University of Agriculture, Faisalabad

Faculty of Sciences

Department of Zoology, Wildlife and Fisheries

B.S. Zoology

Vision

The Department of Zoology. Wildlife and Fisheries aspires to become a leading institute of higher education in zoological sciences for promoting food biosecurity, healthy environment, conservation and management of bio-resources through development of comprehensive knowledge and skills of zoology.

Mission

The mission of the Department of Zoology, Wildlife and Fisheries is to,

- Focus on quality education in zoology and improving technical manpower in multifarious disciplines of Zoology, particularly aimed at addressing the local problems of national interest.
- Educate, services provision and inspire youth in zoological science, to work vigorously in education and research under different disciplines of Zoology such as the biodiversity, wildlife, biology and ecology of aquatic and terrestrial animals, aquatic toxicology, fish genetic resource management and freshwater fisheries.
- Train the youth for leadership through development of intellectual, interpersonal and social skills.

Program Educational Objectives (PEOs)

After 4 years of graduation i.e. BS Zoology, the graduates will be able to;

1. Demonstrate the principles of organization and inter-relationship in the biological systems with reference to animal diversity to achieve goals of sustainable development and food security.
2. Paraphrase the knowledge for advanced studies and specialization on recently emerging technological and multidisciplinary fields such as genetic engineering, biodiversity, environmental science, wildlife & conservation, fisheries & aquaculture, pests & pest management, biotechnology and genetic resource management.
3. Demonstrate professional skills in teaching / research/ managerial positions in wide range of professions related to zoology, wildlife and Fisheries in national and international organizations.

Program Learning Outcomes (PLOs) (Graduate Attributes)

Knowledge: Recognition of basic and applied familiarities of zoological science.

Problem Analysis: Demonstration of zoological knowledge to conserve the biodiversity, environmental management and food security.

Design/Development of Solutions: Apprise the skills for solution of declining biodiversity, pest management and sustainable ecosystem management.

Investigation: Discriminate the causes and threats to ecosystem management, bio-resource management and sustainable food production.

Modern Tool Usage: Restate the latest technologies in the field of zoological science like genetic engineering, bio-geographic tools and eco-friendly technologies.

Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of practice.

Individual and Team Work: Reproduce ability to work effectively, as an individual or in a team, on multifaceted areas of zoological science.

Lifelong Learning: Paraphrase the significance of animals with reference to sustainable biosphere/ ecosystem management and food resource management.

Revised Scheme of Studies for BS Zoology (4 years), 2023

HEC COURSE CATEGORY	UAF SELECTION FOR BS ZOOLOGY		
	COURSE CODE	COURSE TITLE	CREDIT HOURS
GENERAL- I	FA-310	INTRODUCTION TO ART AND HUMANITIES	2(2-0)
GENERAL- II	PY-307	FUNDAMENTALS OF NATURAL SCIENCES	3(2-1)
GENERAL- III	SOC-311	INTRODUCTION TO SOCIOLOGY	2(2-0)
GENERAL- IV	ENG-313	FUNCTIONAL ENGLISH	3(3-0)
GENERAL- V	ENG-314	EXPOSITORY WRITING	3(3-0)
GENERAL- VI	MATH-408	QUANTITATIVE REASONING I	3(3-0)
GENERAL- VII	STAT-408	QUANTITATIVE REASONING II	3(3-0)
GENERAL- VIII	IS-401/ SSH-306	ISLAMIC STUDIES/ ETHICS	2(2-0)/ 2(2-0)
GENERAL- IX	SSH-303	IDEOLOGY AND CONSTITUTION OF PAKISTAN	2(2-0)
GENERAL- X	CS-305	APPLICATIONS OF INFORMATION AND COMMUNICATION TECHNOLOGIES	3(2-1)
GENERAL- XI	BMS-402	ENTREPRENEURSHIP	2(2-0)
GENERAL- XII	EDU-306	CIVICS AND COMMUNITY ENGAGEMENT	2(2-0)
GENERAL- XIII	IS-402/SSH-403	ترجمہ ٔ قرآن / INTERFAITH HORMNY	1(1-0)
GENERAL- XIV	IS-403	روحانیت	1(1-0)
	TGM	TUTORIAL GROUP MEETING	NON CREDIT

		Total Credit Hours	**32**
ALLIED-I	CHEM-310	FUNDAMENTALS OF INORGANIC CHEMISTRY	4(3-1)
ALLIED-II	CHEM-311	FUNDAMENTALS OF ORGANIC CHEMISTRY	4(3-1)
ALLIED-III	BOT-301	DIVERSITY OF PLANTS	4(3-1)
ALLIED-IV	ABG-510	GENERAL GENETICS	4(3-1)
ALLIED-V	BIOCHEM-300	ESSENTIALS OF BIOCHEMISTRY	3(3-0)
ALLIED-VI	BINFO-403	INTRODUCTION TO BIOINFORMATICS	3(2-1)
		Total Credit Hours	**22**
MAJ0R-I	ZOOL-301	ANIMAL DIVERSITY-I	4(3-1)
MAJ0R-II	ZOOL-302	ANIMAL DIVERSITY-II	4(3-1)
MAJ0R-III	ZOOL-402	ANIMAL CELL BIOLOGY	4(3-1)
MAJ0R-IV	ZOOL-406	INTRODUCTION TO WILDLIFE	4(3-1)
MAJ0R-V	ZOOL-407	BIOLOGICAL TECHNIQUES	3(1-2)
MAJ0R-VI	ZOOL-408	ANIMAL FORM AND FUNCTION-I	4(3-1)
MAJ0R-VII	ZOOL-501	ANIMAL ECOLOGY	3(2-1)
MAJ0R-VIII	ZOOL-502	ICHTHYOLOGY	4(3-1)
MAJ0R-VIV	ZOOL-503	ANIMAL FORM AND FUNCTION-II	4(3-1)
MAJ0R-X	ZOOL-504	ETHOLOGY	3(2-1)
MAJ0R-XI	ZOOL-505	EVOLUTION	3(3-0)
MAJ0R-XII	ZOOL-506	PRINCIPLES OF SYSTEMATICS	3(2-1)
MAJ0R-XIII	ZOOL-507	COMPARATIVE ANIMAL PHYSIOLOGY	3(2-1)
MAJ0R-XIV	ZOOL-508	ECONOMIC ZOOLOGY	3(2-1)
MAJ0R-XV	ZOOL-509	FISHERIES	4(3-1)
MAJ0R-XVI	ZOOL-510	ZOOGEOGRAPHY AND PALEONTOLOGY	3(2-1)
MAJ0R-XVII	ZOOL-601	ENVIRONMENTAL TOXICOLOGY	3(2-1)
MAJ0R-XVIII	ZOOL-602	CONSERVATION BIOLOGY	4(3-1)
MAJ0R-XIX	ZOOL-603	DEVELOPMENTAL BIOLOGY	4(3-1)
MAJ0R-XX	ZOOL-604	FUNDAMENTALS OF MOLECULAR BIOLOGY	3(2-1)
MAJ0R-XXI	ZOOL-620	SEMINAR	1(1-0)
		Total Credit Hours	
INTERNSHIP	ZOOL-621	INTERNSHIP	3(0-3)
CAPSTONE PROJECT	ZOOL-622	TECHNICAL REPORT	3(0-3)
		Total Credit Hours	**06**
GRAND TOTAL: 32+22+72+06 =132 Credit Hours			

UNIVERSITY OF AGRICULTURE, FAISALABAD

Department of Zoology, Wildlife and Fisheries

Revised Scheme of Studies for BS Zoology 2023

FIRST SEMESTER

COURSE CODE	COURSE TITLE	CREDIT HOURS
FA-310	INTRODUCTION TO ART AND HUMANITIES	2(2-0)
SOC-311	INTRODUCTION TO SOCIOLOGY	2(2-0)
ENG-313	FUNCTIONAL ENGLISH	3(3-0)
MATH-408	QUANTITATIVE REASONING I	3(3-0)
SSH-303	IDEOLOGY AND CONSTITUTION OF PAKISTAN	2(2-0)
CHEM-310	FUNDAMENTALS OF INORGANIC CHEMISTRY	4(3-1)
ZOOL-301	ANIMAL DIVERSITY-I	4(3-1)
TGM	TUTORIAL GROUP MEETING	NON CREDIT
	TOTAL CREDIT HOURS	**20**

SECOND SEMESTER

COURSE CODE	COURSE TITLE	CREDIT HOURS
ENG-314	EXPOSITORY WRITING	3(3-0)
STAT-408	QUANTITATIVE REASONING II	3(3-0)
BMS-402	ENTREPRENEURSHIP	2(2-0)
CHEM-311	FUNDAMENTALS OF ORGANIC CHEMISTRY	4(3-1)
BOT-301	DIVERSITY OF PLANTS	4(3-1)
ZOOL-302	ANIMAL DIVERSITY-II	4(3-1)
TGM	TUTORIAL GROUP MEETING	NON CREDIT
	TOTAL CREDIT HOURS	**20**

