SCHEME OF STUDY FOR BS ZOOLOGY

(5^{th} Semester Intake)

w.e.f Spring 2023 & onwards

DEPARTMENT OF ZOOLOGY

UNIVERSITY OF SARGODHA

SARGODHA - PAKISTAN

Department of Zoology

University of Sargodha

SEMESTER–I

Course Category	Course Code	Course Title	Credits
FOUNDATION-IV	ZOOL-6301	Research Methodology	2(2+0)
FOUNDATION-V	ZOOL-6302	Economic Zoology	3(2+1)
FOUNDATION-VI	ZOOL-6303	Biochemistry	4(3+1)
MAJOR-III	ZOOL-6304	Cell and Molecular Biology	4(3+1)
FOUNDATION-VII	ZOOL-6305	Evolution & Principles of Systematics	4(3+1)
MAJOR-II	ZOOL-6306	Biological Techniques	3(1+2)
		Total Credits	**20**

SEMESTER–II

Course Category	Course Code	Course Title	Credits
MAJOR-IV	ZOOL-6307	Physiology	4(3+1)
MAJOR-V	ZOOL-6308	Ecology	3(2+1)
MAJOR-VI	ZOOL-6309	Developmental Biology	4(3+1)
MAJOR-VII	ZOOL-6310	Genetics	4(3+1)
MAJOR-VIII	ZOOL-6311	Wildlife	3(2+1)
		Total Credits	**18**

SEMESTER–III

Course Category	Course Code	Course Title	Credits
MAJOR-IX	ZOOL-6XXX	Special Paper A1/ Thesis (Univ. Option)	3(2+1)/(0+3)
COMPULSORY-IX	ZOOL-6312	Biostatistics/Univ. Option	3(2+1)
ELECTIVE-I	ZOOL-6XXX ZOOL-6326	Special Paper A2/ Univ. Option= Ichthyology	3(2+1)
ELECTIVE-II	ZOOL-6XXX /ZOOL-6336	Univ. Option/ Principles & Kinetics Of Toxicology	3(2+1)
MAJOR-X	ZOOL-6313	Bioinformatics	3(1+2)
ELECTIVE-III	ZOOL-6XXX	Univ. Option	3(2+1)
		Total Credits	**18**

SEMESTER–IV

Course Category	Course Code	Course Title	Credits
MAJOR-XI	ZOOL-6314	Animal Behavior	3(3+0)
MAJOR-XII	ZOOL-6XXX	Special Paper B1/ Thesis (Univ. Option)	3(2+1)/(0+3)
ELECTIVE-IV	ZOOL-6XXX /ZOOL-6318	Special Paper B2/ Univ. Option=Biotechnology	3(2+1)
ELECTIVE-V	ZOOL-6XXX	Univ. Option	3(2+1)
MAJOR-XIII	ZOOL-6315	Zoogeography & Paleontology	3(2+1)
ELECTIVE-VI	ZOOL-6XXX	Univ. Option	3(2+1)
		Total Credits	**18**

TOTAL CREDITS 74+60 from ADS = 134

ANNEXURE I (LIST OF OPTIONAL COURSES)

Course Codes	Course Title	Credits
ZOOL-6316	Aquaculture	3(2+1)
ZOOL-6317	Biodiversity and Wildlife	3(2+1)
ZOOL-6318	Biotechnology	3(2+1)
ZOOL-6319	Comparative Developmental Biology	3(2+1)
ZOOL-6320	Endocrinology	3(2+1)
ZOOL-6321	Entomology-I	3(2+1)
ZOOL-6322	Entomology-II	3(2+1)
ZOOL-6323	Environmental Issues	3(2+1)
ZOOL-6324	Fish Physiology and Breeding	3(2+1)
ZOOL-6325	Hematology	3(2+1)
ZOOL-6326	Ichthyology	3(2+1)
ZOOL-6327	Immunology	3(2+1)
ZOOL-6328	Integrated Pest Management	3(2+1)
ZOOL-6329	Microbiology-I	3(2+1)
ZOOL-6330	Microbiology-II	3(2+1)
ZOOL-6331	Molecular and Clinical Endocrinology	3(2+1)
ZOOL-6332	Ornithology	3(2+1)
ZOOL-6333	Physiological Systems and Adaptations	3(2+1)
ZOOL-6334	Physiology of Reproduction	3(2+1)
ZOOL-6335	Principles of Parasitology	3(2+1)
ZOOL-6336	Principles & Kinetics of Toxicology	3(2+1)

SEMESTER I

ZOOL 6301 **Research Methodology** **2(2+0)**

The course is aims to develop research skills, provide understanding how to design scientific research, to collect data and its interpretation; emphasize the importance of ethics in scientific research and enable students to write a research proposal. It also introduces the data collection methods, data processing techniques, analysis options, writing review of literature, to deal with research problem and hypothesis development. The primary objective of this course is to develop a research orientation among the scholars and to acquaint them with fundamentals of research methods. Specifically, the course aims introducing them to the basic concepts used in research and to scientific social research methods and their approach. It includes discussions on sampling techniques, research designs and techniques of analysis by developing an understanding of the ethical dimensions of conducting applied research, identifying various sources of information for literature review and data collection and appreciating the components of scholarly writing and evaluate its quality.

Contents

1. Introduction: objectives of research, motivations
2. Research process: research methods vs. research methodology, scientific method,
3. Types of research, general steps involved in research, problems of research in Pakistan
4. Topic selection
5. Problem identification for research, criteria and evaluation
6. Literature review: importance and sources, referencing and citation and bibliography, plagiarism
7. Research design: parts, important concepts in research design
8. Aims and objectives: Research objectives, qualities of research objectives
9. Material and methods: bioethics, sampling, data collection and data analysis, sampling requirement, scales of measurement, error of measurement and its sources
10. Data analysis: processing, statistics in research, hypothesis testing, t-tests and ANOVA
11. Scientific writing: difference between thesis/report/synopsis/research proposal, parts of synopsis/project proposal, parts of thesis/report.
12. Budgeting: Cost estimates for a research project, funding sources e.g. USAID, HEC, DOST, HED, PMRC, WWF, PSF etc.

Recommended Texts

1. Leedy, P. D., & Ormord, J. E. (2018). *Practical research: planning and design* (12th ed.). New York: Pearson.
2. Creswell, J. W., & Creswell, J. D. (2018). *Research design quantitative qualitative and mixed methods approaches* (5th ed.). California: SAGE Publications.

Suggested Readings

1. Khan, J. A. (2008). *Research methodology*. New Delhi: APH Publishing.
2. Walliman, N. (2005). *Your research project, a step by step guide for the first-time researcher* (2nd ed.). California: SAGE Publications.
3. Hess-Biber, S. N., & Leavy, P. (2004). *Approaches to qualitative research, a reader on theory and practice*. New York: Oxford University Press.
4. Laurel, B. (2003). *Design research, methods and perspectives*. Cambridge: The MIT Press.

ZOOL-6302 Economic Zoology 3(2+1)

The course will enable students to learn about the relationship of commerce with domestic animals, their products, by-products and associated farming practices. They will also learn about the importance of human and domestic animal diseases and their vital relation to the economy. This course also provides knowledge about internal and external parasites and their effects on domestic animals and their farming practices. It also familiarize the students with the value of studying various general practices, principles and techniques in farming and rearing of animals in sericulture (silk worms), apiculture (honey bees), aquaculture (fisheries, pearl culture, prawns and oysters), poultry (domestic fowl and ostriches) and cattle husbandry. Students will acquire basic knowledge of commerce and economics in relation to Zoology. Economic zoology imparts knowledge about application of zoological knowledge for the benefit of mankind which mainly includes culturing animals for mass production for human use and to control or eradicate animals that are injurious to man directly or indirectly.

Contents

1. Basic concepts in Economic Zoology.
2. Parasitic protozoans and human disease.
3. Economic importance of protozoa.
4. Vectors of human and domestic animals.
5. Ecto- and endo-parasites of fish, poultry, cattle and Man (Crustacea, Helminthes and Arachnida).
6. Pests of pulse crops. Pests of oil seed crops, stored grain pests, pests of cotton, vegetables, fruits and tea.
7. Apiculture, and sericulture, lac insect culture and pearl culture
8. Aquaculture and fisheries (edible fresh water, pond and marine fish, prawns, pearl oysters). economic importance of fishes
9. Bird farming (poultry, quail, turkey, ostrich and pigeon).

Practical

1. To study the prepared slides of various types of ecto- and endo-parasites. 2. To observe and study museum specimens of vertebrate and invertebrate,
3. Pests of important crops and stored grains in Pakistan.
4. To visit Honey Bee farm. Write a report on their observations.
5. Visit to Sericulture farm in a nearby locality and write report on their observations.
6. Study visit to fish hatchery, nursery ponds, stocking ponds, commercial fish breeding farms.
7. Report writing.
8. Identification of important species of Fish and their natural animal.
9. Visit to any bird farm and write a report on their observations.

Recommended Texts

1. Ravindranathan, K. R. (2003). *Economic zoology* (1st ed.). New Delhi, India: Dominant Publishers and Distributers.
2. Primack, R. B. (2000). *A Primer of conservation of biology* (2nd ed.). Massachusetts: Sinauer Associates.

Suggested Readings

1. Mirza, Z. B. (1998). *Animal biodiversity of Pakistan* (1st ed.). Rawalpindi: Printopack.
2. Akhtar, M., & Muzaffar, N. (2008). *Introduction to apiculture*. Lahore: Punjab University Press.
3. Blackiston, H. (2001). *Beekeeping for dummies*. Indiana: Wiley Publishing.

ZOOL-6303 Biochemistry 4(3+1)

The course aims to provide in-depth knowledge about the polymerized organic compounds of life. It will develop an understanding about the dynamism in life as it proceeds with inter-conversion of the chemicals from feeding to the liberation of energy for work. It enables students to know how organisms harvest energy for growth and duplication. This course will help students to understand the principles of bioenergetics and the dietary requirements of man and animals. It will also provide knowledge of metabolism of dietary and endogenous carbohydrate, lipid, and protein as well as the principles and major mechanisms of metabolic control and molecular signaling by hormones. This course help students with a basic understanding of the principles of bioenergetics and enzyme catalysis, understand the chemical nature of biological macromolecules, their three dimensional construction, and the principles of molecular recognition and demonstrates understanding of the molecular machinery of living cells in the students.

Contents

1. Amino acids, peptides and proteins: Standard amino acids, their structure and classification; acid/base properties of amino acids and their titration curves; peptides, their ionic behavior and amino acid composition, Cytochrome C; Proteins: level of structural organization, example of structural and functional proteins.
2. Enzymes: Introduction; important characteristics of enzymes; immobilized enzymes; How enzymes work; example of enzymatic reaction; enzyme kinetics, enzyme rate of reaction and substrate concentration, how pH and temperature effect on enzyme activity.
3. Classification, types, important characteristics and structure of carbohydrates; cyclic structure of monosaccharides; cyanohydrin formation; disaccharides their types structure and function;
4. Polysaccharides, storage and structural types; structure and major functions of polysaccharides.
5. Lipids: Fatty acids, their types and major characteristics; storage lipids, acylglycerols; waxes;
6. Structural lipids in membranes; Major functions of lipids; lipoproteins, their types and major functions.
7. Vitamins and cofactors: Occurrence, structure and biochemical function of vitamins B complex group.
8. Metabolism: Detailed description of glycolysis and catabolism of other hexoses; regulation and bioenergetics of glycolysis. Anabolic role of glycolysis; fate of pyruvate under aerobic and anaerobic conditions, lactate, acetyl CoA and ethanol formation; alcoholic fermentation; gluconeogenesis, its regulation and significance in the tissues; feeder pathways in glycolysis; utilization of other carbohydrates in glycolysis phosphorolysis and starch; regulation of glycogen metabolism.
9. Citric acid (TCA) cycle: conversion of pyruvate to acetyl CoA, pyruvate dehydrogenase, a multi-enzyme complex; detailed description of citric acid cycle; bioenergetics and conservation of energy produced in 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 and its components, oxidative phosphorylation, chemiosmotic theory, ATP synthesis, uncouple electron transport and heat generation.
10. Lipid metabolism: oxidation of fatty acids; digestion, mobilization and transport of fats; biosynthesis of triacylglycerol; utilization of triacylglycerol; activation of fatty acids and their transportation to mitochondria; beta-oxidation; bioenergetics of beta-oxidation; oxidation of unsaturated and odd chain fatty acids; omega oxidation pathway; biosynthesis of saturated fatty

acid, supply of raw material for palmitic acid synthesis; fatty acid synthetase (FAS) multienzyme complex
11. Ketone bodies their biosynthesis, utilization and role in the tissues;
12. Cholesterol metabolism: steroid hormones.
13. Nitrogen metabolism: metabolic fate of amino acids; catabolism of amino acids; deamination and transamination; nitrogen excretion and urea cycle; regulation of urea cycle.

Practical

1. Preparation of standard curve for glucose by *ortho*-Toluidine method.
2. Tests for detection of carbohydrates in alkaline and acidic medium.
3. Tests for detection of Disaccharides.
4. Detection of Non-Reducing sugars in the presence of reducing sugars.
5. Demonstration of Acid Hydrolysis of Polysaccharide.
6. Separation and identification of various types of sugars, fatty acid and amino acid Thin Layer Chromatography (TLC).
7. Determination of pKa values of an amino acid by preparation of titration curves.
8. Biochemical tests for detection of different amino acids.
9. Separation of various protein fractions by precipitation method.
10. Demonstration of differential solubility of lipids in various solvents.
11. Quantitative analysis of phospholipids by estimation of inorganic phosphorous.
12. Quantitative analysis of Amylase activity from blood serum or liver.
13. Study on the effect of temperature on the enzymatic rate of reaction

Recommended Texts

1. Nelson, D. L., & Cox, M. M. (2012). *Lehninge principles of biochemistry*. New York: McMillan worth Publishers.
2. Berg, J. M., Tymoczko, J. L., & Stryer, L. (2011). *Biochemistry* (7th ed.). London: Palgrave MacMillan.

