

NATIONAL EDUCATION POLICY-2020



**Common Minimum Syllabus for all
Uttarakhand State Universities and
Colleges for Five Years of Higher Education**

**PROPOSED STRUCTURE
OF P.G. - ZOOLOGY
SYLLABUS**

2023

Curriculum Design Committee, Uttarakhand

S. No.	Name & Designation
1.	Prof. N.K. Joshi Vice-Chancellor, Kumaun University Nainital Chairman
2.	Prof. O.P.S. Negi Vice-Chancellor, Uttarakhand Open University Member
3.	Prof. M.S. Rawat Vice-Chancellor, Sri Dev Suman Uttarakhand University Member
4.	Prof. Jagat Singh Bisht Vice-Chancellor, Soban Singh Jeena University Almora Member
5.	Prof. Surekha Dangwal Vice-Chancellor, Doon University, Dehradun Member
6.	Prof. M.S.M. Rawat Advisor, Rashtriya Uchchar Shiksha Abhiyan, Uttarakhand Member
7.	Prof. K. D. Purohit Advisor, Rashtriya Uchchar Shiksha Abhiyan, Uttarakhand Member

Syllabus Expert Committee

S. No.	Name	Designation	Department	Affiliation
1.	Prof. S.P. S Bisht	Head & Convener	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
2.	Prof. Ila Bisht	Head & Convener	Department of Zoology	S.S. J Campus, S.S.J University, Nainital
3.	Dr. Manoj Kumar Arya	Associate Professor	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
4.	Dr. D. M Tripathi	Professor	Department of Zoology	Shri Dev Suman Uttarakhand, Vishwavidyalaya
5	Prof. H.C.S Bisht	Professor	Department of Zoology	D.S. B Campus, Kumaun University, Nainital
6	Dr. Suchi Upadhyay	Assistant Professor	Food Nutrition and Dietetics	University of Petroleum and Energy Studies, Dehradun
7	Dr. Mahendra Rana	Associate Professor	Pharmacognosy, Herbal Nanotechnology, Pharmaceutical Jurisprudence	Sir J. C. Bose Technical Campus, Bhimtal
8	Miss. Seeta Dewali	Assistant Professor	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
9	Dr. Netrapal Sharma	Assistant Professor	Department of Zoology	D.S.B Campus, Kumaun
10	Miss. Divya Pangtey	Assistant Professor (Guest)	Department of Zoology	D.S.B Campus, Kumaun University, Nainital

11	Dr. Sandeep Mandoli	Assistant Professor	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
----	---------------------	---------------------	-----------------------	---

Syllabus Preparation Committee

S. No.	Name	Designation	Department	Affiliation
1.	Prof. S.P. S Bisht	Head & Convener	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
2	Prof. H.C.S Bisht	Professor	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
2.	Prof. Ila Bisht	Head & Convener	Department of Zoology	S.S.J Campus, S.S.J University, Nainital
3.	Dr. Deepika Goswami	Associate Professor	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
4.	Dr. Manoj Kumar Arya	Associate Professor	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
5	Dr. Deepak Arya	Assistant Professor	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
6	Dr. Himashu P. Lohni	Assistant Professor	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
7	Miss. Seeta Dewali	Assistant Professor	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
8	Dr. Netrapal Sharma	Assistant Professor	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
9	Dr. Sandeep Mandoli	Assistant Professor	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
10	Miss. Divya Pangtey	Assistant Professor	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
11	Dr. Uzma Siddiqui	Assistant Professor	Department of Zoology	D.S.B Campus, Kumaun University, Nainital

YEAR	SEMESTER	PAPER CODE	PAPER TITLE	CREDITS TH+PR
<i>Bachelor (Research) in Faculty</i>				
4	VII	PAPER- I	Fundamentals of Immunology	4
		PAPER- II	Cell and Molecular Biology	4
		PAPER- III	Animal Ecology	4
		PAPER- IV	Medical Laboratory Techniques	4
		PAPER-V	Lab Based on Paper I To Paper IV	4
		Industrial Training/ Survey/Research Project	Concerning Major Papers of Semester-VII	4
			Credit I	24
	VIII	PAPER- I	General Ichthyology	4
		PAPER- II	Applied Ichthyology	4
		PAPER- III	Basic Limnology	4
		PAPER- IV	Aquatic Biotechnology	4
		PAPER-V	Lab Based on Paper I To Paper IV	4
		Industrial Training/Survey/ Research Project	Concerning Major Papers of Semester-VIII	4
			Credit II	24
	VII or VIII	Minor Elective	Applied Zoology or Basic Biotechnology or Economic Zoology Vermicology	4
			Credit I+ II+ Minor Elective	52

<i>Master in Faculty (Zoology)</i>					
5	IX	PAPER- I	Systematics And Applied Entomology	4	
		PAPER- II	Biology Of Insects (Morphology, Physiology & Development)	4	
		PAPER- III	Advanced Human Physiology	4	
		PAPER- IV	Wildlife Conservation and Management	4	
		PAPER-V	Lab Based on Paper I To Paper IV	4	
		Industrial Training/Survey/ Research Project	Concerning Major Papers of Semester-IX	4	
			Credit I	24	
	X	PAPER- I	Taxonomy and Molecular Phylogenetics	4	
		PAPER- II	Animal Biotechnology: Animal Cell Culture	4	
		PAPER- III	Animal Biotechnology: Transgenics, Cloning, And IPR	4	
		PAPER- IV	Biostatistics, Bioinformatics, and Computational Biology	4	
		PAPER-V	Lab Based on Paper I To Paper IV	4	
		Industrial Training/Survey/ Research Project	Concerning Major Papers of Semester-X	4	
				Credit II	24
				Credit I & II	48
			Total Credits	100	

Fourth Year

Semester- VII

Paper-I Fundamentals of Immunology (4 Credits)

Unit - I

Introduction and Historical Background: Cells and Organs of Immune System Definition, Immune System- Anatomical, Physiological and Inflammatory Barriers. Major Contribution of Following Scientists- Edward Jenner, Jacob Henle, Louis Pasteur, Joseph Lister, Robert Koch, Paul Ehrlich, Elie Metchnikoff, Emil Von Behring, Jules Bordet, Karl Landsteiner, Jules Freund, Peter Gorer & George Snell, Tiselius & Kabat, Gerald Eldelman & Rodeny Porter, Cesar Milstein & Georges Kohler, Peter Doherty & Rolf Zinkernagel.

Hematopoiesis–Formation of B-Lymphocytes and T-Lymphocytes and its Regulation. Cells of the Immune System-NK Cells, B-Lymphocytes, T-Lymphocytes, Granulocytic Cells, Dendritic Cells, Primary Lymphoid Organs & their Functional Role-Bone Marrow and Thymus. Secondary Lymphoid Organs & its Functional Role- Lymph Nodes, Spleen, Mucosal-Associated Lymphoid Tissue [MALT], Intraepithelial Lymphocytes [IEL], Cutaneous-Associated Lymphoid Tissue [CALT].

Unit - II

Antigens: Requirements for immunogenicity (Foreignness, size, chemical complexity, dose and route of administration), Haptanes, Antigen-antibody interactions- affinity and avidity, cross-reactivity, Factors affecting antigen-antibody interactions, Adjuvant. Major Histocompatibility complex (MHC): Classes of MHC, Important aspects of MHC. Antigen processing and presentation: Processing and presentation of endogenous antigens by cytosolic pathway, Processing and presentation of exogenous antigens by Endocytic pathway.

Unit-III

Primary & Secondary Line of Defense [Innate & Acquired Immunity], Antigen-Antibody Interactions: Innate Immunity- Phagocytic Barriers. Antigen Presenting Cells. Antigen Processing and Presentation. Acquired Immunity- B-Cell Mediated Immunity, T-Cell Mediated Immunity, Its Mechanism and Regulation. Immune Memory of B-Lymphocytes. Structure of Antibody, Treatment of Antibody with Pepsin, Papain, β -Mercaptoethanol and DMSO. Interaction of Antigen-Antibody- Antibody Affinity, Antibody Avidity, Cross-Reactivity, Precipitation Reactions & Agglutination Reactions.

Unit - IV

Immune Effector Mechanism, Allergy & Hypersensitivity: Cytokines-Properties and Its Receptors. Cytokine Secretion by Th1, Th2 and Th17 Subsets and its Function. The Complement System: Its Components, Functions, Activation and Regulation. Complement Deficiencies. Allergy & Hypersensitivity: Gell & Coombs Classification, IgE Mediated [Type I] Antibody-Mediated Cytotoxicity [Type II], Immune Complex-Mediated [Type III] and T_{DTH}- Mediated [Type IV] Hypersensitivity.