THIRD SEMESTER

COURSE CODE	COURSE TITLE	CREDIT HOURS
PY-307	FUNDAMENTALS OF NATURAL SCIENCE	3(2-1)
IS-401/ SSH-306	ISLAMIC STUDIES/ ETHICS	2(2-0)/ 2(2-0)
CS-305	APPLICATIONS OF INFORMATION AND COMMUNICATION TECHNOLOGIES	3(2-1)
IS-402/ SSH-403	ترجمہ ٔ قرآن / INTERFAITH HORMNY	1(1-0)
ABG-510	GENERAL GENETICS	4(3-1)
BIOCHEM-300	ESSENTIALS OF BIOCHEMISTRY	3(3-0)
ZOOL-402	ANIMAL CELL BIOLOGY	4(3-1)
TGM	TUTORIAL GROUP MEETING	NON CREDIT
	TOTAL CREDIT HOURS	**20**

FOURTH SEMESTER

COURSE CODE	COURSE TITLE	CREDIT HOURS
IS-403	روحانیت	1(1-0)
EDU-306	CIVICS AND COMMUNITY ENGAGEMENT	2(2-0)
BINFO-403	INTRODUCTION TO BIOINFORMATICS	3(2-1)
ZOOL-406	INTRODUCTION TO WILDLIFE	4(3-1)
ZOOL-407	BIOLOGICAL TECHNIQUES	3(1-2)
ZOOL-408	ANIMAL FORM AND FUNCTION-I	4(3-1)
TGM	TUTORIAL GROUP MEETING	NON CREDIT
	TOTAL CREDITS HOURS	**17**

FIFTH SEMESTER

COURSE CODE	COURSE TITLE	CREDIT HOURS
ZOOL-501	ANIMAL ECOLOGY	3(2-1)
ZOOL-502	ICHTHYOLOGY	4(3-1)
ZOOL-503	ANIMAL FORM AND FUNCTION-II	4(3-1)
ZOOL-504	ETHOLOGY	3(2-1)
ZOOL-505	EVOLUTION	3(3-0)
TGM	TUTORIAL GROUP MEETING	NON CREDIT
	TOTAL CREDIT HOURS	**17**

SIXTH SEMESTER

COURSE CODE	COURSE TITLE	CREDIT HOURS
ZOOL-506	PRINCIPLES OF SYSTEMATICS	3(2-1)
ZOOL-507	COMPARATIVE ANIMAL PHYSIOLOGY	4(3-1)
ZOOL-508	ECONOMIC ZOOLOGY	3(2-1)
ZOOL-509	FISHERIES	4(3-1)
ZOOL-510	ZOOGEOGRAPHY AND PALEONTOLOGY	3(2-1)
TGM	TUTORIAL GROUP MEETING	NON CREDIT
	TOTAL CREDIT HOURS	**17**

SEVENTH SEMESTER

COURSE CODE	COURSE TITLE	CREDIT HOURS
ZOOL-601	ENVIRONMENTAL TOXICOLOGY	3(2-1)
ZOOL-602	CONSERVATION BIOLOGY	4(3-1)
ZOOL-603	DEVELOPMENTAL BIOLOGY	4(3-1)
ZOOL-604	FUNDAMENTALS OF MOLECULAR BIOLOGY	3(2-1)
TGM	TUTORIAL GROUP MEETING	NON CREDIT
	TOTAL CREDIT HOURS	**14**

EIGHTH SEMESTER

COURSE CODE	COURSE TITLE	CREDIT HOURS
ZOOL-620	SEMINAR	1(1-0)
ZOOL-621	INTERNSHIP	3(0-3)
ZOOL-622	TECHNICAL REPORT	3(0-3)
TGM	TUTORIAL GROUP MEETING	NON CREDIT
	TOTAL CREDIT HOURS	**07**

Total Credit Hours for BS Zoology (4-Years):

Sem. I	Sem. II	Sem. III	Sem. IV	Sem. V	Sem. VI	Sem. VII	Sem. VIII	**Total**
20	20	20	17	17	17	14	07	**132**

Revised Scheme of Studies for BS Zoology 2023

Existing			Proposed/ Revised		
Course Code	**Course Title**	**Credit Hours**	**Course Code**	**Course Title**	**Credit Hours**
ZOOL-301	ANIMAL DIVERSITY-I	4(3-1)		***No Change***	
ZOOL-302	ANIMAL DIVERSITY-II	4(3-1)		***No Change***	
ZOOL-501	ANIMAL CELL BIOLOGY	4(3-1)	ZOOL-402	ANIMAL CELL BIOLOGY	4(3-1)
ZOOL-402	INTRODUCTION TO WILDLIFE	4(3-1)	ZOOL-406	INTRODUCTION TO WILDLIFE	4(3-1)
	New Course		ZOOL-407	BIOLOGICAL TECHNIQUES	3(1-2)
	New Course		ZOOL-408	ANIMAL FORMS AND FUNCTIONS-I	4(3-1)
ZOOL-502	ANIMAL ECOLOGY	3(2-1)	ZOOL-501	ANIMAL ECOLOGY	3(2-1)
ZOOL-503	ICHTHYOLOGY	4(3-1)	ZOOL-502	ICHTHYOLOGY	4(3-1)
	New Course		ZOOL-503	ANIMAL FORMS AND FUNCTIONS-II	4(3-1)
ZOOL-505	ETHOLOGY	3(2-1)	ZOOL-504	ETHOLOGY	3(2-1)
	New Course		ZOOL-505	EVOLUTION	3(3-0)
	New Course		ZOOL-506	PRINCIPLES OF SYSTEMATICS	3(2-1)
	New Course		ZOOL-507	COMPARATIVE ANIMAL PHYSIOLOGY	3(2-1)
ZOOL-602	ECONOMIC ZOOLOGY	3(2-1)	ZOOL-508	ECONOMIC ZOOLOGY	3(2-1)
ZOOL-603	FISHERIES	4(3-1)	ZOOL-509	FISHERIES	4(3-1)
ZOOL-407	ZOOGEOGRAPHY AND PALEONTOLOGY	4(3-1)	ZOOL-510	ZOOGEOGRAPHY AND PALEONTOLOGY	3(2-1)
	New Course		ZOOL-601	ENVIRONMENTAL TOXICOLOGY	3(2-1)
ZOOL-601	CONSERVATION BIOLOGY	4(3-1)	ZOOL-602	CONSERVATION BIOLOGY	4(3-1)
ZOOL-406	DEVELOPMENTAL BIOLOGY	4(3-1)	ZOOL-603	DEVELOPMENTAL BIOLOGY	4(3-1)
	New Course		ZOOL-604	FUNDAMENTALS OF MOLECULAR BIOLOGY	3(2-1)
	New Course		ZOOL-620	SEMINAR	1(1-0)
	New Course		ZOOL-621	INTERNSHIP	3(0-3)
ZOOL-621	TECHNICAL REPORT	3(0-3)	ZOOL-622	TECHNICAL REPORT	3(0-3)
ZOOL-408	EVOLUTION AND PRINCIPLES OF SYSTEMATICS	3(3-0)		***Deleted***	
ZOOL-504	COMPARATIVE ANIMAL ANATOMY AND PHYSIOLOGY	3(2-1)		***Deleted***	
ZOOL-506	PRINCIPLES OF WILDLIFE MANAGEMENT	3(2-1)		***Deleted***	
ZOOL-604	FISH ECOLOGY	3(2-1)		***Deleted***	
ZOOL-605	LIMNOLOGY	3(2-1)		***Deleted***	
ZOOL-606	FISH AND AQUATIC TOXICOLOGY	3(2-1)		***Deleted***	
ZOOL-608	ESSENTIALS OF WILDLIFE CONSERVATION	3(2-1)		***Deleted***	
ZOOL-612	FISH BREEDING AND HEALTH	3(2-1)		***Deleted***	

Detailed Course Contents

ZOOL-301 ANIMAL DIVERSITY-I 4(3-1)

Course Learning Outcomes

By the end of this course students will be able to:

1. Identify the importance of animal diversity, and what biodiversity is.
2. Explain diversity, and systematics of animals.
3. Discuss the evolutionary history of the animal kingdom.
4. Describe the invertebrate fauna.