Suggested Readings

1. Lodish, H., Berk, A., Zipursky, S. L., Paul, M., Baltimore, D., & Darnell, J. (2012). *Molecular cell biology.* New York: Freeman.
2. McKee, T., & McKee, J. R. (2003). *Biochemistry: The molecular basis of life* (3rd ed.). New York: McGraw Hill.
3. Wilson, K., & Walker, J. (1994). *Practical biochemistry: principles and techniques* (4th ed.). Cambridge: Cambridge University Press.

ZOOL-6304 Cell and Molecular Biology 4(3+1)

The course aims to impart knowledge about the animal cell and its complex organization and architecture. It enables students to understand various ultra-structural, molecular and functional aspects of the cells. Students will be able to describe and discuss the properties and biological significance of the major classes of molecules found in living organisms and the relationship between molecular structure and biological function, can relate how cell movement and cell-cell communication occur and discuss mechanisms of signal transduction and the lab work will provide platform to became familiar with various cell types through techniques of slide preparation. Understanding of microscopy to study cell structure and cellular compartmentalization will be provided to learners. Main emphasis of course is to develop familiarity with structure and function of cells at the molecular level, including the flow of information from genes to proteins, and regulation of cellular processes, signaling and proliferation in eukaryotic cells.

Contents

1. Introduction to prokaryotic and eukaryotic cells: plasma membrane**,** its chemical composition structure and functions of plasma membranes, cell permeability, active transport, endocytosis, phagocytosis.
2. Cytoskeleton: microfilaments, microtubules, intermediate filaments.
3. Cytoplasmic Organelles: Membrane system, structural and functional commonalities.
4. Ultrastructure, chemical composition and functions of endoplasmic reticulum and their role in protein synthesis and drug metabolism, Golgi apparatus its role in synthesis of glycoprotein,
5. Mitochondrial respiration and its significance as semi- autonomous organelle;
6. Lysosome, its diverse roles due to hydrolytic activity of enzymes, Peroxisome, its role in metabolism of hydrogen peroxide, glycoxysome with reference to glyoxylic acid cycle.
7. Nucleus**:** chromatin, heterochromatin, euchromatin, chromosome structure, coiling and nucleosome during different phases of cell cycle.
8. Replication: mechanism, DNA replication in prokaryotes specially with reference to variety of DNA polymerases and other proteins involved, DNA replication in eukaryotes with emphasis on DNA polymerases, concept of replicons etc.,
9. 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 Post transcriptional processing, RNA transduction, Genetic code, point mutations.
10. Translation: specific role of ribosomes, various factors, and posttranslational processing, control of gene expression in Prokaryotes.

Practical

1. Identification of cell organelles
2. Preparation of temporary whole mount.
3. Preparation of permanent whole mount (demonstration)
4. Preparation of human blood smear and identification of Leucocytes.
5. Tissues (permanent slides of epithelial tissues, striated muscle, smooth muscle, cartilage, bone).
6. Squash preparation of onion root tip for mitotic stages.
7. Mounting of polytene chromosome (Drosophila/Chironomous.) Demonstration.
8. Detection and quantitative determination of chromosomal DNA and RNA.

9. Cultural and staining of bacteria and yeast.
10. Separation of different sized DNA fragments on agarose gel.
11. Isolation and characterization of proteins on polyacrylamide gel electrophoresis (native and subunit molecular weights).

Recommended Texts

1. Cooper, G. M., & Hausman, R. E. (2018). *The cell: A molecular approach* (8th ed.). Massachusetts: Sinauer Associates.
2. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K. C. (2016). *Molecular cell biology* (8th ed.). New York: W. H. Freeman.

Suggested Readings

1. Iwasa, J., & Marshall, W. (2016). *Karp's cell and molecular biology: concepts and experiments* (8th ed.). New Jersey: John Wiley and Sons.
2. De-Robertis, E. D. (2014). *Cell and molecular biology* (8th ed.). New York: Lea &Febiger.
3. Alberts, B., Johnson, A. D., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular biology of the cell* (6th ed.). New York: W. W. Norton & Company.

ZOOL-6305 Evolution & Principles of Systematics 4(3+1)

The course aims to provide extensive knowledge about origin of life and concepts about forces responsible for evolutionary changes. This study covers the importance and history of systematics with basic rules and regulations about the identification and naming of organisms. This course will also provide information about origin, classification and evolution of fauna. The students will be able to understand classification, philosophy of nomenclature, species concepts, phylogenetic inference and evolutionary perspectives of biodiversity. Moreover, the students will be able to understand the basic principles of evolution and systematics, and the inference of evolutionary patterns in the major animal groups. Students will be able to demonstrate evolutionary implications of animal diversity, nature and origin to life, Systematic Zoology, microtaxonomy and taxonomic categories. The practical section will enable the students to preserve invertebrate species and classify them up to class level, how to identify animal by the help of key and how to make keys of different types for identification of animals.

Contents

Evolution:

1. The causes of micro-evolution; Hardy-Weinberg equilibrium, Mutation, Gene flow, Genetic drift, Nonrandom breeding, and natural selection.
2. Types of natural selection: directional, disruptive and stabilizing selection.
3. Causes of polymorphism in populations: Density dependent selection and Heterozygote advantage.
4. General selection model: one locus and two locus selection model, Genetic load, Cost of selection, Hitch-hiking, Linkage disequilibrium. and shifting balance theory.
5. Units of selection: allele, cell line, organisms, kin group and group.
6. Sexualselection: Theories of sexual selection; Darwin, Fisher and Zahavi.
7. Macroevolution: Evolutionary developmental biology: allometery, heterochrony, Evolutionary innovation and origin of higher taxa.
8. Rates of evolution; Evolutionary trends and laws, Gradualism and punctuated equilibrium.

Principles of Systematics:

1. Concepts of taxon, phenon and category.
2. Species concepts and its problems: Typological; Nominalistic, Biological, Evolutionary.
3. Subspecies, Polytypic species and Superspecies: concept and problems
4. Modes of speciation: Allopatric, Sympatric, Parapatric
5. Intrapopulation variation: Types and application
6. Taxonomic characters: Different kinds of taxonomic characters. Weightage of taxonomic characters.
7. Classification and its types; Phenetic, Cladistic and evolutionary classification.
8. Taxonomic collections and the process of identification.
9. The rules of zoological nomenclature: interpretation and application of the code (stability, priority, first revisor principle) range of authority of code; concept of availability, type method formation of specific names, synonym, homonym.

Practical

1. Calculation of gene and genotype frequency for generations.
2. To calculate deviation of genotype from Hardy Weinberg equilibrium.
3. Simulate to check the effects of natural selection and genetic drift in changing environments. Simulation of assess the role population size in evolution.
4. Discussion on the evidences of evolution, role of biodiversity in evolution.
5. Simulation experiment to show the process of coevolution.
6. The study of a group of organisms while utilizing key.
7. Collection, preservation, labelling and identification of a group of specimen according to expertise available in the institute.
8. Preparation of bracket and indent key.
9. Phylogeny Reconstruction using phenetic (Similarity and dissimilarity matrix and unweighted pair group method) and cladistic (compatibility method) analysis to a group of mock "organisms".

Recommended Texts

Evolution:

1. Strickberger, M. W. (2012). *Evolution.* Burlington: Jones & Bartlett Publisher.
2. Ridley, M. (1993). *Evolution*. New Jersey: Blackwell Scientific Publications.

Suggested Readings

1. Moody, P. A. (1989). *Introduction to evolution*. New York: Harper and Row Publishers.
2. Dobzhansky, T., Ayala, F. J., Stebbins, G. L., & Valentine, J. W. (1977). *Evolution*. New York: W. H. Freeman and Company.

Systematics:

Recommended Texts

1. Wiley, E. O., & Lieberman, B. S. (2011). *Phylogenetics: Theory and practice of phylogenetic systematic.* New Jersey: Wiley-Blackwell.
2. Mayer, E. (1994). *Principles of systematic zoology*. New York: McGraw-Hill.

Suggested Readings

1. Heywood, V. H. (1975). *Taxonomy and ecology*. London: Academic Press.
2. Whili, M. J. D. (1978). *Modes of speciation*. San Francisco: W.H. Freeman and Co.

ZOOL-6306 Biological Techniques 3(1+2)

Students will be able to identify the instrument and to use instrument for identification, measurement, fixation and cutting of tissue. It also enables students to apply a practical and research skill and to operate the lab equipment efficiently. Students will learn to collect and preserve the specimen in dry and wet form and develop expertise in preservation techniques like taxidermy, rearing techniques in laboratory and field. At the end of the course students will have some understanding of the basic generally applicable tools, techniques, methodologies and methods of analysis in biological research and become comfortable and proficient working in the lab, the field, and on the computer for those tools, techniques, etc. Moreover learner will know how to acquire, learn about and implement a new tool or technique, how to order and store supplies and will learn what scientific lab integrity is all about.

Contents

1. Microscopy: Principles of light microscopy. Magnification, resolution, types of microscopy (bright field, dark field, phase contrast), confocal microscopy, electron microscope: scanning electron microscope and transmission electron microscope (SEM and TEM).
2. Standard unit system for weight, length, volume and Different measurement systems (length; surface; weight, volume, temperature), calculations and related conversions , concentrations-percent volume; ppt; ppm - molarity, normality, molality , preparation of stock solutions of various strength
3. Micrometery: Use of stage and ocular micrometers, calibration of ocular micrometer and measurement of size animal and plant cell and nuclei.
4. Specimen preparation for optical microscopy: introduction to microtome and its types, tissue fixation, dehydration, clearing, embedding, section cutting (transverse, longitudinal section), tissue mounting (dry mount, wet mount), staining: hematoxylin and eosin staining.
5. Separation and purification techniques, cell fractionation, centrifugation and its types, filtration
6. Chromatography: principle, applications, types, paper chromatography and thin layer chromatography, column chromatography, high pressure liquid chromatography,
7. Electrophoresis: principle, applications and types (agarose and PAGE).
8. Spectrophotometry: principle, applications, types, visible/UV spectrophotometry
9. Basic principles of sampling and preservation: sampling from soil, water, air, plants and animals, preservation of dry and wet specimens, preservation techniques, lyophilization, preservation in ethanol, formalin etc.
10. DNA sequencing: Polymerase chain reaction (PCR), principle and application, DNA sequencing.

Practical

1. Preparation of slides (dry mount and wet mount)
2. Observation of wet mounts of human cheek cells employing bright and dark field microscopy
3. Measurement of cell size: bacterial and eukaryotic Cell
4. Recording of microscopic observations with the help of camera lucida
5. Liquid handling: proper use of pipettes and micropipettes
6. Hematoxylin and eosin staining
7. Gram's staining,
8. Handling of centrifuge machines

9. Paper Chromatography, Thin layer chromatography of amino acids
10. Spectrophotometric estimation of glucose
11. Collection and Preservation of representative animals of various phyla

Recommended Texts

1. Cheesbrough, M. (2005). *District laboratory practice in tropical countries (Part I)* (2nd ed.). Cambridge: Cambridge University Press.
2. Cheesbrough, M. (2009). *District laboratory practice in tropical countries* (*Part II).* Cambridge: Cambridge University Press.

Suggested Readings

1. Gallagher, S. R., & Wiley E. A. (2008). *Current protocols essential laboratory Techniques*. New Jersey: John Wiley & Sons.
2. Jones, A., Reed, R., & Weyers, J. (1994). *Practical skills in biology*. Singapore: Longman Ltd.

SEMMESTER II

ZOOL-6307 **Physiology** **4(3+1)**

This course will provide an introduction to the basic physiological principles common to humans and other animals. It will include basic physical and chemical processes in animal tissues, detailed consideration of organ systems, and an integrative approach to understand how animals meet the demands in variable conditions. It will not only emphasize human physiology, but also will consider other animal systems for comparison. This course enable the students to understand the molecular and cellular mechanisms of physiological function as the basis of unity in diverse animals e.g. membrane excitability, exchange of respiratory gases, removal of nitrogenous wastes, osmosis and other physiological mechanisms underlying animal homeostasis and temperature effects. On the completion of course students will be able to understand mechanisms and adaptations of physiological systems in animals and understand the working of various systems of organisms. The practical portion will let the learners to investigate physiological questions, and collecting, analyzing, interpreting, and reporting experimental data.

Content

1. Concept of Physiology: Principles of homeostasis and conformity, principles of regulation and adaptation
2. Membrane Physiology: Ionic distribution across membrane, resting membrane potentials: electrogenic ion pump, Donnan equilibrium, Ion channels
3. Muscle Physiology: Action potentials in neurons, electrical and chemical synaptic transmission , Neurotransmitters in communications, receptors of neurotransmitters in diverse physiological responses, excitatory and inhibitory postsynaptic potentials, neuronal networks and their role in nervous integration,
4. Muscles: Structure, types, components, muscle proteins, molecular basis of muscle contraction, Sarcoplasmic reticulum and role of calcium, neuromuscular interaction at cell and molecular level muscle, types of muscle contractions and muscle fatigue.
5. Endocrine Physiology: Hormones of invertebrates and specifically of arthropods for the functions in their modes of life, hormones of various vertebrates' endocrine organs and comparison of their roles in adaptability of mode of life, mechanisms of hormone actions, hormone receptors, signal transduction and hormonal coordination.
6. Cardiovascular Physiology: Electrical activity of heart; self-excitability and auto-rhythmicity of myogenic heart, neurogenic heart and their expression, electrocardiography and Kymograph, hemodynamics, relationship between blood flow, pressure and resistance. Their role in performance of the function in variety of vertebrates, control of cardiac activity, cardiac output and peripheral circulation
7. Respiratory Physiology: mechanism of respiratory gases exchange in aquatic and terrestrial respiratory structures, Control of respiration and stimulus factors in various animals, respiration adaptations in hypoxia and percapniaetc, air breathing and respiratory adaptations diver animals.
8. Excretory Physiology: Strategy of mammalian large glomerular filtration and reabsorption in nitrogenous excretion, patterns of nitrogenous excretion in various animals and their phylogenetic significance.
9. Physiology of Nutrition: Adaptation of nutritive canal for digestion and absorption of nutrients in different animals specifically the vertebrates, regulation of digestive secretions, mechanisms of

water, ions and nutrients absorptions and their significances in diverse groups, potential and movements in gastrointestinal tract and control of motility.