Paper II- Cell and Molecular Biology (4 Credits)

Unit – I

Cell Structure and Function: Structure of eukaryotic cells; Plasma membrane; Transport across the plasma membrane, endocytosis, exocytosis. Cellular organelles; Ribosome, Mitochondria, ER, Golgi complex and cytoskeleton; Microtubules, microfilament, intermediate filaments and centriole. Molecular aspects of cell division; Eukaryotic Cell cycle-cell cycle regulation, cell cycle checkpoints. Cellular communication: general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation. Cellular responses to environmental signals in bacteria and animals; cell signaling molecules, Receptors, GPCR & G protein, Ion channel linked receptor, Enzyme-linked receptor, Nitric oxide, Quorum sensing. Biology of cancer: Molecular basis of cancer, Proto-oncogenes, Tumor suppressor genes, Carcinogen, Retinoblastoma, Oncovirus or tumor virus, coronavirus Apoptosis && Necrosis.

Unit – II

Introduction to Molecular Biology: Structure and organization of the genome, Chemistry of the gene, Structure of nucleic acids. Fine Structure of gene; Regulation of Gene expression in eukaryotes and prokaryotes: Operon (lac operon, trp operon, ara operon). Nucleic acid sequencing; Introduction and landmarks in DNA sequencing, Maxam Gilbert method, Sanger's method, Pyrosequencing, Nextgen sequencing & Whole genome sequencing. RNA interference Technology- Molecular mechanism of antisense molecules, Biochemistry of ribozyme; hammerhead, hairpin & other ribozymes; strategies for designing ribozymes, Applications of antisense & ribozyme technologies.

Unit – III

DNA Replication - Prokaryotic and eukaryotic DNA replication, Molecular Mechanisms of DNA replication, Enzymes, and Accessory Proteins involved in DNA replication. DNA Damage and Repair (Direct repair, Excision repair, Mismatch repair, Recombinational Repair, Repair of double-strand DNA break, SOS response), Recombination, Homologous Recombination: Holliday junction, gene targeting, gene disruption, FLP/FRT and Cre/Lox recombination, Rec-A proteins & other recombinases.

Unit – IV

Transcription- Prokaryotic and Eukaryotic transcription, RNA polymerase, General & specific transcription factors, transcription signals, promoter sites, rho & sigma factor, Regulatory elements & mechanisms of transcription regulation Transcription termination, Transcriptional and post-transcriptional modification: 5'-Cap formation, 3'-end processing and polyadenylation, Splicing; Ribonucleoproteins, RNA editing, nuclear export of mRNA and stability.

Translation-Prokaryotic and eukaryotic translation, Mechanisms of initiation, elongation and termination, Regulation of translation, co-and post-translational modifications of proteins. Genetic code: Properties, codon usage patterns and codon bias (Wobble Hypothesis). Bacterial genetics: recombination, transduction and transformation.

Paper III- Animal Ecology (4 Credits)

Unit-I

Ecology: Its Relevance to Human Welfare, Subdivisions & Scope. The Environment: Biotic & Abiotic Interactions. Habitat & Niche: Concept of Habitat & Niche, Niche Width & Overlap, Fundamental & Realized Niche, Resource Partitioning & Character Displacement. Ecosystem's Structure & Function: types of ecosystems, ecosystem Productivity- Primary (NPP & GPP) and Secondary Productivity, Energy flow in an ecosystem, Energy Efficiency. Thermal Stratification & Circulation and Lake's Typology.

Unit-II

Limiting Factors: Laws of Limiting Factors, Impact of Temperature, Moisture and pH on Organisms. Structure and Function of Some Indian Ecosystems: Terrestrial (Forest, Grassland) and Aquatic (Fresh Water, Marine and Estuarine). Population Ecology: Characteristics of a Population; Population Growth Curves; Population Regulation; Life History Strategies (r and k Selection); Concept of Meta-Population, Demes and Dispersal, Interdemic Extinctions, Age Structured.

Community Ecology: Community Attributes Namely Dominance, Various Types of Diversity Indices (Lincoln Peterson Index, Simpson Index, Shannon Weiner Index, Berger Parker Index and Brillouin Index). Similarity Coefficient and Niche Concept, Community Nomenclature. Lotka-Volterra Model of Species Competition.

Unit-III

Stressed Water Ecosystems: Point and Non-Point Sources of Pollution, Assessment of Freshwater Pollution using Various Parameters. Water Quality Monitoring Using Abiotic Factors (pH, Oxygen, Nitrate, Ammonia, Phosphate, BOD), Bio-Monitoring (Phytoplankton, Zooplankton and Zoo Benthos), Environmental Impact Assessment (EIA): Impact of Environmental Stress on Biotic and Abiotic Factors. Eutrophication: Its Causes, Assessment, Consequences and Control. Indicators of Pollution and Eutrophication.

Unit-IV

Ecological Succession: Types; Mechanisms; Changes Involved in Succession; Concept of Climax. Biogeography: Major Terrestrial Biomes; Theory of Island Biogeography; Bio- Geographical Zones of India.

Applied Ecology: Environmental Pollution; Global Environmental Change; Biodiversity: Status, Monitoring and Documentation; Major Drivers of Biodiversity Change; Biodiversity Management Approaches. Global Conventions on Environmental Pollution (Kyoto Protocol, Montreal Protocol, Earth Summit 2002 and Copenhagen Accord).

Conservation Biology: Principles of Conservation, Major Approaches to Management, Indian Case Studies on Conservation /Management Strategy (Project Tiger, Biosphere Reserves and Lakes).

Paper IV-Medical Laboratory Techniques (4 Credits)

Unit I

Basic Laboratory Principles - Code of Conduct of Medical Laboratory Personnel. Organization and Functioning of Clinical Laboratory. Safety Measures: Safety Equipment, Safety Symbols. Hazards in the Laboratory (Chemical Hazards, Clinical Hazards, Electrical Hazards, Biological Hazards & Waste Disposal).

Unit II

Introduction of Common Laboratory Equipment: Hot Air Oven, Incubator, Autoclave, Water Bath and Centrifuges. Microscope: Fundamentals of Microscopy, Resolution and Magnification, Light Microscopy, Electron Microscopy (SEM and TEM), PCR Machine (Thermal Cycler), Electrophoresis Unit & UV Trans Illuminator etc.

Unit III

Specimen Collection, Processing and Analytical Techniques Collection and Preservation of Blood, Urine, Stool, Sputum, Pus, Body Fluids and Swabs. Preparation of Blood Smears. Sources of Biological Variations and Pre-Analytical Variables.

Unit IV

Preparation of Reagents: Buffers and pH, Normal, Percent and Molar Solution, Normal Saline- Methods of Measuring Liquids. Clinical Laboratory Records-Modern Laboratory Set Up- Quality Control: Accuracy, Precision, and Reference Values, Disposal of Biomedical Waste, Laboratory Safety Protocols and Guidelines

Paper-V Lab Based on Paper I to IV (4 Credits)

Industrial Training/Survey/Research Project (4 Credits)

Semester VIII

Paper I-General Ichthyology (4 Credits)

Unit I

Classification of Fishes, Systematic Position, Habit and Habitat, Morphology, Distribution, Significance and Affinities of Holocephali and Dipnoi. Fins, Their Origin and Evolution; Locomotion in Fishes.

Histomorphology and Elementary Physiology: Digestive System (with Particular Reference to Food and Feeding Habits of Freshwater Fishes), Excretory System (with Particular Reference to Acid-Base Balance and Osmoregulation), Accessory Respiratory Organs in Fishes.

Unit II

General Survey of the Marine, Estuarine and Inland Capture Fisheries of India with Particular Reference to Fishery Resources of Uttarakhand: adaptation of hill stream fishes, checklist of common fishes of Garhwal & Kumaun, culture of trout's (snow trout, brown trout and Mahsheer), marketed fishes of Uttarakhand. Methods of Fishing: Fishing Gears and Crafts. Cold Water Fishery Sewage-Fed Fishery and Shell –Fish Fishery.

Nutrition and Growth Including Age and Growth Relationship, Chemical Composition of Fish Flesh, Length–Weight Relationship, Natural Food and Artificial Feed and Their Role in Fish Culture. Plankton and Benthos in Relation to Fish Production.

Unit III

Electric Organs in Fishes. Brief Knowledge of Sexual Dimorphism, Courtship and Parental Care. Migratory Instincts, Hill Stream Adaptations.