Theory

Major subdivisions of animal kingdom along with evolutionary perspective, taxonomy, phylogeny and general organizations (Structure, function, mode of life, reproduction, life cycles, adaptation, distribution and economic importance of major groups. Animal–like Protists: The Protozoa; Origin and phylogenetic relationship of protozoa; Protozoan taxonomy; Economic importance and harmful protozoa. Multicellular and Tissue Levels of Organization: Origins of multicellularity; Phylum Porifera: Evolution of canal system; skeleton and reproductive system in Porifera. Cnidaria (Coelenterate): Body wall and nematocysts; Polymorphism; Reproduction and classification up to class; Coral and coral reefs; Platyhelminthes: The triploblastic acoelomate body plan; Free-living flatworms and the tapeworms; Arasitic adaptation; Nematoda: The pseudocoelomate body plan: Aschelminthes: Feeding and the digestive system; Reproduction and development; Parasitic nematodes of humans. Annelida: The metameric body form; Phylogenetic consideration; Metamerism and tagmatization; Feeding and the digestive system; Gas exchange and circulation, nervous and sensory functions, excretion, regeneration, reproduction and development in different classes. Mollusca: Relationships to other animals; Origin of coelom; Molluscan characteristics; Classification up to class; Systems: feeding, digestion, gas exchange, locomotion, reproduction and development, other maintenance functions; Torsion and shell in Mollusca. Arthropoda: Blueprint for success; Classification; Metamerism and tagmatization; The exoskeleton; Metamorphosis; Ecdysis; Appendages; Feeding; Respiration; Social insect; Economic importance of insects; Echinodermata: Characteristics and Classification; Regeneration; Reproduction and development; Skeleton; Water vascular system.

Practical

Study of museum specimens and their classification; Study of morphological and anatomical features of some representatives of different Phyla; Microscopic studies of various tissues of vertebrates; Skeletons of rabbit and frog; Dissection of reprehensive of each major invertebrate taxon

Suggested Readings

1. El-Bawab, F. 2020. Invertebrate Embryology and Reproduction, Academic Press, USA.
2. Giribet, G. and G.D. Edgecombe. 2020. The Invertebrate Tree of Life, Princeton University Press. USA.
3. Hickman, C.P., L.S. Roberts and A. Larson. 2017. Integrated Principles of Zoology, 17th Ed. McGraw Hill. Singapore.

4. Miller, S.A. and J.B. Harley. 2016. Zoology, 10th Ed. McGraw Hill. Singapore.
5. Pechenik, J.A. 2015. Biology of Invertebrates, 7th Ed. McGraw Hill. Singapore.
6. Watson, R., 2020. Invertebrate Zoology, Syrawood Publishing House. New York, USA.

ZOOL-302 ANIMAL DIVERSITY-II 4(3-1)

Course Learning Outcomes

By the end of this course students will be able to:

1. Understand the community structure and adaptations of animals to changing environments.
2. Know that they share their environment with many other animals.
3. Compare differences among individuals of higher animals.
4. Demonstrate vertebrate tax on the globe.

Theory

Protochrodates: Structure, anatomy and organ systems; reproduction; Life histories and metamorphosis; Origin of chordates; Basic plan of vertebrate body; Earliest known vertebrates. Phylogenetic relationships; further phylogenetic considerations; Fishes: Vertebrate success in water; Primitive jawed vertebrates, Evolution of jaw in vertebrata, Agnatha and Gnathostomata; Locomotory adaptations; Nutrition and the digestive system; Circulation; Gaseous exchange; Nervous and sensory functions; Swim bladder in fishes; Excretion and osmoregulation; Reproduction and development; Amphibian: First terrestrial vertebrates: Evolutionary perspective; Caudata, Gymnophiona, and Anura; Structure and locomotory adaptations; Nutrition and digestive system; Circulation; Gasous exchange; Thermoregulation; Nervous and sensory functions; Excretion and osmoregulation; Reproduction and development; Metamorphosis; Phylogenetic considerations; Reptile: The first amniotes; Evolution of reptilia; Rise and fall of reptiles; Extinction of dinosaurs; Cladistic interpretation of the amniotic lineage; Testudines or Chelonia, Rhynchocephalia, Squamata, and Crocodilia; Adaptations in external structure and locomotion; Nutrition and the digestive system; Circulation; Exchange of gases; Thermoregulation; Nervous and sensory functions; Excretion and osmoregulation; Reproduction and development; Aves: Birds: Feathers, Flight and endothermy; Evolution of flight in Aves; Aerial adaptation; Diversity of modern birds; Adaptation in external structure and locomotion; Nutrition and the digestive system; Circulation; Gasous exchange; Nervous and sensory systems; Eexcretion and osmoregulation; Reproduction and development; Migration and navigation; Mammalia: Origin of mammals; Evolutionary perspectives; Characteristic features; Mammalian diversity; Adaptations in external structure and locomotion; Nutrition and digestive system; Circulation; Gasous exchange; Thermoregulation; Nervous and sensory functions; Excretion and osmoregulation; Behavior; Reproduction and development; Dentition and vertebrae; Comparative account of evolution of heart, gridles, skull, development, nervous system, stomach and urinogenital ducts in vertebrates.

Practical

Museum study of Protochordates, Pisces, Amphibia, Reptilia, Aves, Mammalia; Field trips to study animal diversity in an ecosystem; Dissection of reprehensive of each major vertebrate taxon

Suggested Readings

1. Hickman, C., S. Keen, D. Eisenhour, A. Larson and H. I'Anson. 2020. Integrated Principles of Zoology, 18th Ed. McGraw Hill. Singapore.
2. Hickman, C.P., L.S. Roberts and A. Larson. 2017. Integrated Principles of Zoology, 17th Ed. McGraw Hill. Singapore.
3. Linzey D.W. 2020. Vertebrate Biology Systematics, Taxonomy, Natural History, and Conservation. 3rd Ed. John Hopkins University Press, USA.
4. Miller, S.A. and J.B. Harley. 2016. Zoology, 10th Ed. McGraw Hill. Singapore.
5. Urry L.A., M.L. Cain, S.A. Wasserman, P.V. Minorsky, and J.B. Reece. 2014. Biology 11th Ed. Benjamin/Cummings Publishing Company, Inc., California, USA.

ZOOL-402 ANIMAL CELL BIOLOGY 4(3-1)

Learning Objective

By the end of this course students will be able to:

1. Recognize structures and basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.
2. Demonstrate different techniques used to study the animal cells.
3. Illustrate the cellular division i.e., mitosis and meiosis.
4. Apply their knowledge of cell biology to understand the reasons of changes in cell function.

Theory

History of cell and molecular biology; Cell Theory, prokaryotes, eukaryotes, actinomycetes, mycoplasmas, virus, virion, viroids, prions; Microscopy: Light microscope and electron microscope; Cell fractionation; Cell membrane, membrane receptors and permeability; Molecular models of cell membrane: Sandwich, unit membrane and fluid mosaic model; Plasma membrane: Chemical composition, structure and functions; Modifications of plasma membrane: Microvilli, tight junction, gap junction, desmosomes; Cell membrane permeability: Diffusion, osmosis, passive transport, active transport, endocytosis, phagocytosis, cell coat and cell recognition; Cytoskeleton: Microfilaments, microtubules and intermediate filaments; Endomembrane system: Structural and functional commonalities; Ultrastructure, chemical composition and functions of endoplasmic reticulum with special reference to their role in protein synthesis and drug metabolism; Golgi apparatus: Role in synthesis of glycoprotein; Mitochondria: Cellular respiration and its significance as semi-autonomous organelle; Metabolism: Carbohydrates, lipids, proteins and minerals; Lysosome: Diverse roles due to hydrolytic activity of enzymes; Peroxisome: Metabolism of hydrogen peroxide; Glycoxysome: Glyoxylic acid cycle; Nucleus: Structure and functions, nuclear membrane and nucleolus; Chromatin, heterochromatin, euchromatin, chromosome structure with reference to coiling and nucleosome during different phases of cell cycle; Cell cycle and its different phases. Molecular control of cell cycle; Apoptosis, cancer and its types; Cell communication: Cell signaling and signal hypothesis; Signaling molecules: Neurotransmitters, hormones, growth factors, cytokines, vitamin A and D derivatives; Role of cyclic AMP. Nucleus: chromatin, heterochromatin, euchromatin, chromosome structure, coiling and nucleosome during different phases of cell cycle. 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., Transcription: variety of RNA and their characteristics, synthesis of mRNA, rRNA and tRNA with special reference to enzymes involved, RNA splicing, split genes, concept of ribozymes and posttranscriptional processing, RNA transduction, Genetic code, point mutations. Translation: Specific role of Ribosomes, various factors, and posttranslational processing, control of gene expression in Prokaryotes.