Practical

1. Respiration and Circulation: Study of respiratory pigments in various animals and hemoglobin in various vertebrates, normal cardiac activity in amphibian model, effect of temperature, effect of drug, heart block, tantalization of heart, measurement and effects of various factors on blood pressure.
2. Blood pressure alteration in exercise, oxygen consumption in fish and effect of temperature (by dissolved oxygen meter) and terrestrial animal (mouse). Oxygen consumption (by respirometer),
3. Nerve and Muscle: Study of salient features of electromyography, study of excitable and contractile properties of a nerve-muscle preparation.
4. Nervous System: Study of brains in different animals in relation to complexity of functions, Study of human brain model and different areas eliciting behaviors, videos study on 1 and 2 studies.
5. Hormones System: Video studies on the effects of hormones in breeding season behaviors of various behaviors, Study through clinics data on the insulin and glycaemia in type1 and type 2 diabetic subjects.

Recommended Texts

1. Moyes, C. D., & Schulte, P. M. (2015). *Principles of animal physiology*. New Jersey: Pearson.
2. Guyton, A. C., & Hall, J. E. (2016). *Textbook of medical physiology*. Philadelphia: W. B. Saunders Company.

Suggested Readings

1. Sherwood, L., Klandorf, H., & Yancey, P. (2012). *Animal physiology: from genes to organisms* (2nd ed.). California: Brooks/Cole.
2. Hill, R. W., Wyse, G. A., & Anderson, M. (2016). *Animal physiology* (4th ed.). Massachusetts: Sinauer Associates.

ZOOL-6308 **Ecology** **3(2+1)**

This course will enable students to understand about habitat, ecology, ecosystems and environmental threats. Students will learn about the rehabilitation of destroyed ecosystems. They will also be capable to learn methods to protect and safe environment. The students will be literate about the biogeochemical cycles, applied ecology, population ecology, community ecology and global ecosystems. Upon successful completion of the course students will develop an appreciation of the modern scope of scientific inquiry in the field of Ecology, become familiar with the variety of ways that organisms interact with both the physical and the biological environment and develop an understanding of the differences in the structure and function of different types of ecosystems. Moreover, this subject imparts knowledge to compare the relationships among organisms, including predation, parasitism, competition, commensalism, and mutualism. The students will also able to explain the general distribution of life in aquatic systems as a function of chemistry, geography, light, depth, salinity, and temperature.

Contents

1. Energy: Basic concepts of and types of ecology, laws of thermodynamics, primary and secondary productions , trophic levels and energy variation with increasing trophic levels, energy flow, food chains and food webs.
2. Biogeochemical cycle**:** nitrogen, phosphorus, sulphur, water, carbon and nutrient.
3. Limiting factors: basic concepts, temperature, soil, water, humidity, light and fire.
4. Global ecosystems: atmosphere, hydrosphere, lithosphere and ecosphere, an overview of ecosystem with special reference to ecological niche, basic concepts and types, major ecosystem of world, forest, grassland, desert, tundra and agricultural ecosystems. marine, estuarine, freshwater and wetlands
5. Population ecology: basic population characters, growth and growth curves, population dynamics and regulations.
6. Community ecology: basic concepts, community analysis, ecotones, inter-population interactions
7. Applied Ecology: Resources and their ecological management; mineral, agricultural desalination, weather modification, forest and range management, landscape and land use
8. Pollution: definition, types, water, air, land and noise, sources and management.
9. Radiation ecology: global environmental changes (ozone depletion, acid rain, greenhouse effect and global warming, koyota protocol, radioactivity leakage, environmental laws).
10. Exotic and Invasive Species: desertification, deforestation, exotic and invasive species

Practical

1. Population Sampling Techniques (quadrate, line transact, point count, focal scan and capture and recapture method).
2. Study of different Ecosystems (fresh water, terrestrial, marine/mountain/ desert).
3. Ecological notes.
4. Measurements of physical factors of different ecosystems.
5. Adaptive features of animals in relation to food and environment.
6. Food chain studies through analysis of gut contents.
7. Analysis of polluted and fresh water for biotic and abiotic variations.
8. Field visits for study of selected terrestrial habitat and writing notes.
9. Experimental design and approaches in ecological research; writing a research project

10. Development of an ecological management plan of some selected area

Recommended Texts

1. Molles, M. C. (2005). *Ecology: concepts and applications* (6th ed.). New York: McGraw Hill.
2. Cox, C. B., & Morre, D. (2000). *Biogeography: an ecological and evolutionary approach* (6th ed.). London: Life Sciences King's College.

Suggested Readings

1. Dondson, S. I., Allen, T. F. N., Carpenter, S. R., Ives, A., Jeanne, R. L., Kitchell, J. F., Langston, N. E., & Turner, M. G. (1998). *Ecology*. Oxford: Oxford Univ. Press.
2. Chapman, J. L., & Reiss, M. J. (1997). *Ecology: principles and applications*. Cambridge: Cambridge University Press.
3. Odum, E. P. (1994). *Fundamentals of ecology* (3rd ed.) Philadelphia: W.B. Saunders.

ZOOL-6309 Developmental Biology 4(3+1)

The course aims to provide information on transmission of traits from the parents in their gametes, the formation of zygote and its development; impart detailed knowledge about cellular basis of morphogenesis, mechanisms of cellular differentiation and induction. It provides understanding of the mechanisms of organogenesis, factors controlling growth and oncogenesis. Students will learn how developmental biology is having a significant impact on our understanding of evolution and modern medicine, including the treatment of birth defects, infertility and cancer in humans. The students will be able to understand and compare basic principles of embryology through understanding the developmental patterns with help of morphology and anatomy of embryos of different vertebrates. The practical section will enable them to go through the structure of gametes of animals (like. frog, fish and mammal), to study of fertilization, early development of frog/fish through induced spawning under laboratory conditions and to know about the dactylography and its uses in developmental biology.

Contents

1. Introduction: History and Basic Concepts of developmental biology, Principal features of developmental biology and embryology with special emphasis on vertebrate models, origin of sexual reproduction, developmental patterns
2. Spermatogenesis: Mammalian spermatogenesis as model for all vertebrates, Spermiogenesis or (spermateliosis), The role of Sertoli and Leydig cells in spermatogenesis, Hormonal control of spermatogenesis
3. Primates menstrual cycle
4. Oogenesis: mechanism of oogenesis among various classes of vertebrates, vitellogenesis hormonal control of vitellogenesis and oogenesis
5. Fertilization: external & internal fertilization, species-specific recognition of sperm and egg, fusion of male and female gametes
6. Polyspermy: slow and fast blocks to polyspermy, activation of egg metabolism
7. *IN VITRO* Fertilization (IVF): history, steps and advantages of IVF, disadvantages and risk factors
8. Cleavage & blastulation, patterns of embryonic cleavage and blastulation among different vertebrate classes, mechanism of cleavage
9. Gastrulation: fate maps, gastrulation in amphibians, birds and mammals
10. Early vertebrate development
11. Neurulation, ectoderm, mesoderm and endoderm formation
12. Placenta and extraembryonic membranes
13. Cellular basis of morphogenesis: differential cell affinity, cell adhesion molecules,
14. Organogenesis, Mechanism of teratogenesis
15. Aging and regeneration in vertebrates

Practical

1. Study of the structure of gametes in some representative cases*, i.e.* frog, fish and mammal.
2. Hen's egg internal and external structural details.
3. Microscopic analysis of hen's egg yolk, albumin and shell membranes.
4. Study of cleavage and subsequent development from prepared slides and/or models in various animals i.e., frog, mammals and chick etc.

5. Study of fertilization, early development of frog/fish through induced spawning under laboratory conditions.
6. Study of developmental stages of nematodes through microscopic analysis of animal dung.
7. Semen analysis.
8. Dactylography and its uses in developmental biology.

Recommended Texts

1. Gilbert, S. F., & Barresi, M. J. F. (2020). *Developmental biology* (11th ed.). Oxford: Oxford University Press, Incorporated.
2. Gilbert, S. F. (2016). *Developmental biology* .Sunderland, Massachusetts: Sinauer Associates.

Suggested Readings

1. Klaus, K. (2001). *Biological development* (2nd ed.). New York: McGraw-Hill.
2. Oppenheimer, S. B., & Lefevre, G. (1998). *Introduction to embryonic development* (3rd ed.). San Fransisco: Benjamin Cummings.
3. Davies, J. A. (2014). *Life unfolding: How the human body creates itself*. Oxford: Oxford University Press.
4. Balinsky, B. I. (2012). *An introduction to embryology* (5th ed.). Dehli: Cengage.

ZOOL-6310 **Genetics** **4(3+1)**

This course aims to provide understanding of basic concepts of genetics, providing a conceptual framework for future reference. It provides understanding about the continuity of the life from one generation to other generation is based on the mechanisms involving nucleus, chromosomes and genes. The course develops the concept that continuity not only transfers the traits of the parents but also imparts variations that render the generations sustainable in changing environment; understanding of probability concepts and using these concepts to solve problems. The main goals of this subject are to accurately diagram and describe the processes of replication, transcription, translation, as well as predict the outcomes of these processes, to identify and describe the process and purposes of the cell cycle, meiosis, and mitosis and to describe what causes and consequences of DNA sequence changes and how cells prevent these changes, as well as make predictions about the causes and effects of changes in DNA.

Contents

1. Introduction: Forward and reverse genetics. The basic principles of inheritance (Mendelism): monohybrid and dihybrid crosses (definition - characteristics criss-cross inheritance),
2. Multiple alleles: blood groups and coat color in rabbits, genetics of Rh factor and erythroblastosis foetalis.
3. Chromosomal basis of inheritance: chromosomal theory of inheritance, interaction of genes, epistasis, lethality and pleiotropism.
4. Chromosomal aberrations: changes in chromosomal number, euploidy, aneuploidy (Klinefelters syndrome, and turners syndrome, down syndrome and Edwards syndrome), structural changes, insertion, deletion (Cri du chat syndrome), duplication, inversion and translocation
5. Pedigree Analysis: Normal human chromosome complement; karyotyping, sex-determination and sex-linkage, sex determination in animals and humans, sex linked (hemophilia, muscular dystrophy, color blindness), sex influenced and sex limited traits,
6. Prenatal diagnosis: amniocentesis and choriovillus sampling - ultrasound scanning and fetoscopy. genetic counselling, Eugenics and Euthenics
7. Chromosome mapping: linkage, recombination (crossing over), chromosome mapping in eukaryotes.
8. Molecular genetics: gene concept (classical and modern), genetics of viruses and bacteria, transposons, mutation and DNA repair molecular genetic analysis,
9. Regulation of gene expression in prokaryotes: gene regulation in eukaryotes, genetic basis of diseases, like cancer,
10. Genetic control of animal development, the genetic control of the vertebrate immune system
11. Recombinant technology: the techniques of molecular genetics (elements of genetic engineering), PCR
12. Human genetics: single and multifactorial disorders, autosomal anomalies, pseudoautosomal genes, single gene disorders: gene mutation and disorders;
13. Autosomal single gene disorders (sickle cell anemia, brachydactyly; inborn errors of metabolism such as phenylketonuria, alkaptonuria), complex inheritance patterns, polygenic traits- cleft lip and cleft palate, population genetics,
14. Hardy-Wienberg equilibrium, systematic and dispersive pressures, inbreeding and heterosis

Practical

1. Drosophila culture techniques: preparation and maintenance of culture
2. Identification of male and female fruit fly and isolation of virgin females
3. Study of polytene chromosomes from the salivary glands of Drosophila melanogaster
4. Mutation induction in Drosophila
5. Human karyotyping from photographs prepared slides: paper cut out method
6. Preparation of human metaphase chromosomes from blood lymphocytes
7. Study of mitosis in plants by using onion root tip cells
8. Study of meiosis in the testes of male grasshopper
9. Extraction of genomic DNA from whole blood (lymphocytes)
10. Separation of heterogeneous population of bio-molecules through electrophoresis
11. Study of blood group polymorphisms in local population
12. Study of qualitative traits in humans: a survey of common physical heritable (monogenic) polymorphisms
13. Human Pedigree analysis problems (Determination of inheritance pattern of different human characters (Widows Peak, ear loop, etc), risk estimation and genetic counseling
14. Study of quantitative traits in humans: finger prints as model of polygenic traits
15. Study of Barr bodies in human cell nucleus
16. Dermatoglyphics in normal and mentally retarded subjects
17. Probability problems. Tossing of coins. X^2 test
18. Study of transformed bacteria on the basis of antibiotic resistance
19. PCR

Recommended Texts

1. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A., & Killian, D. (2018). *Concepts of genetics* (12th ed.). New Jersey: Pearson.
2. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2018). *Lewin's Gene-XII* (12th ed.). Massachusetts: Jones & Bartlett Learning.

Suggested Readings

1. Snustad, D. P., Simmons, M. J., & Gardner, E. J. (2003). *Principles of genetics* (8th ed.). New York: John Wiley and Sons Ltd.
2. Tamarin, R. H. (2001). *Principles of genetics* (7th ed.). New York: McGraw-Hill.

ZOOL-6311 Wildlife 3(2+1)

The objective of this course is to enable the student to understand philosophy and significance of wildlife its conservation and management. Literature about geographical distribution, factors effecting distribution and status of different wildlife species will be discussed in this course. Rules and regulations, role of national and international agencies involved in conservation and management of wildlife will be familiarized. Students will be able to apply knowledge to solve problems related to wildlife conservation and management. They will learn about the conservation and management of threatened species (of amphibians, reptiles, birds and mammals). The major aim of the subject includes knowing what type of wildlife exist in Pakistan and what are the threats it is facing and how it can secured in Pakistan? After this course students will become able to participate in conservation of wildlife. The practical section will cover the visit to protected areas of Pakistan (captive, semicaptive and wild areas). Knowledge about use of ecological indices and animal distribution maps will be provided.

