

M.SC. LIFE SCIENCES

The syllabus for M. Sc. Life Science based on semester with credit based pattern comprises of four semesters. The examination shall be of 04 core theory papers, each with 4 credits (4x4=16 credits), 1 elective paper of 4 credits each (1x4=4 credits), 1 laboratory course of 4 credits (1x4=4 credits). The fourth semester consists of 2 core papers for 16 and 8 credits. Thus, each semester offers 24 credits (4x24=96 credits). Each 4 credit theory paper is equivalent to 100 marks and the laboratory course consists of four modules (i.e. one module from each core paper). The Examination in each theory paper and laboratory course shall be of three hours duration.

Special Features of Our Programme

1. Special syllabi on the pattern of UGC-NET with Research/Professional Orientation
2. Choice Based Credit System (CBCS)
3. Semester Pattern

Eligibility criteria:

1. Graduate degree in any discipline of Life Sciences/Animal Science/Agricultural Sciences/Medical Sciences or other allied subjects like Biotechnology/ Microbiology/ Biochemistry with 50% (45% for SC/ST/PH/OBC) aggregate marks from a recognized University.
2. Reservation as per University rules.

BASAHEB BHIMRAO AMBEDKAR UNIVERSITY**Department of Zoology****Syllabus of M. Sc. Life Sciences as per UGC Guidelines on CBCS**

Semester – I					
Sl. No.	Paper Code	Paper Title	Type	L+T+P	Total Credits
1.	LS-101	Physical and Biological Chemistry	Core Course	3+1+0	04
2.	LS-102	Principles of Microbial Sciences	Core Course	3+1+0	04
3.	LS-103	Cell Biology	Core Course	3+1+0	04
4.	LS-104	Developmental Biology	Core Course	3+1+0	04
5.	LS-105	Laboratory Course (Module I,II,III,IV)	Core Course	0+0+4	04
Discipline Specific Elective (DSE)					
1.	LS(OE)-101	Population Ecology	Elective Course	3+1+0	04
Semester – II					
Sl. No.	Paper Code	Paper Title	Type	L+T+P	Total Credits
1.	LS-201	Principles of Plant Sciences	Core Course	3+1+0	04
2.	LS-202	Mammalian Physiology	Core Course	3+1+0	04
3.	LS-203	Ethology & Evolution	Core Course	3+1+0	04
4.	LS-204	Inheritance Biology & Genetics	Core Course	3+1+0	04
5.	LS-205	Laboratory Course (Module I,II,III,IV)	Core Course	0+0+4	04
Discipline Specific Elective (DSE)					
1.	LS(OE)-201	Economic Zoology	Elective Course	3+1+0	04
Semester – III					
Sl. No.	Paper Code	Paper Title	Type	L+T+P	Total Credits
1.	LS-301	Immunology & Immunotechnology	Core Course	3+1+0	04
2.	LS-302	Analytical & Separation Techniques	Core Course	3+1+0	04
3.	LS-303	Bioinstrumentation	Core Course	3+1+0	04
4.	LS-304	Molecular Biology and Animal Biotechnology	Core Course	3+1+0	04
5.	LS-305	Laboratory Course	Core Course	0+0+4	04
Any one from following					
1.	AS-306	Aquarium Management	Elective Course	3+1+0	04
2.	AS-307	Fish Processing Technology	Elective Course	3+1+0	04
Semester – IV					
Sl. No.	Paper Code	Paper Title	Type	L+T+P	Total Credits
1.	LS-401	Dissertation and Viva-voce	Core Course	2+2+12	16
2.	LS-402	Study Tour/Field Attachment and Viva-voce	Core Course	-	08

SEMESTER-I

LS 101: Physical and Biological Chemistry

Credit: 4

Total Marks: 70

Unit – 1: Chemical Foundation

- Structure of Atom, Molecules, Chemical bonds and Stabilizing interactions (Vander Waals ,electrostatic, hydrogen bonding, hydrophobic interactions)
- Acids , Bases , Salts , pH
- Properties of water, Solutions, Buffers
- Physico-chemical properties of the living cell.

Unit – 2: Energy and Thermodynamics

- Bioenergetics, oxidative phosphorylation, Coupled reaction, Group transfer
- First and second Law of thermodynamics, Concept of Free energy
- Principles of catalysis, Enzymes and Enzyme kinetics, Enzyme regulation
- Allosteric enzymes and Isozymes

Unit – 3: Biomolecules - I

- Classification, Nomenclature, Structure and properties of carbohydrates
- Structure and functions of Lipids: Phospholipids and Glycolipids.
- Structure and functions of Steroid
- Metabolism of carbohydrate and lipids

Unit – 4: Biomolecules - II

- Structures, physical properties and functions of amino acids.
- Conformation of proteins (Ramachandran plot, primary, secondary, tertiary, quaternary domains, motifs & folds)
- Conformation of nucleic acids [helix, (A,B,Z), t-RNA, micro RNA]
- Metabolism of amino acids and nucleotides

Suggested Readings:

- Lehninger Biochemistry, Nelson & Cox 6th edition, W.H. Freeman & Company
- Harper's Illustrated Biochemistry by Robert K. Murray, Lange
- Biochemistry C.K. Mathews, K. E. Van Holde, K. G. Ahern Pearson Education , N Delhi 2003
- Biochemistry J. M. Berg, J. L. Tymoczko & L. Stryer W.H.Freeman & Co., NY 2004 Biochemistry and Mol. Biology W.H. Elliott & D.C. Elliott Oxford Press, Oxford 2005
- Chemistry for Life Sciences Sutto R., Rockett B. & Swindells P Taylor & Francis, London 2000

LS-102: Principles of Microbial Sciences

Credit: 4

Total Marks: 70

Unit – 1: Microbial Taxonomy

- Importance and systems of Classification
- Status of Microorganisms into kingdoms
- Basic principles of nomenclature and classification
- Criteria used for classification and identification of microorganisms

- Genetic approaches used for microbial taxonomy.
- Numerical Taxonomy
- Bergey's Manual
- Present State of Bacterial, fungal and Viral taxonomy

Unit – 2: Morphology, Reproduction and Significance

- Bacteria – Staphylococcus (Gram positive) and Escherichia (Gram negative) as model examples
- Moulds – Rhizopus, Penicillium, Puccinia as model examples
- Yeasts – Saccharomyces as model example
- Bacterial Viruses – Coliphage T4 and Lamda phage as model examples
- Animal Viruses – Adenovirus and Influenza virus as model examples
- Plant Viruses – TMV as model example

Unit – 3: Microbial physiology and Genetics

- Principles of microbial nutrition :
 - a) Modes of uptake of nutrients in microorganisms
 - b) Nutritional requirements of microorganisms
 - c) Nutritional classification of microorganisms
- An overview of microbial metabolism
- Microbial growth :
 - a) Growth in prokaryotes and modes of cell division
 - b) Mathematical nature and expression of growth.
 - c) Normal growth curve of microbial population and Diauxic growth.
 - d) Continuous cultivation of microorganisms.
 - e) Methods for measurement of microbial growth.
 - f) Effect of environment on microorganisms
- General principles of Microbial Genetics:
 - a) DNA and its replication
 - b) Bacterial plasmids and Transposable elements
 - c) Recombination methods: Transfection, Transduction, Conjugation, Parasexuality.

Unit – 4: Elements of Microbial Technology:

- Concept of fermentation, Range of fermentation products and processes
- Sources of Industrial Microbes: Isolation, Selection and Screening of industrially important microbes,
- Strain improvement programme,
- Media formulations for fermentation process,
- Bioreactor design,
- Optimization and control of fermentation process parameters,
- Scale-up and scale-down in bioprocess,
- Typical Microbial Fermentation Products :
 - I. Antibiotics : Penicillin,
 - II. Enzymes : Amylase,
 - III. Organic acids : Citric acid
 - IV. Organic solvents : Ethanol
 - V. Amino acids : Lysine
 - VI. Vitamins : B12

Suggested Readings:

- Dairy Microbiology H. A. Modi Aaviskar Pub, Jaipur 2009
- Developments In Food Microbiology R. Davis Applied Sci. Publ., London 2004
- Elementary Microbiology, Vol. 1 & 2 H. A. Modi Akta Prakasan, Nadiad 1996
- Food Microbiology M.R. Adams and M.O. Moss, The Royal Society of Chemistry; Cambridge 2000
- General Microbiology M. M. Michael, J. Stanier et al Latest
- Introductory Food Microbiology H.A. Modi Aavishkar Pub., Jaipur 2007
- Principles of Microbiology R. M. Atlas

LS-103: Cell Biology

Credit: 4

Total Marks: 70

Unit-1: Introduction to cell biology and Bio membranes.

- Discovery of cell, cell theory, prokaryotes and eukaryotes, evolution of eukaryotic cell.
- Structural organization of virus, bacteria and eukaryotic cell- ultra structure of animal cell.
- Bio membranes: chemical composition and molecular arrangement (lipid bilayer, membrane proteins and carbohydrates), models of membranes(fluid mosaic).
- Membrane Transport: Diffusion (simple and facilitated) and active transport (primary and secondary), carrier proteins (uni, sym and anti porters), channel proteins (voltage and ligand gated). Bulk transport-pino, phago and exocytosis. Receptor mediated endocytosis.

Unit-2: Intracellular Compartments

- Nucleus: components, nuclear pore complex, organization of chromatin-nucleosomes, chromosomes, export and import of proteins
- Mitochondria structure & functions
- Endoplasmic reticulum: signal peptide hypothesis, insertion of membrane proteins and glycosylation
- Golgi Complex: secretory and lysosomal proteins. Glycosylation of proteins.

Unit 3: Cell Signalling, cell interactions and cytoskeleton.

- Cell surface receptors: G-protein linked receptors, signal transduction, second messengers, receptor tyrosine kinases and intracellular receptors.
- Cell junctions: tight junction, desmosome, hemidesmosome and gap junctions.
- Cell adhesion molecules: cadherins, Immunoglobulin like molecules, integrins and selectins.
- Cytoskeleton: Microtubules, microfilaments and their dynamics. Centrosome, cilia, flagella. Mitotic apparatus and movement of chromosomes.

