Course Contents for Subjects with Code: ZOOL

This document only contains details of courses having code **ZOOL**.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-101	Zoology-I (Invertebrate Diversity)	3	I

Year	Discipline
1	Botany, Zoology, Chemistry-I

INVERTEBRATE DIVERSITY:
Classification of organisms; definition, concept, evolutionary relationships and tree diagrams; patterns of organization. Biodiversity.

Animal-Like Protists: The Protozoa:
Evolutionary perspective; life within a single plasma membrane; symbiotic life-styles. Protozoan taxonomy: (up to phyla, subphyla and super classes, wherever applicable). Pseudopodia and amoeboid locomotion; cilia and other pellicular structures; symbiotic ciliates; further phylogenetic considerations.

Multicellular and Tissue Levels of Organization:
Evolutionary perspective: origins of multicellularity; animal origins. Phylum porifera: cell types, and skeletons; body forms; maintenance functions. Phylum cnidaria (coelenterata) the body wall and nematocysts; alternation of generations; maintenance functions; reproduction and classification up to class. Phylum ctenophora; further phylogenetic considerations.

The Triploblastic, Acoelomate Body Plan:
Evolutionary perspective; phylum platyhelminthes: classification up to class; the free-living flatworms and the tapeworms; phylum nemertea; phylum gastrotricha; further phylogenetic considerations.

The Pseudocoelomate Body Plan: Aschelminths:
Evolutionary perspective; general characteristics; classification up to phyla; Some important nematode parasites of humans; further phylogenetic considerations.

Molluscan Success:
Evolutionary perspective: relationships to other animals; origin of the coelom; molluscan characteristics; classification up to class. Diversity in gastropods, bivalves and cephalopods; further phylogenetic considerations.

Annelida: The Metameric Body Form:
Evolutionary perspective: metamerism and tagmatization; classification up to class. External structure and locomotion, feeding.

The Arthropods:
Evolutionary perspective: classification and relationships to other animals; classification up to class.

The Hexapods and Myriapods:
Insect and humans; further phylogenetic considerations.

GENETICS:
Mendelion inheritance & Basic concepts, Sex-determination, Probability and X2 test, Multiple alleles and blood groups, Linkage and crossing over, Chromosome changes, Mutations, Inbreeding and Heterosis, Extrachromosomal Inheritance, Quantitative Inheritance, Population Genetics

Books Recommended:

1. Miller, S.A. and Harley, J.B., 1999 & 2002. Zoology, 4th & 5th Edition (International). Singapore: McGraw Hill.

2. Hickman, C.P., Roberts, L.S. and Larson, A., 2004. Integrated Principles of Zoology, 11th Edition (International). Singapore: McGraw Hill.
3. Pechenik, J.A., 2000. Biology of Intervebrates, 4th Edition (International). Singapore: McGraw Hill.
4. Kent, G.C. and Miller, S., 2001. Comparative Anatomy of Vertebrates. New York: McGraw Hill.
5. Campbell, N.A., 2002. Biology 6th Ed. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
8. Snustad, D.P. and Simmons, M.J. 2003. Principles of Genetics. 3rd Ed. John Wiley and Sons Ins. New York, USA.
9. Strickberger, M.W. 1985. Genetics. McMillan, N.Y. USA.
10. James F. Crow., Genetics Notes

Code	Subject Title	Cr. Hrs	Semester
ZOOL-102	Zoology Lab-I (Invertebrate Diversity)	1	I

Year	Discipline
1	Botany, Zoology, Chemistry-I

Invertebrate Diversity:

1) Study of Euglena, Amoeba, Entamoeba, Plasmodium, Trypanosoma, Paramecium as representative of animal like protists. (Prepared slides).
2) Study of sponges and their various body forms.
3) Study of principal representative classes of phylum Coelentrata.
4) Study of principal representative classes of phylum Platyhelminthes.
5) Study of representative of phylum Rotifera, phylum Nematoda.
6) Study of principal representative classes of phylum Mollusca.
7) Study of principal representative classes of phylum Annelida.
8) Study of principal representative classes of groups of phylum Arthropoda.
9) Brief notes on medical/economic importance of the following:
   Silkworm, Citrus butterfly.

Genetics:

Mitosis and Meiosis slide preparation.
Analysis of Blood groups and Barr bodies.
Drosophila morphology and study of giant chromosomes.
Human pedigree analysis.
Human pedigree analysis problems.
Tossing of coins and probability analysis.
Study of same Human Traits.
Numerical problems related with different topics.

Books Recommended:

1. Miller, S.A., 2002. GENERAL ZOOLOGY LABORATORY MANUAL. 5th Edition (International) Singapore: McGraw Hill.
2. Hickman, C.P. and Kats, H.L., 2000. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. Singapore: McGraw Hill.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-103	Zoology-II (Chordate Diversity)	3	II

Year	Discipline
1	Botany, Zoology, Chemistry-I

CHORDATES DIVERSITY:

Echinoderms:

Evolutionary perspective: relationships to other animals; echinoderm characteristics; classification up to class. Asteroidea, ophiuroidea, echinoidea, holothuroidea and crinoidea; some lesser-known invertebrates: the lophophorates, entoprocts, cycliophores, and chaetognaths.

Invertebrates, Hemichordates & Chordates: Evolutionary Perspective: Phylogenetic Relationships; Classification up to subphylum or class where applicable; Further Phylogenetic Considerations.

Fishes: Vertebrate Success in Water:

Evolutionary perspective: phylogenetic relationships; survey of super class agnatha and gnathostomata; further phylogenetic considerations.

Amphibians: The First Terrestrial Vertebrates:

Evolutionary perspective: phylogenetic relationships; survey of order caudata, gymnophiona, and anura. Evolutionary pressures: further phylogenetic considerations.

Reptiles: The First Amniotes:

Evolutionary perspective: cladistic interpretation of the amniotic lineage; survey of order testudines or chelonia, rhynchocephalia, squamata, and crocodilia; evolutionary pressures: adaptations in external structure and locomotion, further phylogenetic considerations.

Birds: Feathers, Flight and Endothermy:

Evolutionary perspective: phylogenetic relationships; ancient birds and the evolution of flight; diversity of modern birds; evolutionary pressures: adaptation in external structure and locomotion, nutrition and the migration and navigation.

Mammals: Specialized Teeth, Endothermy, Hair and Viviparity:

Evolutionary perspective: diversity of mammals; evolutionary pressures: adaptations in external structure.

Recommended Books:

1. Miller, S.A. and Harley, J.B., 1999 & 2002. Zoology, 4th & 5th Edition (International). Singapore: McGraw Hill.
2. Hickman, C.P., Roberts, L.S. and Larson, A., 2004. Integrated Principles of Zoology, 11th Edition (International). Singapore: McGraw Hill.
3. Pechenik, J.A., 2000. Biology of Invertebrates, 4th Edition (International). Singapore: McGraw Hill.
4. Kent, G.C. and Miller, S., 2001. Comparative Anatomy of Vertebrates. New York: McGraw Hill.
5. Campbell, N.A., 2002. Biology Sixth Edition. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc

Code	Subject Title	Cr. Hrs	Semester
ZOOL-104	Zoology Lab-II (Chordate Diversity)	1	II

Year	Discipline
1	Botany, Zoology, Chemistry-I

Chordates Diversity:

1. Study of a representative of hemichordate and invertebrate chordate.
2. Study of representative groups of class fishes.
3. Study of representative groups of class Amphibia.
4. Study of representative groups of class Reptilia.
5. Study of representative groups of class Aves.
6. Study of representative groups of class Mammalia.
7. Field trips to study animal diversity in an ecosystem.

Developmental Biology-I

1. Study of male reproductive system in an invertebrate and a vertebrate representative (Dissection).
2. Study of female reproductive system in an invertebrate and a vertebrate representative (Dissection).
3. Study of preserved advanced stages of avian and mammalian development for amniotic membranes and placenta (Model).

Recommended Books:

1. Miller, S.A., 2002. GENERAL ZOOLOGY LABORATORY MANUAL. 5th Edition (International) Singapore: McGraw Hill.
2. Hickman, C.P. and Kats, H.L., 2002. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. Singapore: McGraw Hill.
3. Miller, S.A., 2000. GENERAL ZOOLOGY LABORATORY MANUAL. 5th Edition (International) Singapore: McGraw Hill.
4. Hickman, C.P. and Kats, H.L., 2000. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. Singapore: McGraw Hill.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-201	Zoology-III (Biochemistry)	3	III

Year	Discipline
2	Botany, Zoology, Chemistry-I

Monomers and Polymers of life, Amino acids, Peptides and Proteins:
Standard Amino acids, their structure and Classification; Acid/Base properties of amino acids and their Titration curves; Non-standard amino acids, their structure and role; Peptides, Biologically active peptides and polypeptides; Covalent structure of proteins and amino acid sequence; Protein; Three dimensional structure of proteins, Secondary structures of proteins; Tertiary and Quaternary structure of proteins, Globular proteins, Structural and functional diversity in globular proteins; Immunoglobulins their types, structure and functions;
Enzymes: Introduction; Important characteristics of enzymes;
How enzymes work, Enzyme rate of reaction and substrate concentration, How pH and temperature effect enzyme activity; Kinetics of Bisubstrate and Multisubstrate reactions; Enzyme Inhibition, Irreversible and Reversible inhibition; Isozymes; Enzyme precursors and Associates.

Carbohydrates:
Classification, types, important characteristics and structure of Carbohydrates; Disaccharides their types structure and function; Polysaccharides, Storage and Structural types; Structure and major functions of polysaccharides; Glycogen, Starch, Cellulose, Chitin; Homo- and Hetero-polysaccharides; Peptidoglycans of bacterial cell wall.

Lipids:
Fatty acids, their types and major characteristics; Storage Lipids, Acylglycerols; Waxes; Structural Lipids in membranes, Glycerophospholipids, Sphingolipids, their role and degradation; Glycolipids; Isoprenoids, Terpenoids and Sterols; Major functions of Lipids.

ENVIRONMENTAL BIOLOGY & EVOLUTION I:

Environmental Biology:
An overview of concepts of ecosystem with emphasis on interaction and homeostasis. Basic global ecosystems (atmosphere, hydrosphere, lithosphere, ecosphere). Biogeochemical cycle: nitrogen, phosphorus, sulpher, water, carbon. Limiting factors: basic concepts, temperature, soil, water and humidity, light, fire. Energy: laws of thermodynamics, primary and secondary productions, trophic levels and energy variation with increasing trophic levels, energy flow, food chains and food webs. Population ecology: basic population characters, growth and growth curves, population dynamics and regulations.

Evolution:
The nature and origin to life. Evidences of evolution. (molecular, embryological & paleontological). Factors initiating elementary evolutionary changes (micro-evolution) by changing gene frequencies, mutation pressure, selection pressure, immigration and crossbreeding, genetic drift.

Books Recommended:

1. David L. Nelson, and Michael M. Cox, 2005. Lehninger Principles of Biochemistry, 4th Edition, Macmillan Worth Publishers, New York.
2. Lubert Stryer, 1995. Biochemistry, 4th Edition, W.H. Freeman & Company, New York.