Contents

1. Wildlife of Pakistan: biodiversity and its categories, wildlife in context of its services, wildlife prior to the establishment of Pakistan,
2. Current status of wildlife, vegetative zones and its associated wildlife in Pakistan
3. Conservation and management of threatened amphibians, reptiles, birds and mammals of major importance in Pakistan
4. Major challenges faced during wildlife conservation
5. Threats to wildlife in Pakistan.
6. Wildlife rules and regulations in Pakistan
7. National and international agencies involved in conservation and management of wildlife in Pakistan, national organizations, international organizations
8. Protected Areas in Pakistan: sanctuaries, game reserves, national parks
9. Ramsar convention: wetlands, ramsar criteria, ramsar sites
10. Threatened species of Pakistan: vulnerable, endangered, critically endangered

Practical

1. Visit to protected areas of Pakistan (captive, semi-captive and wild areas)
2. Ecological indices
3. Animal distribution maps

Recommended Texts

1. Odum, E. P. (2007). *Fundamentals of ecology* (5th ed.). Dehli: Cengage Learning.
2. Miller, A. S., & Harley, J. B. (2016). *Zoology* (10th ed.). New York: McGraw Hill. *Suggested Readings*

1. Smith, R. L., & Smith, T. M. (2000). *Ecology and field biology* (6th ed.). Massachusetts: Benjamin Cummings.
2. Ali, S. S. (1999). *Palaeontology, zoogeography and wildlife management*. Hyderabad: Nasim Book Depot.
3. Roberts, T. J. (1997).*The mammals of Pakistan*. Oxford: Oxford University Press.

SEMMESTER III

ZOOL-6XXX	**Special Paper A1 (University Option/Thesis)**	**3(2+1)/ (0+3)**

Note: **University Option:** *To be selected from the list provided (Annexure-I) as special paper.*

ZOOL-6312 Biostatistics 3(2+1)

The course aims to provide knowledge about the importance and use of statistics in life sciences and familiarize students with the methods of data analysis pertaining to their research work and to assess the significance of their experimental designs. Specific topics include tools for describing central tendency and variability in data; methods for performing inference on population means and proportions. After finishing this course, students will be able to recognize the importance of data collection and its role in determining scope of inference, can demonstrate a solid understanding of interval estimation and hypothesis testing, can choose and apply appropriate statistical methods for analyzing one or two variables and can interpret statistical results correctly, effectively, and in context. More specifically, by the end of the course they will be able to identify cases and variables in a dataset, and classify variables as categorical or quantitative and to recognize when it is, and is not, appropriate to use sample data to infer information about a population.

Contents

1. Introduction: Definition, branches of statistics, scope and importance of statistics
2. Data: Population and sample, variable, categorical and non-categorical data, Scales of measurements, Errors of measurements
3. Presentation of data: descriptive statistics , tabulation of data , parts of table and construction of table, diagrams and graphs, pictogram, historigram, line chart, histogram, applications and uses of histogram, construction of histogram, comparison of data using histogram, bar chart, multiple bar chart, pie chart, gantt chart, timeline, infograph, pedigree chart
4. Frequency distribution: empirical FD, relative FD, cumulative FD, class frequency, class limits, class boundaries, class mark, class interval, midpoints
5. Measures of central tendency : types of averages, arithmetic mean for grouped and ungrouped data, harmonic mean for grouped and ungrouped data, geometric mean for grouped and ungrouped data, median, quartiles, deciles, percentiles and mode, advantages and disadvantages of arithmetic mean, harmonic mean, geometric mean, median and mode.
6. Measures of dispersion: range, grouped and ungrouped data, coefficient of range, mean deviation of grouped and ungrouped data. coefficient of mean deviation, standard deviation and variance of grouped and ungrouped data, variance and standard deviation of population and sample data
7. Probability: definition and properties, experiment and random experiment, event, outcome, trial and multiplication rule, sample space and sample point, mutually exclusive event, combinations and permutations, probability distribution, binomial experiment
8. Tests of significance: hypothesis testing, steps of hypothesis testing, Z-test, t-test; its types, Chisquare, ANOVA, its uses and LSD, Correlation, Regression

Practical

1. Data collection, arrangement and frequency table
2. Data presentation in table, graphs (simple bar chart, multiple bar chart, component bar chart)
3. Construction of timeline, pedigree chart, organogram, Gantt chart, infogram
4. Calculating arithmetic mean, harmonic mean and geometric mean, median and mode from ungrouped and grouped data
5. Calculating mean deviation, standard deviation and variance from ungrouped and grouped data
6. Probability distribution
7. Z-test

8. T-test
9. ANOVA
10. Correlation
11. Regression

Recommended Texts

1. Field, A. (2017). *Discovering statistics with IBM SPSS statistics* (5th ed.). New York: SAGE Publications Ltd.
2. Belle, G. V., Fisher, L. D., Heagerty, P. J., & Lumley, T. (2014). *Biostatistics – A methodology for the health sciences* (2nd ed.). Dehli: Wiley.

Suggested Readings

1. Campbell, M. J., & Swinscow, T. D. V. (2011). *Statistics at square one* (11th ed.).London: BMJ Books.
2. Quinn, G. P., & Keough, M. J. (2002). *Experimental design and data analysis for biologists*. Cambridge: Cambridge University Press.

ZOOL-6XXX **Special Paper A2 (University Option)** **3(2+1)**

Note: **University Option:** *To be selected from the list provided (Annexure-I) as special paper.*

ZOOL-6XXX	**University Option**	**3(2+1)**

Note: **University Option:** *To be selected from the list provided (Annexure-I).*

ZOOL-6313 Bioinformatics 3(1+2)

The course will provide an introduction to bioinformatics with a focus on fundamental bioinformatics problems and information on the tools used to compute solutions to those problems, and the theory upon which those tools are based. This involves algorithm, and storage/database development of genomics data. It also describes the different types of data found at the NCBI and EBI resources. This course has three main objectives i.e. to organize vast reams of molecular biology data in an efficient manner; to develop tools that aid in the analysis of such data; and to interpret the results accurately and meaningfully. The advent and rapid rise of bioinformatics has been due to the massive increases in computing power and laboratory technology in recent years. These advances have made it possible to process and analyze the digital information regarding DNA, genes and genomes. A student completing Bioinformatics course shall be able to apply it for problem-solving skills, including the ability to develop new algorithms and analysis methods.

Contents

1. Introduction: Introduction to computers, software, hardware, operating systems
2. Bioinformatics: scope of bioinformatics, useful websites, aims of bioinformatics, disciplines related to bioinformatics, major tasks involved in bioinformatics analysis, bioinformatics tools
3. Biological databases: data and information, databases, data acquisition, NCBI, major DNA databases around the world, major protein databases in the world, primary protein sequence databases, secondary protein databases, tertiary protein databases, protein structure databases, specialized databases, genome and organism databases, miscellaneous databases
4. Genome mapping: genetic and linkage mapping, physical mapping
5. Gene family: introduction and types, protein family, globin family as an example, globin genes and chains, evolution of globin proteins in human, combination and types of globin proteins in human
6. Data retrieval: Searching sequence databases, FASTA format, retrieval of nucleotide sequence data, retrieval of protein sequence and structure data, retrieval of literature and map data
7. Primer designing: primer and probe, qualities of primer, general rules for primer designing
8. Websites used for primer designing
9. Sequence alignment: importance and significance of alignment, methods for sequence alignment, Local and global alignment, pair-wise local alignment, uses of local alignment
10. BLAST: introduction and types, uses, algorithm , BLAST Score
11. Amino acid matrices: amino acids and their symbols, amino acid scoring matrices, PAM and BLOSUM, comparison of PAM and BLOSUM
12. Multiple sequence alignment: introduction, tools for MSA, uses and importance
13. Phylogenetic analysis: Introduction, interpretation, rooted and unrooted tree, phylogenetic methods, tree terminology, comparison of methods, software
14. Protein structure prediction: homology modelling, threading, *ab initio* modelling, motivation to acquire structure, protein 3D structure, software/databases
15. Molecular docking: introduction, steps, importance and uses
16. Microarrays: Gene expression, differential expression, DNA chips, principle of microarray, types, steps of a microarray experiment, qualitative interpretation of results, applications of microarray, advantages and disadvantages of microarray.

Practical

1. Introduction to NCBI
2. Retrieving Literature from NCBI
3. Classification of an organism using NCBI
4. Retrieving FASTA sequence for nucleotide and protein
5. Retrieving disease gene information
6. Searching gene families
7. Primer Designing
8. BLASTing a nucleotide / amino acid sequence
9. Multiple sequence alignment using different amino acids / nucleotide sequences
10. Phylogenetic analysis of different nucleotide / amino acid sequences
11. Microarrays data retrieval from the web

Recommended Texts

1. Selzer, P. M., Marhofer, R. J., & Kock, O. (2018). *Applied bioinformatics: an introduction*. Berlin: Springer Publishing.
2. Lesk, A. (2019). *Introduction to bioinformatics* (5th ed.). Oxford: Oxford University Press.

Suggested Readings

1. Rastogi, S. C., Mendiratta, N., & Rastogi, P. (2013). *Bioinformatics methods and applications: genomics, proteomics and drug discovery*. Dehli: PHI Publishing.
2. Primrose, S. B., & Twyman, R. M. (2004). *Genomics: applications in human biology.* New York: Willey-Blackwell.
3. Krane, D. E., & Raymer, M. L. (2002). *Fundamental concepts of bioinformatics.* New Jersey: Benjamin Cummings.

SEMESTER IV

ZOOL-6314 **Animal Behavior** **3(3+0)**

This course will give the baseline information about animal behavior and associate the likely role of external and internal stimuli on various animals during the day, season and year. It also relates daily behavioral rhythms in diurnal and nocturnal periodicities and predicts and anticipates variety of animal actions (costs and benefits) as assessed by innate and learned behavioral displays. The unifying theme of this course will be evolution by means of natural and sexual selection. It includes the scientific study of the mechanistic and evolutionary causes of animal behavior, including communication, foraging and anti-predator behavior, spatial behavior, mating behavior, parental care, and social behaviors. After successful completion of this course, students should be capable of understand and identify behaviors in a variety of taxa, can competently discuss the evolutionary origins of various behaviors and can design and implementing experiments to test hypotheses relating to animal behavior.

Contents

1. Introduction: behavior and its types, proximate and ultimate causes of behavior.
2. Development of behavior: Impact of neural and physiological mechanisms; role of external and internal stimuli and animal responses, physiology of behavior in changed environments.
3. Hormones and behavior in animals. Innate behavior and innate releasing mechanisms; built in programmed performance by offspring to that of parents. Innate behavior of three spines stickle back fish. Learned behavior and its mechanisms: quick learners' vs. slow learners.
4. Concept of animal cognition: key to understand and develop multiple behavioral choices, Ecological and genetics to maintain animal behavior, concept of territoriality and defense in animals.
5. Circadian rhythms and concept of bio-rhythmicity in animals.
6. Maintenance of internal biological clock to perform various diurnal and nocturnal periodicities.
7. Costs and benefit ratios in behavior; successful foragers and winners of predator-prey relationships. Altruism and parental sacrifice to nurture the young.
8. Competition for resources; survival of the most suitable individuals; evolutionary arms races in behavior.
9. Social organization in animals and concept of group living; benefits and losses, Aggression, appeasement and selfish individuals. Social organization in insects and mammals.
10. Communication in animals: visual, bio acoustic, electrical, chemical and tactile.
11. Various types of chemical signals in animal's behavior and their importance in ecosystems.

Recommended Texts

1. Dngatkin, L. A. (2012). *Principles of animal behavior*. New York: W.W. Nortan & Co.
2. Alcock, J. (2010). *Animal behavior, an evolutionary approach* (9th ed.). Massachusetts: Sinauer Publishers.

Suggested Readings

1. Scott, G. (2005). *Essential animal behavior.* New York: Blackwell Publishers.
2. Goodenough, J., McGuire, B., & Wallace, R. A. (2009). *Perspective on animal behavior*. New York: John Wiley & Sons.

ZOOL-6XXX **Special Paper B1 (University Option/Thesis)** **3(2+1)/ (0+3)**

Note: University Option: To be selected from the list provided (Annexure-I) as special paper.

ZOOl-6XXX **Special Paper B2 (University Optional)** **3(2+1)**

Note: University Option: To be selected from the list provided (Annexure-I)

ZOOL-6XXX	**University Option**	**3(2+1)**

Note: **University Option:** *To be selected from the list provided (Annexure-I).*

ZOOL-6315 Zoogeography and Paleontology 3(2+1)

The objectives of the course are to provide information on the distribution of animals and their associations in the past and to rationalize their relationship in the present time; to impart knowledge and concepts of evolution mainly on the basis of fossil record and give understanding that fossil records also provide information about the distribution of animals in the past eras. After completion of this course students will be able to reconstruct the biological traits of extinct organisms, can interpret the modes of life of fossil organisms. The students will learn about Paleogeography focusing on theories of continental drift and plate tectonics, zoogeographical regions mainly faunas and affinities of Palaearctic, Nearctic, Oriental, Ethiopian, Australian and Neotropical regions, Zoogeography of Pakistan and Geochronometry. The practical section will empower them with the knowledge of fauna of various zoogeographical regions and invertebrate fossils of coelenterates, trilobites, ammonite, brachiopods, molluscs and echinoderms.

Contents

1. Paleogeography: theories of continental drift and plate tectonics, pangea
2. Animal distribution: cosmopolitan distribution, discontinuous distribution, isolation distribution, bipolar distribution, endemic distribution, barriers and dispersal
3. Zoogeographical regions: zoogeographic division and boundaries, geographic ranges, physical features, climates, faunas and affinities of Palaearctic, Nearctic, Oriental, Ethiopian, Australian, and Neotropical regions,
4. Zoogeography of Pakistan: The planet earth, history, age, shells of earth, atmosphere, hydrosphere, biosphere and lithosphere.
5. Rocks: igneous rocks, sedimentary rocks, metamorphic rocks.
6. Fossil and fossilization: fossil types and uses of fossils, nature of fossils, fossilization, invertebrates and vertebrates fossil, biostratigraphy, fossils of Pakistan, Paleontological important areas of Pakistan.
7. Fossilization: geological time scale, Pre-Cambrian life, Post Cambrian life, Paleozoic life, Mesozoic life, Cenozoic life.
8. Paleontological techniques: excavation techniques, excavation tools and techniques, transportation and processing of fossils, presentation of fossils, pre requisites for paleontological excavation.
9. Geochronometry: Uranium/Lead dating, radiocarbon dating, methods, index fossils, evolutionary history of man, elephant, horse and camel, Paleoecology, Paleomagnetism.

Practical

1. Study of fauna of various zoogeographical regions.
2. Study of mould, cast, pseudomorph, coprolite, petrified fossils of plants and animals.
3. Study of invertebrate fossils of coelenterates, trilobites, ammonite, brachiopods, molluscs and echinoderms.
4. Study of vertebrate fossils e.g. horse/elephant/camel/bovids.
5. Study and identification of Igneous, Sedimentary and Metamorphic rocks 6. Map work for identification of various zoogeographical regions of the World.