Unit 4: Cell cycle, apoptosis and cancer

- Phases of cell cycle. Regulation of cell cycle: Discovery of MPF, cyclins and cyclin dependent kinases, Check points- role of Rb and p53.
- Apoptosis. Neurotrophic factors, caspases, Pathways of apoptosis,
- Cancer. Types and stages. Tumor suppressor genes and protooncogenes. Molecular basis of cancer.
cell senescence

Suggested Readings:

- Cell and Molecular Biology De Robertis, E.D.P. and De Robertis E M F
- Cell and Molecular Biology Garald Karp J. Wiley & Sons, NY
- Cell Biology – Structure and Function David E. Sadava, Jones and Bartlett Pub., IND.
- Cell Biology LabFax G.B.Dealtry & D. Rickwood Bios Scientific Pub.
- Cell Biology, Genetics, Molecular Biology, Evolution and Ecology P.S. Verma, V.K. Agarwal S. Chand Pub., N Delhi
- Cell Growth and Division, A Practical Approach. R. Basega, IRL Press, Oxford Univ. Latest
- Cell in Development and inheritance EB Wilson MacMilan, NY Latest

LS 104: Developmental Biology and Toxicology

Credit: 4

Total Marks: 70

Unit – 1: Basic concepts of development

Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development

Unit – 2: Reproduction

- **Gametogenesis,**
Production of gametes (ovum and sperm),
Types of Ovum & Eggs
- **Fertilization**
Cell surface molecules in sperm-egg recognition in animals;
Zygote formation,

Unit – 3: Early embryonic development:

- Ultrastructure of Sperm & ovum
- Cleavage,
- Blastula formation,
- Embryonic fields,
- Gastrulation and formation of germ layers in animals;

Unit – 4: Late embryonic development:

- Growth, cell proliferation, growth hormones; aging- genes involved in alteration in timing of senescence

- **Morphogenesis and organogenesis in animals** : Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in, amphibia and chick; organogenesis – vulva formation in Caenorhabditis elegans, , limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.
- **Morphogenesis and organogenesis in plants:** Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in Arabidopsis and Antirrhinum.

Suggested Readings:

- Developmental Biology by Gilbert
- An introduction to Embryology B. I. Balinsky A East West Press, N Delhi 2004
- Developmental Biology P.S. Verma and V.K. Agarwal Press S. Chand.
- Human Embryology Inderbir Singh and G.P. Pal Press Jaypee Brothers Pub

LS-105: Laboratory Course

Module I: Physical and Biological Chemistry

- Water analysis and hardness of water
- Preparation of solution of different concentration
- Preparation of buffers, understanding Henderson Hasselbach equation
- To demonstrate effect of temperature, pH and substrate concentration on enzyme activity.
- Qualitative estimations of carbohydrates, proteins and lipids

Module II: Principles of Microbial Sciences

- Preparation of microbial media (bacteria, yeast, algae)
- Sterilization : principles and operations- Autoclave, Hot air oven, Filtration, Laminar air flow
- Isolation of bacteria (streak plate, spread plate, pour plate, serial dilution)
- Identification of micro-organism from the habitats (simple staining, differential staining, acid fast staining)
- Methods of inoculation of different microbes in selective media
- Microscopic measurements, haemocytometer.

Module III: Molecular Cell Biology

- Cell cycle analysis – onion root tip experiment
- Cell counting and viability test
- Sub cellular fractionation of cellular organelle (nuclear, mitochondrial and cytosolic fraction) by differential centrifugation
- Extraction of DNA from biological sample
- Quantification of DNA (optical density method)
- To demonstrate selective permeability of an artificial membrane (cellophane)
- Estimation of Nucleic acid to Protein ratio

- To demonstrate separation of nucleic acid by gel electrophoresis

Module IV: Developmental Biology / Genomes Biology

- Slide preparation of different developmental stages of mammalian embryos
- Fertilized egg preparation and identification through ink marking
- Genotoxicity- micronuclei, single strand breakage (comet assay)
- Estimation of LD₅₀ and LC₅₀

Discipline Specific Elective (DSE)

ZL(OE)-01: Population Ecology

Unit 1

- Population Growth: Population growth and their characteristics, exponential growth, Verhulst – Pearl logistic growth model.
- Stochastic models of population growth, stable age distribution, Life table.

Unit 2

- Competition and Niche Theory: intraspecific and interspecific competition, history of niche concepts, theory of limiting similarity
- Ecological interdependence and interaction (mutualism, commensalism, amensalism, neutralism, symbiosis, parasitism.)
- Evolution of mutualism, Plant – pollinator and animal – animal interactions basic models

Unit 3

- Population Regulation: Extrinsic and Intrinsic Mechanisms
- Hardy- Weinberg Equilibrium (their application, equation, factors affecting the Hardy- Weinberg law)
- Lotka- Volterra Model (their equation, application, measuring parameter of Lotka- Volterra model)

Unit 4

- Life history strategies: Evolution of life history traits, longevity and theories of ageing,
- Geological time scale.
- Parental investment and offspring, reproductive strategies – ecology and evolution of sex and mating systems, optimal body size, r and k selection

Suggested Reading Material

- Begon, M., J.L. Harper and C.R. Townsend. Ecology, Individuals, Populations and Communities. Blackwell Science, Oxford, UK.
- Cherratt, J.M. Ecological concepts. Blackwell Sci. Publi. Oxford, UK.
- Elseth, B.D. and K.M. Baumgartner. Population biology. Van Nostrand Co., New York.
- Jorgensen, S.E. Fundamentals of ecological modeling. Elsevier, New York.
- Krebs, C.J. Ecology. Harper & Row, New York.
- Krebs, C.J. Ecological methodology. Harper & Row, New York.