Practical

Microscopy and staining techniques; Squash preparation of onion root tip for mitotic stages; Preparation of temporary and permanent whole mount; Mounting of polytene chromosomes of drosophila; Studying tissues by permanent slides: Epithelial, striated and smooth muscles, cartilage and bone; Identification of different types of blood cells in human blood through smear technique; Counting of prokaryotic cells (bacteria) and blood cells by using haemocytometer. Tissues (permanent slides of epithelial tissues, striated muscle, smooth muscle, cartilage, bone). Mounting of polytene chromosome (Drosophila/Chironomous.) demonstration. Detection and quantitative determination of chromosomal DNA and RNA. Cell fractionation to study different components of the cell; Separation of different sized DNA fragments on agarose gel. Isolation and characterization of proteins on polyacryl

Suggested Readings

1. Alberts, B., A. Johnson, J. Lewis, M. Raff, K. Roberts and P. Walter. 2013. Molecular Biology of the Cell. Garland Publishing Inc., New York, USA.
2. Geoffrey, M.C. and R.E. Hausman. 2013. The Cell: A Molecular Approach. Sinauer Associates Inc., New York, USA.
3. Karp, J. 2014. Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons Inc., New York, USA.
4. Lodisch, H., A. Berk and C.A. Kaiser. 2012. Molecular Cell Biology. McMillan Education, New York, USA.
5. Stimola, A. 2011. Cell Biology. The Rosen Publishing Group, New York, USA.
6. Urry, L.A., M.L. Cain, S.A. Wasserman, P.V. Minorsky and R.B. Orr. 2020. Campbell Biology, 12th Ed. Pearson Benjamin Cummings, San Francisco, CA, USA.

ZOOL-406 INTRODUCTION TO WILDLIFE 4(3-1)

Course Learning Outcomes

By the end of this course students will be able to:

1. Identify a variety of wild animal species and their habitat.
2. Explain wildlife's' positive and negative values.
3. Know different animal species that are found in Pakistan.
4. Describe its appearance, habitat and factors affecting wildlife.

Theory

Wild populations of vertebrate animals, reasons for management, Wildlife management: Habitat management, vegetation as cover and food; Game and non-game wildlife: rare, threatened, endangered, and extinct species; Nuisance species: Identification of common nuisance species, characteristics, removal techniques for nuisance species, major food sources, behavioral traits; Wildlife biology: Wildlife food, water and cover requirements, reproduction, behavior and mortality; Wildlife of Pakistan: Identification, distribution, current mammalian and avian status, and herpeto fauna found in various ecological regions; Wildlife values: commercial, recreational, biological, scientific, philosophical, educational, esthetic, ethical, social and negative values etc; Threats to wildlife with special reference to Pakistan: Human impact on wildlife and its habitat: Habitat degradation,

overgrazing, pollution, Impacts of urbanization on wildlife "diversity and abundance"; Overview of wildlife conservation with special reference to Pakistan; Protected areas and their role in maintaining biological diversity: National parks, wildlife sanctuaries and game reserves of Pakistan; Role of zoos in wildlife conservation; Wildlife rules and regulations in Pakistan; Measures taken by GOs and NGOs to conserve wildlife in Pakistan.

Practical
Identification of wildlife species based on museum specimen; Capturing and handling techniques for live specimens of large and small vertebrates (mammals, bird, reptiles and amphibians); Survey of urban systems to demonstrate about its impacts on wildlife communities and presentation of report.

Suggested Readings

1. Bishoyi, A.K. 2020. Wildlife conservation and management, Delve Publishing.
2. Bonges de Lima I. and R. J. Green. 2017. Wildlife Tourism, Environmental Learning and Ethical Encounters (Ecological and Conservation Aspects). Springer International Publishing AG, Switzerland.
3. Kevin H.D. 2016. Wildlife and Natural Resource Management. 4th Ed. Cengage Learning, New York, USA.
4. Robert, M., A. Mooreman, P. Christopher and E. Nile. 2014. Urban Wildlife. Springer Verlag, New York, USA.
5. Singh, S.K. 2020. Textbook of Wildlife Management 3rd Ed. Oxford and IBH Publishers, UK.

ZOOL-407 BIOLOGICAL TECHNIQUES 3(1-2) *(New Course)*

Course Learning Outcomes:-
By the end of this course, students will be able to:
1. Paraphrase various scientific instruments,
2. Describe instruments for identification, measurement, fixing and cutting of tissue,
3. Demonstrate lab equipment efficiently,
4. Paraphrase to collect and preserve the specimen in dry and wet form,
5. Discriminate preservation techniques- taxidermy- rearing techniques.

Contents
Microscopy: Principles of light microscopy. Magnification, Resolution, Contrast. Types of microscopy, Phase Contrast Dark field Interference microscope, Electron microscope.
Micrometery and Morphometry: Use of stage and ocular micrometer. Calibration of ocular micrometer. Size measurement (length, width, diameter).
Specimen preparation for optical microscopy.
Standard system for weight, length and volume. Preparation of stock solutions of various strengths.

Microtomy: Fixation, embedding, Section cutting (transverse, longitudinal section, mounting and staining. Sections in paraffin and cryosections.
Extraction techniques: Centrifugation, Ultra centrifugation, cell fractionation, filtration, Distillation, Use of Soxhalet and Rotary evaporator for extraction.
Separation Techniques: Chromatography: Principle, applications, types, thin layer, paper, column, gas, ion exchange chromatography. Electrophoresis: principle, applications, types.
Spectrophotometery: Principle, applications, types, visible spectrum, UV spectrum, atomic absorption.
Basic principles of Sampling and Preservation: Sampling soil organisms, Invertebrates, Aquatic animals, Mammals, Estimation of population size, Preservation of dry and wet specimens.

Suggested Readings

1. Cheesbrough, M. 1998. District Laboratory Practice in Tropical Countries. Part I. Cambridge University Press, UK
2. Cheesbrough, M. 1998. District Laboratory Practice in Tropical Countries. Part II. Cambridge University Press, UK
3. Curos, M. 1999, Environmental Sampling and Analysis: For Technician. CRC Press LLC. USA
4. Dean, J. R. 2019. Extraction Methods for Environmental Analysis. John Wiley and Sons Ltd. UK
5. Kishore R. P. and A. Desai. 2017. Biological Techniques, 4th Ed. Kalyani Publishers, New Delhi, India.
6. Swargiary A. 2023. Biological Tools & Techniques. Kalyani Publishers, New Delhi, India.

ZOOL-408 ANIMAL FORM AND FUNCTION- I 4(3-1) *(New Course)*

Course Learning Outcomes

By the end of this course, students will be able to:

1. Understand that diverse forms adapted to perform the same functions are because of the different past and present conditions.
2. Identify the emergence of diversity of forms for the performance of similar function.
3. Analyze the requirements of diverse forms for the performance of similar functions in their past and present needs.
4. Evaluate the adaptations in forms for its efficiency in managing the function in differing situations in the past and present times.
5. Demonstrate that a form is successfully adapted to perform a function adequately and successfully.

Theory

Protection: the integumentary system of invertebrates and vertebrates; Movement and support: the skeletal system of invertebrates and vertebrates; Movement: non-muscular movement; An introduction to animal muscles; The muscular system of invertebrates and vertebrates; Neurons: structure and function; Sensory reception: baroreceptors, chemoreceptors, georeceptors, hygroreceptors, phonoreceptors, photoreceptors, proprioceptors, tactile receptors, and thermoreceptors of invertebrates; Lateral line system and electrical sensing, lateral-line system and mechanoreception, hearing and equilibrium in air and water, skin sensors of mechanical stimuli, sonar, smell, taste and vision in

vertebrates; Chemical messengers: hormones chemistry, and their feedback systems, mechanisms of hormone action; Hormones with principal function each of porifera, cnidarians, platyhelminthes, nemerteans, nematodes, molluscs, annelids, arthropods, and echinoderms invertebrates; An overview of the vertebrate endocrine system; Endocrine systems of vertebrates, endocrine systems of birds and mammals; Internal transport and circulatory systems in invertebrates; Characteristics of invertebrate coelomic fluid, hemolymph, and blood cells; Transport systems in vertebrates; Characteristics of vertebrate blood, blood cells and vessels; The hearts and circulatory systems of bony fishes, amphibians, reptiles, birds and mammals; The human heart: blood pressure and the lymphatic system; immunity: nonspecific defenses, the immune response.

Practical

Study of insect chitin, fish scale, amphibian skin, reptilian scales, feathers and mammalian skin; Study and notes of skeleton of Labeo *(Labeo rohita)*, Frog *(Hoplobatrachus tigerinus)*, Varanus *(Varanus bengalensis)*, fowl *(Gallus gallus domesticus)* and rabbit *(Oryctolagus cuniculus)*; Earthworm or leech, cockroach, freshwater mussel, Channa or *Catla catla* or Labeo or any other local fish, frog, pigeon and rat or mouse and rabbit dissections as per availability; Study of heart, principal arteries and veins in a representative vertebrate (dissection of representative fish/mammals).