3. Murray, R. K., Granner, D. K., Mayer, P. A. and Rodwells, V. W., 2000. Harper's Biochemistry, McGraw Hill Bok Company, New York.
4. Elliott, W. H. and Elliot, D. C., 2002. Biochemistry and Molecular Biology, Oxford Medical Publications, Oxford University Press.
5. Voet, D., Voet, J. G. and Pratt, C. W., 1999. Biochemistry, John Wiley & Sons.
6. Odum, E. P. 1994. Fundamentals of Ecology. W.B. Saunders.
7. Molles, M.C. Ecology: Concepts and applications McGraw Hill, Boston
8. Dondson, S.I., Allen, T.F.N., Carpenter, S.R., Ives, A., Jeanne, R.L., Kitchell, J.F.,
9. Langston, N.E. and Turner, M.G., 1998. Ecology. Oxford Univ. Press, Oxford.
10. Singby, D. and Cork, D., 1986. Practical Ecology. McMillan Education Ltd. London.
11. Chapman, J.L. and Reiss, M.J.1997. Ecology. Principles and Application. Cambridge Univ. Press, Cambridge.
12. Smith, R.L. 1980. Ecology and Field Biology, Harper and Row.
13. Ridley, M., 1993. Evolution. Blackwell Scientific Publications.
14. Dobzhansky, T., Ayala, F.J., Stebbins, G.L. and Valentine, J.W., 1973. Evolution. W.H. Freeman and Company.
15. Dobzhansky, T. Genetics and the Origin of Species, Columbia University Press, New York.
16. Mayr, E. Populations, Species and Evolution, Harvard University Press.
17. Moody, P.A., 1989. Introduction to Evolution, Harper and Row Publishers, New York.
18. Strickberger. (2000). Evolution. Jones & Barrett Publishers

Code	Subject Title	Cr. Hrs	Semester
ZOOL-202	Zoology Lab-III (Biochemistry)	1	III

Year	Discipline
2	Botany, Zoology, Chemistry-I

Biochemistry

1. Tests for detection of carbohydrates in alkaline medium.
2. Tests for detection of carbohydrates in acidic medium.
3. Test to demonstrate relative instability of glycosidic linkage in carbohydrates.
4. Tests for detection of disaccharides.
5. Detection of Non-reducing sugars in the presence of reducing sugars.
6. Demonstration of acid Hydrolysis of Polysaccharide.
7. Biochemical tests for detection of different amino acids.
8. Separation of various protein fractions by precipitation method.
9. Demonstration of different solubility of lipids in various solvents.
10. Various qualitative Tests for detection of lipids.
11. Demonstration of tests for detection of Nucleic Acids (DNA and RNA)

Environmental Biology-I & Evolution I:

1. Community analysis through different sampling techniques (quadrat, Transect).
2. Population dynamics of grasshoppers.
3. Adaptive features of animals in relation to food and environment.
4. Food chain studies through analysis of gut contents of locally available animals.

Books Recommended:

1. Plummer, David T., 1990. An Introduction to Practical Biochemistry, 4th Edition
2. McGraw-Hill Book Company, London.
3. Wilson, K & Walker, J., 1994. Practical Biochemistry: Principles and Techniques, 4th Edition, Cambridge University Press.
4. Alexander, R.R. and Griffiths, J.M. 1993. Basic biochemical methods. Wiley – Liss, New York.
5. Sawhney, S. K. and Singh, R., 2006. Introductory Practical Biochemistry, 2nd Edition, Narosa Publishing House.
6. Oser, B. L., (Latest Edition). Hawk's Physiological Chemistry, McGraw Hill Book Company.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-203	Zoology-IV (Physiology)	3	IV
Year	Discipline		
2	Botany, Zoology, Chemistry-I		

The animals sustain themselves in their individual as well as in group through the functions of acquiring energy and simplifying it through nutrition, distributing it through circulation and generating energy with oxygen through respiration, eliminating unwanted wastes through excretion; the general concepts of the structural adaptation in different groups of animals to a particular function will be taught.

Communication I Nerves: Neurons:

The Basic Functional Units of the Nervous System. Neuron Structure. Neuron Communication Introductory Aspects: Resting Membrane Potential, Action potential (Nerve Impulse), Transmission of the Action Potential between Cells. Invertebrate and Vertebrate Nervous Systems: The Spinal Cord, Spinal Nerves, The Brain, Cranial Nerves, The Autonomic Nervous System.

Communication II: Senses:

Sensory Reception. Invertebrate Sensory Receptors: Baroreceptors, Chemoreceptors, Georeceptors, Hygroreceptors, Phonoreceptors, Photoreceptors, Proprioceptors, Tactile Receptors, Thermoreceptors, Vertebrate Sensory Receptors:, Lateral-Line System and Electrical Sensing, Lateral-Line System and Mechanoreception, Hearing and Equilibrium in Air, Hearing and Equilibrium in Water, Skin Sensors of Damaging Stimuli, Skin Sensors of Heat and Cold, Skin Sensors of Mechanical Stimuli, Sonar, Smell, Taste, Vision.

Communication III: The Endocrine System and Chemical Messengers:

Chemical Messengers. Introductory aspects of hormones and Their Feedback Systems: Biochemistry of Hormones, Feedback Control System of Hormone Secretion, Mechanisms of Hormone Action, Fixed-Membrane-Receptor Mechanism, Mobile-Receptor Mechanism. Some Hormones of Invertebrates: Porifera, Cnidarians, Platyhelminths, Nemerteans, Nematodes, Molluscs, Annelids, Arthropods, Echinoderms, An Overview of the Vertebrate Endocrine System, Endocrine Systems of Vertebrates Other Than Birds or Mammals, Endocrine Systems of Birds and Mammals.

Circulation and Gas Exchange: Internal Transport and Circulatory Systems: Transport Systems in Invertebrates and Vertebrates. The Hearts and Circulatory Systems of Bony Fishes, Amphibians, Reptiles, Birds and Mammals, Gas Exchange, Respiratory Surfaces, Invertebrate Respiratory Systems, Vertebrate Respiratory Systems, Cutaneous Exchange, Gills, Lungs, Lung Ventilation, Human Respiratory System, Gas Transport.

Nutrition and Digestion:

Evolution of Nutrition. The Metabolic Fates of Nutrients in Heterotrophs. Animal Strategies for Getting and Using Food Continuous Versus Discontinuous Feeders. Diversity in Digestive Structures: Invertebrates and Vertebrates. The Mammalian Digestive System: The various segments and their roles.

Cell Biology:

Introduction to Cell Biology; Difference between prokaryotic and eukaryote cells. Cytoplasmic organelles: Membrane system, Ultrastructure of cell, Endoplasmic reticulum; their role in protein synthesis and drug metabolism. Golgi apparatus: Role in synthesis of glycoprotein. Mitochondria: Cell respiration, significance as semi-autonomous organelle. Lysozomes: Diverse role due to hydrolytic activity of enzymes. Peroxisomes: Metabolism of

hydrogen peroxide. Glyxoxysomes: Plasma membrane and its function: Chemical composition and structure of plasma membrane, cell permeability, active transport, Endocytosis, Phagocytosis, Cytoskeleton: Microfilaments, Microtubules, Intermediate filaments. Introduction to Replication, Transcription and Translation.

Books Recommended

1. Guyton, A.C. and Hall, J.E., 2000. Textbook of Medical Physiology, 10th Edition. W.B. Saunders Company, Philadelphia.
2. Zoology 2002 & 2006. Miller, S.A. and Harley, J.B. WCB/McGraw Hill, New York.
3. Comparative anatomy of vertebrates, 2001. Kent, G.C. and Miller, L. WCB WmC Brown Publishers/McGraw Hill Companies Inc., New York.
4. Bullock, J., Boyle, J. and Wang, M.B., 2001. Physiology, 4th edition. Lippincott, Williams and Wilkins, Philadelphia.
5. Berne, R.M. and Levy, M.N., 2000. Principles of Physiology, 3rd edition. St. Lious, Mosby.
6. Vertebrate anatomy, function, evolution, 2002. Kardong, K.V. WCB WmC Brown Publishers/McGraw Hill Companies Inc., New York.
7. De Robertis and De Robertis. (Latest Edition)Cell and Molecular Biology. Lea and Fibiger, New York.
8. Gerald Karep. Cell and Molecular Biology. John Wiley & Sons. Inc. USA.
9. Lodisch, H., Darnell, Jr., J. and Balimore D. Molecular Cell Biology. Scientific American Inc. New York.
10. Albert, B., Bray, D., Lewis, J., Raff, M. et al.(Latest Edition) Molecular Biology of the cell. Garland publishing Inc. New York.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-204	Zoology Lab-IV (Physiology)	1	IV

Year	Discipline
2	Botany, Zoology, Chemistry-I

Physiology

Comparative adaptations to the particular function in different systems such as nervous system, receptors, endocrine and reproductive system, circulatory system, respiratory system, excretory and nutritive systems in various animal groups will be demonstrated with preserved tissues, organs and organ systems.

Cell Biology:

Laboratory safety: Physical, Chemical and biological hazards.
Total Erythrocyte counting using haemocytometer.
TLC (total Leukocyte count) using haemocytometer.
Identification of blood cells in normal blood smear and DLC (differential leukocyte count.)
Culture and staining of bacteria and yeast.
Detection and quantitative determination of chromosomal DNA and RNA.
Nucleic acid staining using Methyl greed and pyronin.
Study of histological sections of tissues to study various types of cells.

Books Recommended

1. EXPERIMENTS IN PHYSIOLOGY, 2002. Tharp, G.D. McMillan Publishing Company, New York.
2. ZOOLOGY, 1999 & 2006. Miller, S.A. and Harley, J.B. WCB/McGraw Hill, New York

Code	Subject Title	Cr. Hrs	Semester
ZOOL-301	Cell and Molecular Biology II	3	V
Year	Discipline		
3	Zoology		

Nucleus:
Chromatin, heterochromatin, euchromatin, chromosome structure with reference to coiling and nucleosome during different phases of cell cycle, **DNA physical and chemical structure**, characteristics of DNA, **DNA replication** (mechanism, DNA replication in prokaryotes specially with reference to variety of DNA polymerases and other proteins involved, DNA replication in Eukaryotes with special reference to DNA polymerases, concept of Replicons etc.), DNA repair, **Transcription** (variety of RNA and their characteristics, synthesis of mRNA, rRNA and tRNA with special reference to enzymes, involved, RNA splicing, split genes, concept of Ribozymes and posttranscriptional processing), RNA transduction, Genetic code, point mutations, **Translation** (with reference to the specific role of Ribosomes, various factors, and posttranslational processing), **Regulation of Gene Expression** (enzyme induction, enzyme repression, role of promoter and operator to be elucidated taking examples of Lac operon and Trip Operon, Gene Regulation in Eukaryotes with reference to elaborate promoter and diverse transcription factors involved, concept of examples of Transcriptional Regulation and Translational Regulation). **Nuclear Envelope**, Nucleolus
Recombinant DNA technology
General Principles, molecular tools involved (vectors, enzymes, expression system) DNA sequencing, chromosome walking, PCR techniques.
Role of Genetic Engineering in Economic Development in the areas of **Medicine and Human Health** (Therapeutic Drug, Vaccines, Monoclonal antibodies, Gene therapy, Animal Cloning, Human Genome Project, Stem Cells, Transgenics Ethical issues), **Agriculture** (Livestock Health, increase in agricultural produce), **Industry** (organic solvents, petroleum industry, ore leaching etc.).

Textbook

1. De Robertis and De Robertis. (Latest Edition)Cell and Molecular Biology. Lea and Fibiger, New York.

Additional Readings

1. Karp, G. 2007. Cell and Molecular Biology. John Wiley & Sons. Inc. USA.
2. Lodisch, H., Darnell, Jr., J. and Balimore D. 2000. Molecular Cell Biology. Scientific American Inc. New York.
3. Weaver. F.F. 2005. Molecular Biology 3rd Ed. The McGraw Hill companies Inc. International Edition.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-302	Cell and Molecular Biology II Lab	1	V
Year	Discipline		
3	Zoology		

1. Histochemistry of tissues, preparation and study of tissue structure.
2. Extraction of DNA (bacterial).
3. Minipreparation of plasmid DNA.
4. Restriction digestion of plasmid DNA.
5. Isolation and characterization of proteins on polyacrylamide gel electrophoresis.
6. Western blotting.
7. Cloning and transformation.
8. PCR amplification of DNA.