- Ludwig, J.A. and J.F. Reynolds, 1988. Statistical ecology. John Wiley & Sons, New York.
- Pianka, E.R. Evolutionary ecology. Harper & Row, New York.
- Ricklefs, R.E. and G. Miller. Ecology, W.H. Freeman & Co., New York.
- Roughgarden, J., Ecological methods. Southwood, T.R.E.
- Swartzman, G.L. and S.P. Kaluzny. Ecological simulation primer. MacMillan, New York.
- Roff, O.A. The evolution of life histories. Theory and Analysis. Chapman & Hall, London, UK.

SEMESTER-II

LS 201: Principles of Plant Sciences

Credit: 4

Total Marks: 70

Unit – 1: Plant Cell and its Growth

- Shoot and Root Apical Meristem, Cellular manifestation and factors affecting development
- Growth and Development: Concepts, qualitative – quantitative changes
- Growth regulators: (Plant hormones viz auxin, cytokinin, gibberellins, ABA, ethylene) biosynthesis, bioassay, mechanism of action, physiological effects, applications

Unit – 2: Plant Physiology

- Photosynthesis – Light harvesting complexes, mechanism of electron transport, CO₂ fixation, C₃, C₄ & CAM pathways
- Respiration- Plant mitochondrial electron transport & ATP synthesis, photo respiratory pathways
- Plant Tissue Culture- basics

Unit – 3: Environmental Biology

- Concept and dynamics of ecosystem – Organization and functions, Types,
- Energy flow, food chain, food web and trophic levels; ecological pyramids;
- Biogeochemical cycles (C, N, P and S)
- Ecological factors: Soil, light, water etc, Principle of limiting factors; biotic factors,
- Population ecology – concept, types, fluctuation, factors regulating size, autecology, mortality, natality
- Ecological succession and Niche theory

Unit – 4: Plant Breeding

- Plant breeding – objectives, origin, domestication, hybrid vigour
- Principles and methods of plant Breeding, Self pollinated crops, cross pollinated crops, Clonal crops
- Plant Introductions – NBPGR

Suggested Readings:

- Plant Breeding B.D. Singh
- Plant Physiology Taiz L& Zeiger E
- Plant Tissue Culture Razdan M. K.
- Plant Physiology by Salisbury & Ross

LS 202: Mammalian Physiology

Credit: 4

Total Marks: 70

Unit – 1: Movement and Coordination

- Organization of Body
- Structure of skeletal, cardiac and smooth and Physiology of muscle contraction.
- Structure of Brain and Neurons.
- Physiology of nerve impulse conduction, excitability of membranes, electrical and chemical transmission between cells.
- Chemical coordination - Endocrine organs and Hormones,

Unit – 2: Respiration and Nutrition

- Physiology of respiration
- Exchange and transport of gases and its regulation.
- Physiology of digestion, regulation of food intake and digestive secretions.
- Nutrition and metabolism

Unit – 3: Transport and Sense organs

- Physiology of blood – compositions & structure, Haemopoiesis, coagulation,
- Heart : beat, initiation , conduction and regulation
- Physiology of Circulation
- Sense organs: vision, hearing & tactile response

Unit – 4: Excretion and Reproduction

- Internal structure of Kidney and Nephron
- Physiology of excretion- role of kidney in urine formation, waste elimination, water balance, blood volume, blood pressure, electrolyte balance and acid base balance ,
- Reproduction- reproductive processes, gametogenesis, ovulation and its neuroendocrine regulation

Suggested Readings:

- Anatomy and Physiology Thibodeau G.A. & Patton K.T. Mosby 1996
- Marshall's Physiology of Reproduction Vol 1 and 2 G. E. Lamming. Churchill Livingstone 1990
- Principles of Anatomy and physiology Tortora G.J. & Grabowski S. R. 2001
- Textbook of Medical physiology Guyton A.C. and Hall. J.E.
- The Physiology of Reproduction Vol. 1 and 2 E. Knobil and J. D. Neill. Raven Press, NY 1988

LS 203: Ethology and Evolution

Credit: 4

Total Marks: 70

Unit – 1: General aspect of Behaviour

- Introduction of Behaviour
- Evolutionary approach to Behaviour, Levels of Natural selection
- Genetic basis of behaviour, Hereditary and Behaviour
- Sensory world of animals – Physical stimulus and Behavioural equipments
- Behavioural patterns -Individual and Homing Behaviour,

- Instinct , imprinting and learning Behaviour; Mechanism of learning,

Unit – 2: Interactive Behaviour

- Reproductive behavioural patterns, Courtship, Mating and Parental cares,
- Stickle Back behaviour
- Social organization and Behaviours – Dominance, Territoriality, Aggression and social facilitation,
- Animal communication systems and role of pheromones in communication
- Dance language of the bees
- Human ethology - General aspects.