Reproduction in a Major Carps- Structure of Gonad, Spawning, Early Development and Metamorphosis. Microscopic Structure and Hormonal Functions of the Following Endocrine Glands: Pituitary, Thyroid, Pancreas, Adrenal, Corpuscles of Stannins, Ultimobranchial Glands, Caudal Neurosecretory System and Sex Hormones. Current Trends in Induced Breeding in Fishes.

Unit IV

Brief Knowledge of Sense Organs: Organs of Smell, Eyes, Hearing, Ampulla of Lorenzeni, Bio-Luminescence, Sound Production and Lateral Line System, Parental Care in Fishes, Venomous and Non-Venomous Fishes, Fish Pheromones, Coloration in Fishes.

Paper II-Applied Ichthyology (4 Credits)

Unit I

Important Cultivable Fishes

Important Cultivable Shellfishes

Biology of Cultivated Fish and Shellfish

Unit II

Ecology and Productivity of Fish Ponds. Pollution concerning Fisheries. Carp Culture: Mono Culture, Poly Culture and Composite Fish Culture. Live Fish Culture. Management Practices: Weed, Insect and Carnivorous Fishes.

Unit III

Maturation and Fecundity, Spawning and Seed Collection, Induced Breeding, Hatching Techniques and Hatcheries, Nursery Management, Packing and Transport of Fish.

Unit IV

Integrated Aquaculture: Fish-Cum Poultry, Fish-Cum Duckery, Fish-Cum Piggery, Paddy-Cum Fish Culture and Dairy-Cum Fish Culture. Induced Spawning and Hybridization. Factors Responsive for Induced Breeding, Hypophysation. Use of Different Synthetic and Natural Hormones.

Larvivores Fishes and Public Health. Fish Diseases and Their Management. Exotic Fishes and Their Merits and Demerits, Cryopreservation of Gametes and Embryos. Ornamental Fish Culture.

Paper III- Basic Limnology (4 Credits)

Unit I

Introduction and Development of Limnology in India

Inland Waters Distribution: Ponds, Lakes, Streams, River

Unit II

Lakes: Thermal Classification of Lakes, Famous Lakes of India and World, Nature of Inland Water Environment.

Physical Characteristics: Pressure, Compressibility, Density Mobility, Buoyancy, Movement of Water
Thermal Stratification Light, Color and Turbidity.

Unit III

Chemical Characteristics: Dissolved Gases–Oxygen, Carbon Dioxide and Other Dissolved Gases
Dissolved Solids and Dissolved Organic Matter Influence of Physical and Chemical Conditions on Living
Organisms in Inland Water Bodies.

Planktonic Organisms: Classifications of Organisms in Water Distribution of Plankton Food for Plankton
Organisms.

Unit IV

Biological Productivity, Circulation of Food Material, Classification of Lakes Based on Productivity,
Laws of Minimum, Biotic Potential and Environmental Resistance, Quantitative Relations in a Standing
Crop

Water Pollution, Eutrophication, Algal Blooms, Water Borne Diseases and Drinking Water
Parameters Bioremediation of Polluted Water Bodies.

Paper IV- Aquatic Biotechnology (4 Credits)

Unit-I

Introduction, the present status of the knowledge, scope and importance of aquatic biotechnology physicochemical aspects of aquatic biology.

Planktons & their role in aquatic biotechnology, nutritional biology of freshwater fishes. Marine Ecosystem & Principles of Oceanography. Marine Pollution & Bio-deterioration. Marine Biotechnology and its Potential.

Unit-II

Drugs and Bioactive compounds from the seaweeds of coastal regions of India, screening of oil-degrading microorganisms, Risk assessment of genetically modified organisms. Isolation & characterization of biotechnologically necessary enzymes from hot water springs and marine organisms from India. Biological productivity characteristics of microbial fauna in the Bay of Bengal; Extremophilic, thermophilic, hypersaline.

Unit-III

Seaweed resources of coastal regions of India, cultivation and propagation, Bio-regulatory, therapeutic and agricultural applications of blue-green algae, bio-absorption by seaweeds. Modern concepts in fish biotechnology, Fish genetics, and Development of transgenic fishes. Cryo- preservation in fishes, genetic requirements for transgenic fish production. Applications of transgenic fishes and biotechnology. Cytogenetics of fishes, Biochemical and molecular genetics. Genome manipulation in fishes.

Unit-IV

Chromosomal manipulation in fishes, fish hormones, induced breeding, DNA fingerprinting in aquatic biotechnology, Genotoxicity assays for environmental impact assessment, Probiotics in aqua- culture, Microbial diseases of fishes and their control.

Paper V- Lab Based on papers I to IV (4 Credits)

Industrial Training/Survey/Research Project (4 Credits)

Minor Elective

Applied Zoology (4 Credits)

Parasitic protozoa: *Entamoeba histolytica*, *Trypanosomes*, *Leishmania* and *Plasmodium* Economically important Helminth parasites of man and domesticated animals: *Ancylostoma*, *Schistosoma*, *Fasciola*, *Ascaris*, *Filaria*, *Wucheria* and *Taenia*. Detailed information on: Aquaculture and Fish culture, Sericulture, Apiculture, Lac culture.

Bionomics and control measures of the common pests of fruits (*Papilio demoleus* and *Quadraspidiotus perniciosus*), Vegetables (*Thrips tabaci* and *Aulacophora foveicollis*) and stored grains (*Callosobruchus chinensis* and *Trogoderma granarium*). Polyphagous pests (Locust and Termites). Common insect pests of temperate fruits of Uttarakhand. Pest management, including insect pest control and integrated pest management.

Introduction to vectors of human diseases (mosquitoes, lice, flies and ticks). A note on Bioethics. Economic importance of birds and mammals.

Or

Basic Biotechnology (4 Credits)

Origin and definition, scope and importance of Biotechnology. Recombinant DNA technology and Genetic engineering - Restriction enzymes and cloning techniques, DNA fingerprinting. Biochips. Biotechnological innovations in the area of medical, agricultural, industrial & forensic sciences. Environmental Biotechnology addresses environmental problems, such as the removal of pollution, renewable energy generation or biomass production.

Or

Economic Zoology (4 Credits)

The General Study of Parasites in Terms of Morphology, Mode of Transmission, Symptoms, Prevention and Control. Types of Parasites: Unicellular Parasite. Protozoans (*Entamoeba histolytica*, *Plasmodium Spp.*, *Trypanosoma Spp.*, *Leishmania Spp.* etc.) *Giardia* and Vector Biology.

Study: Multicellular Parasites, Platyhelminthes (Tape Worms and Liver Flukes), Aschelminthes

(*Ascaris*) Nematoda- *C. elegans*. Pests and Parasites, Apiculture, Sericulture, Lac Culture, Pisciculture, Dairy and Farming's Products. Pesticides (Organochlorines, Organophosphates, Carbamates, Pyrethroids, Triazines, Bardeux Nixture), Mode of Action of Pesticides, Advantages and Disadvantages of Pesticides Hazards of Pesticides. Biological Methods of Pest Control.

Or

Vermicology (4 Credits)

Earthworm Diversity: Classification Earthworm Types: White Worm Behavior of Earthworms as Indicators of Soil Fertility, Earthworms as Bioreactors; Earthworms and Plant Growth, Organic Matter-Dynamics and Nutrient Cycling, Feeding Habit and Food. Vermicomposting: Advantages of Vermicomposting, Vermicomposting in Daily Life, Vermiculture Vs. Vermicomposting, Chemical Composition of Vermicompost, Vermicomposting at Home and Agricultural Farm; The Business of Worms; Interaction of Vermicompost Earthworms. Earthworm Bio-Technology: Fundamentals of Sustainability; Enrichment of Vermicompost and Earthworms for Sustainable Production, Earthworms in Bio-Remediation, Earthworms in Alternative Medicine, Earthworm Meal Production, Transgenic Earthworms.

Organic Farming: Eco-Friendly Farming System Technologies. Evaluation Study of Ecological Constraints (Climatic and Edaphic). Appropriate Technologies in Agro-Forestry, Natural-Management, and Planted Forests (Ranching, Farmer's Perception to Organic Farming and any Case Study).