Recommended Texts

1. Beddard, F. E. (2015). *A textbook of zoogeography*. Cambridge: Cambridge University Press.

2. Tiwari, S. K. (2006). *Fundamentals of world zoogeography.* Delhi: Sarup & Sons.

Suggested Readings

1. Michael, J. B., & Haper, D. A. T. (2009). *Paleobiology and the fossil record*. New York: Wiley & Blackwell.
2. Foote, M., & Millar, A. I. (2006). *Principles of paleontology*. New York: W. H. Freeman & Co.
3. Ali, S. S. (1999). *Palaeontology, zoogeography and wildlife management*. Hyderabad: Nasim Book Depot.

ANNEXURE-I

ZOOL-6316 Aquaculture 3(2+1)

As there is an increased demand of natural and organic food globally, there are various scientific strategies being adapted at commercial level to fulfill the demand of natural food resources with growing population. This course will equip the students with advanced knowledge about aquaculture, its development and future role in human nutrition. This will enable the young students to understand principles of aquaculture and its relationship with biological systems which is important for better planning and management of aquatic resources in Pakistan. Different assisted reproductive technologies and rearing techniques will be discussed for maximum growth of required species on large scale. It will teach about different aquaculture species, their rearing facilities and management by using advanced techniques in practical section. Students will be able to understand the basic requirements to develop aquaculture on commercial scale and be familiar with the outcomes with relevance to their practical life.

Contents

1. The concept of aquaculture, principles of aquaculture management. 2.
Aquaculture in raceways, cages and enclosures,
3. Use of waste waters in aquaculture.
4. Mari-culture: substrate system, sea water, ponds.
5. Aquaculture in fresh and brackish waters.
6. Aquaculture in practice: culture of algae, culture of seaweed, culture of mollusks, culture of crustaceans.
8. Culture of freshwater prawns and shrimps:
9. Artificial feeds for aquaculture: Feed constituents, Diet formulation and Processing.
10. Role of biotechnology in sustainable aquaculture development.

Practical

1. Determination of water quality for aquaculture
2. Determination of metals (Cd, Zn, Co, Mn, Fe) in water, plankton and fish 3.
Fish feed formulation and processing

Recommended Texts

1. Metha, V. (2009). *Fisheries and aquaculture biotechnology* (2nd ed.). New Dehli: Campus Books International.
2. Sharma, O. P. (2009). *Handbook of fisheries and aquaculture*. New Dehli: Agrotech Publishing.

Suggested Readings

1. Stickney, R. R. (2009). *Aquaculture: an introductory text*. London: CABI Publishing.
2. Pandey, B. N., Deshpande, S., & Pandey, P. N. (2007). *Aquaculture.* New Dehli: APH Publishing Corporation.
3. Parker, R. O. (2004). *Aquaculture science* (4th ed.). London: Delmar Learning.

ZOOL-6317 Biodiversity and Wildlife 3(2+1)

The objective of this course is to enable the student to understand philosophy and significance of wildlife conservation; understand the wildlife management rules and regulations in Pakistan and to understand how national and international agencies are involved in conservation and management of wildlife. Students will be able to apply knowledge to solve problems related to wildlife conservation and management. They will learn about the biodiversity of amphibians, reptiles, birds and mammals, along with the wildlife and its distribution in different major eco zones of Pakistan. The major aims of the subject include knowing what type of wildlife exist in Pakistan and its biodiversity, moreover, how wildlife is being secured in Pakistan. After this course students will become able to participate in wildlife census. The practical section will cover the mammal's population census techniques, ecological indices and procedures for studying species richness, Simpson Index, Shannon and Weiner Function.

Contents

1. Biodiversity: definition, types, levels,
2. Status of biodiversity; importance
3. Natural resources and biodiversity: ecological aspects, impacts, loss of biodiversity,
4. Protection and conservation of biodiversity.
5. Wildlife: introduction, important wild animals of Pakistan,
6. Wildlife importance, wildlife management.
7. Eco zones of Pakistan: wildlife and its distribution in different major eco zones of Pakistan.
8. Wildlife census techniques
9. Modern census techniques for mammals and birds, diversity indices.

Practical

1. Procedures for studying species richness, Simpson Index, Shannon and Weiner Function.
2. Population of some local subterranean animals.
3. Bird's population census techniques.
4. Mammal's population census techniques.
5. Study of wildlife habitats.

Recommended Texts

1. Kumar, U., & Asija, M. J. (2002). *Biodiversity: principles and conservation*. Ohio: Crescent News.
2. Starr, C., & Taggart, R. (2005). Biology: *the unit and diversity of life* (11th ed.). India: Cengage Learning.

Suggested Readings

1. Fryxell, J. M., Sinclair, A. R., & Caughley, G. (2014). *Wildlife ecology, conservation, and management* (3rd ed.). West Sussex: Wiley-Blackwell.
2. Bolen, E. G., & Robinson, W. (2002). *Wildlife ecology and management* (5th ed.). London: Pearson.

ZOOL-6318 Biotechnology 3(2+1)

This course is designed to familiarize students with the basic concepts and significance of biotechnology. This course is designed to introduce learners with a solid understanding of science, technology and business management, along with the entrepreneurial skills required to exploit technological advances within a competitive environment. The goal of biotechnology is to produce pharmaceutical products by using living organisms such as bacterial cells, yeast, mammalian cells, etc., that are placed in culture to produce substances with pharmacological activity, such as monoclonal antibodies for the treatment of tumors. The main objectives of the subject are to teach, train and qualify skilled scientists in many disciplines of biotechnology and to provide an intensive and in-depth learning about technical and critical thinking skills necessary for success in the field of biotechnology. Upon completion of the course, the students will develop awareness and knowledge of different basic topics of biotechnology through lectures and practical classes.

Contents

1. Introduction: definitions, classes, types of modern biotechnology and historical perspective,
2. Genetics and biotechnology: genome, human genome, diversity of human genome, short tandem repeats, nomenclature,
3. Polymerase Chain Reaction, principle, requirements, procedures and applications, gel electrophoresis, definition, principle, steps/methods involved, DNA ladder, allelic ladder
4. Genetic engineering introduction, steps, vectors and its types, characteristics of vectors, plasmids and restriction enzymes, screening, blue white screen, negative and positive control, competent cells, insulin as an example, genetically modified organisms,
5. Cloning, its types of cloning, cell cloning, molecular cloning, organism cloning, applications and uses
6. Animal and insect biotechnology: introduction, reasons for producing GM animals.
7. Bioprocess technology: introduction, requirements of bioreactors, types of bioreactors, bacterial and mammalian cell culturing, production of industrially important chemicals
8. Biotechnology and medicine: applications, monoclonal antibodies, importance, steps for production of monoclonal antibodies
9. Public perception of biotechnology: current issues in bioethics (autopsy, GMOs, stem cells, euthanasia, organ transplant, human cloning, IVF, surrogacy and sperm donor)
10. Bioethics and Islam: introduction and principles of bioethics, concept of bioethics in different religions, principles of Islamic bioethics.

Practical

1. DNA Extraction from different sources
2. Quantification of DNA using gel electrophoresis and spectrophotometer
3. Amplification of DNA using PCR
4. PCR product measurement using gel electrophoresis
5. Gender typing of human and animal samples using PCR
6. Restriction fragment length polymorphism of samples
7. Species identification of different animal samples using PCR and RFLP

Recommended Texts

1. Clark, D. B., & Pazdernik, N. J. (2015). *Biotechnology* (2nd ed.). Amsterdam: Academic Cell.
2. Schmid, R. D., Schmidt-Dannert, C., & Hammelehle, R. (2016). *Biotechnology: an illustrated primer.* New York: Willey-Blackwell.

Suggested Readings

1. Brown, T. A. (2016).*Gene cloning and DNA analysis: an introduction* (7th ed.). New York: Willey- Blackwell.
2. Butler, J. M. (2009). *Fundamentals of forensic DNA typing*. Amsterdam, Boston: Academic Press.
3. Furr, A. K. (2008). *CRC handbook of laboratory safety* (5th ed.). Florida: CRC Press.
4. Smith, J. E. (2009). *Biotechnology* (5th ed.). Cambridge: Cambridge University Press.

ZOOL-6319 Comparative Developmental Biology 3(2+1)

The course aims to provide information on transmission of traits from the parents in their gametes, the formation of zygote and its development; impart detailed knowledge about cellular basis of morphogenesis, mechanisms of cellular differentiation and induction and provide understanding of the mechanisms of organogenesis, factors controlling growth and oncogenesis. Students will learn how developmental biology is having a significant impact on our understanding of modern molecular techniques in developmental biology and Uses of transgenic animals in developmental biology. The students will be able to understand and compare basic principles of embryology through understanding the embryonic adaptations with help of morphology and anatomy of embryos of different vertebrates. The practical section will enable them to go through study of prepared slides for the development of amphioxus, mammals, frog and chick isolation, identification and culture of various developmental stages.

Contents

1. Historical review of embryology.
2. Uses of modern molecular techniques in developmental biology.
3. Origin of germ cells (gametogenesis).
4. Spermatogenesis & oogenesis, structure and organization of male and female gametes.
5. Fertilization: chemistry of fertilization, molecular biology of fertilization, surface changes in the egg and sperm surface.
6. Twinning, parthenogenesis, cleavage, blastulation, fate maps and their preparation,
7. Morphogenetic movements and gastrulation in mammals and frog.
8. Stem cells technology and its uses in developmental biology.
9. Embryonic adaptations and placentation, umbilical cord and parturition.
10. Aging

Practical

1. Study of model eggs of different invertebrates and vertebrates.
2. Dactylography, and its uses in embryology.
3. Isolation, identification and culture of various developmental stages of *Ascaris lumbricoides* eggs from human/ *Neoascaris vituolarum* eggs from cattle dung (kept for 3 weeks at 240°C in desiccator) by using Telman's centrifugation technique.
4. Study of prepared slides for the development of Amphioxus, mammals, frog and chick.
5. Semen analysis by using improved Neubar Hemocytmeter, Use of dactylography in developmental biology,
6. Peripheral blood smear (abnormal erythrocyte morphology e.g., target cells, microcyte, macrocytes, slit cell, acanthocytes& tear drop cells as screening procedures for thalassemia diagnosis.

Recommended Texts

1. Gilbert, S. F., & Barresi, M. J. F. (2020). *Developmental biology* (11th ed.). Oxford: Oxford University Press, Incorporated.
2. Patten, B. N. (2004). *Foundation of embryology*. New York, London: McGraw Hill Books Company, Inc.

Suggested Readings

1. Oppenheiner, S. (2004). *Introduction to embryonic development* (4th ed.). New Jersey: Pearson Education.
2. Saddler, T. W. (2011). *Langmans medical embryology* (Revised ed.). New York: Wolters Kluwer Health.

ZOOL-6320 **Endocrinology** **3(2+1)**

The course is aimed to impart knowledge about endocrine glands, their anatomy, the hormones released from them and the physiological role of these hormones in body. Endocrinology involves the evaluation and management of disorders of the body's glands, hormonal secretions, and resultant changes in body metabolic activity. The course is designed to provide an understanding to structures and function of endocrine glands. It also provides an understanding of the common endocrine disorders, metabolic regulations, and metabolic abnormalities, and their management. Furthermore, in all body cells, hormones influence the metabolism of nucleotides, proteins, lipids, carbohydrates, vitamins, water, and therefore, knowledge of endocrinology and metabolism is important. The students will study the endocrine system in terms of structure, function and its role in regulating metabolism, growth and reproduction in different animals, with reference to some disorders resulting from dysfunction. By the end of this course, the students should be able to examine and describe glands and can determine hormonal impact and syndromes.

Contents

1. The endocrine system; type of hormones; endocrine and nervous system relationship
2. Hypothalamus and pituitary: hypothalamic hormones: origin, chemistry and actions; anterior pituitary & hormones: hypothalamic pituitary regulation, general chemistry, physiological action and metabolism of prolactin-growth hormone family, glycoprotein hormone family, corticotrophins and other pro-opiomelanocortin peptides; posterior pituitary: release, regulation and actions of vasopressin and oxytocin.
3. Thyroid gland: anatomy and histology of gland; formation and secretion of thyroid hormones; factors affecting thyroid function.
4. Calciotropic and mineral metabolism hormones: chemistry, physiological actions and metabolism of parathyroid hormone, calcitonin and calciferols.
5. Pancreatic hormones and regulatory peptides of the gut: anatomy and histology for sources of the hormones; chemistry, physiological roles and mechanism of action of insulin and glucagon
6. Adrenal medulla and catecholamines: chromaffin cell and organization; structure of adrenal medulla; biosynthesis, storage, release and metabolism; adrenergic receptors.
7. Adrenal cortex: steroid biochemistry; physiological actions of corticoid hormones; regulation and metabolism of glucocorticoids, mineralocorticoids and adrenal sex steroids.
8. Testes: androgenic tissue: structure and chemistry; transport, metabolism and mechanism of action.
9. Ovaries: ovarian hormones: steroid biochemistry and biosynthesis; transport, metabolism and mechanism of action.
10. Overview of endocrine mechanisms in invertebrates.

Practical

1. Demonstration of endocrine glands and associated structures in dissections, transparencies, computer projections etc.
2. Histological and ultra-structure features of endocrine glands;
3. Experiments to demonstrate physiological roles of hormones of different endocrine glands;
4. Experiments to demonstrate regulation of hormones releases.
5. Experiments to demonstrate functional diversity of hormones in different vertebrates.
6. Experiments on endocrine mechanism in vertebrates.

Recommended Texts

1. Greenspan, F. S., & Strewler, G. J. (2002). *Basic and clinical endocrinology* (5th ed.). London: Prentice Hall International Inc.
2. Wilson, J. D., Foster, D. W., Kronenberg, H. M., & Larsen, P. R. (2008). *William's textbook of endocrinology.* Philadelphia: W.D. Saunders Company.

Suggested Readings

1. DeGroot, L. J., & Jameson, J. L. (2001). *Endocrinology (*4th ed.). Philadelphia: W.B. Saunders.
2. Giffin, J. E., & Ojeda, S. R. (2000). *Textbook of endocrine physiology* (4th ed.). Oxford: Oxford University Press.