Suggested Readings

1. Butler, P., A. Brown, G. Stephenson and J. Speakman. 2021. Animal Physiology: An Environmental Perspective. Oxford University Press, Oxford, UK.
2. Hickman, C.J., L. Roberts, A. Larson and H. I'Anson. 2021. Laboratory Studies in Integrated Principles of Zoology. 19th Ed. Singapore: McGraw-Hill.
3. Hickman, C.P., L.S. Roberts and A. Larson. 2017. Integrated Principles of Zoology, 17th Ed. McGraw Hill. Singapore.
4. Miller, S.A. and J.B. Harley. 2016. Zoology, 10th Ed. McGraw Hill. Singapore.
5. Tortora, G.J. and B.H. Derrickson. 2018. Principles of Anatomy and Physiology. 15th Ed. John Wiley & Sons, Hoboken, USA.
6. Urry, L.A., M.L. Cain, S.A. Wasserman, P.V. Minorsky and R.B. Orr. 2020. Campbell Biology, 12th Ed. Pearson Benjamin Cummings, San Francisco, CA, USA.

ZOOL-501 ANIMAL ECOLOGY 3(2-1)

Course Learning Outcomes

By the end of this course students will be able to:

1. Record the contemporary themes in ecological research.
2. Illustrate trophic structure and energy flow in different ecosystem.
3. Know fundamental concepts of population and community ecology that attempts to sustain ecosystems.
4. Measure abiotic components and estimate biotic community of different ecosystems.

Theory

Energy: Laws of thermodynamics, primary and secondary productions, trophic levels and energy variations with increasing trophic levels, energy flow, food chain and food web; Biogeochemical cycles: Nitrogen, phosphorus, sulphur, water and carbon; Limiting factors: Basic concepts, temperature, soil, water, humidity, light and fire; Global ecosystem:

Atmosphere, hydrosphere, lithosphere, ecosphere; Ecosystem with reference to ecological niche: Basic concepts and types; Major ecosystems of world: Marine, estuarine, freshwater, wetland, tundra, forest, grassland and desert; Population ecology: Basic characters, growth and growth curves; Population dynamics and regulations; Community ecology: Basic concepts, community analysis, ecotones and inter-population interactions; Applied ecology: Resources and their ecological management viz. mineral, agricultural desalination and weather modification, forest and range management, landscape and land use; Pollution: Definition, types, cost, origin and management; Water: Sources, domestic and industrial pollution and heavy metals; Air: Sulphur dioxide, nitrogen oxide, carbon monoxide, ozone, smog and PAN, MTBE and CFCs; Land pollution viz. pesticides, bacterial toxins, synthetic hormones; Noise pollution; Radiation ecology: **G**lobal environmental changes viz. ozone depletion, acid rain, greenhouse effect and global warming, Koyoto protocoal, desertification, deforestation, exotic and invasive species, radioactivity leakage, environmental laws.

Practical

Measurement of environmental factors for land, water and air; Study of different ecosystems: Pond, agricultural or grassland and forest; Community analysis through different sampling techniques: Quadrate and transect; Adaptive features of animals in relation to food and environment; Food chain studies through analysis of gut contents; Field visits for study of selected terrestrial habitat and writing notes; Experimental design and approaches in ecological research; Writing a research project.

Suggested Readings

1. Cardinale, B., P. Richard and M. James. 2019. Conservation Biology. 1st Ed. Sinauer Associates. Inc. New York, USA.
2. Nicholas, B.D., J.R. Krebs and S.A. West. 2012. An Introduction to Behavioral Ecology. 4th Ed. Wiley-Blackwell Publishing, New York, USA.
3. Morrison, M.L., L.A. Brennan, B.G. Marcot, W.M. Block and K.S. McKelvey. 2020. Foundation of Advancing Animal Ecology. Johns Hopkins University Press. USA.
4. Odum, E.P. 1994. Fundamentals of Ecology. 3rd Ed. W. B. Saunders. Philadelphia, PA., USA.
5. Thomas, M. S and R.L. Smith. 2015. Elements of Ecology. 9th Ed. Benjamin Cummings, San Francisco, CA, USA.
6. Townsend C.R., M. Begon and J.L. Harper. 2008. Essentials of Ecology 3rd Ed., Blackwell Publishing, Oxford, UK.

ZOOL-502 ICHTHYOLOGY 4(3-1)

Course Learning Outcomes

By the end of this course students will be able to:

1. Examine the evolution and taxonomy of fish.
2. Distinguish the knowledge regarding fish biology.
3. Paraphrase the anatomy and physiology of fish.
4. Appraise species identification skills for fishes found in Pakistan.

Theory

Classification of Fish: Systematic position of fish in animal kingdom; Fish as ancestor to man, External features of fish, Epidermis and exoskeleton; Fins and their origin; Structure and function of gills; Swim bladder and its modification; Fish muscular system, locomotion and energetics of swimming; Physiology of respiration and air breathing among fishes;

Physiology of gas bladder: Use of gas by the fish as a source of static lift; Gas in the gas bladder: Loss, retention and secretion of gas; Digestion and control of gastrointestinal motility in fish; Cardiovascular system, blood and its circulation; Control of kidney function in fish; Reproduction: Gonads, testes and ovaries; Mutation and reproductive cells types of reproduction; Sex differences; Sexual maturity; Sensory system and communication in fish: Acoustico-lateralis system, sound reception and production; Hydro mineral balance: osmoregulation, ionic regulation, stress responses, freezing resistance and acid-base balance; Process of aestivation in fish.

Practical

Systematic identification, collection and preservation of important freshwater fish species of Pakistan; Study of fish anatomy, cranium, skeleton; Elaboration of different organ systems of fish, digestive, excretory and respiratory; Study of blood cells of fish.

Suggested Readings

1. Hart, P.J.B. and J.D. Reynold. 2010. The Hand Book of Fish Biology and Fisheries. Vol II. Blackwell Publishing, New York, USA.
2. Lagler, K.F., J E. Baradach and R.R. Miller. 2012. Ichthyology. 2nd Ed. John Wiley and Sons, Inc., New York, USA.
3. Lawrence M. and Brooks M. B. 2020. Field Guide to Freshwater Fishes. 2nd Ed. Intl Kindle. UK.
4. Moyle, P.B. and J.J. Cech. 2008. Fishes: An Introduction to Ichthyology. 6th Ed. Prentice Hall, New Jersey, USA.
5. Pinnock W. 2022. A Catechism of Ichthyology.3rd Ed. Leopold Classics. USA.

ZOOL-503 ANIMAL FORM AND FUNCTION- II 4(3-1) *(New Course)*

Course Learning Outcomes

By the end of this course, students will be able to:

1. Understand that diverse forms adapted to perform the same functions are because of the different past and present conditions.
2. Identify the emergence of diversity of forms for the performance of similar function.
3. Analyze the requirements of diverse forms for the performance of similar functions in their past and present needs.
4. Evaluate the adaptations in forms for its efficiency in managing the function in differing situations in the past and present times.
5. Demonstrate that a form is successfully adapted to perform a function adequately and successfully.

Theory

Evolution of nutrition; The metabolic fates of nutrients in heterotrophs; digestion; Animal strategies for getting and using food, diversity in digestive structures of invertebrates; The mammalian digestive system: gastrointestinal motility and its control; Oral cavity, pharynx and esophagus, stomach, small intestine: main site of digestion; Large intestine; Role of the pancreas in digestion; Role of the liver and gallbladder in digestion; Homeostasis and temperature regulation; The impact of temperature on animal life; Heat gains and losses; Some solutions to temperature fluctuations; Temperature regulation in invertebrates, fishes, amphibians, reptiles, birds and mammals; Heat production in birds and mammals; Control of water and solutes (osmoregulation and excretion); Invertebrate and vertebrate; Excretory systems; How vertebrates achieve osmoregulation; Vertebrate

kidney variations; Mechanism in metanephric kidney functions; reproduction and development; Asexual reproduction in invertebrates; Advantages and disadvantages of asexual reproduction; Sexual reproduction in invertebrates; advantages and disadvantages of sexual reproduction; Sexual reproduction in vertebrates; Reproductive strategies; Examples of reproduction among various vertebrate classes; The human male reproductive system: spermatogenesis, transport and hormonal control, reproductive function; The human female reproductive system: folliculogenesis, transport and hormonal control, reproductive function; Hormonal regulation in gestation; Prenatal development and birth: the placenta; Milk production and lactation.

Practical

Study of excretory system in an invertebrate and a vertebrate representative (model); Dissection and study of digestive, respiratory, and excretory systems in invertebrate and a vertebrate representative; Dissection and study of male and female reproductive system in vertebrates and invertebrates.

Suggested Readings

1. Aspinall, V., M. Cappello and C. Phillips. 2020. Introduction to Animal and Veterinary Anatomy and Physiology. 4th Ed. CABI, Oxfordshire, UK.
2. Hickman, C.J., L. Roberts, A. Larson and H. I'Anson. 2021. Laboratory Studies in Integrated Principles of Zoology. 19th Ed, McGraw-Hill, Singapore.
3. Hickman, C.P., L.S. Roberts and A. Larson. 2017. Integrated Principles of Zoology, 17th Ed. McGraw Hill. Singapore.
4. Miller, S.A. and J.B. Harley. 2016. Zoology, 10th Ed. McGraw Hill. Singapore.
5. Pechenik, J.A. 2015. Biology of Invertebrates, 7th Ed. McGraw Hill. Singapore.
6. Urry, L.A., M.L. Cain, S.A. Wasserman, P.V. Minorsky and R.B. Orr. 2020. Campbell Biology, 12th Ed. Pearson Benjamin Cummings, San Francisco, CA, USA.