Fifth Year

Semester- IX

Paper I- Systematics and Applied Entomology (4 Credits)

Unit I

Ancestry and Evolution of Insects Classification of Insects Principles of Construction and Use of Dichotomous Keys in Insect Identification Methods of Collection, Preservation and Culture of Insects Parental Care in Insects

Unit II

Brief Knowledge of Habit, Habitats and General Characters of the Following Orders with special reference to the families mentioned: Thysanura (Machilidae, Lepismatidae), Collembola, Odonata, Orthoptera (Acrididae, Tettigonidae, Gryllidae), Phase Theory in Locusts, Phthioptera (Anoplura, Mallophaga), Isoptera, Thysanoptera, Heteroptera (Pentatomidae, Belostomatidae), Homoptera (Aphidae, Coccidae), Coleoptera (Coccinellidae, Curculionidae), Lepidoptera (Noctuidae, Nymphalidae), Hymenoptera (Ichneumonidae, Formicidae); Diptera (Muscidae, Syrphidae)

Unit III

Principles and Practices of Pest Control: Pest Control Procedures: Natural Control, Applied Control (Cultural, Biological and Insecticidal) Modes of Action of Insecticides, Factors Affecting Toxicity of Insecticides

Non-Insecticidal Methods: Antifeedants, Attractants and Repellents, Feeding Deterrents, Chemosterilants, Pheromones and Insect Growth Regulators (IGR's) Integrated Pest Management (IPM) Insecticide Application equipment: Sprayers, Dusters, Granule Applicators

Distribution, Habit and Habitats, Life-Cycle, Nature of Damage and Control of Pests of: **Stored Grains** (*Sitophilus oryzae*, *Tribolium castaneum*, *Callosobruchus chinensis*); **Sugarcane** (*Pyrilla perpusilla*, *Chio infuscatellus*); **Paddy** (*Leptocorisa acuta*, *Hieroglyphus banian/nigrorepletus*), **Cotton** (*Dysdercus koengii*, *Pectinophora gossypiella*); **Cereals** (*Heliocoverpa armigera*, *Agrotis ipsilon*) **Vegetables** (*Raphidopalpa (Aulacophora) foveicollis*, *Pieris brassicae*); **Fruits** (*Bactrocera (Dacus)*)

cucurbitae, *Papilio demoleus*); **Forests (Defoliator:** Tasar Silkworm, *Antheraea paphia*; **Sap-Sucker** of Khamer or Gamhar, *Tingis beesoni*; **Teak Borer**, *Aeolesthes holosericea*); and **Polyphagous Pests** (Locusts, Termites)

Unit IV

Lac Industry: Strains of Lac Insects, Lac Cultivation, Composition and Uses of Lac

Apiculture: Kinds of Honey Bees and Bee Hives, Structure of Typical Bee Hive Organization of Honey Bees, The Language of Honey Bees, Bee Keeping Methods, Economic Importance and Diseases of Honey Bees. Parasites of Honey Bee (*Varroa destructor*, *Varroa jacobsoni* and *Galleria mellonella*).

Sericulture: Mulberry and Non-Mulberry Sericulture, Composition Processing of Silk and Silk Industry in India. Diseases of Silkworm (White Muscadine and Pebrine Disease).

Life-Cycle and Control of Insects of Medical Importance to Man and Animals: House Flies, Mosquitoes, *Phelbotomus* (Sandfly) and *Tabanus* (Horse Fly)

Paper II-Biology of Insects (Morphology, Physiology & Development) (4 Credits)

Unit I

Integument: Structure, Functions and Modifications of Insect Cuticle, Moulting and Sclerotization Structure of an Insect Head, Thorax and Abdomen; Appendages of Head (Mouthparts and Antennae) and Thorax (Legs and Wings). Structure of a Wing of an Insect, Types of Wings, Hypothetical Wing Venation, Wing-Coupling Mechanisms and Flight Mechanism. Structure and Modifications of Male and Female Genitalia in Insects.

Unit II

Structure and Modifications of Alimentary Canal; Food and Feeding Mechanism of a Generalized Insect with Special Reference to Physiology of Digestion in Different Insects Structure and Functions of Blood and Mode of Circulation in Insects Principal Organs of Excretion of Insects Found in Different Habitats, Physiology of Excretion with Special Reference to Osmoregulation in Insects

Unit III

Structure and Functioning of Various Types of Respiratory Organs, Modes of Respiration, Physiology of Respiration in Terrestrial, Aquatic and Endo parasitic Insects. Generalized Plan of Nervous System in Insects and its Modifications. Neuroendocrine System in Insects and the Role of Neurosecretion in Various Metabolic Activities, Metamorphosis and Development of Insects. Structure and Functions of Different Types of Visual and Sound Producing Organs in Insects.

Unit IV

Structure, Function and Physiology of Mechanoreceptors and Chemo Receptors in Insects. Bioluminescence: Light Producing Organs, Mechanism and Significance of Light Production in Insect. Structure of Pheromone Producing Glands, Different Types of Pheromones and their Chemical Nature. Structure and Modification of Male and Female Reproductive Systems in Insects. Development: Structure of Egg, Maturation, Cleavage, Blastokinesis, Formation of Germ Layers and Segmentation; Different Types of Larvae and Pupae, Polyembryony and Parthenogenesis in Insects.

Paper III- Advanced Human Physiology (4 Credits)

Unit I

Human Digestive system: Nutrition: Stimulation, secretion and action of digestive fluids (including enzymes and hormones). Digestion, absorption and assimilation of various nutrients. Recommended dietary allowance, balanced diet BMR.

Human Respiratory system: cellular Structure of respiratory organs, molecular mechanism of respiration. Transport and exchanges, respiratory disorders. Exchange of gases.

Unit II

Blood composition and circulation in humans: Hemopoiesis, Plasma function, blood volume regulation. Blood pressure. Blood groups. Structure and function of Hemoglobin, hemostasis. **Cardiovascular system:** Structure of myogenic heart, specialized tissue. ECG- its principle and significance. Cardiac cycle, heart as a pump.

Human Nervous System: Gross neuro-anatomy of the brain and spinal cord. Central and peripheral nervous system. Neurons. Structure of neuron, nature, origin and propagation of nerve impulse. Synaptic

transmission. Action potential. Chemistry and function of neurotransmitters. Neural control of muscle tone and posture.

Muscle Physiology in Humans: Structure, kinds and characteristics of muscles. Mechanism of muscle stimulation and contraction.

Unit III

Excretion and osmoregulation in Human: Comparative physiology of excretion: kidney. Functions of kidney. Types of nitrogenous waste in different animal groups. Renal secretion in vertebrates: Urine formation, urine concentration. Waste elimination, micturition. Regulation of water balance, electrolyte balance, acid-base balance.

Sense Organs: Sensory Physiology: Receptors. Vision, hearing and tactile response. Pathways and physiology of smell and taste.

Thermoregulation: Comfort zone, body temperature- physical, chemical, neural regulation, acclimatization. Temperature tolerance. Homoeothermic adaptations and regulatory mechanisms.

Unit IV

Human Endocrine System: Mechanism of hormone action: Complete knowledge of the generalized mechanisms of action (at molecular level) of protein (Plasma membrane mediated actions as well as intracellular Camp mediated actions) and steroid hormones (nuclear activated mediated actions).

Hypothalamo-hypophysial System: General organization, Neuro-hypophysial octapeptides, adeno-hypophysial hormones.

Detailed Structure of mammalian Pituitary gland, Pancreas, Thyroid Gland, Parathyroid Gland, Adrenal Gland (Adrenal medulla and cortex), Pineal Gland. Their hormonal synthesis, storage, control, transport and release. Biosynthesis and physiological actions of insulin and glucagon. Morphological and chemical consequences of excess and deficiency of various thyroid hormones. Role of parathormone: Calcitonin and vitamin-D in calcium homeostasis. Physiological roles and

control of catecholamine, mineralocorticoids and glucocorticoid secretion. Physiological actions of pineal hormones.

Molecular Structure, origin, release and Transport of sex hormones and their Role in reproductive physiology.

Paper IV Wildlife Conservation and Management (4 Credits)

Unit I

Indian Wildlife: Introduction, Distribution of Wildlife in Ecological Subdivision of India, IUCN Categories.

Protected Area Network: National Parks, Wildlife Sanctuaries, Biosphere Reserves and Zoos in India, Gene Pool, Habit, Habitat and Breeding Biology of Few Mammals (Viz., Elephant and Tiger).

Unit II

Reasons for Wildlife Depletion: Habitat Fragmentation, Habitat Destruction, Commercial Wildlife Exploitation, Overgrazing Etc.,

Wildlife Conservation (Policies and Programmes), Special Projects for Endangered Species (Project Tiger, Gir Lion Sanctuary Project and Crocodile Breeding Project).