Textbook

1. De Robertis and De Robertis. (Latest Edition)Cell and Molecular Biology. Lea and Fibiger, New York.

Additional Readings

1. Karp, G. 2007. Cell and Molecular Biology. John Wiley & Sons. Inc. USA.
2. Lodisch, H., Darnell, Jr., J. and Balimore D. 2000. Molecular Cell Biology. Scientific American Inc. New York.
3. Weaver. F.F. 2005. Molecular Biology 3rd Ed. The McGraw Hill companies Inc. International Edition.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-303	Biochemistry II	3	V
Year	Discipline		
3	Zoology		

Bioenergetics: Concept of Free Energy; Standard Free Energy change: Energy rich compounds and their role in metabolism.

Metabolism: description of Glycolysis Regulation and Bioenergetics of Glycolysis. Anabolic role of Glycolysis; Fate of Pyruvate; Gluconeogenesis, its Regulation and significance in tissues; Utilization of other carbohydrates Glycogen synthesis and degradation; Regulation of Glycogen metabolism;; Pentose phosphate pathway and its major role in the animal tissues.

Citric acid (TCA) cycle: Conversion of Pyruvate to Acetyl CoA, Pyruvate dehydrogenase, a multi-enzyme complex; description of citric acid cycle; Bioenergetics of the cycle. Anabolic or Biosynthetic role of citric acid cycle intermediates; Replenishing or Anaplerotic reactions and their role; Regulation of Citric acid cycle; Electron transport chain.

Lipid metabolism: Fate of dietary fat; Activation of Fatty acids and their transportation to mitochondria; Beta-Oxidation; Alpha oxidation; Bioenergetics of Beta-oxidation; Oxidation of unsaturated and Odd chain fatty acids; Omega oxidation pathway; Biosynthesis of Saturated Fatty acid; Biosynthesis of unsaturated Fatty acids. Ketone bodies their biosynthesis, utilization and role in the tissues; Cholesterol metabolism: Cholesterol biosynthesis and its Regulation.

Nitrogen Metabolism: Metabolic fate of amino acids; Catabolism of Amino acids; Deamination and Transamination; Nitrogen Excretion and Urea cycle; Regulation of Urea cycle; Decarboxylation of Amino acids to Biological Amines.; Purine and Pyrimidine synthesis showing the sources of various atoms in both molecules.

Recommended text book

1. David L. Nelson, and Michael M. Cox, 2000. Lehninger Principles of Biochemistry, 3rd Ed., Macmillan Worth Publishers, New York.

Additional reading material

1. Stryer, L., 1995. Biochemistry, 6th Ed., W.H. Freeman and Company, New York.
2. Murray, R.K., Granner, D.K., Mayer, P.A. and Rodwells, V.W., 2000. Voet. D., Voet, J.G., and Pratt, C.W., 1999. Fundamentals of Biochemistry, John Wiley and Sons, Inc., New York.
3. Zubay, G., 1995. Biochemistry, 4th Ed., Wm. C. Brown Publishers, Inc., Oxford, England.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-304	Biochemistry II Lab	1	V
Year	Discipline		
3	Zoology		

1. Preparation of standard curve for glucose by *o*-Toluidine method.
2. Preparation of standard curve for proteins by Buiret method.
3. Separation and identification of various amino acids by paper chromatography.
4. Preparation of standard curve and estimation of DNA by colorimetric analysis using Diphenylamine method.
5. Preparation of standard curve and estimation of total RNA by colorimetric analysis using Orcinol method.
6. Preparation of standard curve and estimation of lipid by vanilline reagent.
7. Demonstration of the effect temperature on the enzymatic rate of reaction.
8. Demonstration of the effect of pH on the enzymatic rate of reaction.

Books Recommended

1. Plummer, David T., 1990. An Introduction to Practical Biochemistry, 4th Edition
2. McGraw-Hill Book Company, London.
3. Wilson, K and Walker, J., 1994. Practical Biochemistry: Principles and Techniques, 4th Edition, Cambridge University Press.
4. Alexander, R.R. and Griffiths, J.M. 1993. Basic biochemical methods. Wiley – Liss,
5. New York.
6. Sawhney, S. K. and Singh, R., 2006. Introductory Practical Biochemistry, 2nd Edition,
7. Narosa Publishing House.
8. Oser, B. L., (Latest Edition). Hawk's Physiological Chemistry, McGraw Hill Book Company

Code	Subject Title	Cr. Hrs	Semester
ZOOL-305	Animal Physiology II	3	V
Year	Discipline		
3	Zoology		

Physiological Mechanisms at Cell: Cellular membrane and transmembrane transport; resting membrane potentials; Generation and conduction of action potentials; synaptic transmission; Membrane receptors.

Nervous System: Organization of nervous system; General sensory system; Visual, Auditory, Vestibular and Chemical sensory system.

Muscle and Movements: Molecular basis of contraction; Muscles activity on skeleton; Adaptation of muscles for various activities; Muscles in the walls of hollow organs.

Endocrine System: General principles of endocrine physiology; Hormones in homeostasis of metabolism; Endocrine regulation of metabolism of calcium and phosphate; Parathyroid gland, Calcitonin and Cholecalciferol; Hypothalamus and Pituitary: Hypothalamic regulation of pituitary, pituitary gland hormone in physiological coordination; Thyroid gland: Functional anatomy, biosynthesis, regulation and roles in physiological functions, mechanism of thyroid hormones action; Adrenal cortex: Hormones biosynthesis, physiological roles and control; Adrenal medulla: Hormones biosynthesis, physiological roles, and hypothalamic-pituitary-adrenocortical axis, adrenal medulla and sympathetic nervous system together integrate responses to stress; General reproductive mechanisms: Synthesis and physiological roles of gonadal steroids, Second messenger and signal-transduction pathways.

Textbooks

1. Guyton, A.C. and Hall, J.E., 2006. Textbook of Medical Physiology, 11th Edition. W.B. Saunders Company, Philadelphia.
2. *Withers, P.C., 1992. Comparative Animal Physiology. Saunders College Publishing, Philadelphia.*
3. Tharp, G. and Woodman, D., 2011. Experiments in Physiology, 10th Edition. Prentice Hall, London.

Additional Readings

1. *Randall, D., Burggren, W., French, K. and Fernald, R., 2002. Eckert Animal Physiology: Mechanisms and Adaptations, 5th ed. W.H. Freeman and Company, New York*

Code	Subject Title	Cr. Hrs	Semester
ZOOL-306	Animal Physiology II Lab	1	V
Year	Discipline		
3	Zoology		

1. Recording of action potentials on oscilloscope and effects of various factors on its characters.
2. Study of synaptic activity with neuromuscular preparations.
3. Sciatic nerve compound action potential.
4. Demonstration of nervous system organization while studying brain, cranial nerve, spinal cord and spinal nerves.
5. Experiments on sensory organs study.
6. Experiments on characteristics of skeletal muscle contractions;
7. Responses of intestinal muscles and effect of drugs.
8. Demonstration of endocrine glands in a mammal (mouse).
9. Effect of hormones on glycemia and calcemia.
10. Effect of thyroxine on oxygen consumption.
11. Effect of androgen on accessory sex organs and of estrogens on target tissues.
12. Study of estrous cycle and effects of the hormones.

Textbooks

1. Guyton, A.C. and Hall, J.E., 2006. Textbook of Medical Physiology, 11th Edition. W.B. Saunders Company, Philadelphia.
2. *Withers, P.C., 1992. Comparative Animal Physiology. Saunders College Publishing, Philadelphia.*
3. Tharp, G. and Woodman, D., 2011. Experiments in Physiology, 10th Edition. Prentice Hall, London.

Additional Readings

1. *Randall, D., Burggren, W., French, K. and Fernald, R., 2002. Eckert Animal Physiology: Mechanisms and Adaptations, 5th ed. W.H. Freeman and Company, New York*

Code	Subject Title	Cr. Hrs	Semester
ZOOL-307	Biostatistics	2	V
Year	Discipline		
3	Zoology		

Introduction and scope, use of statistics in biology. Population and sample. Stages of research, types of data and methods of data collection. Data arrangement and presentation, formation of tables and charts. Measures of central tendency computation of mean, media and mode from grouped and ungrouped data. Measures of dispersion, computation of variance, standard deviation, standard error and their coefficients. Probability rules. Binomial, poison and normal distributions. Hypothesis testing, student's 't' test, Chi square test, Analysis of variance and LSD. Correlation and regression. Experimental designing, planning of an experiment, replication and randomization.

Textbook

1. Bluman, A. G. Elementry Statistics A Step By Step Approach, (Latest Addition)

Additional Readings

1. Geoffery, R. Norman, David L. Streiner 2000. Biostatistics: The Bare Essentials. B.C. Decke Inc.
2. Gerry, P. Quinn, Michael J. Keough, 2002. Experimental design and data analysis for biologists. Cambridge University Press.
3. Richard Colin Campbell, 1989. Statistics for Biologists. Cambridge University Press.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-308	Evolution	2	V
Year	Discipline		
3	Zoology		

Origin of life: Panspermia and Chemical theory; The causes of micro-evolution; Hardy-Weinberg equilibrium, Mutation, Gene flow, Genetic drift, Nonrandom breeding, and natural selection. Types of natural selection, its measurement. Causes of polymorphism in populations. The general selection model: (one locus and two locus), Genetic load, Cost of selection, Hitch-hiking, Linkage disequilibrium and shifting balance theory. Fitness and its measurement, Dependence of fitness on frequency of individual. Concept of phenotypic variation: Polygenic traits and Heritability. Explanation for adaptation, genetics of adaptation, reasons of imperfect adaptation. The Units of selection (allele, cell line, organisms, kin group and group). Sexual selection, Theories of sexual selection; Darwin, Fisher and Zahavi. Macroevolution: Evolutionary developmental biology: allometery, heterochrony, species selection, Evolutionary innovation and origin of higher taxa. Rates of evolution; Evolutionary trends and laws, Gradualism and punctuated equilibrium. Coevolution and co adaptations.

Textbook

Ridley, M. 2004. Evolution, 3rd edition. Blackwell Science.

Additional Readings

1. Bell, G. 1997. Selection: the mechanism of evolution. Chapman & Hall, NY.
2. Dawkins, R. 1986. The blind watchmaker. Longman Scientific and Technical. Essex, England.
3. Dawkins, R. 1978. The selfish gene. Oxford University Press, NY.
4. Freeman, S. and Herron, J. C. 2004. Evolutionary analysis, 3rd ed. Pearson Prentice Hall.
5. Futuyma, D. J. 1997. Evolutionary Biology, 3rd ed. Sinauer Associates, Inc. Sunderland, Massachusetts.
6. Gould, S. J. 1977. Ever since Darwin. W. W. Norton and Company, NY.
7. Ridley, M. 2000. Genome. New York: Perennial. Great reading.
8. Stearns, S. C. and Hoekstra, R. F. 2000. Evolution, an introduction. Oxford University Press.
9. Strickberger, (3rd or latest edition) Evolution. Jones and Barrett Publishers.
10. Freeman Dyson, 1999. Origin of life, Cambridge University Press.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-309	Evolution Lab	1	V
Year	Discipline		
3	Zoology		

Calculation of gene and genotype frequency for generations. To calculate deviation of genotype from Hardy Weinberg equilibrium. Simulate to check the effects of natural selection and genetic drift in changing environments. Simulation of assess the role population size in evolution. Discussion on the evidences of evolution, role of biodiversity in evolution. Simulation experiment to show the process of coevolution.