ZOOL-504 ETHOLOGY 3(2-1)

Course Learning Outcomes

By the end of this course students will be able to:

1. Label basic modules in animal behavior development in domestic and wild conditions.
2. Predict different strategies of maintenance of dominance in varied ecological conditions.
3. Recognize between fixed action patterns and stereo-typed learning.
4. Estimate optimal foraging, social behaviour and life histories of animals with reference to their adaptations**.**

Theory

Animal behavior: evolution and development. Basic and applied themes of ethology; role of neural, hormonal and genetics in animals. Animal domestication and its impact on animal behavior. Learning in animals. Theoretical and descriptive models in ethology; foraging strategies and anti-predatory behaviour; Defense and territoriality in animals; aggression and its consequences in changing environments. Animal motivation and its theories. Stimulus filtering, impacts of external and internal stimuli on animal performance. Social organization in animals and benefits to communities. Innate releasing mechanisms and role in animal adaptations. Neural management of animal behaviour; Bioenergetics,

homeostasis, kinesis, telotaxis and temporal fixation in animals. Concept of cognitive learning in animals and the behavioural signals. Habituation of animals, sensitization and imprinting mechanisms. Human-animals interactions in the complex and simple environments.

Practical
Visit to the wildlife parks to study behavior of animals; Research notes on various ecological habits of animals; Field data sheets with recording of animal behavioural aspects.

Suggested Readings

1. Alocock, J. 2020. Animal Behaviour: An Evolutionary Approach. 2nd Edition: Oxford Univ. Press, England.
2. Breed, M. and J. Moore. 2021. Animal Behaviour: 4th Edition, W.B. Saunders Inc., USA.
3. Breed, M., C.R. Townsend and R.L. Harper. 2020. Ethology and Animal Behavior. Erik Freeman Press, USA.
4. Casey, R., S. Heath and H. Zulch. 2022. Animal Behaviour Problems. CABI, Press, London, England.
5. Dugatkin, L.A. 2022. Power in the Wild. 3rd Edition, Blackwell Publishing Co. Inc., New Jersey, USA.

ZOOL-505 EVOLUTION 3(3-0) ***(New Course)***

Course Learning Outcomes
By the end of this course, students will be able to:
1. Develop a deep understanding of fundamental evolutionary processes, including natural selection, genetic drift, gene flow, and speciation.
2. Interpret and critically evaluate evolutionary evidence, such as the fossil record, biogeography, and genetic data, to draw informed conclusions about the history of life on Earth.
3. Illustrate how natural selection ultimately underpins all biological processes and how evolution has generated biological diversity.
4. Understand the multidisciplinary knowledge from various modules to comprehensive understand the evolutionary biology, recognize the interconnectedness of genetics, ecology, and paleontology.

Theory
The nature and origin of life; Theories to explain the diversity and unity of life; Evidences of evolution: Homology, fossils, embryology, biogeography and DNA sequences; Lamarckism; Darwinism and special creation; Modern synthetic Theory; Origin of hereditary variation; Genetic structure of populations; Factors initiating elementary evolutionary changes by changing allele frequencies: Mutation pressure, selection pressure, immigration, cross breeding and genetic drift; Hardy–Weinberg principle; Factors of large evolutionary changes; Allometry, orthogenesis and adaptive radiations; Modern concept of natural selection; Various modes of natural selection; Selection patterns, Natural selection leading to convergence, radiation and extinction; Natural selection and mimicry– Batesian and Mullerian; Role of isolation in evolution; Allopatric and sympatric speciation; Races, subspecies and their origin; Reproductive isolation and hybrid zones; Rates of evolution; Key events in life's history: Continental drift, mass extinctions and

adaptive radiations in relation to rise and fall of dominant groups; Fisher's view; Zahavi's handicap theory and recapitulation theory; Human Evolution; The Early Hominins, Homo habilis, Homo erectus, Neanderthals, Global Dispersal.

Suggested Readings

1. Benton, M.J., and D.A. Harper. 2020. Introduction to Paleobiology and the Fossil Record. John Wiley & Sons. UK
2. Bolhuis, J.J., L.A. Giraldeau, and J.A. Hogan. 2021. The Behavior of Animals: Mechanisms, Function, and Evolution. John Wiley & Sons. UK
3. Browne, J. 2021. A Most Interesting Problem: What Darwin's Descent of Man Got Right and Wrong about Human Evolution. Princeton University Press. USA
4. Darwin, S., and E.M. Sadowski. 2023. Evolution. What on Earth Books Publishing, UK
5. Delisle, R.G. 2021. Natural Selection: Revisiting its Explanatory Role in Evolutionary Biology (Vol. 3). Springer Nature, Netherland.
6. Langdon, J.H. 2023. Human Evolution: Bones, Cultures, and Genes. Springer Nature, Netherland.

ZOOL- 506 PRINCIPLES OF SYSTEMATICS 3(2-1) *(New Course)*

Course Learning Outcomes

By the end of this course, students will be able to:

1. Apply fundamental concepts of systematics, demonstrating a clear understanding of its history and basic terminology in the context of taxonomy.
2. Differentiate between phenon and taxon in micro-taxonomy, and classify organisms into specific, infraspecific, and higher taxonomic categories.
3. Equipped with the skills to use cladistic and phylogenetic tools for analyzing evolutionary relationships, understanding species concepts, and making taxonomic decisions.
4. Capable of evaluating major variations within a single population, understanding the mechanisms of speciation.
5. Proficient in navigating the principles of nomenclature, including the interpretation and application of the code, prioritizing stability, and understanding the first reviser principle.

Theory

Introduction to systematics; History of taxonomy: systematics, basic terminology of systematics; Micro-taxonomy: Phenon and taxon; Taxonomic categories: Specific, infraspecific and higher categories; Formation of specific names, brief concept of cladistics, phylogenetics. Theory and practice of cladistics and phylogenetic systematics. Species concepts: Species mate recognition, non-dimensional, multidimensional, cohesion, polytypic species, subspecies, super species, sibling species and difficulties in the application of biological species concept; Study of major type of variations within a single population; Speciation and taxonomic decision; Cladistic analysis; Different kinds of taxonomic characters, taxonomic collection and identification; Theory of nomenclature: Interpretation and application of the code viz. stability, priority and first reviser principle; Integration of molecular data in resolving taxonomic uncertainties; Importance and applications of systematics; International code of zoological nomenclature; its objective, principles, interpretation, application of important rules, with reference to: Zoological nomenclature, law of priority and validity of names.

Practical
Study of preserved invertebrate species and their classification up to class level; Collection, preservation and identification of common species with the help of keys; Preparation of keys for the identification of specimens; Calculation of gene and genotype frequency for generations; Identification of animal residing in an area through their tracks or traces.

Suggested Readings

1. Brower, A.V., and R.T. Schuh. 2021. Biological Systematics: Principles and Applications. Cornell University Press, USA
2. Cantino, P.D., and K. De Queiroz. 2020. PhyloCode: A Phylogenetic Code of Biological Nomenclature. Boca Raton: CRC Press, UK
3. Mayr, E. 2015. Principles of Systematic Zoology. Scientific Publishers. UK
4. Pavlinov, I. 2021. Biological Systematics: History and Theory. CRC Press, UK
5. Williams, D.M., and M.C. Ebach. 2020. Cladistics (Vol. 88). Cambridge University Press, UK

ZOOL-507 COMPARATIVE ANIMAL PHYSIOLOGY 4(3-1) *(New Course)*

Course Learning Outcomes
By the end of this course, students will be able to:
1. Understand of critical concepts, processes, and factual information in the performance of functions and changing conditions.
2. Identify the strategies to sustain diverse forms of animal life kept in dynamic environmental conditions.
3. Utilize knowledge of animal physiology in critical study and for making intelligent decisions in professional life.
4. Analyze and interpret experimental/investigative data critically in performance of functions in changed conditions
5. Distinguish between normal and failure of the function in abnormal conditions even through results of experiments/data from laboratory and fields.

Theory
Principles of homeostasis and conformity; Principles of regulation and adaptation; Ionic distribution across membrane; Resting membrane potentials: electrogenic ion pump, Donnan equilibrium, ion channels; 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; 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; 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; Electrical activity of heart; self-excitability and auto-rhythmicity of myogenic heart; Neurogenic heart and their expression; Electrocardiography and kymography; 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; 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 percapnia etc.; Air breathing and respiratory adaptations diver animals; Strategy of mammalian large glomerular filtration and reabsorption in nitrogenous excretion; Patterns of nitrogenous excretion in various animals and their phylogenetic significance; 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

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, tetanization of heart; Measurement and effects of various factors on blood pressure; 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); Study of salient features of electromyography; Study of excitable and contractile properties of a nerve-muscle preparation; Video studies of brains in different animals in relation to complexity of functions; Video studies of human brain model and different areas eliciting behaviors; Video studies on the effects of hormones in breeding season behaviors of various behaviors; Study through clinics data on the insulin and glycemia in type1 and type 2 diabetic subjects.