Unit III

Principle and Practice of Wildlife Management: Management of Special Habitats; Riparian Zones, Grasslands Introduction to Conservation Biology, Conservation Values and Ethics of Conservation of Natural Resources.

Conservation of Biodiversity, Patterns and Processes, Concepts of Biodiversity, Levels of Biodiversity, Genetic Diversity, Intra Specific Diversity, Species Richness, Richness of Higher Taxa, Ecosystem and Biome Diversity.

Unit IV

International Conventions on Conservation (Ex-Situ and in-Situ Conservation, Conservation Breeding (E.G. Vulture, Pygmy Hog, Gharial, Etc.), Institutions and their Role in Conservation (Zoos, Natural History Museums and Collections, Zoological Survey of India and Its Regional Centres). National and International Zoological Institutes, Societies and Academic Bodies.

Brief Account of Wildlife Acts and Their Amendments in India and World. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Paper V- Lab Based on papers I to IV (4 Credits)

Industrial Training/Survey/Research Project (4 Credits)

Semester- X

Paper I-Taxonomy and Molecular Phylogenetics (4 Credits)

Unit I

Introduction to Taxonomy and Systematics: History of animal taxonomy. Introduction and scope of systematics. Modern approaches in taxonomy. Species concepts (Typological, Nominalist, Biological and Evolutionary). Principles of classification, functions, components and systems of classification, Linnean Hierarchy. Nomenclature: Binomial and Trinomial. Taxonomic methodology and tools, Taxonomic aids (museum, national parks and keys). Preparation of keys, Techniques of museum preparation. Rules of Zoological Nomenclature: International Commission on Zoological Nomenclature (ICZN), Taxon, Rank and Categories. Collection, Preservation and Identification of insects and other specimens using keys.

Unit II

Background Knowledge: Evolutionary Biology – From atoms to molecules to life, Hypothesis of evolution, Darwin's theory of evolution, from taxonomy to molecular phylogenetics – Linnaeus' classification systems- Whittaker's five kingdom system, Carl Woese's three-domain system; Traditional Systematics/phylogeny.

Tree concept: Molecular data as molecular fossils; Molecular-clock-hypothesis; The terminology of phylogenetics- Trees, Root, branches, Node, Leaf, Clade; lineage sorting, orthology, paralogy, xenology; "basal" lineages, crown vs. stem groups, Phylogram vs. cladogram.

Unit III

Molecular phylogeny: Gene phylogeny vs. species phylogeny; Different types of trees- rooted vs. unrooted trees, dichotomy vs. polytomy, monophyletic vs. paraphyletic, ultra-metric v/s unconstrained; Constructing phylogenetic trees-Choice of molecular markers.

Phylogenetic Algorithms: Clustering based methods-UPGMA and neighbor-joining, Optimality based: Fitch-Margoliash and minimum evolution algorithm; Character-based methods- Maximum Parsimony (MP) and Maximum Likelihood (ML) methods; Bayesian inference, Evaluation of phylogenetic trees-reliability and significance, Bootstrapping, Jackknifing.

Unit IV

Phylogenetic software & applications: Multiple sequence alignment & Tree building software – Clustal W, Mega, Phylip, Phylodraw, Phylml, RaxML; Case studies- Phylip/Mega.

Flexi module- Only for Internal Assessment. Lecturers may expand and/ or interpret the syllabus to update it or suit the particular cohort in any way) **Allied topics:** Population genetics. Genetic polymorphism, variations, alleles, Human Y-chromosome haplogroups, Mitochondriomics:- Mitochondrial haplogroups, rCRS, SNP, Mitochondrial eve, Human mitochondrial molecular clock, the prevalence in mitochondrial haplogroups, Human Genographic project, mitochondrial polymorphism, Dysfunction and disease studies.

Paper II-Animal Biotechnology: Animal Cell Culture (4 Credits)

Unit I

Animal Cell Culture: Equipment and Materials for Animal Cell Culture Technology. Design and Layout of Culture Room, Sterilization and Aseptic Techniques.

Culture Medium: Natural Media, Synthetic Media, Sera. Introduction to Balanced Salt Solutions and Simple Growth Medium. Brief Discussion on the Chemical, Physical and Metabolic Functions of Different Constituents of Culture Medium, Role of Carbon Dioxide, Serum and Supplements in Animal Cell Culture. Selection of medium and serum, Characteristics of Cells in Culture: Contact Inhibition, Anchorage Dependence and Cell-Cell Communication.

Unit II

Mechanical and Enzymatic Disaggregation of Tissue and Setting up of Primary Cultures, Candling of Eggs, Preparation of Chick Fibroblast, Culture of Lymphocytes for Chromosomal Studies. Roller and Suspension Culture Techniques. Large-Scale Production of Cells Using Bioreactors, Micro- Carriers and Perfusion Techniques. Measurement of Viability and Cytotoxicity. Biological Characterization of the Cultured Cells, Karyotyping, Cryopreservation and Revival. Detection of Contaminants in Cell Cultures.

Unit III

Fermentation Technology for the Growth of Animal Cells and their Products (Bioreactors, Hollow Fiber Reactors, Air-Lift Fermenters, Chemostats and Microcarriers). Established Cell Line Cultures: Definition of Cell Lines, Maintenance and Management; Cell Adaptation.

Stem Cell Cultures, Embryonic Stem Cells and their Applications. Somatic Cell Genetics. Organ and Histotypic Cultures.

Cell Cloning, Cell Synchronization and Cell Manipulation. Various Methods of Separation of Cell Types, Advantages and Limitations; Flow Cytometry. Production and Characterization of Monoclonal Antibodies and their Application.

Unit IV

Commercial Applications of Animal Cell Culture: Cell Culture Based Vaccines, Tissue Culture as a Screening System; Cytotoxicity, *in-vitro* Testing of Drugs and Diagnostic Tests. Mass Production of Biologically Important Compounds e.g., vaccines and Pharmaceutical Proteins).

Production of Recombinant Hemoglobin, Blood Substituents, and Artificial Blood. Harvesting of Products, Purification and Assays. Three-Dimensional Cultures and Tissue Engineering (Artificial Skin and Artificial Cartilage).

Paper III- Animal Biotechnology: Transgenics, Cloning and IPR (4 Credits)

Unit I

Gene Transfer Technology in Animals: Viral and Non-Viral Methods, Sperm Mediated Gene Transfer, Transfection of Animal Cell Lines and their Immortalization, Gene Knock Out Animal Models, Current Status of Production of Transgenic Animals. Animal Cloning: Techniques, Relevance, Case Studies and Ethical Issues.

Unit II

In Vitro Fertilization (IVF) and Embryo Transfer (ET) Technology in Humans; Superovulation, Micromanipulation, IVF And Embryo Culture in Farm Animals (E.G. Cow); Embryo Transfer In Cattle, Gene Transfer or Transfection (Using Eggs And Cultured Stem Cells): Targeted Gene Transfer; Transgenic Animals (Mice, Sheep, Pigs, Rabbits, Goats, Cows and Fish).

Unit III

Introduction to Biosafety Regulations; Primary Containment for Biohazards and Biosafety Levels, Biosafety Guidelines – Government of India. Definition of Genetically Modified Organisms (GMOs) & Living Modified Organisms (LMOs); Roles of Institutional Animal Ethical Committee, Review Committee on Genetic Manipulation (RCGM), Genetic Engineering Approval Committee (GEAC) etc.

Prevention of Cruelty on Animals Act Govt. of India, Concept of Bioethics, Public Concerns on Human Genome Research and Transgenics – Genetic Testing and Screening, Ethics in Clinical Trials and Good Clinical Practices (GCP), Ethical, Legal and Social Implications (ELSI) & Human Genome Project; Ethics in Human Cloning and Patenting Human Genes.

Unit I

Intellectual Property Rights and their Types-Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs, Basics of Patents (Types, Patent Application and Specifications), Concept of Prior Art and Patent Filing Procedures, Process Patent Vs Product Patent.

Introduction to General Agreement on Tariffs and Trade (GATT), World Trade Organization (WTO), World Intellectual Property Organization (WIPO) and Trade Related Intellectual Property Rights (TRIPS)

Paper IV Biostatistics, Bioinformatics and Computational Biology (4 Credits)

Unit I

Introduction to Biostatistics, terminology and Symbols. Applications of statistics in biological research. Collection and representation of data (Pie chart, Bar diagram, Histogram, Frequency polygon and Gantt chart). Measures of central tendency (Mean, Mode, Median). Variance, Coefficient of Variation, Standard Deviation. Standard error of the mean, Analysis of variation (ANOVA), One-way ANOVA and Two-way ANOVA. Measures of dispersion, Distribution patterns (Binomial, Poisson & Normal), Tests of significance ('t' test, 'f' test & chi-square test), Probability, Correlation and Regression Analysis. Introduction to statistical software and handling (SPSS and Excel data sheets).

