester VI – Theory

Course: SLSC604	ENVIRONMENTAL BIOTECHNOLOGY II (Credits: 04 Lectures/Week: 04)	
	Objectives: On completion of the course, the student must be able to: 1. Understand the basic sustainability concepts of homeostasis, carrying-capacity, recycling. 2. Articulate the interdisciplinary context of environmental issues. 3. Prepare for career success in natural resources and its conservation, public health, environmental monitoring, industrial environmental management. 4. Develop a sense of community responsibility by becoming aware of scientific issues in the larger social context. 5. Develop standards of professional behaviour that include rules of ethics and etiquette. 6. Understand the basic theoretical concepts and methodologies of both the physical and social sciences. 7. Learn how to solve large-scale problems using a multitude of tools and approaches. **Outcomes:** The students will be introduced to fundamentals of environmental science, rural environment and urbanization, natural resources and energy conservation, environmental impact analysis and environmental audits, public participation, environmental safety and society.	
Unit I	**(A) Population dynamics :** Factors that influence Human Population size and growth, population fluctuations, carrying capacity, density and population reduction (density dependent and independent factors). **(B) Urbanization** in developing countries. Urban crisis, suburban sprawl, land use planning, urban open spaces, Morbidity caused by air pollution, diseases of future(cancer & respiratory diseases).Urban growth Challenges: water and waste management, , water shortage, using less water, pricing of water. Air pollution and mobility **(C) Rural environment** : Availability of fresh water, use of fresh water, ground water, contamination of ground water, rural sewage management, freshwater wet lands, Impact of cities on rural environment eg; Delhi & Yamuna, Spread of air pollution, Problems at catchment areas of Dams. **(D) Impact of Environmental degradation on Women.** **(E) Toxic and solid waste management**: Toxic Waste Trading: An environmentally destructive trade activity.	**15L**

Unit II	**(A) Natural resources**: energy conservation and renewable energy: Reserves of non renewable energy resources: Hidden costs of using	**15L**

	natural resources electricity, generation and storing electricity. **(B) Evaluating energy resources**: Nuclear power, coal, Natural gas, biomass burning, gas turbines, biofuels. **(C) Alternative energy resources**: Geothermal, Tidal/wave power, ocean thermal energy conversions, inland solar ponds, Energy efficient buildings.	
Unit III	**(A) Environmental Impact Analysis of a Development Project:** Environmental audit: protocols and data collection and analysis. Case studies of any development projects. (e.g. Solid waste Management of a Municipal corporation, and an industrial plant etc) **(B) Public Participation**: Methodology and approach for public participation in Environmental & development decision making. Example: Plachimada struggle, Narmada Bachao andolan, Chipko movement Regulatory requirements for public participation eg Jaitapur or ENRON issues. Advantages and disadvantages of Public participation. Identification of participants and conflict management. Incorporation of results in decision makings**.**	**15L**
Unit IV	**(A) Society and environment:** Nuclear proliferation, environment and war : E.g. use of Agent orange in Vietnam war, cost, benefit and risks, cost benefit analysis, risk management (EIA and Environment protection agency) perception of risk and gain, setting up standards, International cooperation - Treaties, planning for future. Vision of the world 2040. **(B) Safety, Health and Environment:** Lessons after 25 years of Bhopal gas tragedy. Perspectives and concerns of citizens: Environment as the ultimate beneficiary / loser. Safety and Health Hazards: Identification of potential safety and health hazards in industrial and development projects, reduction strategies, policies and legislation, international and national perspective, safety standards and management systems, ISO 18000 (Occupational Health and Safety Management Systems)	**15L**
	References: 1. Misra and Pandey (2011), "Essential environmental studies", Ane Books 2. Martens (1998),"Health and climate change ", Earth Scan 3. Saxena (1998), "Environmental Analysis of soil and air", Agrobotanica 4. Chakraborti (2005),"Energy efficient and environment friendly technologies for rural development " ,Allied Publishers	

	5. Dash M C (2004) "Ecology, chemistry and Management of environmental Pollution ",Mac Millan India 6. Nayak ,Amar(2006) "Sustainable sewage water Management ",Mc Millan India 7. Dolder, Willi (2009), "Endangered animals, Parragon 8. Gupta P K (2000)," Methods in environmental Analysis", Agrobio (India) 9. Fumento, Michael (2003),"Bioevolution : How biotechnology is changing our world" , California encounter Books 10. Kapur (2010) "Vulnerable India ", SAGE 11. Jacob, Miriam(2004) ," Silent Invaders" , Orient Longman 12. Mc Cafferty (1998) ,"Aquatic Entomology ", Jones and Barlett 13. Subramnyam (2006),"Ecology " , 2nd ed.Narosa 14. Dilip Kumar, Rajvaidya (2004)," Environmental Biotechnology ", APH 15. Sharma and Khan (2004)," Ozone Depletion and Environmental Impacts" ,Pointer publishers	