Textbook

1. Ridley, M. 2004. Evolution, 3rd edition. Blackwell Science.

Additional Readings

1. Bell, G. 1997. Selection: the mechanism of evolution. Chapman & Hall, NY.
2. Dawkins, R. 1986. The blind watchmaker. Longman Scientific and Technical. Essex, England.
3. Dawkins, R. 1978. The selfish gene. Oxford University Press, NY.
4. Freeman, S. and Herron, J. C. 2004. Evolutionary analysis, 3rd ed. Pearson Prentice Hall.
5. Futuyma, D. J. 1997. Evolutionary Biology, 3rd ed. Sinauer Associates, Inc. Sunderland, Massachusetts.
6. Gould, S. J. 1977. Ever since Darwin. W. W. Norton and Company, NY.
7. Ridley, M. 2000. Genome. New York: Perennial. Great reading.
8. Stearns, S. C. and Hoekstra, R. F. 2000. Evolution, an introduction. Oxford University Press.
9. Strickberger, (3rd or latest edition) Evolution. Jones and Barrett Publishers.
10. Freeman Dyson, 1999. Origin of life, Cambridge University Press.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-310	Molecular Genetics II	3	VI
Year	Discipline		
3	Zoology		

Introduction to molecular genetics. DNA and Topology of DNA; Eukaryotic genome organization, Techniques of molecular genetics. Replication, Rolling circle model. Transcription; Structure of promoter, Leader and trailer sequence, Splicing. Translation; Bacterial genetics. Complementation mapping. Gene regulation; Arabinose operon, Role of operator, promoter and repressor in gene regulation. Transposable elements; Their characteristics and mechanism. Gene therapy.

Books recommended

1. Snustad, D.P and Simmons, M.J., 2010. Principles of Genetics, 5th edition, John Wiley and Sons (Asia) Pte Ltd.
2. Weaver, R., 2011. *Molecular Biology* 5th Ed. McGraw-Hill.

Additional Reading Material

1. Kornberg, A., 2005. *DNA Replication*, 2 Ed. University Science Books;
2. Waston, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R., 2007.*Molecular Biology of the Gene* (6th Ed.) Benjamin Cummings sLewin, B., 2007 . *Genes IX*. 9 Ed. Jones and Barlett Publication.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-311	Molecular Genetics II Lab	1	VI
Year	Discipline		
3	Zoology		

1) Preparation of overnight bacterial culture
2) Isolation of genomic DNA
3) Isolation of Plasmid DNA
4) Preparation of insert
5) Preparation of vector
6) Ligation of insert in vector
7) Transformation of recombinant DNA into *E. coli*.

Books recommended

1. Snustad, D.P and Simmons, M.J., 2010. Principles of Genetics, 5th edition, John Wiley and Sons (Asia) Pte Ltd.
2. Weaver, R., 2011. *Molecular Biology* 5th Ed. McGraw-Hill.

Additional Reading Material

1. Kornberg, A., 2005. *DNA Replication*, 2 Ed. University Science Books;
2. Waston, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R., 2007.*Molecular Biology of the Gene* (6th Ed.) Benjamin Cummings sLewin, B., 2007 . *Genes IX*. 9 Ed. Jones and Barlett Publication.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-312	Analysis of Development	2	VI
Year	Discipline		
3	Zoology		

Cellular Basis of Morphogenesis: Differential cell affinity, cell adhesion molecules; Mechanism of Cellular Differentiation: RNA processing, translational regulation of developmental process, cell-fate by progressive determinants, autonomous cell specification by cytoplasmic determinants, establishment of body axes and mechanism of teratogenesis; Secondary Induction; Organogenesis: A brief account; Origin and Migration of Germ Cells in Vertebrates; Factors controlling Growth and Oncogenesis. Hormones as Mediators of Development; Regeneration in Vertebrates.

Textbook

1. Gilbert, S. F., 2008. Developmental Biology, Sinauer Associates, Sunderland, MA.
2. Balinsky, B. I., 1985. An Introduction to Embryology, Saunders.

Additional Readings

1. Saunders, J. W., 1982. Development Biology, McMillan.
2. Oppenheimer, S.S., 1984. Introduction to Embryonic Development, Allen and Bacon.
3. Bodemer, C. W., 1968. Modern Embryology. Holt, Rinehart and Winston.
4. Ham, R. G. and Veomett, M. J., 1980. Mechanism of Development. C.V. Mosby Co.
5. Berril, N. J. and Karp, G., 1978. Development. McGraw Hill.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-313	Analysis of Development Lab	1	VI
Year	Discipline		
3	Zoology		

1. *Preparation and study of serial sections of frog or chick embryos.*
2. *Application of microsurgical techniques on chick embryos* in vitro.
3. *Preparation and staining of histological slides.*

Textbook

1. Gilbert, S. F., 2008. Developmental Biology, Sinauer Associates, Sunderland, MA.
2. Balinsky, B. I., 1985. An Introduction to Embryology, Saunders.

Additional Readings

3. Saunders, J. W., 1982. Development Biology, McMillan.
4. Oppenheimer, S.S., 1984. Introduction to Embryonic Development, Allen and Bacon.
5. Bodemer, C. W., 1968. Modern Embryology. Holt, Rinehart and Winston.
6. Ham, R. G. and Veomett, M. J., 1980. Mechanism of Development. C.V. Mosby Co.
7. Berril, N. J. and Karp, G., 1978. Development. McGraw Hill.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-314	Wildlife	2	VI
Year	Discipline		
3	Zoology		

Introduction to wildlife, Philosophy and significance of wildlife. Animal distribution in Pakistan and their affinities. Important wild animals, distribution, status, conservation and management (population estimates and diversity indices). IUCN categories of wildlife status. In-situ, ex-situ conservation, Wildlife Benefits, Zoonotic diseases, Provincial wildlife rules in Pakistan, Zoo rules, National and International organizations involved in conservation and management of wildlife, National Park, Wildlife Sanctuary, and Game Reserves in Pakistan, IUCN protected areas, Eco-regions, Ramsar Convention, Ramsar sites of Pakistan, Major threats to wetlands. Threatened species of Pakistan.

Books Recommended

1. Bailey, J.A., 1986. Principles of Wildlife Management, John Wiley.
2. Gaston, G. and J. Spicer. 2007. Biodiversity. Blackwell Publishing & Co. London, UK.
3. Grimmett, R. Inskipp, C. and Inskipp, T., 2001, Birds of the Indian Sub-Continent. Helm.
4. Grimmett, R. Roberts, T. J and Inskipp, T. 2008.Birds of Pakistan. Helm Field Guide.
5. Hickman, Roberts, and Larsen, 2003. Animal Diversity (3rd Edition).McGraw Hill, New York.
6. Hickman, Roberts, and Larsen, 2004. Integrated principles of Zoology (12th Edition).McGraw Hill, New York.
7. Jordan, E. L. and Verma, P. S. 2011.Invertebrate Zoology, S. Chand and Company.
8. M . S. Khan. 2006. Amphibians and Reptiles of Pakistan. Krieger Publishing Company, Florida USA.
9. M. M. Shafique, 2005. Wildlife Acts and Rules of Pakistan. PFI, Peshawar.
10. Miller and Harly, 2007. Zoology (7th Edition). McGraw Hill, New York.
11. Mirza . Z. B. 1998. Illustrated handbook of Animal Biodiversity of Pakistan. Printopak.
12. Mitsch, W. J. and Gosselink, J. G. 2007. Wetlands 4th ed. John Wiley & Sons, Inc.
13. Odum, E.P., 1994. Fundamentals of Ecology, W.B. Saunders.
14. Pough, F. H., Janis, C. M. and Heiser, J. B. 2006. Vertebrate Life, 6th Ed. Pearson Prentice Hall.
15. Prasad, S. N. and Kashyap, V. 2011.A textbook of Vertebrate Zoology, New Age International Publishers.
16. Punjab Wildlife Act 1974. Government of the Punjab.
17. Roberts, T. J. 1991. Birds of Pakistan. Vol. I Oxford
18. Roberts, T. J. 1992. Birds of Pakistan. Vol. II. Oxford
19. Roberts, T. J. 1997. Mammals of Pakistan. Vol. II. Oxford
20. Roberts, T. J. 2005. Field Guide to the large and Medium-sized Mammals of Pakistan. Oxford
21. Roberts, T. J. 2005. Field Guide to the small Mammals of Pakistan. Oxford
22. Robinson, W.L. and Bolen, E.G., 1984. Wildlife Ecology and Management. McMillan, Cambridge.

23. S. S. Ali, 1999. Zoogeography, Paleontology and Wildlife Management, Naseem Book Depot, Hyderabad.
24. Singh, S. K., 2005. Text Book of Wildlife Management. IBDC
25. Smith, R. L., 1980. Ecology and field biology, Harper and Row.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-315	Wildlife Lab	1	VI
Year	Discipline		
3	Zoology		

Study of museum specimens with their notes on adaptive characteristics, ecology and habitats.
Field work and study of species richness, species evenness, relative abundance, Simpson Index, Shannon Weiner Index.
Demonstration of distribution of animal species of Pakistan, (Blank map will be provided).
Individual presentation of threatened wild animal of Pakistan assigned to students.

Books Recommended

1. Bailey, J.A., 1986. Principles of Wildlife Management, John Wiley.
2. Gaston, G. and J. Spicer. 2007. Biodiversity. Blackwell Publishing & Co. London, UK.
3. Grimmett, R. Inskipp, C. and Inskipp, T., 2001, Birds of the Indian Sub-Continent. Helm.
4. Grimmett, R. Roberts, T. J and Inskipp, T. 2008.Birds of Pakistan. Helm Field Guide.
5. Hickman, Roberts, and Larsen, 2003. Animal Diversity (3rd Edition).McGraw Hill, New York.
6. Hickman, Roberts, and Larsen, 2004. Integrated principles of Zoology (12th Edition).McGraw Hill, New York.
7. Jordan, E. L. and Verma, P. S. 2011.Invertebrate Zoology, S. Chand and Company.
8. M . S. Khan. 2006. Amphibians and Reptiles of Pakistan. Krieger Publishing Company, Florida USA.
9. M. M. Shafique, 2005. Wildlife Acts and Rules of Pakistan. PFI, Peshawar.
10. Miller and Harly, 2007. Zoology (7th Edition). McGraw Hill, New York.
11. Mirza . Z. B. 1998. Illustrated handbook of Animal Biodiversity of Pakistan. Printopak.
12. Mitsch, W. J. and Gosselink, J. G. 2007. Wetlands 4th ed. John Wiley & Sons, Inc.
13. Odum, E.P., 1994. Fundamentals of Ecology, W.B. Saunders.
14. Pough, F. H., Janis, C. M. and Heiser, J. B. 2006. Vertebrate Life, 6th Ed. Pearson Prentice Hall.
15. Prasad, S. N. and Kashyap, V. 2011.A textbook of Vertebrate Zoology, New Age International Publishers.
16. Punjab Wildlife Act 1974. Government of the Punjab.
17. Roberts, T. J. 1991. Birds of Pakistan. Vol. I Oxford
18. Roberts, T. J. 1992. Birds of Pakistan. Vol. II. Oxford
19. Roberts, T. J. 1997. Mammals of Pakistan. Vol. II. Oxford
20. Roberts, T. J. 2005. Field Guide to the large and Medium-sized Mammals of Pakistan. Oxford
21. Roberts, T. J. 2005. Field Guide to the small Mammals of Pakistan. Oxford
22. Robinson, W.L. and Bolen, E.G., 1984. Wildlife Ecology and Management. McMillan, Cambridge.
23. S. S. Ali, 1999. Zoogeography, Paleontology and Wildlife Management, Naseem Book Depot, Hyderabad.
24. Singh, S. K., 2005. Text Book of Wildlife Management. IBDC

25. Smith, R. L., 1980. Ecology and field biology, Harper and Row.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-316	Environmental Biology	3	VI
Year	Discipline		
3	Zoology		

Succession and Stability: Community change during succession, Ecosystem change during succession, Mechanism of succession, Community and ecosystem stability

Environmental Pollution: Primary and secondary pollutants, point and non point pollutants, Air Pollution sources: Origin, dispersion and impact on human, crops and forest of Particulates, Sulphur oxides, Nitrogen oxides & volatile organic compounds, Carbon monoxide, carbon dioxide, Smog & PAN, MTBE (methyl tertiary butyl ether) & CFCs (chlorofluorocarbons), Noise pollution; Measuring noise, Health damage from noise, Control of noise, Water pollution; Sources of water pollution, Fate of water pollution, Composition and properties of water pollutants, Domestic and industrial effluents, Heavy metals and their impact on aquatic life, Water purification in nature, Waste water treatment, Wetland sewage treatment; cleaner water, cheaper, and prettier, Land Pollution; Pesticides (pollutants made to kill), Inorganic pesticides, Synthetic organic pesticides, Biochemical (bacterial toxins and synthetic hormones), Chemical pesticides (non-target toxicity), Chlorine, dioxin and PCBs (polychlorinated biphenyls), Reducing pesticide use, Thermal pollution, Warm water drainage from nuclear reactor, Radioactive pollution, Radioactivity leakage from nuclear reactor.