Unit II

Introduction to computers. Computer fundamentals (Hardware & Software). Input, Output devices and Storage devices. Web browsers, Search Engines. Flow Chart. Methods and types of networks. Intra and Internet. Introduction to MS-office. Fundamentals of Bioinformatics, scope and applications of Bioinformatics. Types of Biological databases: Primary Databases: GenBank, EMBL, DDBJ; Composite Databases: NRDB, UniProt; Literature Databases: Open access and open sources, PubMed, PLoS, Biomed Central, NAR databases; Bioinformatic Resources: NCBI, EBI, ExPASy, RCSB. Docking techniques and tools: QSAR (Quantitative Structure-Activity Relationship). 2D QSAR: Linear free energy relationship descriptors for QSAR - experimental and theoretical.

Unit III

Biological or Genome Databases, Viral genome database: ICTVdb; Bacterial Genomes database: Genomes on Line Database–GOLD, Microbial Genome Database-MBGD; Genome Browsers: Ensembl, VEGA genome browser, NCBI-NCBI map viewer, KEGG, MIPS, UCSC Genome Browser; Archeal Genomics. Next Generation Sequencing methods, Overview of data compression, Need for compression, Scope of NGS data compression. Bioinformatics Database search engines– Text-based search engines (Entrez, DBGET / LinkDB). Sequence similarity-based search engines (BLAST and FASTA). Motif-based search engines (ScanProsite and eMOTIF).

Unit IV

Systems biology: Self-organization, emergence, modularity and abstraction, feedback, control analysis, Enzyme Kinetics and Thermodynamics: The Law of Mass Action; Reaction Kinetics, Rate Equation, Michaelis-Menten Equation, Hill Equation, Interaction networks overview- Gene Regulatory Network, Protein
– Protein Interaction Network, Signaling Pathways, Metabolic pathways; network motifs, Systems Biology tools and standards: Matlab -Systems Biology toolbox; SBML; SBGL (Systems Biology Graphical Language); KEGG; Tools for systems Biology- Cell designer; Cytoscape.

Paper-V Lab Based on Paper I to IV (4 Credits)

Industrial Training/Survey/Research Project (4 Credits)

Recommended books for PG:

- "Biochemical Engineering fundamentals" 2nd ed. by J E Bailey and D F Ollis, McGraw - Hill (1986). Chapters 13 & 14.
- "Environmental Biotechnology" by C. F. Forster and D. A. J. Wase.
- "Environmental Biotechnology" by Jogdand.
- "New Processes of Waste water treatment and recovery" by G. Mattock (ED) Ellis Horwood.
- "Waste Water Management" by Arceivala.
- "Water Pollution Management Hand Book" by Lopathak.
- . Intellectual property rights in biotechnology. A status report (1993). Singh, K.
- A Biologist guide to principles and techniques of practical biochemistry (1975). Bryan,W. & Keith,W.
- A manual of laboratory experiences in Cell Biology. (1992). Gasque, C.E.
- A. Osbarne. (Freeman).
- Academic Press, Inc., San Diego, 1990.
- Advances in biochemical engineering / Biotechnology – Anderson, al.
- Alon, U. (2006). An introduction to systems biology: design principles of biological circuits. CRC press.
- An introduction to fishes, Dr.S.S .Khanna, Central Book Depot Allahabad, UP
- An introduction to Genetic engineering (1994). Nicholl,D.S.T.
- An introduction to plant tissue culture – M K Razdan.
- Animal cell biotechnology. (1989). Spier, R.E. & Griffith, J.B. (Ed).
- Animal Cell Culture - Practical Approach, Ed. John R.W. Masters, OXFORD,
- Animal Cell Culture Techniques. Ed. Martin Clynes, Springer.
- Animal cell culture. (1981). Pollack, R. & Feiffer, S.P.
- Applied and fundamental aspects of plant cell tissue and organ culture edited by Reinert & Bajaj Y P S, SpringerVerlag.
- Aspect of Biophysics. (1979). Hughes,W.
- Basega, R. (ed): Cell Growth and Division: A Practical Approach. IRL Press.
- Basic and clinical immunology (1984). Stites, D.P., Stobo, J.D., Fudenberg, H.H. & Wells, J.V.
- Basics Bioinformatics by S. Ignacimuthu

- Benson, G. (2003). Algorithms in Bioinformatics. Springer Berlin Heidelberg.
- Berger and A.R. Kimmel, Academic Press, Inc. San Diego, 1998.
- Biochemical Engineering, Aiba, S., Humphrey, A.E. and Millis, N.F. Univ. of Tokyo Press, Tokyo.
- Biochemical Reactors, Atkinson, B., Pion Ltd. London.
- Bioethics for scientists by Bryant.
- Bioinformatics- a Practical Guide to the Analysis of Genes and Proteins by Baxevanis, A.D. and Francis Ouellette, B.F., Wiley India Pvt Ltd. 2009
- Bioinformatics a practical guide to the analysis of genes and proteins by Baxevanis and Quellette.
- Bioinformatics and human Genome by Mishra
- Bioinformatics Basics: Applications in Biological Science and Medicine by Hooman H. Rashidi, J. Howard Parish.
- Bioinformatics by Taylor
- Bioinformatics managing scientific data by Zoelacroix.
- Bioinformatics sequence and genome analysis David W. Mount.
- Bioinformatics: A Practical Approach- K. Mani & N. Vijayaraj-Aparna Publishers New Delhi
- Bioinformatics: Concepts, Skills and applications-Rastogi, S.C., et al-CBS Publishers, New Delhi
- Bioinformatics: Machine Learning approach 2nd Edition by Baldi.
- Bioinformatics: Sequence and Genome Analysis by Mount D., Cold Spring Harbor Laboratory Press, New York. 2004
- Biological chemistry by H.R. Mahler and E. Cordes (1986)
- Biological Chemistry. (1986). Mahler, H.R. and Cordes E.
- Biological Sequence Analysis-Durbin et al, Cambridge University press
- Biophysical chemistry Part I & III by Cantor and Schimmel (1980) WH Freeman & Company.
- Biophysics. (1983). Volkenstein, M.V.
- Bioprocess engineering: Downstream processing & recovery of bioproducts, safety in biotechnology and regulations. (1990). Behrens, D. & Kramer, P. (Ed).
- Biotechnological Methods of Pollution control Dr. Abbasi, University Press, New Delhi.
- Biotechnology and pharmacy (1993). Pezzato, J.M., Johnson, M.E. & Manasse, H.R. (Ed).
- Biotechnology current progress Vol.-I. (1990). Cheremisinoff, P.N. & Fenante, L.M. (Ed)
- Biotechnology for Aerospace Applications (1989). Obringer, J.W. & Tilling, H.S.(Ed)
- Biotechnology, Annual Review Edited by M.R. EL-Gewelly Elsevier Publications, Amsterdam.

- Biotechnology. (1998). Singh, B.D.
- Boogerd, F., Bruggeman, F. J., Hofmeyr, J. H. S., & Westerhoff, H. V. (Eds.). (2007). Systems bi- ology: philosophical foundations. Elsevier.
- Brock's Biology of microorganisms. (1997). Madigan, M., Martinko & Parker, J.
- Butler, M and Dawson, M. (eds.): Cell Culture Lab Fax, Eds., Bios Scientific Publications Ltd., Oxford.
- Cell and Molecular biology: G. Karp
- Cell Biology: De Robertis and De Robertis
- Cell culture and somatic cell genetics of plants (Vols. 1 to 3) – A K Vasil, A. Press.
- Cell Culture Lab Fax. Eds. M Butler & M. Dawson, Bios Scientific Publications Ltd. Oxford.
- Cell Growth and Division: A Practical Approach. Ed. R. Basega, IRL Press.
- Cell in Development and inheritance, EB Wilson, MacMilan, New York.
- Chemical engineering. (1984). Coulson, J.M. & Richardson, J.F.
- Choi, S. (Ed.). (2007). Introduction to systems biology. New Jersey: Humana Press.
- Clynes, M. (ed): Animal Cell Culture Techniques. Springer.
- Cold Spring Harbor Laboratory Press, New York, 2000
- Comprehensive Biotechnology. Vol. 4, M. Moo-Young (Ed-in-chief), Pergamon
- Comprehensive Biotechnology: Murray Moo Young
- Computer aided Drug Design: Methods and Application. Thomas J Perun, Marcel Dekke
- Concepts in Biotechnology – Editors D. Balasubramanian et al. University Press, (1996).
- Culture of Animal Cells, (3rd Edition), Frshney, Wiley-Liss.
- Culture of animal cells: A manual of basic techniques. (1987). Frshney, R.I.
- Demin, O. & Goryanin, I. (2010). Kinetic modelling in systems biology. CRC Press.
- Developmental Biology, SF Gilbert, Sinauer Associates Inc.
- Diagnostic Molecular Microbiology. Principles and Application Edited by David H.Persing et al. American Society for
- Discovering Genomics, Proteomics and Bioinformatics 2nd edition - by A. Malcolm Campbell and Laurie
- DNA Cloning: A Practical Approach, M. Glover and B.D. Hames, IRL Press, (1995).
- DNA Science. A First Course in Recombinant Technology, D, A. Mickloss and
- Elements of biotechnology – P K Gupta.
- Encyclopedia of bioprocess technology. Vol 1-5. (1999). Flickinger, M.C. & Drew, S.W.(Ed).