Semester VI – Practical

Course: SLSC6PR1	**Practical 1 (Credits: 04 Practicals/Week: 02)**

Paper – I: Genetics and Immunology

1. Giant Chromosome preparation (*Drosophila* / *Chironomus larvae*)
2. Estimation of bacteriophage titre by plaque assay
3. Effect of UV radiation on microorganisms (Light repair and Dark repair)
4. Isolation of antibiotic resistant / auxotrophic mutants using Replica plate
5. PCR
6. Ouchterlony test for Immunodiffusion
7. Mancini test – Single Radial Immunodiffusion
8. Agarose slide gel electrophoresis of Serum
9. Separation of Mononuclear cells
10. ELISA

Paper – II:: Developmental Biology and Neurobiology

1. Effect of boron / calcium on pollen tube germination in *Vinca rosa* or any other suitable sample
2. Role of GA in seed germination
3. Plant Tissue Culture: Initiation of plant tissue culture from germinated chick pea/any other suitable source
4. Live observations of Development of *C. Elegans/ Dictostelium/ Drosophila/ Zebra fish*
5. Imaginal discs of *Drosophila*
6. Regeneration in earthworm / any other suitable system / hydra (using permanent slide / photographs)
7. Differential staining of white and grey matter of vertebrate brain.
8. Temporary mounts of any three of the following:
   a) Cornea of prawn.
   b) Statocyst of prawn.
   c) Columella of bird.
   d) Striated / smooth muscle fibre.
   e) Methylene blue staining of earthworm nerve cord or any other suitable nerve cord or brain to observe organization of neuronal cell bodies in invertebrates
   f) Olfactory & gustatory sensillae
   g) Histological staining of neuronal tissue using Heamotoxilin-Eosin stainningorNessil's staining.
9. Making clay model of vertebrate brain and cranial nerves
10. Stroop test
11. Olfactory /Gustatory Behavioral study: Snail / Earthworm / insect larvae or any other suitable system.
12. Associative conditioning
13. Knee-jerk and pupillary reflex
14. Testing for locating the Blind Spot in the retina

Course: SLSC6PR2	**Practical 2 (Credits: 04 Practicals/Week: 02)**

Paper – III: Fermentation technology & Genetic engineering: a Biotechnological approach

1. Thin layer chromatography of lipids/plant alkaloids/any other suitable extract
2. Bioassay of antibiotic for anti-bacterial activity
3. Assay of fermentation product:
   (a) Alcohol
   (b) Sugar
4. Extraction of plasmid DNA& Agarose Gel Electrophoresis of plasmid DNA/Restriction Digest with costing of the experiment
5. Bioinformatics: Sequence annotation, Translation, Sequence alignment
6. ***Open-ended projects:***
   (a) Home Wine production / Home-Vinegar production from any convenient source & assay for fermentation products
   (b) Plant tissue culture: i) Callus production ii) Preparation of protoplasts and estimate viability by trypan blue staining
   (c) Growth curve of *E coli*
   (d) Culturing & biomass estimation of mushroom/ *Spirulina /chlorella* by cell count/dry weight and estimation of percentage total protein.

Paper – IV: Environmental Biotechnology

1. EC, conductivity,
2. N/P/K/Sulphates/ Na/ Ca.
3. Estimation of Co2+ and Ni2+ by colorimetry / spectrophotometry /
4. Water analysis for physico-chemical characteristics
5. Estimation of Heavy metal in various samples by titrimetry or spectrometry
6. Potability of the given drinking water sample by MPN.
7. Remote Sensing and GIS : Principles of Remote Sensing and its application of Environmental Science. Application of GIS in Environmental Management
8. Collection and Interpretation of weather data/Climatology of Mumbai city (Satellite images and statistical analysis of weather data)
9. Study of effect of a metal toxicity on the heart beat of Daphnia and statistical analysis of the same T Test/LC 50
10. Field visit to river/lake and waste water treatment plant
11. Identification of local plant species as : Ecological indicators, exotic species.

Evaluation Scheme

[A] Evaluation scheme for Theory courses:
Semester End Examination (SEE) – 100 Marks

[B] Evaluation scheme for Practical courses:
Semester End Examination – 50 Marks (Per Paper)