Unit – 3: Evolution I

- Animal diversity and its significance
- Concept of Evolution,
- Origin of life on Earth
- Molecules to Cell, Origin of Prokaryotic and Eukaryotic Cell
- Source of Evolution,
- Variations; Role of Mutations; Recombination; Polyploidy; Isolation,

Unit – 4: Evolution II

- Adaptation- various types, Habitat preference,
- Natural selection, Evolution in Action;
- Concept of Species – Speciation, Genetic drift, Hardy-Weinberg law;
- Mimicry; Polymorphism, Molecular phylogeny;
- Tempo of Evolution, Macro and Micro – evolution;
- Trends in Evolution, Future prospects.

Suggested Readings:

- Animal Behaviour McFarland D.
- Animal Behaviour & Evolutionary Approach Alcock J.
- Comparative animal Behaviour Donald A. Dewsbury McGraw Hill Book 1978
- Integral animal behaviour David E Davis. MacMillian Co, NY 1967
- Evolution by Eaton H.
- Evolution by Strickberger Prentice Hall
- Animal Behaviour & Evolutionary Approach Alcock J.
- Cell Biology, Genetics, Molecular Biology, Evolution and Ecology P.S. Verma, V.K. Agarwal S. Chand Pub., N Delhi 2004

LS 204: Inheritance Biology / Genetics

Credit: 4

Total Marks: 70

Unit – 1: Mendelian Genetics

- Genetics – principles of inheritance, pea as a model hybrids
- Gene interactions, linkage and crossing over, genetic mapping
- Extra chromosomal inheritance, chloroplast, Mitochondria, genome and genes.

Unit -2: Quantitative Genetics

- Polygenic inheritance, heritability & its measurements, QTL mapping
- Mutation : Types, causes, & detection , mutant types, lethal, conditional , biochemical , loss of function, gain of function, germinal versus somatic mutants, insertional mutagenesis

Unit -3: Alterations of chromosomes & recombination

- Deletion, duplication, inversion, translocation, ploidy and their genetic manipulation
- Homologous and non homologous recombination including transposition, site specific recombination

Unit -4 : Regulation of Gene Expression:

- Regulation of gene activity in lac and trp operons of E. coli.;General introduction to gene regulation in eukaryotes at transcriptional and posttranscriptional levels;
- Chromatin organization
- gene expression, transcription factors, enhancers and silencers, non coding genes.

Suggested Readings:

- Genetics and origin of species Dobzhansky
- Human Cytogenetics – A practical approach (Vol. I & II) Rooney & Czepulkowski IRL Press at Oxford University Press, NY 1992
- Principles of Genetics E. J. Gardner, M. J. Simmons & D. P. Snustad John Wiley & Sons, NY 2001
- Principles of Genetics Robert H. Tamarin Tata McGraw Hill, N Delhi 2002
- Applied Molecular Genetics. Miesfield Wiley & Sons Publication 1999
- Basic Genetics R. F. Weaver & P. W. Hedrick Wm C. Brown Pub, Oxford 1995
- Cell Biology, Genetics, Molecular Biology, Evolution and Ecology P.S. Verma, V.K. Agarwal S. Chand Pub., N Delhi 2004

LS 205: Laboratory Course**Credit: 4****Total Marks: 70****Module I: Principles of Plant Sciences**

1. Determination of primary production of an area by harvest method
2. Determination of primary production of an area by chlorophyll method
3. Determination of primary aquatic production by harvest method
4. Effect of water and salinity stress on chlorophyll content of leaves
5. Estimation of the total nitrogen content of a plant using Kjeldahl's method
6. Estimation of ascorbic acid in ripe and unripe fruits
7. Assaying IAA oxidase activity in green and senescent leaves
8. Studies on induction of amylase activity by GA3 in germinating cereal grains

Module II: Mammalian Physiology

1. Study of heart of cockroach, determination of the rate of heart beat in Daphnia, study of permanent preparation of whole mounts and LS of following hearts: fish (2-chambered), frog (3-chambered), mammal (4-chambered)
2. Study of ECG in human
3. Study of accessory respiratory organs: Anabas, Clarius, Sacchobranthus and Boleopthalmus
4. Study of nutritional apparatus: amoeba, L.S. of Hydra, Planaria, digestive system of cockroach and earthworm (by demonstration only), detection of activity of digestive enzymes Invertase, amylase, protease and lipase.

Module III: Ethology and Evolution

1. Mathematical problems in Population genetics, Hardy-Weinberg Law
2. Study of animal interaction:
 - a) Commensalism
 - b) Mutualism
 - c) Antibiosis: effect of antibiotic on bacterial growth on Petri plate
 - d) Parasitism
 - e) Predation

Module IV: Inheritance Biology / Genetics

1. Mendelian Genetics – problem solving
2. Demonstration of PCR and Gel electrophoreses.
3. Comparison of genomes- bioinformatics analysis
4. DNA or RNA isolation from human blood cell corpuscles.

Discipline Specific Elective (DSE)
ZL(OE)-02: Economic Zoology

Unit 1: Apiculture

History & Classification, Biology of Honey Bees, Social Organization of Bee Colony(Queen, Drone, Worker).Economic Importance, Scope in Apiculture, Diseases & its control, Rearing of Bees, Bee Keeping Equipment.Bee Economy & Entrepreneurship in Apiculture.