- Environmental Chemistry. A.K. De, Wiley Eastern Ltd., New Delhi.
- Enzyme Structure and mechanism: Alan Fersht, Reading, USA.
- Enzymes by Dixon and Webb
- Enzymes. (1979). Dixon M. & Webb E.C.
- Essential genomics and bioinformatics by Senson.
- Essential Immunology, (1997), Roitt, L.M.
- Fermentation technology. (1994). Cassida.
- Fertilization, FT Longo, Chapman and Hall.
- Fish Biotechnology/M. M. Ranga and Q. J. Shammi. Jodhpur, Agrobios, 2002, 259 p., \$33. ISBN 81-7754-093-9.
- Fish Genetics & Biotechnology Dr. W.S. Lakra. ICAR Publication.
- Foundations of Immunology, Baret.
- Freshney, R. I.: Culture of Animal Cells. Wiley-Liss.
- From Genes to Clones: Introduction to Gene Technology. (1987). Winnacker, E.L.
- Fundamentals of Biochemistry. (1986). Mahler, H.R. and Cordes, E.
- Fundamentals of Bioinformatics, by Dan E. Krane, Michael L. Raymaer
- Fundamentals of biotechnology. (1987). Prave, P., Fanst, V., Sitting, W. & Sukatesh, D.A. (Ed.)
- Fundamentals of Enzymology: Nicholes C. Price and Lewis Stevens, Oxford Univ. Press.
- Fundamentals of Immunology, (1996). Boyd, W.C.
- Fundamentals of Immunology, William Paul.
- G.A. Froyer. Cold Spring Harbor Laboratory Press, New York, 1990.
- Gautham, N. (2006). Bioinformatics: Databases and Algorithms. Alpha Science Int'l Ltd.
- Gene therapy-Edited by N.R.Lemoine and D.N.cooper BIOS Scienrific Publishers, Oxford.
- Gene V by B. Lewin (1994) Oxford University Press, Oxford.
- Gene VI (6th Edition) Benjamin Lewin, Oxford University Press, U.K., 1998 VCH
- Gene VI by Benjamin Lewin (1997).
- General Microbiology, Stainer, R.Y., Ingraham, J.L., Wheelis, M.L. and Painter, P.R. The Macmillan Press Ltd.
- General Microbiology. (1987). Stanier, R.Y., Ingraham, Wheelis and Painter
- Genes VII. (2000). Lewin, B.

- Genetic engineering fundamentals: An introduction to principles & applications. (1989). Kammermeyer, K. & Virginica, C.
- Genetic engineering Vol I-IV (1981). Williamson, R. (Editor).
- Genetic Engineering. An Introduction to gene analysis and exploitation in
- Genetic engineering: principles & practice (1996). Mitra, S.
- Genomes, T.S. Brown
- Geoffrey Sunshine. (Wiley-Liss)
- Gusfield, D. (1997). Algorithms on strings, trees and sequences: computer science and computational biology. Cambridge University Press.
- Handbook of Experimental Immunology. Vol. I & II. (1986) by Weir, D.M.
- Handbook of plant cell culture (Vols. 1 to 4) – Evans et. al., Macmillan.
- Harrison's Principles of internal medicine vol.I & II (1987). Braunwald, E., Isselbacher, K.J., Petersdorf, R.G., Wilson, J.D., Martin, J.B. & Fauci, A.S.
- Immobilized enzymes: An introduction & application in biotechnology. (1980). Trevan, M.D.
- Immunogenetics: Zaleski, D. & Cunningham, N.
- Immunology by I.M. Roitt, J. Brostoff and D.K. Male (1993) Gower Medical Publishing, London.
- Immunology by J. Kuby (1991) Freeman and Company.
- Immunology for students of Medicine, Humfrey, J.H. & White, R.G.
- Immunology, by Roitt and others.
- Immunology, Paul
- Immunology. (1996). Reeves and Todd
- Immunology. (2000) Kuby, J.
- Immunology: Roitt, Brostoff, Mole.
- Immunology-A short Course, 4th Edition, - Eli Benjamini, Richard Coico, Inc., Tata McGraw Hill, New Delhi.
- Instant notes Bioinformatics by P.M. Lydyard, A. Whelan and M.W. Fanger
- Instrumental methods of analysis: D.A.Skoog
- Intellectual Property in agricultural Biotechnology by F.H Erbisch & C.Velazquez.
- Intellectual property rights in biotechnology. A status report (1993). Singh, K. Biotechnology: The science and business (1991). Moses, V. & Cape, R.E. Biotechnology and Genetic Engineering reviews (1988). Russel, G.E.

- Introduction to Biodeterioration. D. Allsopp and K.J. Seal. ELBS/Edward
- Introduction to bioinformatics by Teresa K. Attwood, David J. Parry-Smith. Pearson Education. 1999
- Introduction to Bioinformatics T.K Attawood.
- Introduction to Biophysical Chemistry, RB Martin, McGraw Hill, New York.
- Introduction to Biophysical Chemistry. Martin
- Introduction to Practical Molecular Biology, P.D. Dabre, John Wiley & Sons Ltd, New York, 1988.
- Introductory Immunology: Huw Davies.
- Introductory Microbiology. (1986). Merrill, C.H.
- Iyengar, S. (2010). Symbolic Systems Biology. Jones and Bartlett.
- Klipp, E., Liebermeister, W., Wierling, C., Kowald, A., Lehrach, H., & Herwig, R. (2013). Systems biology. John Wiley & Sons.
- Krawetz, S. A. (2009). Bioinformatics for systems biology. Springer.
- Kuby Immunology, 4th Edition, -R.A. Goldsby, Thomas J. Kindt, Barbara,
- Laboratory Manual of Biochemistry by J. Jayaraman (1980) Wiley Eastern.
- Laboratory Methods in Microbiology. (1973). Harrigan, W.F. & McCance, M.E.
- Leister, D. & Herrmann, J. (Eds.). (2007). Mitochondria: practical protocols (Vol. 372). Springer
- Mallick, B. (2008). Bioinformatics: principles and applications. Oxford University Press.
- Maniatis, Cold Spring Harbor Laboratory Press, New York, 2000.
- Manual of Clinical Laboratory Immunology (1997), Rose, N.R.
- Marine and Estuarine Microbiology Laboratory Manual. (1975). Colwell, R. et al.
- Masters, J. R. W. (ed): Animal Cell Culture – Practical Approach, Oxford Univ. Press.
- Mather, J.P and Barnes, D. (eds.): Methods in Cell Biology, Vol. 57, Animal Cell Culture Methods. Academic Press.
- Methods for general and Molecular Bacteriology by Gerhardt et al. (1994) ASM Press.
- Methods in enzymology (relevant volumes of the series)
- Methods in Enzymology Vol 185, Gene Expression Technology, D.V. Goeddel,
- Methods in Enzymology Vol. 152, Guide to Molecular Cloning Techniques, S.L.
- Methods in enzymology. Vol XXII. Colowick, S.P. & Kaplan, N.O.
- Methods in Industrial Microbiology: Sikyt
- Methods in Molecular Biology vol.62 Edited by R.S.Tuan, Humana Press, Totowa, New Jersey.
- Methods in Molecular Biology, Vol.7, Humana Press.