ZOOL-6321 Entomology-I 3(2+1)

The course is designed to impart knowledge to students about morphology and body parts of the insects. The objective of the entomology undergraduate is to provide students with a broadly-based education in the science and practice of entomology. After this course, students can demonstrate an understanding of insect identification, structure, and function. It includes general characteristics of insects, relationship with other arthropods and evolutionary study of insects splitting up into different evolutionary lines. This subject also imparts knowledge about ecology of insects by learning carrying capacity, food chains, predation and competition, diapause insect population and community studies and insect communication. The practical section will enable the students to prepare permanent slides, distinguish the several body parts (antennae, mouth parts, wings, legs, terminal segments and genitalia) of insects; can study the different systems, especially digestive, reproductive of the insect and be able to address complex problems facing entomology.

Contents

1. General characteristics of insects and their classification
2. Hard parts: general segmentation, tagmatosis and organization.
3. Cuticle: colors of insects, cuticular outgrowths and appendages sclerotization.
4. Head: cephalization, sclerites, modifications.
5. Antennae: different modes of ingestion and types of mouth parts.
6. Neck: sclerites, thorax: sclerites: legs, their different modifications and functions.
7. Wings: origin; development and basal attachments, main veins and their branches 8. Abdomen: secondary appendages and external genitalia,
9. Flight; types of flight.
10. Soft parts: muscular system; basic structure, types of muscles
11. Sense organs: sound and light producing organs.
12. Nutritive requirements: fat body, exocrine and endocrine glands
13. Reproduction: reproductive organs and different types of reproduction in insects,
14. Development: embryology up to dorsal closure, different types of metamorphosis, apolysis and ecdysis and the role of endocrine secretions.
15. Ecology: insect population and community studies, insect communication.

Practical

1. Preparation of permanent slides.
2. All the hard parts (antennae, mouth parts, wings, legs, terminal segments and genitalia).
3. Different systems, especially digestive, reproductive of the following insects.
4. American cockroach, gryllus, grasshopper, housefly, butterfly, mosquito, any common beetle.
5. Red cotton bug.
6. Wasp and honey bee.
7. Sympathetic nervous system of cockroach and gryllus.
8. Salivary glands of cockroach, red cotton bug and honey bee.

Recommended Texts

1. Richards, O. W., & Davies, R. G. (1977). *Imm's general textbook of entomology* (Vol. 1; 10th ed.). London: Chapman & hall.
2. Chapman, R. F. (2013). *The insects: structure and function* (5th ed.). Cambridge: Cambridge University Press.

Suggested Readings

1. Wigglesworth, V. B. (2012). The principles of *insect physiology.* London: Springer Science & Business Media.
2. Tembhare, D. B. (2002). *Modern entomology.* Dehli: Himalaya Publishing House.
3. Henderson, P. A., & Southhood, T. R. E. (2016). *Ecological methods*. London: Wiley Blackwell.
4. Peterson, P. G. (2018). *Elements of insect ecology.* London: Ed- Tech Press.

ZOOL-6322 **Entomology-II** **3(2+1)**

The main objective of the course is to develop knowledge about classification of insect orders and their economic importance. This subject provides students with a broadly-based education in the science and practice of entomology. After this course, students can classify the insects up to orders level. It also includes diagnostic characters of the insect orders, knowledge about insects of economic and medical importance and brief account of biological control, chemical control and integrated pest management. This subject also imparts knowledge about common sampling techniques in insect pest management, concept of economic levels, economic damage and economic boundary of insects. Moreover, some brief account on household pests and their management and knowledge of pests of cotton, rice and sugarcane will also be the part of learning. The practical section will enable the students to collect, preserve and identify insects up to families and can have core knowledge of entomology.

Contents

1. A general account including classification of insect orders: Collembola, Orthoptera, Dictyptera, Isoptera, Hemiptera, Lepidoptera, Diptera, Hymenoptera, Coleoptera.
2. Only diagnostic characters of the remaining insect orders: Thysanura, Diplura, Protura, Ephemeroptera, Odonata, Plecoptera, Grylloblattoidea, Phasmida, Dermaptera, Embioptera, Zoraptera, Psocoptera, Mallophaga, Siphunculata, Thysanoptera,
3. Insects of economic importance.
4. Brief account of integrated pest management.
5. Concept of economic levels
6. Household pests and their management.
7. Knowledge of pests of cotton, rice, sugarcane.

Practical

1. Collection, preservation and identification of insects up to families.
2. Identification up to species of a few pests of great economic importance with the help of keys/literature.

Recommended Texts

1. Pedigo, L. P., & Rice, M. E. (2015). *Entomology and pest management* (6th ed.). Long Grove: Waveland Press.
2. Richards, O. W., & Davies, R. J. (1977). *Imm's general textbook of entomology* (Vol-II, 10th ed.). London: Chapman & Hall.

Suggested Readings

1. Metcalf, C. L., & Flint, W. P. (2018). *Destructive and useful insects: their habits and control*. New Dehli: Agri Horti Press.

ZOOL-6323 Environmental Issues 3(2+1)

This course is designed to provide review of the different environmental subjects including ecological, conservation, pollution, resources, population and socioeconomic issues of Pakistan. To impart knowledge about management and planning issues using case studies. The environmental study prepares students for careers as leaders in understanding and addressing complex environmental issues from a problem-oriented, interdisciplinary perspective. In this subject students will learn about environmental and social impacts of growing population and affluence by addressing population problems, food production and its distribution, integrated pest management and several types of pollution with their impact on human life and their combating strategies. The learners will also have knowledge about major atmospheric changes due to acid deposition, global warming, greenhouse effect and ozone depletion. Energy sources and issues related to fossil fuel and nuclear power will also be discussed along with the alternate energy resources. In the end of this course students will be able to identify and analyze various environmental issues.

Contents

1. Environmental and social impacts of growing
2. Food production and its distribution
3. Pest and pest control: need and approach to pest control.
4. Water pollution: human impact on water resources,
5. Sewage pollution: sewage hazards and sewage managements.
6. Hazardous chemical pollution: nature of chemical risks, pollution sources and control.
7. Major atmospheric changes: acid deposition, global warming / cooling, greenhouse effect, ozone depletion.
8. Solid waste: landfills, incineration, management and solutions.
9. Energy resources: energy sources and uses; issues related to fossil fuel and nuclear power, alternate energy resources.
10. Environmental issues in Pakistan
11. Issues related to conservation of habitat and biodiversity:
12. Conservation strategies. Industrial pollution: sources and remediation.

Practical

1. Study of the various characteristics of the population with the help of the statistical data (Age profile, family size and educational status, etc.).
2. Study of the types of the pesticides and their characteristics.
3. Study of the relationship between relative humidity and temperature of Lahore for a particular time period.
4. Estimation of total particulate matter in air by using air sampler.
5. Determination of Sodium and Potassium in various water samples using flame photometer.
6. Determination of Chromium, Lead and Copper in industrial effluent.
7. To study the urban environment and urban environmental issues.
8. To study the eutrophic conditions in various ponds.
9. To study noise level at different places in city (main road crossings, railway station, hospital) using noise level meter.
10. To study the level of occurrence of various diseases among families of (i) Class students (ii) Low income groups, high income groups.

Recommended Texts

1. Botkin, D. B., & Keller, E. A. (2000). *Environmental science: earth as a living planet* (3rd ed.). New York: John Wiley and Sons Inc.
2. Wright, R. T., & Nebel, B. J. (2008). *Environmental science* (10th ed.). London: Pearson Prentice Hall

Suggested Readings

1. Bradbury, I. K. (1999). *The biosphere* (2nd ed.). New Jersey: Wiley.
2. Ahmad, R. Z. (2000). *Pakistan- a descriptive atlas: a comprehensive geo-politics course* (1st ed.). Lahore: Feroze sons Pvt. Ltd.
3. Khan, F. K. (1993). *A geography of Pakistan environment (environment, people and economy)* (1st ed.). New York: Oxford University Press.

ZOOL-6324 Fish Physiology and Breeding 3(2+1)

This course is formulated to provide sufficient knowledge about all physiological phenomena in fishes. The objective of this course is to provide practical information to obtain better growth of fishes during extensive or semi-intensive culture, to impart knowledge about breeding of most culturable freshwater fishes by manipulating reproductive and endocrinological aspects during natural season as well as off seasons. The course presents an introduction to physiological adaptations in fish in relation to their environment. An important part of the course relates to functional physiological regulatory mechanisms. The course is adapted to a focus of fish physiology, breeding including other physiological processes in fishes as respiration, circulation, acid-base balance, osmoregulation and ionic regulation, swimming and buoyancy, sensory physiology, egg and larval physiology, digestion, energetic and growth, reproduction, fish health and diseases. In the end of the course the students will also have knowledge of fish migration (to nursery ground, to maturation grounds, freshwater to marine water, and marine water to freshwater) and fish behavior (learning and memory, light response for maturation, courtship behavior, aquarium fish behavior).

Contents

1. Fish nutrition: digestive system, stomach less fishes, stomach fishes, digestion and absorption, food,
2. Transportation: blood, blood cells, circulation, arterial system, venous system, capillaries,
3. Respiration: gills, lungs, skin, swim bladder, homeostasis
4. Excretion: kidneys, osmoregulation
5. Reproduction: gonads, testes and ovaries, artificial fertilization of sex cells.
6. Breeding: natural (seasonal), artificial, hormonal induced breeding, temperature & photoperiod, control induced breeding
7. Growth: extensive culture, semi intensive culture, Intensive culture
8. Fish health: water quality, hygiene of fish culture facilities, hygiene of equipment used in fish culture
9. Diseases and their control: viral, bacterial, fungal, parasitic, protozoan, helminths, arthropods
10. Fish migration: to nursery ground, to maturation grounds, freshwater to marine water, marine water to freshwater
11. Fish behavior: learning and memory, courtship behavior, aquarium fish behavior

Practical

1. Study of gut contents.
2. Study of feeding modification and adaptation in fish.
3. Study of respiratory adaptation in fish.
4. Study of blood cells and their counts in normal and diseased fish.
5. Study of water quality parameters (DO, NH_3, hardness, alkalinity, turbidity, transparency, temperature, salinity).
6. Study of various forms of swim bladder as hydrostatic organ.
7. Study fecundity of various fish species.
8. Study the effects of reproductive hormone (GnRH) on fish maturation.
9. Diagnosis of bacterial infection in infected fish.
10. Study of fish parasites.
11. Visit to various fish seed hatcheries during breeding seasons.

Recommended Texts

1. Kestin, S. C., & Warris, P. D. (2002). *Kestin farmed fish quality*. Oxford: Blackwell Science.
2. Saksena, D. N. (1999). *Ichthyology: recent research advances*. Dehli: Oscar Publications.

Suggested Readings

1. Stickney, R. R. (2016). *Aquaculture* (3rd ed.).Oxfordshire: CABI.
2. Maseke, C. (1987). *Fish aquaculture*. Oxford: Pergamon Press, Oxford.
3. Huet, M. (1973). *Textbook of fish culture: breeding and cultivation*. London: Blackwell Publishing Company.
4. Gorbman, A. (1983). *Comparative endocrinology* (1st ed.). New York: John Wiley & Sons.

ZOOL-6325 **Hematology** **3(2+1)**

This course provides knowledge about blood formation, morphology, physiology and biochemistry of blood cells, basic mechanisms and types. This course presents the functional morphology of blood cells (normal and abnormal), how important blood diseases manifest, and the approaches to diagnosis and treatment of blood and clotting diseases. It imparts knowledge about advanced techniques in studying serological and hematological techniques including blood coagulation. By the end of this course the student should be able to demonstrate an understanding of the components of human blood and characteristics, functions, abnormalities and disease states of each and can demonstrate proficiency in the skills necessary to perform blood cell counts, and evaluation of blood elements within stated limits of accuracy. After the laboratory practice they will be able to apply principles of safety, quality assurance and quality control in hematology, can compare and contrast hematology values under normal and abnormal conditions and can evaluate normal and abnormal cell morphology with associated diseases.

Contents

1. Blood formed elements and plasma.
2. Erythropoiesis and general aspects of anemia 3. Megaloblastic anemia and other meroblastic anemia.
4. Blood collection techniques.
5. Anticoagulants. Hemolytic anemia.
6. Structure, types and genetic disorders of hemoglobin.
7. Leukopoiesis. Lymphocytes, monocytes, granulocytes and their disorders.
8. Platelets and thrombopoiesis.
9. Blood coagulation. Bleeding disorders.

Practical

1. Blood smear of different vertebrates to compare the RBCs morphology.
2. Total erythrocyte and leucocyte counts. Study of granulocytes and agranulocytes.
3. Differential leukocytes. Estimation of Hemoglobin. Study of erythrocytes sedimentation.
4. Comparison of blood counts of diseased (Anemia) and healthy individuals.
5. Morphological alterations in erythrocytes in various disease conditions like sickle cell anemia.

Recommended Texts

1. Hoffbrand, A. V., & Moss, P.A.H. (2002). *Essential hematology*. New York: Blackwell Publishing.
2. Bain, B. J., Bates, I., & Laffan, M. A. (2016). *Dacie & Lewis practical haematology* (12th ed.). London: Elsevier Health Sciences.

Suggested Readings

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., & Watson, J. D. (2017). *Molecular biology of the cell*. New York: Garland Publishing Inc.
2. Cooper, G. (2018). *The cell: A molecular approach* (8th ed.). Oxford: Oxford University Press.

ZOOL-6326 **Ichthyology** **3(2+1)**

This course is formulated to study the evolution and taxonomy of fish, to provide the knowledge regarding fish biology and to elaborate the anatomy and physiology of fish. The overarching goal of this course is to learn how the biological evolution process has shaped the existing taxonomic diversity and physiological variability of fishes. To achieve this goal, students will allow to survey fish diversity and examine the connections between anatomical traits and biological function as exemplified by living fish species. After this course students will be able to describe how the aquatic environment shapes all aspects of the biology of fish species, can explain how anatomy relates to function across major organ systems in fishes and can describe the basic function and organization of fish organ systems. The course focuses on physiological processes in fish including, respiration, circulation, acid-base balance, osmoregulation and ionic regulation, locomotion and energetics of swimming, swimming and buoyancy and digestion and control of gastro-intestinal motility in fish. Therefore, students will be provided an in-depth review of each topic in ichthyology.