Population Ecology: Population dynamics, Pattern of survival and dispersion, Age of distribution, sex ratio, Dispersal, Population growth, Geometric & exponential population growth, Logistic population growth, Limits of population growth.

Population Ecology of man: Chemical & biological warfare, Ecocrises, Environmental management, Environmental ethics & politics, Economics of ecology, Community studies, Concepts of animal behaviour communication.

Contemporary environmental themes: Ozone depletion, Green house effect, Global warming , Acid rain, Desertification, Deforestation, Environmental laws.

Textbooks

1. M.L. McKinney, 1999. Environmental Science: System and Solution Jones & Bartlett Publication, Boston
2. R. Lloyd, 1992. Pollution and Freshwater Fishing News Books.
3. Manuel C. Moller Jr. 2002. Ecology (Concepts and solutions). McGraw-Hill publishers.

Additional Readings

1. C.E. Mason, 1996. Biology of Freshwater Pollution, Longman Publication.
2. Smith, 1988. Ecology and Field Biology, National Book Foundation.
3. Krebs, 2000. Ecology: The experimental analysis of distribution and application.
4. E.P. Odum, 1996. Ecology: A Bridge between science & society.
5. R.K. Singh, 1998. Human Ecology.
6. Miller, Jr., 2002. Living in the environment. Ed.
7. Peter Stillig, 2002. Ecology (Theories and Applications). Prentice Hall publications.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-317	Environmental Biology Lab	1	VI
Year	Discipline		
3	Zoology		

1. Methods and analysis of population dynamics, Quadrate method:
   a. Determining frequency of different species (population analysis).
   b. Determining density of species in habitat.
2. Measurement of pollutants levels:
   a. In atmosphere (NO_2, SO_2, O_3 and comparison with rural air).
   b. In soil (toxic chemical, fertilizer, insecticides, pesticides, herbicides); and in plants and animals.
3. Analysis of polluted and freshwater for, Various pollutants; heavy metals, -CO_3, -HCO_3, NO_3, BOD, COD, pH, EC, total, soluble solids.
4. Impact of radiation on microbes and plants.
5. Effects of noise on animal behaviour.

Textbooks

1. M.L. McKinney, 1999. Environmental Science: System and Solution Jones & Bartlett Publication, Boston
2. R. Lloyd, 1992. Pollution and Freshwater Fishing News Books.
3. Manuel C. Moller Jr. 2002. Ecology (Concepts and solutions). McGraw-Hill publishers.

Additional Readings

1. C.E. Mason, 1996. Biology of Freshwater Pollution, Longman Publication.
2. Smith, 1988. Ecology and Field Biology, National Book Foundation.
3. Krebs, 2000. Ecology: The experimental analysis of distribution and application.
4. E.P. Odum, 1996. Ecology: A Bridge between science & society.
5. R.K. Singh, 1998. Human Ecology.
6. Miller, Jr., 2002. Living in the environment. Ed.
7. Peter Stillig, 2002. Ecology (Theories and Applications). Prentice Hall publications.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-318	Animal Behaviour	2	VI
Year	Discipline		
3	Zoology		

The Study of Animal Behaviour: Introduction. History of Animal Behaviour. Approaches and Methods.
Behaviour Genetics and Evolution: Genes and Evolution. Behavioural Genetics. Evolution of Behaviour Patterns.
Mechanisms of Behaviour: The Nervous System and Behaviour. Hormones and Behaviour and Immunology and Behaviour. Biological Rhythms. Development of Behaviour. Learning Behaviour. Communication.
Finding Food and Shelter: Migration, Orientation and Navigation. Habitat Selection. Foraging Behaviour.
Social Organization and Mating Systems: Conflict. Sexual Reproduction and Parental Care. Mating Systems and Parental Care. Social Systems.

Textbook

1. Scott, Graham, 2004. Essential Animal Behaviour. Willey-Blalckwell.

Additional Readings

1. Drickamer, L.C., Vessey, S.H. and Jacob, E., 2002. Animal Behaviour: Mechanism, Ecology, Evolution. 5th Edition, McGraw-Hill Publishers.
2. Alcock, John, 2009. Animal Behaviour: An evolutionary approach (9th Ed.) Sinasser Associates, Inc.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-319	Animal Behaviour Lab	1	VI
Year	Discipline		
3	Zoology		

Experiments on reflexes, latency, after-discharge, summation, warm up, fatigue, inhibition and feedback. Experiments on habituation, conditioned reflex type I and trial and error learning. Experiments showing hormonal involvement in behavioural responses. Study of social integration in social insects. Study of hibernation and biological rhythms.

Textbook

1. Scott, Graham, 2004. Essential Animal Behaviour. Willey-Blalckwell.

Additional Readings

1. Drickamer, L.C., Vessey, S.H. and Jacob, E., 2002. Animal Behaviour: Mechanism, Ecology, Evolution. 5th Edition, McGraw-Hill Publishers.
2. Alcock, John, 2009. Animal Behaviour: An evolutionary approach (9th Ed.) Sinasser Associates, Inc.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-401	**Principle of Systematics**	**2**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

Contribution of systematics to Biology: Concepts of taxon, phenon and category, species concepts and its problems (Typological; Nominalistic, Biological, Evolutionary). Subspecies concept, Clines and hybrid zones, Polytypic species, super species. Modes of speciation. Intrapopulation variation. Different kinds of taxonomic characters. Weightage of taxonomic characters. Classification and its types; Phenetic, Cladistic and evolutionary classification. Difference between types of classification. Taxonomic collections and the process of identification. Types of taxonomic publications, major features of taxonomic articles. The rules of zoological nomenclature (interpretation and application of the code (stability, priority, first reviser principle) range of authority of code; concept of availability, type method formation of specific names, synonym, homonym.

Recommended Books

- Mayr, E. and Ashlock, P.D., (Latest edition). Principles of Systematic Zoology, McGraw-Hill Inc. New York.
- Simpson, G.G., (Latest edition). Principles of Animal Taxonomy, Columbia University Press, N.Y.
- Soka, R., and Snaeth P.H.A. (Latest edition). Principles of numerical taxonomy. W.H. Freeman and company, London.
- Kapoor, V.C. Principles and practices of animal Taxonomy. Science Publishers, 2nd Ed.

Code	Subject Title	Cr. Hrs	Semester
ZOOL- 402	**Lab. Principles of Systematics**	**1**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

The study of a group of organisms while utilizing key. Collection, preservation, labelling and identification of a group of specimen according to expertise available in the institute. Preparation of bracket and indent key. Biometry Rationale, collection of data, statistical analysis (F test, t test, Z test, analysis of variance, regression and correlation) and interpretation. Phylogeny Reconstruction. Application of phonetic (Similarity and dissimilarity matrix and unweighted pair group method) and cladistic (compatibility method) analysis to a group of mock "organisms".

Recommended Books

- Mayr, E. and Ashlock, P.D., (Latest edition). Principles of Systematic Zoology, McGraw-Hill Inc. New York.
- Simpson, G.G., (Latest edition). Principles of Animal Taxonomy, Columbia University Press, N.Y.
- Soka, R., and Snaeth P.H.A. (Latest edition). Principles of numerical taxonomy. W.H. Freeman and company, London.
- Kapoor, V.C. Principles and practices of animal Taxonomy. Science Publishers, 2nd Ed.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-403	**Palaeontology**	**2**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

Introduction; Earth, Shells of earth (Atmosphere, hydrosphere, biosphere and lithosphere); Rock, types of rocks (lgneous rocks, sedimentary rocks and metamorphic rocks); Fossil, types and uses of fossils, Nature of fossils, Processes of fossilization (Study of process of dying and what processes occur to animals after their death, concepts of Fossilization); Geological time scale; Pre-Cambrian life, Post-Cambrian life (Paleozoic life, Mesozoic life, Cenozoic life); A brief history of the Siwaliks; Geochronometry (Uranium/Lead dating, radiocarbon dating, Fission track dating and palaeomagnetism); Evolutionary histories of camels, horses, elephants and man.

Recommended Books

- Brouwer, A., 1977. General Palaeontology, Oliver and Boyed, London.
- Michael Foote and Arnold I. Miller, 2007. Principles of Palaeontology (3rd Ed.) Freeman and Company.
- Michael, J.B. and David, A.T. Harper, 2009. Palaeobiology and the fossil record (3rd Ed.). Wiley Blackwell.
- J.Z. Young (7th edition). Life of vertebrates
- Dunbar C.O., 1969. Historical Geology, John Willey and Sons Inc. New York.
- Glbert, Colbert, E.H., 1980. Evolution of vertebrates, John Willey and Sons Inc. New York.
- Moore, R.C. Lalicker, G.C., Fisher, A.G., Invertebrate Fossils.
- S.S. Ali, 1999. Palaeontology, Zoogeography and Wildlife Management.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-404	**Lab. Palaeontology**	**1**	**VII**
Year	Discipline		
2	**Zoology**		

Course Contents

Study of rocks (Igneous, sedimentary and metamorphic rocks).
Identification and classification of vertebrates and invertebrate fossils.
Study of molds, casts, pseudomorphs, petrified fossils, imprints, foot prints and coprolites.
Study of vertebrate fossils of evolutionary importance e.g. Horses, Elephants, Primates and Camels etc.

Recommended Books

- Brouwer, A., 1977. General Palaeontology, Oliver and Boyed, London.
- Michael Foote and Arnold I. Miller, 2007. Principles of Palaeontology (3rd Ed.) Freeman and Company.
- Michael, J.B. and David, A.T. Harper, 2009. Palaeobiology and the fossil record (3rd Ed.). Wiley Blackwell.
- J.Z. Young (7th edition). Life of vertebrates
- Dunbar C.O., 1969. Historical Geology, John Willey and Sons Inc. New York.
- Glbert, Colbert, E.H., 1980. Evolution of vertebrates, John Willey and Sons Inc. New York.
- Moore, R.C. Lalicker, G.C., Fisher, A.G., Invertebrate Fossils.
- S.S. Ali, 1999. Palaeontology, Zoogeography and Wildlife Management.
-

Code	Subject Title	Cr. Hrs	Semester
ZOOL- 405	**Economic Zoology**	**2**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

Parasitic protozoa and human diseases. Economic importance of protozoa. Parasitic nematodes and their control. Helminth parasites of man and other domestic animals and their control. Mites and ticks and their control. Household insects. Insects affecting fruits and fruit trees. Insect control. Pests of pulse crops. Pests of oil seed crops. Stored grain pests. Pests of cotton. Pests of vegetables. Pests of fruits. Pests of tea. Honey bee. Lac culture. Apiculture. Sericulture. Pearl culture. Fish industry. Preservation of fishes. Edible freshwater fishes. Economic importance of fishes. Birds (Poultry). Piggery. Animals use for research purpose (archaeopteryx, frog, rabbit, rat). Economic importance of mammals. Rats: their control

Recommended Books

- Manju Yadav, 2003. Economic Zoology. New Delhi, Discovery, pp. 348.
- Ravindranathan K.R., 2003. Economic Zoology. Dominan publishers, New Delhi.
- Vishwapremi, K.K.C., 1995. Economic Zoology Delhi, ISSBN 81-7158-194.
- Philippa, S. Esdaila, 1999. Economic Zoology. Oscar publications.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-406	**Lab. Economic Zoology**	**1**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

1. Apiculture

Preparing to handle honeybee colonies; Inspection of bees, organization within the colony; Examination of colonies for disease and other problems: Equipment making and using top-bar hives, frame hives, frames, smokers, and other equipment; Nailing/wiring of frames and fixing combs; Queen raring; preparation of queen cells, grafting larvae, Management: supplemental feeding, making candy, uniting colonies; collecting pollen propolis; Honey harvesting and preparing for marketing; Harvesting and possessing bees wax; and seasonal management.