- Microbial Genetics, Maloy, S.R., Cronan, J.E. Jr. and Freifelder, D. Jones, Bartlett Publishers.
- Microbiological Applications, (A Laboratory Manual in General Microbiology) Benson, H.J. WCB: Wm C. Brown Publishers.
- Microbiology a laboratory Manual, Cappuccino, J.G. and Sherman, N. Addison Wesley.
- Microbiology by Prescott, Harley and Klein (1996) William C. Brown Press.
- Microbiology Methods. (1975). Collins, C.H. and Lyne, P.M.
- Microbiology, Pelczar, M.J. Jr., Chan, E.C.S. and Kreig, N.R., Tata McGraw Hill.
- Microbiology. (1980). Davis, D. et al.
- Microbiology: Fundamentals and Applications. (1989). Atlas, R.M.
- Milestones in Biotechnology. Classic papers on Genetic Engineering, J.A. Davies
- Molecular and Cellular Methods in Biology and Medicine, P.B. Kaufman, W.
- Molecular Biology Lab Fax, T.A. Brown (Ed.), Bios Scientific Publishers Ltd., Oxford, 1991.
- Molecular Biology of Steroid and Nuclear Hormone Receptors, LP Freedman,
- Molecular Biology of the Cell (2nd Edition) B. Alberts, D. Bray, J. Lewis, Raff, K.
- Molecular Biology of the Cell, Alberts. B. Garland publishing, Inc., New York et al.
- Molecular Biology of the cell: J.D. Watson et al.
- Molecular Biology of the Gene (4th Edition), J.D. Watson, N.H. Hopkins, J.W.
- Molecular Biology of the Gene. (1987). Watson. et al.
- Molecular Biotechnology – Glick
- Molecular Biotechnology (2nd Edn.), S.B. Primrose. Blackwell Scientific
- Molecular Biotechnology, II edition, Bernard R Glick and Jack J. Pasternack. Asm Press.
- Molecular Biotechnology: Principles and applications of recombinant DNA. (1994) Glick, B.R. & Pasternack, J.J.
- Molecular Cell Biology (2nd Edition) J. Darnell, H. Lodish and D. Baltimore, Scientific American Books, Inc., USA, 1994

- Molecular Cell Biology (2nd Edition) J. Darnell, H. Lodish and D. Baltimore,
- Molecular cell biology by Lodish et al. (1995) Scientific American press.
- Molecular Cell Biology, Lodish Scientific American Books, Inc., USA et al.
- Molecular cloning (1989) Maniatis, T. et al
- Molecular Cloning: A Laboratory Manual, J. Sambrook, E.F. Fritsch and T Maniatis,
- Molecular Cloning: A Laboratory Manual, J. Sambrook, E.F. Fritsch and T Maniatis, Cold Spring Harbor Laboratory Press, New York, 2000.
- Molecular Genetics of Photosynthesis by B.Anderson, H.Salter and J.Barber (1996), IRL Press, Oxford.
- Monoclonal antibodies: Principles and practice (1983). Golding, J.W.
- N. Claude Cohen (Ed.). (1996). Guidebook on molecular modeling in drug design. Gulf Professional Publishing.
- Nucleic acid structure by S.Neidle (ed) (1987) VCH Publishing, Weinheim.
- PCR strategies by MA. Innis, DH.Gelfand & JJ. Sninsky (1995) Academic Press.
- Physical Biochemistry: David Freifelder Instrumental methods of analysis: Willard, Merrit, Dean and Settle. Spectroscopy: D.R.Browning
- Physical Chemistry of Macromolecules, Tanford, C., John Wiley and Sons.
- Plant Biochemistry and Molecular Biology by P.J.Lea and R.C.Leegood (1993) John Wiley & Sons.
- Plant biotechnology – J Hammond, et. al., Springer Verlag.
- Plant cell & tissue culture. (1994). Vasil, I.K. & Thorpe, T.A.
- Plant cell and tissue culture – S Narayanswamy, Tata Mc Graw Hill Co.
- Plant cell and tissue culture for production of food ingredients – T J Fu, G Singh, et. al. Biotechnology in crop improvement – H S Chawla. Practical application of plant molecular biology – R J Henry, Chapman & Hall.
- Plant cell culture technology – M M Yeoman. Plant tissue culture and its biotechnological applications – W Bary, et. al., Springer Verlag.
- Plant Molecular Biology by Grierson and S.N. Covey (1988) Blackie.
- Plant propagation by tissue culture. (1984) George, E.F. & Sherrington, P.D.
- Plant propagation by tissue culture: The technology (Vols. 1 & 2) – Edwin George.
- Plant tissue and cell culture – H E Street, Blackwell Scientific.

- Plant tissue culture: Applications and limits. (1990). Bhojwani, S.S.
- Plant tissue culture: Theory and Practice. (1983). Bhojwani, S.S. & Razdan, M.K.
- Plant Virology (3rd Edition) by R.E.E.Mathews (1991) Academic Press.
- Plants, Genes and Agriculture by M.J. Chrispeels and D.F.Sadava (1994) Jones and Bartlett.
- Principles of fermentation technology. (1984). Stanbury, F. & Whitaker, A.
- Principles of Fermentation Technology: Whitekar & Stanbury
- Principles of gene manipulation by RN.Old & SB.Primrose (1994) Blackwell Scientific Publications.
- Principles of Instrumental analysis by D.S. Skoog (1985) H.L.Saunders.
- Principles of plant biotechnology: An introduction to genetic engineering in plants – S H Mantell, et. al.
- Rastogi, S. C., Mendiratta, N., & Rastogi, P. (2013). Bioinformatics: Methods and Applications: (Genomics, Proteomics and Drug Discovery). PHI Learning Pvt. Ltd.
- Rastogi, S. C., Mendiratta, N., & Rastogi, P. (2013). Bioinformatics: Methods and Applications-(Genomics, Proteomics and Drug Discovery). PHI Learning Pvt. Ltd.
- Recent Advances in Bioinformatics by Khan.
- Recombinant DNA methodology. (1985). Dillon, R.G., Nasim, A. & Nestmann. E.R.
- Recombinant DNA (1992). J.D. Watson, M. Gilamn, J. Witkowski and M. Zoller.
- Reproduction in Eukaryotic cells, DM Prescott, Academic press.
- Roberts, and J. D. Watson. Garland publishing, Inc., New York, 1994
- Roberts, and J. D. Watson. Garland publishing, Inc., New York, 1994
- Roberts, J.A. Steitz and A.M. Weiner, The Benjamin/Cummings Publ. Co., Inc., California, 1987.
- Route Maps in Gene Technology, M.R. Walker and R. Rapley, Blackwell Science
- Scientific American Books, Inc., USA, 1994.
- Scientific American Books, NY.
- Smith, H. J., & Williams, H. (2005). Smith and Williams' introduction to the principles of drug design and action. CRC Press.
- Source book of Experiment for the teaching of Microbiology. (1982). Primrose, S.B. and Wardlaw, A.C.
- Textbook of Fish Genetics and Biotechnology/edited by P.V.G.K. Reddy, S. Ayyappan, D.M. Thampy and Gopal Krishna. New Delhi, Indian Council of Agricultural Research.

- The basic principles of gene cloning (1996). Brown, T.A.
- The chemical kinetics of enzyme action: K. J. Laider and P. S. Bunting, Oxford University Press, London
- The Coiled Spring, Ethan Bier, Cold Spring Harbor Press.
- The Experimental Foundations of Modern Immunology, (1983). Clark, W.R.
- The Molecular Biology of the Cell by Alberts et al. (1991).
- The Molecular Biology of the Gene by J. D. Watson et al. (1987) Benjamin Cummings.
- The Structure and action of proteins by Dickerson and Geis (1969) Benjamin/ Cummings Publishing.
- Topics in enzyme & fermentation technology. (1984). Wiseman, A. (Ed).
- Understanding Enzymes: Trevor Palmer
- Voigt, C. (2011). Synthetic Biology, Part B: Computer Aided Design and DNA Assembly. Methods in enzymology. Elsevier Science
- Waste water Engineering Treatment and Disposal and Reuse" by Metcalf & Eddy.
- Williamd, B.L. and Wilson, K, Principles and techniques of practical biochemistry (1995) Edward Arnold.
- Wu. D. Kim and L.J; Cseke, CRC Press, Florida, 1995.
- Xiong, J. (2006). Essential bioinformatics. Cambridge University Press.
- Zvelebil, M. J., & Baum, J. O. (2008). Understanding bioinformatics. Garland Science.