Contents

1. Classification of Pisces. Morphological features of fish,
2. Fish muscular system and locomotion.
3. Physiology of respiration and air breathing among fishes.
4. Cardiovascular system, blood and its circulation
5. Digestion and control of gastro-intestinal motility in fish.
6. Physiology of gas bladder: use of gas by the fish as a source of static lift.
7. Gas in the gas bladder: loss, retention and secretion of gas.
8. Process of aestivation in fish. Sensory system and communication in fish: Sound reception

Practical

1. Study of classification of fishes and some selected fish species
2. Study of Fish anatomy, physiology and adaptations, fish dissections
3. Study of fish habitats, fish fauna of Pakistan
4. Study of fish reproduction, oocytes and aquaculture and food requirements
5. Study of environmental, ecological and economic importance of fishes
6. Study of ornamental fishes. Field visits to fish hatcheries

Recommended Texts

1. Lagler, K. F., Baradach, J. E., & Miller, R. R. (2009). *Ichthyology.* New York: John Wiley and Sons, Inc.
2. Moyle, P. B., & Cech, J. J. (2008). *Fishes: An introduction to ichthyology* (6th ed.). New Jersey: Prentice Hall.

Suggested Readings

1. David, H. (2003). *The physiology of fishes* (3rd ed.). Florida: CRC Press.
2. Smith, L. S. (2002). *Introduction to fish physiology* (2nd ed.). Washington DC: Argent Labs.

ZOOL-6327 **Immunology** **3(2+1)**

The course aims to give understanding of the basic concepts of immunology and its importance in biological sciences, provide information about immunological mechanisms against different diseases and gives understanding of immunization, immunological tolerance etc. After this course the students will be able to understand immunobiology, immunophysiology and immunopathology. The course has brief account on natural and acquired immunity, active and passive immunity, antigens and elicitation of immune responses. The students will be able to describe immunological response and how it is triggered and regulated. This subject also focuses on detection and application of antigen-antibody reactions, antigen antibody interactions and monoclonal antibodies. Cellular basis of immune response will also be discussed in detail along with the immunological tolerance and autoimmunity. The students will be able to describe immunological response and how it is triggered and regulated and they acquire for problem solving capacity about immune responsiveness.

Contents

1. Immunology: introduction.
2. Immunity: types: natural and acquired immunity.
3. Antigens and their types, antigenicity, factors important for immunogenicity of an antigen, cell mediated and humoral: nature of antigens
4. Immunoglobulins: synthesis of antibodies, types of antibodies
5. Detection and application of antigen-antibody reactions
6. Antigen antibody interactions
7. Monoclonal antibodies: importance, synthesis. Major histocompatibility complex: types and importance.
8. Cellular basis of immune response: origin of lymphocytes, primary and secondary lymphoid organs, specific response of individual lymphocytes to antigenic stimulation,
9. Hypersensitivity: Immediate hypersensitivity, delayed type or cell mediated hypersensitivity.
10. Immunological tolerance and autoimmunity: autoimmune diseases and types, factors responsible for autoimmunity. Transplantation immunology, immunity against infectious diseases, immuno deficiency diseases.
11. Immunization; immunization procedures, vaccines and their types.

Practical

1. Study of different types of leucocytes in: blood, bone marrow, spleen and thymus in mammals.
2. Estimations of total serum proteins, albumins and globulin concentrations in mammalian blood.
3. Differentiation of globulin proteins in blood serum of mouse by electrophoresis.
4. Diagnosis of immunoglobulin proteins by enzyme linked immunosorbent assay (ELISA).
5. Isolation of lymphocytes and resetting technique.
6. Antigen-antibody reaction by agglutination and precipitation reaction.
7. Antigen antibody reaction by using adjuvant.
8. Diagnosis of typhoid fever by Widal test.
9. Visit to pathological laboratory and report writing.

Recommended Texts

1. Punt, J., Stranford, S., Jones, P., & Owen, J. A. (2018). *Kuby's immunology* (8th ed.). New York: W. H. Freeman Company.
2. Delves, P. J., Martin, J. S., Burton, D. R., & Roitt, I. M. (2017). *Roitt's essential immunology* (13th ed.). New York: Wiley Blackwell.

Suggested Readings

1. Abbas, A., Lichtman, A., & Pilla, S. (2017). *Cellular and molecular immunology* (9th ed.). Amsterdam: Elsevier.
2. Abbas, A. K., Lichtman, A. H., & Pillai, S. (1994). *Cellular and molecular immunology*. London: Elsevier Health Sciences

ZOOL-6328 Integrated Pest Management 3(2+1)

The course aims to impart knowledge about approaches to control pest in an integrated manner. It will develop the understanding of multiple strategies to control various pests of human interest. This course will provide introduction, historical background and geographical distribution of various insect species along factors that makes them pest. Available biological pest control, their identification and distribution will be introduced through these learning's. Students will be given knowledge about biological features and varieties of biological mediators to control insect pests. Theoretical foundation of pest control will be highlighted. Moreover, it includes opportunities and challenges for insect pest control in developing countries, concept of economic threshold level and concept of classical biological control. Understanding about recent strategies which are in practice nationally or internationally to manage pests will be given to students. Several techniques which are commercially used for rearing of biological pest control agents including culturing of bacteria and virus will be familiarized.

Contents

1. Introduction: foundation, approaches and objectives.
2. Opportunities and challenges for insect pest control.
3. Concept of economic threshold level, economic injury level.
4. Ranking of natural enemies, major threats to the natural enemies.
5. Concept of classical biological control.
6. Effects of different agronomic practices on the population of predators.
7. Relationship of biological control to the sustainable agriculture.
8. Augmentation and inoculation of natural enemies.
9. Limitation of biological control and modern trends to overcome this problem.

Practical

1. Collection and identification of important pests and their enemies,
2. Techniques to culture and maintain selected natural enemies of insect pests in the laboratory and in the fields.

Recommended Texts

1. Bradford, A. H., & Howard V. C. (2008). *Theoretical approaches to biological control*. New York: Cambridge University Press.
2. DeBach, P. (1991). *Biological control by natural enemies* (2nd ed.). Cambridge: Cambridge University Press.

Suggested Readings

1. Dent, D. (2005). *Insect pest management* (2nd ed.). London: CABI.
2. Pedigo, L. P., & Rice, M. E. (2015). *Entomology and pest management* (6th ed.). Amsterdam: Waveland Press.
3. Van Driesche, R. G., & Bellows, T. S. Jr. (2012). *Biological control*. London: Springer Science & Business Media.

ZOOL-6329 **Microbiology-I** **3(2+1)**

Microbiology is the study of microorganisms which include: bacteria, viruses, viroids, yeast, molds, protozoans, algae, fungi and other very small organisms. Microbiology is important because it helps us to understand and treat diseases. This course covers basic principles of microbiology and provides an introduction to the characterization and classification of microorganisms and cultivation of bacteria. Students are expected to gain a fundamental understanding of microbes including viruses, Bacteria, Archaea and eukaryotic microorganisms. After completion of the lecture component of the course, successful students will be able to understand morphology and fine structure of bacteria, cultural characteristics and microbial metabolism processes. It will also help students to recognize how microorganisms solve the fundamental problems their environments present. The laboratory practice can help them to study of bacteria, fungi and protozoa, staining techniques and can apply scientific method to collect, interpret, and present scientific data in microbiology and related fields.

Contents

1. Microbiology introduction and history.
2. Microscopic examination of microorganisms.
3. Characterization and classification of microorganisms.
4. Morphology of bacteria.
5. Morphology of Protozoa
6. Methods of bacteria cultivation
7. Culturing techniques
8. Observation of culture and metabolism

Practical

1. Study of bacteria, fungi and protozoa.
2. Staining of microorganisms: simple staining, negative staining.
3. Demonstration of special structures by stains; capsular stain, spore stain, metachromatic granule stain, acid fast stain, flagella stain.

Recommended Texts

1. Benson, H. J. (2002). *Microbial applications: laboratory manual in general microbiology* (8th ed.). London: McGraw-Hill.
2. Pelczar, Jr., Chan, E. C. S., & Krieg, M. R. (2010). *Microbiology: application based approach.* London: McGraw Hill.

Suggested Readings

1. Madigan, M. T. (2009). *Brock biology of microorganisms* (12th ed.). London: Pearson/Benjamin Cummings.
2. Stainier, R. Y., Ingraham, J. L., Wheelis, M. L., & Painter, R. R. (1986). *The microbial world.* London: Prentice Hall.

ZOOL-6330 Microbiology-II 3(2+1)

The course aims to develop knowledge about phylogeny of bacteria, their mode of nutrition and their diversity. The course will impart knowledge about phylogenetic relationship of the bacteria with other prokaryotes. Microbiology is important because it helps us to understand and treat diseases. This course covers basic evolutionary lineage of bacteria (proteobacteria). Students are provided fundamental understanding of phototrophic, chemo lithotrophic and methanotrophic proteobacteria, aerobic and facultative aerobic chemo organotrophic proteobacteria and morphologically unusual proteobacteria. After completion of the lecture component of the course, successful students will be able to understand the structural similarities and differences among delta and epsilon proteobacteria, firmicutes, mollicutes and action bacteria. It will also help students to appreciate the diversity of cyanobacteria and prochlorophytes and can recognize how microorganisms solve the fundamental problems their environments.

Contents

1. Diversity of Archea,
2. The phylogeny of bacteria and proteobacteria,
3. Aerobic and facultative aerobic proteobacteria,
4. Bacterial physiology
5. Delta and epsilon proteobacteria,
6. Firmicutes, mollicutes and actinobacteria,
7. Cyanobacteria and prochlorophytes,
8. Chlamydia, the planctomycetes,
9. Verrucomicrobia, Flavobacteria and Acidobacteria,
10. Cytophaga group, Green Sulfur bacteria, Spirochetes, Dienococci, the green non sulfur bacteria.

Practical

1. Culturing of microorganisms: preparation and sterilization of culture media, broth culture, agar slope, agar slab, streak plates, pour plates.
2. Isolation and stock culturing of bacteria.
3. Quantitative plating method. The turbidimetric estimation of microbial growth.
4. Study of bacterial viruses. Biochemical characterization of bacteria.

Recommended Texts

1. Madigan, M. T. (2009). *Brock biology of microorganisms* (12th ed.). London: Pearson/Benjamin Cummings.
2. Benson, H. J. (2002). *Microbial applications: laboratory manual in general microbiology* (8th ed.). Montreal: McGraw-Hill.

Suggested Readings

1. Pelczar, Jr., Chan, E. C. S., & Krieg, M. R. (2010). *Microbiology: application based approach.* London: McGraw Hill.
2. Stainier, R. Y., Ingraham, J. L., Wheelis, M. L., & Painter, R. R. (1986). *The microbial world.* London: Prentice Hall.

ZOOL-6331 Molecular and Clinical Endocrinology 3(2+1)

The course is designed to develop understanding of molecular mechanisms of hormone action, their molecular assessment and use of molecular techniques to treat endocrine disorders. The course of Molecular and Clinical Endocrinology aims to provide excellence in clinical care for all aspects of health and disease related to endocrine management like thyroid, adrenal, parathyroid, diabetes, pituitary, bone, and obesity and lipid disorders. It also provides an understanding of the general mechanisms in molecular endocrinology, radioimmunoassay, immune radiometric, immune chemiluminometric and radio receptor assays and their statistical procedures. Furthermore, in all body cells, hormones influence the metabolism of nucleotides, proteins, lipids, carbohydrates, vitamins, water, and therefore, knowledge of endocrinology and metabolism is important. The students will study the endocrine system in terms functional pathology in endocrine glands, disorders of growth and puberty, endocrine hypertension and Poly endocrine syndromes. By the end of this course, the students should be able to examine and describe glands and can determine their hormonal impacts.

Contents

1. General mechanisms in molecular endocrinology: subcellular structure of cells secreting protein hormones; Process of hormone secretion;
2. Mechanisms of action of hormones: hormone systems and intracellular communication;
3. Hormones acting at cell surface: properties of hormone receptor interaction,
4. Biochemistry and molecular interaction of steroid receptor, gene expression,
5. Functional pathology in endocrine glands: neuroendocrine disorder of gonadotrophin, prolactin, growth hormone, corticotrophin regulation;
6. Pituitary disorders: prolactinomas, acromegaly, Cushing's syndrome. Diabetes insipidus,
7. Thyroid diseases of excess and deficient hormones
8. Adrenal gland: disorders of cortex; disorders of adrenal medulla
9. Disorders of ovarian function and hormonal therapy; 10. Abnormalities of testicular functions and hormonal therapy.
11. Fuel homeostasis: glucose homeostasis and hypoglycemia; diabetes mellitus; disorders of lipoprotein metabolism; eating disorders: obesity, anorexia nervosa and bulimia nervosa.
12. Development and growth: disorders of growth and puberty.
13. Hormones and Cancers: Hormones Effect on Tumors, Breast and Prostate Cancer;
14. Measurements of hormones: radioimmunoassay, immune radiometric, immune chemiluminometric and radio receptor assays and their statistical procedures

Practical

1. Studies on recognition and response of receptors.
2. Studies of disorders of pituitary by observing anatomical and histological features.
3. Studies of thyroid status in deficient and excess hormone functions.
4. Studies of type 1 and type 2 diabetes mellitus: Epidemiology of the types in population, studies of management of the type 2.
5. Model studies of disorders of ovarian and testicular disorders.
6. Model studies of obesity and anorexia.

7. Studies of hormonal status in puberty and aging.

Recommended Texts

1. Greenspan, F. S., & Strewler, G. J. (2002). *Basic and clinical endocrinology* (5th ed.). London: Prentice Hall International Inc.
2. Larsen, P. R., Kronenberg, H. M., Melmed, S., & Plonsky, K. S. (2003). *William's textbook of endocrinology* (10th ed.). Philadelphia: W.B. Saunders Company.

Suggested Readings

1. DeGroot, L. J., & Jameson, J. L. (2001). *Endocrinology* (4th ed.). Philadelphia: W.B. Saunders.

2. Griffin, J. E., & Ojeda, S. R. (2000). *Textbook of endocrine physiology* (4th ed.). Oxford: Oxford University Press.
3. Neal, J. M. (2000). *Basic endocrinology: an interactive approach.* London: Blackwell Science Inc.