2. Sericulture

Rearing techniques for breeding of the silkworm Bombyx mori.
Field visit to demonstration site in a house-bold in a near by locality across Changa Manga.

3. Aquaculture

Identification of important species of Fish and their natural enemies.
Study visit to fish Hatchery, Nursery ponds, Stocking ponds and commercial fish breeding farms

Recommended Books

- Ahmad, R. and Muzaffar, N., 1987. Rearing of Silkworm. Misc. Pub. Pak. Agric. Res. Council, pp. 53.
- Akhtar, M. and Muzaffar, N., 2008. Introduction to Apiculture, Department of Zoology, Punjab University Press, 36 pp.
- Anon, 1986. The Hive and the Honeybee. Dadant & Sons. Illinois, USA, pp. 740.
- Anon, 1999. FAO Bulletins on Sericulture Nos. 1 & 2. FAO Office, Rome, Italy.
- Blackiston, H., 2001. Beekeeping for Dummies. Wiley Publishing, Inc. Indiana, USA, pp. 303.
- Shukla, G.S. and Upadhayay, V.B., 1997. Economic Zoology, 3rd Ed. Rastogi Publications, Mearut, India, pp. 369.
-

Code	Subject Title	Cr. Hrs	Semester
ZOOL-411	**Entomology (Morphology, Physiology of Insects)**	**2**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

General characteristics of insects. Relationship with other Arthropoda,
Hard Parts: General segmentation, Cuticle: Detailed structure. Epidermal layer; its structure and function. Basement membrane. Colours of insects. Cuticular outgrowths and appendages, sclerotization. Metamorphosis.
Head: Cephalization, Sclerites, Modifications. Antennae: Different modes of ingestion and types of mouth parts.
Thorax; legs, their different modifications and functions.
Wings: Different regions. Development. Basal attachments. Main veins and their branches (generalized insects). Wing coupling apparatus.
Abdomen: Secondary appendages and external genitalia. Endoskeleton: Head, thorax and abdomen.
Comparative structure of all the systems, e.g., digestive, excretory, respiratory, circulatory, and nervous system and their physiology. Sense organs: sound and light producing organs. Exocrine and Endocrine glands including pheromones and their functions.
Reproduction: Reproductive organs and different types of reproduction in insects. Types of larvae and pupae.

Recommended Books

- General Text Book of Entomology. Imm. Richards and Davies, Vol.1.
-
- Additional Readings
- The Insects: Structure and Function, 2000. Chapman.
- Insect Physiology. Wiggles Worth.
- Insect Physiology. Pattons.
- Insect Ecology. Price.
- Ecology: The Experimental Analysist Abundance. Krebs.
- Modern Entomology, 1997. Tembhare.
- Ecological Methods, 1978. T.R.E. Southhood.
- Elements of Insect Ecology, 1997. S.S. Yasbani and M.L. Agarwal.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-412	**Lab. Entomology (Morphology, Physiology of Insects)**	**1**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

Preparation of permanent slides. All the hard parts (terminal segments, wings, antennae, legs, mouth parts). Different systems, especially digestive, reproductive of the following insects. American cockroach, grasshopper, housefly, mosquito, any common beetle. Sympathetic nervous system of cockroach.

Recommended Books

- General Text Book of Entomology. Imm. Richards and Davies, Vol.1.
- Additional Readings
- The Insects: Structure and Function, 2000. Chapman.
- Insect Physiology. Wiggles Worth.
- Insect Physiology. Pattons.
- Insect Ecology. Price.
- Ecology: The Experimental Analysist Abundance. Krebs.
- Modern Entomology, 1997. Tembhare.
- Ecological Methods, 1978. T.R.E. Southhood.
- Elements of Insect Ecology, 1997. S.S. Yasbani and M.L. Agarwal

Code	Subject Title	Cr. Hrs	Semester
ZOOL-413	**Medical Entomology**	**2**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

Introduction to Medical Entomology. Arhtropods as a cause and cause and carrier of disease. Development and Classification of insets and arachnids. Mouth parts and their importance in the transmission of disease. Insecticidal and acaricidal practices. Morphology, life cycle, medical importance and control of the following insects and arachnids.
Cockraches and beetles; Bed bugs, conenose and other bugs, Sucking and biting Lice; Simulid Gnats, Phlebotomus flies and Mosquitoes; Horse flies, Deer flies, Snipe flies, Syrphid flies, Musoeoid flies, Louse fly, House fly and its relatives. Tsetse flies, Stomoxys flies, Horn flies, Myiasis causing flies, Fleas and Ticks. Mites and Pentasomids, Venomous and Urticarial Arthropods.

Recommended Books

- Wall, R. and Shearer, D. 2001. “Veterinary Ectoparasites: Biology Pathology and Control” 2nd Ed. Blackwell Science Publication, UK.
- Geogri, J.R., Georgi M.C. and Theodorides, V.J. 1999. “Parasitology for Veterinarian.” 7th Ed. W.B. Sunders Co., London.
- Wall, R. and Shearer, D. 1997. “Veterinary Entomology” Chapman and Hall, London.
- Herms, W.B. and James, M.T. 1996. Medical Entomology. The Mc Millian Co. New York, USA.
- Kettle, D.S. 1995. “Medical and Veterinary Entomology” CAB International, Wallingford, Oxan. U.K.
- Service M.W. 1980. A guide to Medical Entomology. The McMillan Press Ltd. London.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-414	**Lab Medical Entomology**	**1**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

Collection, preservation and pinning of adult insects and arachnids of medical importance.
Mouth parts of insets and arachnids. Wing venation of insects,
Mounting of stigmal plates and their identification.
Demonstration of life cycle stages of typical insect and arachnids.
Methods of preparation and examination of skin scrapings for mites.
Methods for dissecting arthropod vectors to determine infection rates.
Identification of various species of cockroaches, bettles, bugs, lice, flies, fleas ticks and mites.

Recommended Books

- Wall, R. and Shearer, D. 2001. “Veterinary Ectoparasites: Biology Pathology and Control” 2nd Ed. Blackwell Science Publication, UK.
- Geogri, J.R., Georgi M.C. and Theodorides, V.J. 1999. “Parasitology for Veterinarian.” 7th Ed. W.B. Sunders Co., London.
- Wall, R. and Shearer, D. 1997. “Veterinary Entomology” Chapman and Hall, London.
- Herms, W.B. and James, M.T. 1996. Medical Entomology. The Mc Millian Co. New York, USA.
- Kettle, D.S. 1995. “Medical and Veterinary Entomology” CAB International, Wallingford, Oxan. U.K.
- Service M.W. 1980. A guide to Medical Entomology. The McMillan Press Ltd. London.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-415	**General Microbiology**	**2**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

Introduction: history of microbiology, development of laboratory techniques to study microorganisms, their importance and applications. The scope of microbiology; classifications of microorgansis, prokaryotic and eucaryotic microorgansis, archaeobacteria, eubacteria. Distinctive characteristics of major groups of microorganisms; protozoa, algae, fungi, bacteria and viruses.

Characterization of microorganisms; pure culture techniques, microscopes. Nutritional requirements and microbiological media. Cultivation and growth of microorganisms. Control of microorganisms; principles, chemical and physical agents. Major groups of prokaryotic microorganisms: bacteria; Eubacteri; Gram-negative bacteria, Gram-positive bacteria, Mycoplasmas, Archaeobacteria; methanogens, red extreme halophiles, sulfur-dependent archaeobactera, thermoplasmas.

Microbiology of natural waters, drinking water and waste water. Microorganisms and disease, nosocomial infections, airborne diseases, foodborne and air borne diseases. Biotechnology, the industrial applications of microbiology; products of microbial dissimilation, products of microbial synthesis.

Recommended Books

- Pelczar, M.J. Jr., Chan, E.C.S. and Krieg, N.R. 1986. Microbiology– McGraw Hill Inc., New York.
- Benson, H.J., 1994. Microbiological applications. WmC Brown Publishers, Dubuque, USA.
- Alcamo, E. 1994. Fundamentals of Microbiology. The Benjamin/Cummings Publishing Co. Inc. Redwood city, CA 94065.
- Pelczar, M.J. Jr., Chan, E.C.S. and Krieg, N.R. 1993. Microbiology concepts and applications – McGraw Hill Inc., New York.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-416	**Lab. General Microbiology**	**1**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

Microscopic study of algae, fungi, protozoa and bacteria. Staining of bacteria; negative, simple, capsular, Gram, Spore, acid-fast and flagellar. Motility determination of bacteria. Culture Methods: Culture media preparation, pure culture techniques, bacterial population counts. Isolation of phage from sewage. Environmental influences and control of microbial growth; lethal effects of temperature and UV light, osmotic pressure and bacterial growth, evaluation of antiseptics, antimicrobial sensitivity test.

Recommended Books

- Pelczar, M.J. Jr., Chan, E.C.S. and Krieg, N.R. 1986. Microbiology– McGraw Hill Inc., New York.
- Benson, H.J., 1994. Microbiological applications. WmC Brown Publishers, Dubuque, USA.
- Alcamo, E. 1994. Fundamentals of Microbiology. The Benjamin/Cummings Publishing Co. Inc. Redwood city, CA 94065.
- Pelczar, M.J. Jr., Chan, E.C.S. and Krieg, N.R. 1993. Microbiology concepts and applications – McGraw Hill Inc., New York.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-417	**Applied Microbiology**	**2**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

Control of microorganisms: Fundamentals of control, control by physical and chemical agents, antibiotics and other chemotherapentic agents. Microorganisms and disease: Host-microbe interactions. Resistance and immunity. Air, food and water-borne human infections. Human contact disease. Infectious diseases of animals. Environmental Microbiology: Fundamentals of microbial ecology. Microbiology of Air. Soil microbiology. Microbiology of domestic water and sewage. Microbiology of food, milk and milk products. Industrial microbiology: Scope of industrial microbiology in food production, control of insects, human therapy, petroleum, mining and bioremediation. Biotechnology and its role in modern human comforts.

Recommended Books

- Pelczar, M.J. Jr., Chan, E.C.S. and Krieg, N.R. 1986. Microbiology– McGraw Hill Inc., New York.
- Benson, H.J., 1994. Microbiological applications. WmC Brown Publishers, Dubuque, USA.
- Alcamo, E. 1994. Fundamentals of Microbiology. The Bengamin/Cummings Publishing Co. Inc. Redwood city, CA 94065.
- Pelczar, M.J. Jr., Chan, E.C.S. and Krieg, N.R. 1993. Microbiology concepts and applications – McGraw Hill Inc., New York.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-418	**Lab. Applied Microbiology**	**1**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

Bacteriological examination of water; isolation and identification of coliform bacteria and enteric pathogens. Isolation of pathogenic *Staphylococci*. Normal throat flora and reaction on blood agar. Enumeration and identification of microorganisms in urinary tract infections. Isolation and identification of microorganisms from the diseased ear. Inhibition and destruction of microorganism by physical agents. Action of disinfectants on bacteria. Bacteriostatic action of certain dyes and drugs. Bacterial sensitivity tests (some contemporary antibiotics). Bacterial examination of food, raw milk. Surveys of microorganisms' activities based industries.