Suggested Readings

1. Butler, P., A. Brown, G. Stephenson and J. Speakman. 2021. Animal Physiology: An Environmental Perspective. Oxford University Press, Oxford, UK.
2. Hickman, C.J., L. Roberts, A. Larson and H. I'Anson. 2021. Laboratory Studies in Integrated Principles of Zoology. 19th Ed. McGraw-Hill, Singapore.
3. Hill, R.W., M. Anderson and D. Cavanaugh. 2021. Animal Physiology, 5th Ed. Oxford University Press, Massachusetts, USA.
4. Laughton, S., J. Hanley, S. Hinic-Frlog and N. Adbalahad. 2020. Introductory Animal Physiology, 2nd Ed. University of Toronto, Mississauga, Canada.
5. Miller, S.A. and J.B. Harley. 2016. Zoology, 10th Ed. McGraw Hill. Singapore.
6. Urry, L.A., M.L. Cain, S.A. Wasserman, P.V. Minorsky and R.B. Orr. 2020. Campbell Biology, 12th Ed. Pearson Benjamin Cummings, San Francisco, CA, USA.

ZOOL-508 ECONOMIC ZOOLOGY 3(2-1)

Course Learning Outcomes

By the end of this course students will be able to:

1. Record the esthetic and economical values of different fauna.
2. Predict the damage done by different groups of animals.
3. Implementation of different animal rearing technology on commercial scale.
4. Discover optimal culture practices of beneficial animal groups.

Theory

Economic importance of common household pests; Different groups of pests; Insect pests, animal pests, natural enemies, beneficial insects, beneficial animals Pests of stored products and vegetables, their biology and control; Sericulture; Species and life cycle of silk worm; Science of sericulture, production and recovery of cocoon and post cocoon production; Types and uses of silk; Pearl culture; Pearl industry: Pearl formation, collection and rearing of oyster, insertion of nucleus, harvesting of pearl, problems of pearl industry, artificial pearl; Pisciculture ; Ornamental fisheries; biology, growth and breeding, Feasibility of ornamental fishery as cottage industry; Pet bird farming: Feasibility as cottage industry, quail, brown partridge, ring necked pheasant, silver pheasant, ostrich and parakeet farming; Apiculture: Species of bees, colonial organization and division of labor among bees, honey, bees wax and enemies of bees. Crustacean fisheries; fresh water Prawn culture: Lac-culture, Parasites; Introduction, kinds of Hosts and Parasites, Parasites of Domestic Animals and Humans, Injurious protozoan to man, diseases induced by protozoan, Trypanosoma, Giardia, Leishmaniasis, Schistomiasis.

Practical

Study of Apiculture; Bee keeping, Hive maintenance and management, Sericulture; collection and incubation of Silkworm eggs, Recovery and Reeling of cocoons, Pearl culture and Lac-culture: collection of stored products like grains, rice, cereals, vegetable and fodder crop seeds infested by different pests. Visit of fish farms.

Suggested Readings

1. Chaudhuri, S. 2021. Economic Zoology. New Central Book Agency, India.
2. Graham, W. 2021. Pearls: A Practical Guide. The Crowood Press, UK.
3. Islam, A. 2016. A Text Book of Economic Zoology. I.K. International Publishing House, Pvt. Ltd, Delhi, India.
4. Jaiswal, V. and K.K. Jaiswal. 2014. Economic Zoology. Prentice-Hall Pvt. Ltd. Bombay, India.
5. Osborn, H. 2012. Economic Zoology: An Introductory Text-Book in Zoology, With Special Reference to its Applications in Agriculture, Commerce and Medicine. Ulan Press, Nelson, Virginia, USA.
6. Rathoure, A. K., N. Z. Deshmukh, D. Kumar and R. Goswami. 2015. Applied and Economic Zoology, Abe Books, London, UK.

ZOOL-509 FISHERIES 4(3-1)

Course Learning Outcomes

By the end of this course students will be able to:

1. Restate the important aquatic fauna present on the globe and Pakistan.
2. Paraphrase the pre-requisite and operations of freshwater fish culture.
3. Categorize different techniques to improve fish production.
4. Demonstrate fish capture and handling techniques.

Theory
External morphology of Fish; Fish culture and its types; International and national trends in fish production and culture; Pond fish culture: Planning and construction of fish pond, water quality criteria, conditions suitable for fish culture; Biological production cycle of fish pond; Culturable fishes of Pakistan; Fertilization of fish pond: Organic and inorganic fertilizers; Supplementary feeding in fish pond; Fish feeding methods; Different components of fish feed; Composition of commonly available feed ingredients; Preparation and feed storage methods; Integrated fish farming: Concepts and practices; Fish enemies; Fish diseases and remedial measures; Fish hatchery management; Fishing gears, pre- and post-harvesting care of fish, maintenance of fish catch quality during transportation, storage and marketing.

Practical
Dose calculation and use of different organic, inorganic fertilizers and feed in fish ponds; Identification of various freshwater fish species of Pakistan with the help of key; Study of morphological characters and identification of culturable fish species; Practical demonstration of induced fish breeding.

Suggested Readings

1. Boyd, C.E. and A.A. McNevin. 2014. Aquaculture, Resource Use, and the Environment. Wiley-Blackwell, New York, USA.
2. Chen, X. and Y. Zohu. 2020. Brief Introduction to Fisheries. Springer, Singapore.
3. Einarsson, A. and A. D. Olaottir. 2020. Fisheries and Aquaculture: The Food Security of the Future. Academic Press.
4. Hart, P.J.B. and J.D. Reynolds. 2008. Handbook of Fish Biology and Fisheries, Volume 2. Blackwell Science Ltd., New York, USA.
5. Sharma, O.P. 2009. Handbook of Fisheries and Aquaculture. Agrotech Publishing Academy, New Delhi, India.

ZOOL-510 ZOOGEOGRAPHY AND PALEONTOLOGY 3(2-1)

Course Learning Outcomes
By the end of this course students will be able to:
1. Identify the distribution of animals through time and space.
2. Predict animals' association in the past and environmental factors.
3. Recognize fossils and their formation under rocks.
4. Summarize significance of fossils, their use and geological time scale.

Theory
Branches of zoogeography: Descriptive, faunistics, systematic, biocoenotic, causal, ecological, historical, experimental and applied; Animal distribution: Cosmopolitan, discontinuous, isolation, bipolar and endemic distributions; Dispersal and barriers; Zoogeographical regions: Division, geographic ranges, physical features, climates, faunas and affinities; Paleartctic, Oriental, Ethiopian, Australian, Neotropical and Nearctic regions; Insular fauna; Zoogeography of Pakistan; Palaeogeography: Theories of continental drift and permanence of continents; Paleontology: Earth; Shells of earth: Atmosphere, hydrosphere, biosphere and lithosphere; Rocks: Igneous, sedimentary and metamorphic rocks;

Fossil: Types, nature and uses of fossils; Fossilization: Geological time scale; Pre-Cambrian life; Post-Cambrian life: Palaeozoic, Mesozoic and Cenozoic. Geochronometry: Uranium/lead dating and radiocarbon dating methods; Micropaleontology; Index fossils; Paleoecology; Paleomagnetism.

Practical

Survey and identification of fauna of different faunal regions; Study of different kinds of fossils viz. mould, cast and petrified fossils of animals; Study and identification of kinds of rocks: Igneous, sedimentary and metamorphic; Map work for identification of various zoogeographical regions of the world along with endemic animals.

Suggested Readings

1. Ali, S.S. 2021. Paleontology, Zoogeography and Wildlife Management. Nasim Book Depot, Hyderabad, Pakistan.
2. Bainbridge, D. 2022. Paleontology; An Illustrated History. Princeton University Press. USA.
3. Susan, H.G. 2012. Paleontology: The Study of Prehistoric Life, True Book Series, Scholistic, London UK.
4. Tiwari S.K. 2006. Fundamentals of World Zoogeography. Ivy Publishing House. UK.
5. Turner, D. 2011. Paleontology: A Philosophical Introduction. Cambridge University Press, Cambridge, UK.