Unit 2: Aquaculture

Introduction to fresh water aquaculture, aquaculture systems, Integrated farming Systems; Paddy cum fish culture, poultry cum fish culture, poultry-piggery cum fish culture, Waste water fed aquaculture.Physico-chemical properties of soil and water, Productivity & nutrient quality & quantity of soil and water, Soil and water quality monitoring and management.

Unit 3: Sericulture

Introduction to Sericulture, Types of mulberry and non-mulberry silkworms, Food plants of Silkworms. Different methods of Rearing, Diseases of silkworm and their control, Reeling methods. Economic income of Silk Industry.

Unit 4: Vermicomposting

Earthworms, Ecological role and economic importance of earthworms.Vermiculture – definition, scope and importance; Environmental requirements; Culture methods, Vermicomposting – applications, Future perspectives, Potentials and constraints for vermiculture in India.

Suggested Reading Materials:

- Prost, P. J. (1962). Apiculture. Oxford and IBH, New Delhi.
- Thomas PC, Rath SC & Mohapatra KD. 2003. Breeding and Seed Production of Finfish and Shellfish. Daya Publ.
- Edwards CA, Hendrix P and Arancon N (2014) Biology and Ecology of Earthworms, Springer Publishers.
- Edwards CA, Arancon NQ and Sherman RL (2011) Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management, CRC Press, USA.
- Ismail SA (2005) The Earthworm Book. Edition, Other India Press, Apusa, Goa, India.

SEMESTER-III

LS 301: Immunology and Immunotechnology

Credit: 4

Total Marks: 70

Unit – 1: Basic Immunology I

- History and Significance of Immunology,
- Immunity and its types,
- Introduction to Immune system, Cells and Organs involved,
- Complement system,
- Cytokines and their significance,
- Cancer and Immune responses (Tumour Immunology),

Unit – 2: Basic Immunology II

- Antigens – General Properties and Criteria for antigens, Types of Antigens
- Antigenicity, MHC and HLA complex,
- Immunoglobulins : Basic structure and types,
- Immunogenetics : Genetic basis of Clonal selection and Generation of antibody diversity,
- In vivo antigen-antibody interactions

Unit – 3: Immunotechnology

- In-vitro antigen-antibody reactions and diagnostic significance ,
- Agglutination tests,
- Precipitation and Immunodiffusion tests,
- Modern tests like ELISA, (RIA), RAST, FAT,
- Hybridoma technology and applications of Monoclonal antibodies,
- Vaccines and immunotherapy,

Unit – 4: Dysfunction Immunity

- Hypersensitivity reactions,
- Tolerance and auto-immunity; Auto immune diseases,
- Immunodeficiency and their consequences, - HIV
- Transplantation Immunology,
- Hazards of Vaccine,

Suggested Readings:

- Immunology (Kuby) R.A. Goldsby, T. J. Kindt, B. A. Osborne, J. Kuby W. H. Freeman & Co. NY 2002 Immunology Ivan M. Roitt, Jonathan Brostoff and David K. Male Glower Medical Pub. Mosley / London 2000
- Immunology and Immunotechnology A.K.Chakravarty
- A Text Book of Immunology By J.K. Sinha & S. Bhattacharya, Academic Publishers
- Monoclonal Antibodies : Principles and Practice J. W. Golding Academic Press, NY Latest

LS 302: Analytical and Separation Techniques

Credit: 4

Total Marks: 70

Unit – 1: Spectroscopic Methods:

- Principles of biophysical methods used for analysis of Biomolecules,
- Electrochemistry: pH meter – Principles and applications,
- Electromagnetic Spectrum; Light , Absorption of Light,
- Principle of Spectroscopy
- Types of spectrometer/detectors: UV, Visible
- ORD/CD, Fluorescence, Infra-red spectroscopy
- NMR spectrometer, X-ray Crystallography
- Flame-photometry
- Atomic absorption spectroscopy, MS and MALDI-TOF

Unit – 2: Chromatography

- Principles of Chromatographic Separation, Solvent extraction; Theory, principle and applications of Paper, Gel-permeation(Size exclusion), Ion-exchange and Affinity chromatography; Thin layer chromatography (TLC),
- HPTLC, HPLC and Gas chromatography;
- Super critical fluid Chromatography;

Unit – 3: Centrifugation

- Theory and Principles of Centrifugation, Sedimentation velocity and Sedimentation Equilibrium
- Types of Centrifugation and centrifuge machines:- Preparative and Analytical,
- Differential Centrifugation, Density Gradient Centrifugation
- Ultracentrifugation (velocity and buoyant density),

Unit – 4: Electrophoresis

- Basic Principles of Electrophoresis, Factors affecting Separation,
- Theory and Applications of Paper, Starch, Agarose and Polyacrylamide (Native and SDS) Gel Electrophoresis
- Gradient Gel Electrophoresis
- Iso-electric focussing, 2D and Capillary electrophoresis, Blotting Techniques

Suggested Readings:

- Principles & Techniques of Biochemistry and Molecular Biology K. Wilson & J. Walker Cambridge University Press, NY 2006
- Basic techniques in Molecular Biology Surzycki's Press, Springer Verlag.
- Techniques in Microscopy and Cell Biology A. K. Sharma Tata MacGraw Hill Pub. Co., N Delhi 1991
- Light Microscopy in Biology A. J. Lacey IRL Press, Oxford Univ. Press, New York, 1989

LS 303: Bioinstrumentation**Credit: 4****Total Marks: 70****Unit – 1: Histochemical and Microtome:**

- **Sample preparation:** In situ fixation of tissue/ organ, Dehydration of tissue,
- Preparation of paraffin wax block
- **Microtomy:** Principles & types, sample preparation and sectioning parameters
- **Histochemical procedures:** Staining procedures (H&E), Immunohistochemical procedures (DAB and immunofluorescence)

Unit – 2: Microscopy

- Principles, working and application of Bright field and Dark field microscope,
- Phase contrast and Interference, Differential Interference Contrast Microscope,
- Fluorescence Microscopy; Immunofluorescence,
- Confocal Microscopy,
- Specimen fixation, processing and staining in Light Microscopy,

Unit – 3: Electron Microscopy & Imaging

- Electron Microscopy; TEM, SEM, and STEM,
- Cryoelectron microscopy;
- Processing of Biological sample for EM,
- Special Techniques in EM: Negative staining,
- Shadow casting and Freeze fracture deep etch replication techniques;
- Micro CT (CAT, PET);
- Cytometry and Flow Cytometry,

Unit – 4: Radiochemical Methods :

- Principles and applications of tracer techniques in biology: Techniques of RIA, IRMA, EIA and radio receptor assay;
- Radiation Dosimetry; Radioactive isotopes and half life of isotopes;
- Liquid scintillation spectrometry; Autoradiography;
- Principles of Bio-assay and applications,
- Effect of radiation on Biological system

Suggested Readings:

- Principles & Techniques of Biochemistry and Molecular Biology K. Wilson & J. Walker Cambridge University Press, NY 2006
- Basic techniques in Molecular Biology Surzycki's Press, Springer Verlag.
- Techniques in Microscopy and Cell Biology A. K. Sharma Tata MacGraw Hill Pub. Co., N Delhi 1991
- Light Microscopy in Biology A. J. Lacey IRL Press, Oxford Univ. Press, New York, 1989
- Molecular Biotechnology S. B. Primrose Blackwell Sci. Pub., Oxford 1994
- Recombinant DNA and Biotechnology Krenzer & Massey ASM Press, USA 2000
- Textbook of Biotechnology H.K. Das Latest

LS 304: Molecular Biology and Animal Biotechnology

Credit: 4

Total Marks: 70

Unit – 1 : Molecular Biology :

- Chromatin chemistry,
- DNA, Histones, Non-histone proteins,
- Organization of Chromosomes:
- DNA Replication and Regulation, DNA Repair mechanism,
- Transcription and Regulation of Gene Expression
- Cytogenetics and Molecular genetics of Cancer; Oncogenes,
- Cellular Communication: Intra cellular interactions,
- Receptor ligand interaction;
- Signal transduction, role of second messengers and G-proteins, Signalling Molecules

Unit – 2 : Molecular Genetics

- Isolation and Purification of DNA,
- Chemical synthesis of DNA and Sequencing,
- Recombinant DNA techniques, Types of vectors,
- Gene cloning, Restrictions enzymes,
- Introduction of DNA/Gene into living cell,
- PCR system and gene amplification, Blotting techniques,
- RFLP and DNA fingerprinting, Applications in present perspective.
- Human genome Project, Gene therapy, Microarrays. FISH

Unit – 3 Animal Cell Culture

- Laboratory, equipments and Conditions for Animal cell culture,
- Cell dissociations and preparations of primary cell culture,
- Cell synchronization of animal cells and Characterization – Measurement of Viability and Cytotoxicity, Growth parameters
- Culture media for animal cell culture and their requirements
- Risks and Safety in the animal cell culture,

Unit – 4 : Animal Biotechnology

- Short-term and mass cultivations,
- Cultivation of specialized cells i.e. Nerve cell, skin cells and Haemopoetic stem cell (bone marrow);
- Cell Banks, Stem cells and their applications,
- Techniques of Isolation and Purification of Enzymes
- Various techniques used for the Immobilization of enzymes,
- Applications of immobilized enzyme in Biotechnology.

Suggested Readings:

- Molecular Biotechnology S. B. Primrose Blackwell Sci. Pub., Oxford 1994
- Recombinant DNA and Biotechnology Krenzer & Massey ASM Press, USA 2000
- Textbook of Biotechnology H.K. Das Latest
- Molecular Bio methods Hand book Rapley & Walker Latest
- Molecular Biology LabFax T.A. Brown Bios Sci. Publ., Oxford 1991
- Molecular Biology of the Cell B. Albert, A. Johnson, J. Levis, M. Raff, K. Roberts, & P. Walter. Garland Science 2002
- Molecular Biology of the Reproductive System Decretser. Academic Press, NY Latest