ZOOL-6332 Ornithology 3(2+1)

The course will provide knowledge about bird diversity, avian anatomy, physiology and adaptations, bird behavior and socioeconomic and ecological importance. This course is an advanced undergraduate survey of ornithology. This means that students will learn about both science and birds at the same time. This course combines traditional zoology with an emphasis upon avian biology and diversity, and is delivered along with aspects of conservation management and practices. Students will learn about birds: how to identify them, what are the major characteristics and distinguishing features of the major groups of birds, and how birds function in a diversity of environments. However, this course will also cover a modern scientific approach to birds, which has as its goal not just understanding birds, but using birds as a means to uncover general biological principles that may apply to all living things. Students will acquire by the end of the course a new appreciation and knowledge of birds, additional understanding of biological concepts, and an improved ability to be an active scientist.

Contents

1. Introduction to ornithology, class Aves, taxonomy of birds up to orders, families and major species;
2. Biology of fossil bird's archaeopteryx, archaeornithes, neoornithes;
3. Morphology and surface anatomy of bird, and development structure of feathers, plumage;
4. Structure of bones;
5. Basic embryology of birds;
6. Internal anatomy of birds;
7. Systems physiology;
8. Blood circulatory, cardiovascular physiology, heart, blood cells
9. Respiratory system, air sacs, ventilation of lungs, metabolic rates, oxygen consumption;
10. Urinary system, kidney physiology and production of solid or semisolid excreta, brain physiology and anatomy, special senses, olfaction, vision, taste;
11. Digestive system, anatomy,
12. Morphological and physiological adaptations of birds to flying,
13. Reproductive organs anatomy and physiology
14. Types of behavior in birds
15. Endangered species of birds; bird conservation and sanctuaries.
16. Anatomy and physiology of game and predatory species.
17. Birds of Pakistan: aquatic, forest and game birds and birds of prey.
18. Birds as pests.

Practical

1. Identification characteristics and taxonomy of birds to orders and families
2. Dissection of sparrow, pigeon, myna, other available birds
3. Anatomy of bones, skull, girdles, spine, vertebrae, feathers, plumage
4. Study of gut contents of birds to understand feeding habits
5. Incubation of chicken eggs to learn avian embryogenesis
6. Bird stuffing and preservation of eggs
7. Identification of bird species through feathers and egg shells
8. Beak and claw structures

9. Study of bird songs, recording bird songs, fundamental experimentation to understand bird songs in sensitive and sensorimotor phases
10. Bird watching and preparation of ethograms
11. Study of Predator-prey relationship among birds
12. Study of Brood parasitism
13. Study of flying mechanics through models

Recommended Texts

1. Howell, S. N. G. (2010). *Peterson reference guide to molt in north American birds.* Amzaon: Peterson Reference Guides.
2. Urfi, A. J. (2009). *Birds of India: a literary companion.* New York: Oxford University Press.

Suggested Readings

1. Rank, B. (2004). *Ornithology: ecology and evolution of Darwin's finches.* New Jersey: Princeton. W. H. Freeman.
2. Sibley, D. A., & Alfred, A. (2002). *Sibley's birding basics.* New York: New York Press.
3. Ali, S. S., & Ripley, D. (2001). *Handbook of the birds of India and Pakistan: together with those of Bangladesh, Nepal, Bhutan and Sri Lanka*. Reprint. New Delhi: Oxford University Press.

ZOOL-6333 Physiological Systems and Adaptations 3(2+1)

This course gives details of physiological systems maintaining the homeostasis of animals. Interrelations of the systems and regulatory features of the each system's function will be focused. The major goal of the course is to provide a course of study in mammalian, principally human, systems physiology, building on knowledge of basic physiological principles. Its contents mainly cover cardiovascular system, respiratory system, renal system, gastrointestinal system and osmoregulation. It also focuses on environmental challenges of temperature regulation like temperature and animal energetics, temperature relation of ectotherms, heterotherms and endotherms. Laboratory practice will enable the students to study of heart in prepared frogs, to study blood pressure in various physiological states, study of electrocardiograms and to determine the oxygen consumption in fish and mouse and effects of various factors affecting it. Physiological systems and adaptations also focus on how the metabolic, neuromuscular, cardiovascular, and respiratory systems respond to the demands of varying adaptations and it modifies these systems.

Contents

1. Cardiovascular System: blood and homeostasis
2. Arterial system; microcirculation and lymphatics; control of cardiac output; special circulations: cutaneous, skeletal, coronary, cerebral and fetal.
3. Respiratory System: overview of respiratory system; mechanical aspects of breathing; transport of oxygen and carbon dioxide; respiratory responses in extreme conditions.
4. Renal System: elements of renal function; tubular function in nephron and osmolarity;
5. Gastrointestinal System: gastrointestinal secretions and their control: salivary, gastric, pancreatic and liver; digestion and absorption of carbohydrates, proteins, lipids, vitamins, ions and water; motility of gastrointestinal tract:
6. Osmoregulation: Problems of osmoregulation; obligatory exchange of ions and water; osmoregulators and osmoconformers; osmoregulation in aqueous and terrestrial environments.
7. Environmental challenges: temperature relation of ectotherms, heterotherms and endotherms; dormancy: special metabolic state;
8. Body rhythms.

Practical

1. Experiments on the study of heart in prepared frogs.
2. Study of blood pressure in various physiological states.
3. Study of electrocardiograms.
4. Blood coagulation study. Determination of oxygen consumption in fish and mouse and effects of factors.
5. Demonstration of respiratory volume and pulmonary function tests.
6. Experiments on digestion on nutrients by enzymes and effects of factors; Study of exocrine secretion in stomach or pancreas and effects of factors. Experiments on kidney regulation of osmolality.
7. Urine analysis.
8. Study of osmoregulatory adaptations in animals inhabiting various environments; Demonstration of effect of temperature on several physiological responses; Study of animals in various types of dormancy.

Recommended Texts

1. Randall, D., Burggren, W., French, K., & Fernald, R. (2002). *Eckert animal physiology: mechanisms and adaptations* (5th ed.). New York: W.H. Freeman & Company.
2. Tharp, G., & Woodman, D. (2002). *Experiments in physiology* (8th ed.). London: Prentice Hall.

Suggested Readings

1. Berne, R. M., & Levy, M. N. (2000). *Principles of physiology* (3rd ed.). St. Lious: Mosby.
2. Guyton, A. C., & Hall, J. E. (2015). *Textbook of medical physiology* (12th ed.). Philadelphia: W.B. Saunders Company.

ZOOL-6334 Physiology of Reproduction 3(2+1)

The course aims to provide knowledge about reproductive system and its role in the behavior of the animals. It will enable the students to develop the understanding about the role of sex hormone in sexual behavior and their interaction during development. The major objective of this course is to provide students with a sound coverage of human reproductive physiology within the framework of human body. This is achieved by first covering fundamentals of the structure and function of the male and female reproductive tracts, gametogenesis, fertilization, early embryogenesis, fetal development and preparation for birth, contraceptive methods and maternal adaptations to pregnancy. It particularly emphasize on the hormonal control of reproduction. This in turn provides an important foundation to consider sexual differentiation and development, contraception, infertility and current reproductive technologies. Finally, human reproductive behavior and its implications to our future are considered in the light of our evolutionary history, culture and society.

Contents

1. Introduction, sex determination and differentiation:
2. Hormonal and neural factors and their interaction in ovarian, testicular and reproductive targets functions;
3. The interactions in development in estrous and menstrual cycle
4. Reproductive behaviors: Physiological basis of male and female sexual behavior and maternal behavior;
5. Endocrine basis of communication in reproduction
6. Pheromone in mammalian reproduction;
7. Rhythms in reproduction and pregnancy;
8. Hormonal mechanism in fertilization, zygote transport and implantation.
9. Placental steroid and polypeptide hormones; maternal metabolism gestation, hormonal mechanism in parturition.
10. Lactation: Hormonal mechanism in lactation,
11. Hormonal and metabolic aspects in menopause
12. Fertility control mechanisms in male and female

Practical

1. Study of male and female reproductive tract; physiological histology of segments of male and female reproductive tracts;
2. Recognition of spermatogonial cells, ovarian follicles and corpus luteum in gonads; study of hormonal mechanisms in super ovulation and implantation;
3. Tests for pregnancy recognition;
4. Experiments on role of gonads in maintenance of accessory sex gland in males and target structures in females;
5. Study of fertility control procedures in populations.

Recommended Texts

1. Evert, B. J., & Johnson, M. H. (2000). *Essential reproduction.* Oxford: Blackwell Science Inc.
2. Larsen, P. R., Kronenberg, H. M., Melmed, S., & Plonsky, K. S. (2003). *William's textbook of endocrinology* (10th ed.). Philadelphia: W.B. Saunders Company.

Suggested Readings

1. Knobil, E., & Neill, J. D. (2006). *The physiology of reproduction* (Vol. 2). Housten: Gulf Professional Publishing.

ZOOL-6335 Principles of Parasitology 3(2+1)

This course will provide knowledge regarding different modes of transmission of parasites of medical and veterinary importance knowledge about their pathology, host parasite relationship and control measures. Overall aim of the course is to provide students with knowledge concerning biological, epidemiological and ecological aspects of parasites causing diseases to humans, enable them to understand the pathogenesis, clinical presentations and complications of parasitic diseases, to establish knowledge regarding pathogenesis, clinical presentations and complications of parasitic diseases and to provide students with adequate knowledge about endemic parasites and national parasitic problems as well as re-emerging parasitic infection. By the end of the courses, students will be able to describe the world distribution of important parasitic infections and the epidemiologic principles and the effect of social and demographic patterns on parasitic disease and vulnerability and can describe molecular, biochemical and cellular mechanisms that occur in the body of humans infected with parasites.

Contents

1. Introduction to parasitology.
2. Relationship to other sciences.
3. Some basic definitions: basic principles and concepts.
4. Immunology and pathology.
5. Susceptibility and resistance, innate defense mechanisms.
6. Acquired immune response in vertebrates
7. Immunodiagnosis and pathogenesis of parasitic infections.
8. Host-parasite relationship.
9. Parasitic protozoa, form, function and classification: Kinetoplasta, trypanosomes and their kin, forms of trypanosomatidae.
10. The Amoebas: Order Amoebida, order Schizopyrenida.
11. Phylum Apicomplexa, Gregarines, Coccidia and relatedorganisms. 12. Phylum ciliophora, ciliated protistan parasites,
13. Classification of Phylum Mesozoa.
14. Systematics, morphology and biology of Arthropods (causing or responsible for transmission of disease).
15. Chemical and non-chemical control of Arthropods of medical and veterinary importance.
16. Pathology of Helminths: host parasite relationships and control of parasitic Helminths with particular reference to Helminths of Medical and Veterinary importance.

Practical

1. Preparation of temporary and permanent slides and identification of parasitic protozoan and local helminthes of medical and veterinary importance.
2. Section cutting of the infected tissues and the study of their pathology.
3. Methods of collection, preservation and transportation of parasitic material.
4. Qualitative and quantitative fecal examination for helminth ova.
5. Collection, preservation and preparation of slides of local helminthes and their identification.
6. Identification of insects of medical and veterinary importance.

Recommended Texts

1. Roberts, L. S., & Janovy, J. Jr. (2005). *Foundations of parasitology* (7th ed.). Chicago, London, Tokyo, Toronto: W.M. Brown Publishers.
2. Urquhart, G. M., Hucan, J. L., Dunn, A. M., & Jennings, F. W. (2000). *Veterinary parasitology.* London: Longman Scientific and Technical publications.

Suggested Readings

1. Watson, J. M. (2014). *Introduction to animal parasitology.* London: Elsevier
2. Cheesbrough, M. (2006). *Laboratory practice in tropical countries* (2nd ed.). Cambridge: University Press Cambridge.

ZOOL-6336 Principles and Kinetics of Toxicology 3(2+1)

The course objectives are to provide knowledge about the nature and mode of action of different categories of toxicants and to provide knowledge about the procedural protocols used in toxicological studies. The major contents of the course includes measuring toxicity and assessing risk, chemistry of toxicants; toxicity testing methods; routes of exposure, responses to varying doses of substances and LD50 experiments. Toxico kinetics aims to empower the students with the understanding of absorption and bioavailability and contrasting kinetics of lipophilic substances, routes of absorption (the oral, respiratory and dermal) and elimination. In addition, students will learn about bio transformation (phase I reaction and phase II reaction), cellular sites of action, effect of toxicants on enzymes and mechanism of cell death (apoptosis, necrosis, stress, repair) and recovery. The aim of this subject is to train high-quality scientists in applied toxicology with a heightened respect for the environment. Students will develop a broad range of skills, knowledge and experience required for successful careers.

Contents

1. Introduction, Chemistry of toxicants; routes of exposure, responses to varying doses of substances, time of exposure; the LD50 experiments,
2. Toxicokinetics: Introduction; pharmacokinetics and toxicokinetics,
3. Absorption: the oral, respiratory and dermal route of exposure, distribution, Elimination, toxicokinetic models: mathematical models of elimination, Absorption and bioavailability; contrasting kinetics of lipophilic substances.
4. Biotransformation: Introduction, Primary biotransformation (phase I reaction)
5. Secondary metabolism (phase II reaction).
6. Cellular sites of action, introduction, interaction of toxicants with proteins,
7. Effect of toxicants on enzymes, receptors and ion channels,
8. Effects of toxicants on lipids and nucleic acids,
9. Mechanism of cell death; apoptosis, necrosis, stress, repair and recovery.

Practical

1. Study of Biotoxicity assay for LC50.
2. Study the effects of different teratogenic chemicals on the development of human/rat embryo.
3. Study the effect of Ethanol on the development of chick embryo with different doses.
4. Study the effect of Xylene on the development of chick embryo.

Recommended Texts

1. Stine, K. E., & Brown, T. M. (2015). *Principles of toxicology.* London: CRC press, Taylor and Francis Group.
2. Marquardt, H., Schafer, S. G., Mcclellan, R. O., & Welsch, F. (2004). *Toxicology*. San Diego: Academic press.
3. Barile, F. A. (2013). *Principles of toxicology testing*. London: CRC Press, Taylor and Franci