Recommended Books

- Pelczar, M.J. Jr., Chan, E.C.S. and Krieg, N.R. 1986. Microbiology– McGraw Hill Inc., New York.
- Benson, H.J., 1994. Microbiological applications. WmC Brown Publishers, Dubuque, USA.
- Alcamo, E. 1994. Fundamentals of Microbiology. The Bengamin/Cummings Publishing Co. Inc. Redwood city, CA 94065.
- Pelczar, M.J. Jr., Chan, E.C.S. and Krieg, N.R. 1993. Microbiology concepts and applications – McGraw Hill Inc., New York.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-421	**Techniques in Fisheries Research**	**1**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

The literature of fish and fisheries, a method of compiling bibliography, literature sources, general bibliography on fish, forms for recording data in fishery surveys, recording, length, weight, sex and age determination, preparation of impressions, photographs and slides of scales, scale reading, types of tags and information sought, techniques of tagging and recovery, fishery statistics.

Recommended Books

- Sinha, V.R.P. and Srivastava, H.C. 1991. Aquaulture Productivity. Oxford & IBH Publishing o. N. Delhi.
- Sheri, A.N. 1974. Selected Bibliography of Fishes and Fisheries of Pakistan (1864-1966). University of Agriculture, Faisalabad.
- Ricker, W.E. 1958. Hand Book of Computation for Biological Statistics of Fish Population. Fish Res. Bd. of Canada. Bull. No. 119.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-422	**Lab. Techniques in Fisheries Research**	**2**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

Survey of literature, recording data, preparing and reading scales, tagging and population estimation.

Recommended Books

- Sinha, V.R.P. and Srivastava, H.C. 1991. Aquaulture Productivity. Oxford & IBH Publishing o. N. Delhi.
- Sheri, A.N. 1974. Selected Bibliography of Fishes and Fisheries of Pakistan (1864-1966). University of Agriculture, Faisalabad.
- Ricker, W.E. 1958. Hand Book of Computation for Biological Statistics of Fish Population. Fish Res. Bd. of Canada. Bull. No. 119.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-423	**Environmental Biology of Fishes**	**2**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

Fish and their Environments. Feeding and Nutrition. Environmental Biology of Fish Growth. Osmoregulation and Ion Balance. Environmental Biology of Reproduction. Behaviour. Water Pollution. Waste Management. Sustainability and Environmental Issues**.**

Recommended Books

- Weatherley, A.H., 1972. Growth and Ecology of Fish Populations.
- Wootton, R.J., 1990. Ecology of Teleost Fishes. Chapman and Hall, London.
- Wootton, R.J., 1998. Ecology of Teleost Fishes. 2nd Edition, Kluwer.
- Jobling, M., 1995. Environmental Biology of Fishes. Chapman & Hall, U.K.
- Weatherley, A.H. and Gill, H.S., 1987. The Biology of Fish Growth. Chapman & Hall, U.K.
- Evans, D.H., 1998. The Physiology of Fishes, 2nd Ed. CRC Press, Boca Raton, New York.
- Boyd, C.E. and Tucker, C.S., 1998. Pond Aquaculture Water Quality management, Boston, Kluwer.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-424	**Lab. Environmental Biology of Fishes**	**1**	**VII**
Year	Discipline		
4	**Zoology**		

Course Contents

Weight length and condition factor in relation to different environments. Gut contents of different fish species. Effect of temperature on fish growth. Effect of salinity on fish growth. Induce spawning. Effect of different pollutants on survival of fish. Assignment.

Recommended Books

- Weatherley, A.H., 1972. Growth and Ecology of Fish Populations.
- Wootton, R.J., 1990. Ecology of Teleost Fishes. Chapman and Hall, London.
- Wootton, R.J., 1998. Ecology of Teleost Fishes. 2nd Edition, Kluwer.
- Jobling, M., 1995. Environmental Biology of Fishes. Chapman & Hall, U.K.
- Weatherley, A.H. and Gill, H.S., 1987. The Biology of Fish Growth. Chapman & Hall, U.K.
- Evans, D.H., 1998. The Physiology of Fishes, 2nd Ed. CRC Press, Boca Raton, New York.
- Boyd, C.E. and Tucker, C.S., 1998. Pond Aquaculture Water Quality management, Boston, Kluwer.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-407	**Biological Techniques**	**2**	**VIII**
Year	Discipline		
4	**Zoology**		

Course Contents

Size measurement: Animals, Tissues, Cell nuclei, other organelles, surface area and volume; Scale vernier caliper, stage micrometer ocular micrometer, Microscopy: Staining: Purpose, procedure, examples, Gram's staining, Animal / Plant tissue, Haematoxylin and Eoisin, Methylene Blue; Microtomy: Sections, C.S. (T.S.), L.S., S.S., Fixation, Embedding, Sectioning, Slide mounting; Photometer: Visible spectrum, U.V. spectrum; How the principle work? Operational instructions; Centrifugation: Ultra centrifuge, Cell fractionation, Separation techniques; Filtration: Chromatography: Paper, Thin layer, Column, Gas Chromatography, HPLC; Oven: Distillery: Distillation; Incubator: Gel electrophoresis: DNA separation, protein separation; Collection and preservation of animals and plants: Precautions at the time of collection; Preservation; Principles; Some procedures of preservations; Data collection and its analysis: Statistical tests; Write up: How you should present (Write and compile) your project or research work; How a research paper is written.

Recommended Books

- Gallagher, S.R. and Wiley E.A. 2008. Current protocols essential laboratory Techniques. John Wiley & Sons Inc, USA.
- Jones, A. Reed, R and Weyers, J. 1994. Practical skills in Biology. Longman Singapore Publishers (Pte) Ltd.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-408	**Lab. Biological Techniques**	**1**	**VIII**
Year	Discipline		
4	**Zoology**		

Course Contents

Study of microscopy, Microscopic measurements, isolation and determining of protein and DNA from animal tissues by spectrophotometry; Histochemistry of paraffin embedded tissues for the visualized and fat contents. Separation of proteins of different molecular weights using gel electrophometric method, culturing of protozoans. Study of haematological techniques.

Recommended Books

- Gallagher, S.R. and Wiley E.A. 2008. Current protocols essential laboratory Techniques. John Wiley & Sons Inc, USA.
- Jones, A. Reed, R and Weyers, J. 1994. Practical skills in Biology. Longman Singapore Publishers (Pte) Ltd.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-409	**Zoogeography**	**2**	**VIII**
Year	Discipline		
4	**Zoology**		

Course Contents

Branches of zoogeography; (Descriptive, Chorology, Faunistics, Systematic, Biocoenotic, Causal, Ecological, Historical, Experimental and Applied Zoogeography). Animal distribution (Cosmopolitan distribution, Discontinuous distribution, Isolation distribution, Bipolar and Endemic distribution). Occurrence and significance of Discontinuous distribution. Factors affecting animal distribution. Barriers and Means of dispersal. Types of barriers (Topographic and climatic barriers). Barriers and Means of dispersal in Marine, Freshwater and Terrestrial environments. Zoogeographical regions, Division of the world into various zoogeographical regions. (Palaearctic, Nearctic, Oriental, Ethiopian, Australian and Neotropical regions). Geographic ranges, physical features, climates, faunas of Nearctic, Palaearctic, Oriental, Ethiopian, Australian, and Neotropical regions. Insolar fauna; (Continental, Oceanic and Ancient Islands). Palaeogeography (Theories of Permanence of Continents, Land Bridges, Continental Drift and Plate Tectonics.

Recommended Books

- Frank Evers Beddard, 2008. A textbook of Zoogeography. Published by BiblioBazar, LLC, pp. 192.
- S.K. Tiwari, 2006. Fundamentals of World Zoogeography. Wedams eBooks (P) Ltd. (India), pp. 384. Sarup & Sons, Ansari Rd. Daryaganj, Delhi.
- Shivkumar Tiwari, 1985. Readings in Indian Zoogeography (Vol. 1) Today & Tomorrow Printers & Publisher, pp. 395.
- De Beaufort, 1951. Zoogeography of the Land Inland Waters, Sidgwick and Jackson.
- Darlington, 1963. Zoogeography, John Wiley.
- Muller, 1974. Aspects of Zoogeography, Hague.
- Barry, C. and Moore, P.D., 2010. Biogeography and Ecological and evolutionary approach (8th Ed.). John Wiley.
- Hesse, 1963. Ecological Animal Geography, John Wiley.
- Ekman, 1953. Zoogeography of the sea. Sedgwick and Jackson.
- Lillies, 1974. Introduction to Zoogeography, London.
- Terry, A. Vaughan, J. M. Ryan and N.J. Czaplewbki, 2009. Mammalogy. 5th Ed. Jones and Barjlett publishers.
- S.S. Ali, 1999. Palaeontology, Zoogeography and Wildlife Management.
- Hickman, Roberts and Larson, 2001. Integrated Principles of Zoology (11th Edition). McGraw Hill, New York.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-410	**Lab. Zoogeography**	**1**	**VIII**
Year	Discipline		
4	**Zoology**		

Course Contents

Identification, classification upto species and Zoogeographical distribution of the following animal groups of Zoogeographical regions:
Fishes (*Neoceratodus, Lepidosiren* and *Protopterus*).
Amphibian (Caecilians, Newts and Salamanders, Toads and Frogs).
Reptiles (*Sphenodon*, Lizards and Snakes, Turtles and Tortoises and Crocodiles).
Aves (Kiwis, Cassowaries, Emus, Ostriches and Rheas).
Mammals:
Egg-laying mammals (Echidna and Platypus).
Marsupial mammals (Opossum, Australian cat, Numbat Kangaroos, Marsupial moles, Bandicoots, Koala and Wombats).
Placental Mammals (Elepahnts, Giraffes, Rhinoceroses, Tapirs, Blackbuck, Four-horned antelope, *Bos, Bison, Bubalus, Capra, Ovis, Boselaphus* and Camels).

Recommended Books

- Frank Evers Beddard, 2008. A textbook of Zoogeography. Published by BiblioBazar, LLC, pp. 192.
- S.K. Tiwari, 2006. Fundamentals of World Zoogeography. Wedams eBooks (P) Ltd. (India), pp. 384. Sarup & Sons, Ansari Rd. Daryaganj, Delhi.
- Shivkumar Tiwari, 1985. Readings in Indian Zoogeography (Vol. 1) Today & Tomorrow Printers & Publisher, pp. 395.
- De Beaufort, 1951. Zoogeography of the Land Inland Waters, Sidgwick and Jackson.
- Darlington, 1963. Zoogeography, John Wiley.
- Muller, 1974. Aspects of Zoogeography, Hague.
- Barry, C. and Moore, P.D., 2010. Biogeography and Ecological and evolutionary approach (8th Ed.). John Wiley.
- Hesse, 1963. Ecological Animal Geography, John Wiley.
- Ekman, 1953. Zoogeography of the sea. Sedgwick and Jackson.
- Lillies, 1974. Introduction to Zoogeography, London.
- Terry, A. Vaughan, J. M. Ryan and N.J. Czaplewbki, 2009. Mammalogy. 5th Ed. Jones and Barjlett publishers.
- S.S. Ali, 1999. Palaeontology, Zoogeography and Wildlife Management.
- Hickman, Roberts and Larson, 2001. Integrated Principles of Zoology (11th Edition). McGraw Hill, New York.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-425	**Integrated Pest Management**	**2**	**VIII**
Year	Discipline		
4	**Zoology**		

Course Contents

Brief account of integrated pest management: common sampling techniques in insect pest management, concept of economic levels, economic damage and economic boundary, economic injury level and economic threshold. Pest management Theory; Biological control, ecological management of crop environment, Insecticide and its application, managing insect with resistant plant and sterile technique: Managing ecological black lash.