- Molecular Biotechnology S. B. Primrose Blackwell Sci. Pub., Oxford 1994
- Molecular Cell Biology H. Lodish, D. Baltimore, A. Berk, S. L. Zipursky, P. Matsudara and J. Darnell, Scientific American books, USA 1995
- Molecular Cloning : A Laboratory Manual J. Sambrook, E. F. Fritsch, & T. Maniatis ColdSpring Harbor Lab. Presss, NY 2000

LS 305: Laboratory Course

Credit: 4

Total Marks: 70

Module I: Immunology and Immunotechnology

- Grouping of blood and Rh typing
- Latex agglutination test for rheumatoid factor and pregnancy
- ELISA (kit)
- Antigen-Antibody reaction- Agglutination (Blood grouping testing)
- Antibody titration (Ouchterlony Double Diffusion)
- Antigen-Antibody reactions – Immunoelectrophoresis, Rocket immune-electrophoresis
- Antigen-antibody reactions-Coomb's test
- Antigen- antibody reactions-ELISA

Module II: Analytical and Separation Techniques

- Quantitative estimations of carbohydrate (glucose)
- Quantitative estimations of proteins (albumin)
- Quantitative estimations of lipids
- Column Chromatography- separation of a mixture of proteins and salt using Sephadex column
- Paper chromatography- ascending and descending- separation of amino acids
- Thin layer chromatography of amino acids
- Demonstration of HPLC

Module III: Bioinstrumentation

- Counting of viable and dead cells using hemocytometer
- Nucleus staining, Karyotyping
- Demonstration of SDS-PAGE
- Detection of protein in sub cellular extracts by western blotting
- RNA isolation from blood
- Quantification of RNA by O.D. method
- Integrity of RNA by electrophoresis

Module IV: Molecular Biology and Animal Biotechnology

- Preparation of culture media and Reagents-Media composition , Nutrition, Hormone
- In vitro culture-
 - a) washing and sterilization
 - b) Preparatory steps for primary tissue culture
 - c) Aseptic tissue transfer
 - d) Incubation of culture
 - e) Cell lines
 - f) cryopreservation
- Gene transfer:
 - a) Electroporation
 - b) Transfection
- Analysis at the level of gene transcription-
 - a) Northern blot
 - b) Real- Time PCR
- Analysis of DNA protein interactions: Electrophoretic mobility shift assay (EMSA)
- Transgenic mice- Homologous and Heterologous typing using kit

Elective Courses

LS-306: Aquarium Management

Unit 1

- Ornamental fishes: taxonomy, general and identifying character of Fresh water ornamental fish: Catfish, Cichlids, Cyprinids, Live-bearers,
- Marine water ornamental fish: Angelfish, Butterfly fish ,Damsels, Eels, Flatfish, Gobies, Lionfish, Parrotfish, Pipefish, Rabbitfish, Rays, Scorpionfish, Seahorse, Sharks, Snappers, Tangs, Tilefish, Triggerfish.

Unit 2

- Construction of aquarium: types, filters, heater, calcium reactor, feed pump, bog-wood, driftwood, air-stone, live rock, substrate, fish-cam, fish feeder, lighting, other accessories.
- Coloration and Pigmentation: category; types; formation; dietary, neuronal, hormonal control. Uses and functions; morphology and physiology of color changes and its significance

Unit 3

- Culture with respect to Puntius and Clown fishes: Gonads (ovary, testis) morphology, histology and physiology, Endocrine and environmental control over gonadal cycle, Reproduction, fertilization, Different developmental stages.
- Feed formulation and feeding management.

Unit 4

- Diseases caused by ectoparasite and endoparasites: protozoan, helminth, bacterial, fungal, viral parasites, their symptoms
- Treatments and prophylaxis.

Suggested Reading Material

- 1. S. Felix, T.V. Anna Mercy, Saroj Kumar Swain (2013), Ornamental Aquaculture: Technology and Trade in India, Daya Publication House, New Delhi
- 2. Mac E. Hadley (2004), Endocrinology, 5th ed., Pearson Education (Singapore) Pt. Ltd.

LS-307: Fish Processing Technology

Unit 1

- Fishing crafts; Principles of design and construction; Corrosion protection; Craft, materials - wood, marine plywood, fibreglass, reinforced plastic, aluminium, steel, ferro-cement; Bio-deterioration and preventive measures; Different types of fishing vessels in India; General arrangements of fishing vessels; Modern navigation equipment, navigation and fishing lights; Life saving devices

Unit 2

- Principles of fish preservation; Preservation of fish, sanitary requirements for maintenance of quality, processing ways of fish, Fish trade and its component,

Unit 3

- Fish craft as secondary earning of the fish trade person. Secondary utilization of fishery waste, as organic fertilizer, composition of fish waste in agriculture benefits, decorative piece as fish crafts, useful conversion of fish waste, different ways and their techniques.

Unit 4

- Economic importance of fish, it's by products and application, their processing ways, Fish market as a big trade, understanding of fish trade, employment types linked with fish trade, gender role in fish trade.

Suggested Reading Material

- W.S hoar and D.J Randall : fish physiology
- K.C. Jayaram: The freshwater fishes of India

SEMESTER-IV

LS-401 Dissertation and Viva-voce

Credit: 16

LS-402: Study Tour/Field Attachment and Viva-voce

Credit: 8

Total Marks:400

Total Marks: 200