Recommended Books

- Pedigo, L.P., 1991. Entomology and Pest Management. Maxwell MacMillan.
- Richards, O.W. and Davies, R.J., 1977. Imm's General Textbook of Entomology. Vol-2
- Metcalf, C.L. and Flint, W.P., 1962. Destructive and Useful Insects, McGraw-Hill.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-426	**Lab Integrated Pest Management**	**1**	**VIII**
Year	Discipline		
4	**Zoology**		

Course Contents

Collection, preservation and identification of insect pests upto families (except for the identification upto species of a few pests of great economic importance), with the help of keys/literature. Pollution estimation of insect using different sampling methods. Effect of insecticides on predators and insect pest (Mortality and behaviour).

Recommended Books

- Pedigo, L.P., 1991. Entomology and Pest Management. Maxwell MacMillan.
- Richards, O.W. and Davies, R.J., 1977. Imm's General Textbook of Entomology. Vol-2
- Metcalf, C.L. and Flint, W.P., 1962. Destructive and Useful Insects, McGraw-Hill.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-427	**Classification of Insects**	**2**	**VIII**
Year	Discipline		
4	**Zoology**		

Course Contents

A general account including classification of insect orders: Collembola, Orthoptera, Dictyoptera, Isoptera, Hemiptera, Lepidoptera, Diptera, Hymenoptera, Coleoptera. Only diagnostic characters of the remaining insect orders: Thysanura, Diplura, Protura, Ephemeroptera, Odonata, Plecoptera, Grylloblattoidea, Phasmida, Dermaptera, Embioptera, Zoraptera, Psocoptera, Mallophaga, Siphunculata, Thysanoptera, Neuroptera, Meco- ptera, Tricoptera, Siphonaptera, Strepsiptera.

Recommended Books

- Pedigo, L.P., 1991. Entomology and Pest Management. Maxwell MacMillan.
- Richards, O.W. and Davies, R.J., 1977. Imm's General Textbook of Entomology. Vol-2
- Metcalf, C.L. and Flint, W.P., 1962. *Destructive and Useful Insects*, McGraw-Hill.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-428	**Lab. Classification of Insects**	**1**	**VIII**
Year	Discipline		
4	**Zoology**		

Course Contents

Collection, preservation and identification of insects upto families (except for the identification upto species of a few pests of great economic importance), with the help of keys/literature.

Recommended Books

- Pedigo, L.P., 1991. Entomology and Pest Management. Maxwell MacMillan.
- Richards, O.W. and Davies, R.J., 1977. Imm's General Textbook of Entomology. Vol-2
- Metcalf, C.L. and Flint, W.P., 1962. *Destructive and Useful Insects*, McGraw-Hill.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-429	**Bacteriology**	**2**	**VIII**
Year	Discipline		
4	**Zoology**		

Course Contents

Laboratory equipment and procedures: Pure culture, pure culture technique, culture preservation, Aseptic technique, Sterilization, Chemical Sterilization, Staining techniques, Microscopy, visible light microscopy, Ultraviolet and electron microscopes.

Metabolic pathways: Life needs, growth factors, the environment, Classification: a Physiological method, Energy production, Aerobic cellular respiration, Fat and protein metabolism, biosynthesis and metabolism, controlling metabolism.

Growth and reproduction: Increasing mass and populations, the population growth curve, The growth curve; home, industry and hospital, counting methods, viable cell count, Biomass determination, biological assay.

Collection, cultivation and identification of microbes:

Laboratory work, Symptoms, Collecting and handling specimens, Media selection and preparation, balancing the environment, Oxygen requirements for culturing.

The Control of Microbes: Different approaches to control, factors that influence success, surface active agents, the methods and material of control, the ideal antibiotic, the development of drug resistance, overcoming resistant pathogens.

Recommended Books

- Pelczar, M.J. Jr., Chan, E.C.S. and Krieg, N.R. 1986. Microbiology– McGraw Hill Inc., New York.
- Benson, H.J., 1994. Microbiological applications. WmC Brown Publishers, Dubuque, USA.
- Alcamo, E. 1994. Fundamentals of Microbiology. The Bengamin/Cummings Publishing Co. Inc. Redwood city, CA 94065.
- Pelczar, M.J. Jr., Chan, E.C.S. and Krieg, N.R. 1993. Microbiology concepts and applications – McGraw Hill Inc., New York.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-430	**Lab. Bacteriology**	**1**	**VIII**
Year	Discipline		
4	**Zoology**		

Course Contents

Microscopic examinations of microorganisms' wet mount, hanging drop method; Gram's staining, Negative staining capsular ling staining Preparation and sterilization of growth media. Viable counting of bacteria, correlating number/cell mass with optical density, making and preservation of pure cultures of bacteria evaluating bacrteriostatic and bactericidal effects of antimicrobial agents, antibiotic susseptility of some bacterial isolates, some physiochemical tests of bacteria.

Recommended Books

- Pelczar, M.J. Jr., Chan, E.C.S. and Krieg, N.R. 1986. Microbiology– McGraw Hill Inc., New York.
- Benson, H.J., 1994. Microbiological applications. WmC Brown Publishers, Dubuque, USA.
- Alcamo, E. 1994. Fundamentals of Microbiology. The Bengamin/Cummings Publishing Co. Inc. Redwood city, CA 94065.
- Pelczar, M.J. Jr., Chan, E.C.S. and Krieg, N.R. 1993. Microbiology concepts and applications – McGraw Hill Inc., New York.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-431	**Environmental Microbiology**	**2**	**VIII**
Year	Discipline		
4	**Zoology**		

Course Contents

Fundamentals of microbial ecology: The nature of microbial communities. Life at low nutrient concentrations. Physicochemical factors affecting the environmental fate of Microorganisms. Competitive strategies of microorganisms. Interactions involving microorganisms. Microbiology of air. Aquatic microbiology. Soil microbiology. Microbiology of domestic water and sewage. Microbiology of food, milk and milk products.

Recommended Books

- Microbiology: A Human Perspective , 2001. Eugene W. Nester, Denise, G., Anderson, Martha, T., Nester, C., Evans Roberts, Nancy, N. McGraw Hill Higher Education.
- Microbiology Principles and Explorations, 2001. Jacquelyn, G.G. Wiley John & Sons Inc.
- Microbiology, 1986. Pelczar Jr., Chan, E.C.S. and Krieg, M.R., 1986. Mc-Graw Hill, London.
- Environmental Microbiology, 2000. Alan H. Varnam and Malcolm G. Evans, Manson publishing London, NW11 7DL, UK.
- Microbial Applications: Lab Manual in General Microbiology, 1994. Benson, H.J. WMC Brown Publishers, England.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-432	**Lab. Environmental Microbiology**	**1**	**VIII**
Year	Discipline		
4	**Zoology**		

Course Contents

Isolation and identification of coliform from water, milk and vegetables samples. Bacterial examination of food and raw milk. Surveys of microorganisms' activities based industries. Isolation and study of antibiotics producing bacteria. Isolation and study of cellulolytic bacteria. Isolation and identification of nitrogen fixing bacteria.

Recommended Books

- Microbiology: A Human Perspective , 2001. Eugene W. Nester, Denise, G., Anderson, Martha, T., Nester, C., Evans Roberts, Nancy, N. McGraw Hill Higher Education.
- Microbiology Principles and Explorations, 2001. Jacquelyn, G.G. Wiley John & Sons Inc.
- Microbiology, 1986. Pelczar Jr., Chan, E.C.S. and Krieg, M.R., 1986. Mc-Graw Hill, London.
- Environmental Microbiology, 2000. Alan H. Varnam and Malcolm G. Evans, Manson publishing London, NW11 7DL, UK.
- Microbial Applications: Lab Manual in General Microbiology, 1994. Benson, H.J. WMC Brown Publishers, England.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-433	**Advances in Aquaculture-I**	**2**	**VIII**
Year	Discipline		
4	**Zoology**		

Course Contents

Physical problems in fish farm construction, hydrometrology in pond fish culture, application of lime and fertilizers in fish farm, new trends in fish farm management, warm water fish seed production, enhancing production of carp fingerlings by the use of growth promoting substances, intensive and semi-intensive culture of major carps, tillet flavour problem in fish culture, fish diseases and their control in aquaculture.

Recommended Books

- Pillay, T. V. R., 1999. Aquaculture: Principles and Practices. Fishing News Books.
- Agrawal, V. P. 1999. Recent Trends in Aquaculture. Society of Biosciences. India.
- Reddy, M. S. and K.R.S. SambasivaRao. 1999. A Text Book of Aquaculture. Discovery Publishing House, N. Delhi.
- Meade, J. W. 1998. Aquaculture Management. Chapman & Hall Inc. N. York.
- Parker, R. 1994. Aquaculture Science. Delmar publishers, N. York.
- Deborah, A. T. 1989. Aquaculture, Mansell, N. York.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-434	**Lab. Advances in Aquaculture -I**	**1**	**VIII**
Year	Discipline		
4	**Zoology**		

Course Contents

1. Collection and preservation of water sample.
2. Eradication of weed plants/algal blooms.
3. Eradication of predators and predatory insects.
4. Stocking density and ratio of fish.
5. Control of parasites and diseases.
6. Identification of Indian major carps.
7. Fishing gears.
8. Determination of forage ratio of a given fish.

Recommended Books

- Pillay, T. V. R., 1999. Aquaculture: Principles and Practices. Fishing News Books.
- Agrawal, V. P. 1999. Recent Trends in Aquaculture. Society of Biosciences. India.
- Reddy, M. S. and K.R.S. SambasivaRao. 1999. A Text Book of Aquaculture. Discovery Publishing House, N. Delhi.
- Meade, J. W. 1998. Aquaculture Management. Chapman & Hall Inc. N. York.
- Parker, R. 1994. Aquaculture Science. Delmar publishers, N. York.
- Deborah, A. T. 1989. Aquaculture, Mansell, N. York

Code	Subject Title	Cr. Hrs	Semester
ZOOL-435	**Advances in Aquaculture -II**	**2**	**VIII**
Year	Discipline		
4	**Zoology**		

Course Contents

Introduction to advanced aquaculture. Culture of freshwater prawns shrimps and freshwater shrimps, Oyster culture, Aquaculture in raceways, Cages, enclosures and ponds with particulars references to the site and design of cages, use of agricultural and urban wastes in aquaculture, paddy culture.

Recommended Books

- Pillay, T. V. R., 1999. Aquaculture: Principles and Practices. Fishing News Books, London.
- Agrawal, V. P. 1999. Recent Trends in Aquaculture. Society of Biosciences. India.
- Karunasagar, I, I. Karunasagar and A. Reilly. 1999. Aquaculture and Biotechnology. Oxford & IBH Publishing Co., N. Delhi.
- Stickney, R.R. 1992. Principles of Warmwater Aquaculture. John Wiley & Sons, N. York.
- Meade, J. W. 1998. Aquaculture Management. Chapman & Hall Inc. N. York.
- Deborah, A. T. 1989. Aquaculture, Mansell, N. York.

Code	Subject Title	Cr. Hrs	Semester
ZOOL-436	**Lab. Advances in Aquaculture -II**	**1**	**VIII**
Year	Discipline		
4	**Zoology**		

Course Contents

1. Determinant of water temperature.
2. Determination of water flow/velocity.
3. Determination of pH of the water.
4. Determination of total dissolved solid (DTS).
5. Determination of water salinity.
6. Determination of dissolved carbondyoxide.
7. Determination of water alkalinity.
8. Determination of various toxicant in water that may affect fish/shrimp growth.

Recommended Books

- Pillay, T. V. R., 1999. Aquaculture: Principles and Practices. Fishing News Books, London.
- Agrawal, V. P. 1999. Recent Trends in Aquaculture. Society of Biosciences. India.
- Karunasagar, I, I. Karunasagar and A. Reilly. 1999. Aquaculture and Biotechnology. Oxford & IBH Publishing Co., N. Delhi.
- Stickney, R.R. 1992. Principles of Warmwater Aquaculture. John Wiley & Sons, N. York.
- Meade, J. W. 1998. Aquaculture Management. Chapman & Hall Inc. N. York.
- Deborah, A. T. 1989. Aquaculture, Mansell, N. York