ZOOL-601 ENVIRONMENT TOXICOLOGY 3(2-1) ***(New Course)***

Course Learning Outcomes:

By the end of end of this course, students will be able to:

1. Discriminate basic concepts of environmental pollutants
2. Paraphrase how organisms metabolize organic chemicals and fundamental mechanisms of chemical toxicity
3. Discover the designs of toxicity and relate to the structure and function of tissues and organs in organisms
4. Recognize the toxicokinetics and turnover of chemical substances in organisms

Theory

Introduction, Major classes of pollutants; air, soil and water; inorganic, organic pollutants, sources and routes by which pollutants enter the ecosystem, effects of pollutants on ecosystem. Chemistry of toxicants, toxicity testing methods and route of exposure; Determine the responses to varying doses of substances and time of exposure; Origin and sources of toxicants. Classification, transport, entry and fate of toxicants in water environment and pollution cycles; Parameters and procedures of toxicity testing; Biological surveillance of toxicants; Measuring toxicity and assigning risk; targets and models organ system toxicology; Teratogenesis, mutagenesis, and carcinogenesis in animals; Risk assessment and bioremediation; Monitoring and pollution control through stabilization, recycling and treatment; Role of modeling ecotoxicology; Acute and chronic effects of toxicants; Bioaccumulation, biomagnifications and biotransformation of toxins introduction, primary biotransformation hydrolysis, oxidation, reduction, secondary metabolism glutathione conjugation; Mechanisms of toxicity; Chemical, biochemical and genetic toxins.

Practical

Collection of environmental samples from different sources; Determination of heavy metals through Atomic Absorption Spectrophotometer; Estimation of lethal and sub-lethal effects of toxicants on organisms; Studies on behavioral responses of organisms to toxicants.

Suggested Readings

1. Timbrell, J. and F.A. Barile. 2023. Introduction to Toxicology, 4th Edition, CRC Press, Taylor and Francis Group, UK
2. Roberts, S.M., R.C. James and P.L. Williams. (Eds.). 2022. Principles of Toxicology: Environmental and Industrial Applications. John Wiley and Sons. USA
3. Hughes, W. 2019. Essentials of Environmental Toxicology. CRC Press, Taylor and Francis Group, UK
4. Hauser-Davis, R. A. and T. E. Parente**.** 2018. Ecotoxicology: Perspectives on Special Issues. CRC Press, Taylor and Francis Group, UK
5. Blasco, J., P. M. Chapman, O. Campana, M. Hampel. 2016. Marine Ecotoxicology. Current Knowledge and Future Issues. Academic Press. London, UK
6. Lawrence, T. V. 2017. Ecological Risk Assessment, Innovative Field and Laboratory Studies. CRC press, Taylor and Francis Group, UK

ZOOL-602 CONSERVATION BIOLOGY 4(3-1)

Course Learning Outcomes

By the end of this course students will be able to:

1. Paraphrase why to conserve biodiversity while explaining intrinsic values of biodiversity.
2. Discriminate the crisis to biodiversity with the aim to sustain entire biota.
3. Appraise the fundamental concepts of restoration ecology that attempts to restore degraded ecosystems.
4. Illustrate the basic skills of capturing and handling of endangered as well as threatened species in in-situ and ex-situ.

Theory

Conservation biology; Philosophy, historical perspective, ethics and principles of conservation; Valuing biodiversity; Utilitarianism and intrinsic values; Loss of biodiversity; The concepts of integrity and sustainability; Species diversity; Single species conservation, choosing species; Problems of small populations; The meta populations, endangered species act; Invasive species and their impacts; Mass extinctions and global change; Anthropogenic, ecological and genetic factors in extinction and conservation; Genetic diversity; Effective population number and size; Population bottlenecks; Gene flow, selection and migration, inbreeding and outbreeding depressions; Processes that diminish genetic diversity; Molecular genetics and conservation; Conservation forensics; Island biogeographic, Theory and conservation practices; Ecosystem diversity; Ecosystem stress, degradation and loss, habitat fragmentation, overexploitation and its consequences; Conservation strategies; Ecological restoration, community level conservation; Protecting and managing ecosystems; Politics, legislations and actions; International agencies and conservation; Economics and conservation.

Practical

Study of in-situ and ex-situ conservation techniques. Visit of some important areas under conservation as seed /gene bank, botanical gardens, zoos, national parks. Capturing and handling techniques for endangered and threatened animals. Survey and sampling of some landscapes to review agricultural practices. Writing project report on conservation of animals. Study the indicators for biological monitoring of waters and for ecological monitoring in the field for fauna and flora.

Suggested Readings

1. Cardinale, B., P. Richard. and M. James. 2019. Conservation Biology. 1st Ed. Sinauer Associates. Inc. New York, USA.
2. Dyke, F.V. 2008. Conservation Biology: foundations, concepts, applications. 2nd Ed. Springer. Dordrecht. McGraw Hill, New York.
3. Primak, R.B. 2014. Essentials of Conservation Biology. 6th Ed. Sinauer Associates Inc. New York, USA.
4. Richard, B. and P. Sunderland. 2014. Essentials of Conservation Biology. 6th Ed. Sinauer Associates. Inc. New York, USA.
5. Sodhi, N.S. and P.R. Ehrlich. 2011. Conservation Biology. Oxford University Press, New York, USA.

ZOOL-603 DEVELOPMENTAL BIOLOGY 4(3-1)

Course Learning Outcomes

By the end of this course students will be able to:

1. Devise information on transmission of traits from the parents in their gametes.
2. Recognize detailed knowledge about gamete formation, cellular basis of morphogenesis, mechanisms of cellular differentiation and induction.
3. Discover understanding of the mechanisms of organogenesis, factors controlling growth and oncogenesis.
4. Generalize knowledge about the basis of regeneration and teratogenesis in vertebrates.

Theory

Introduction: History and branches of developmental biology; Principal of development, Origin of sexual reproduction, developmental patterns; Spermatogenesis; Oogenesis; Fertilization: Recognition of sperm and egg, fusion of gametes, activation of egg metabolism, rearrangement of egg cytoplasm; Cleavage: Patterns of embryonic cleavage; Characteristics, biochemical activities during cleavage, types, patterns and laws, and cleavage in various vertebrate groups; Gastrulation: Characteristics, biochemical changes, techniques to study gastrulatory movements, mechanism and types of movements, fate maps and gastrulation in various vertebrate groups; Embryonic adaptations: Development and function of extra-embryonic envelop viz; amnion, chorion, allentois, yolk sac and placenta; Organogenesis: Changes in the body shape and development of ectodermal, mesodermal and endodermal organs; Embryonic inductions: Origin, types, mode of action, chemical nature and specificity of inducer substances, artificial and abnormal inducers; Regeneration: Types, mechanism and biochemical activities during regeneration; Regeneration in various animal groups; Cellular basis of morphogenesis: Differential cell affinity, and cell adhesion molecules; Mechanism of cellular differentiation: RNA processing, translational regulation of developmental process, cell-fate by progressive determinants, autonomous cell specification by cytoplasmic determinants, establishment of body axes and mechanism of teratogenesis; Factors controlling growth and oncogenesis; Hormones as mediators of development; Animal Cloning: Types, techniques and cytological basis; Advantages and disadvantages of cloning; In-vitro fertilization.

Practical

Study of the structure of gametes in some representative cases, i.e. frog, fish, fowl and a mammal from prepared slides, Study of cleavage and subsequent development from prepared slides and/or whole mounts in various animals i.e., frog, chick etc. Study of fertilization, early development of frog/fish through induced spawning under laboratory conditions, Study of sexual dimorphism in fish and identification of sexes; Study of reproductive systems of male and female fish and observations on developmental stages of gametes; Study of different stages of sexual maturity of male and female fish and estimation of gonadosomatic indices; Preparation and staining of histological slides.

Suggested Readings

1. Balinsky, B.I. 2013. An Introduction to Embryology. 6th Ed. W. B. Saunders Inc., New Jersy, USA.
2. Gilbert, S.F. 2010. Developmental Biology 9th Ed. Sinauer Associates Inc., New York, USA.
3. Hodge, R. 2010. Developmental Biology. Facts on File, Inc. New York, USA.
4. Leonardo R. 2022. Essential of Developmental Biology. Murphy and Moore, UK.
5. Sergei,Y.S. 2021. Amphibian Models of Development and Disease. 1st Ed. Julep Brow. USA.

ZOOL- 604 FUNDAMENTALS OF MOLECULAR BIOLOGY 3(2-1) *(New Course)*

Course Learning Outcomes

By the end of this course, students will be able to:

1. Explain how the structure and chemistry of nucleic acids relate to their functions, relative stability, and interactions with proteins.
2. Understand the regulation of proteins and nucleic acids interaction.
3. Compare and contrast mechanisms of DNA replication, transcription, translation, repair, recombination, gene regulation, RNA processing in prokaryotes and eukaryotes.
4. Apply molecular knowledge to identify human genetic disorders and to understand underlying molecular mechanism.

Theory

Introduction to nucleic acids; Chromosome structure and chromatin; DNA forms, structures and packaging; RNA types and structures; DNA replication in prokaryotes; DNA replication in eukaryotes; Enzymology of replication; DNA damage and repair; Types of RNA polymerases in prokaryotes and eukaryotes; Synthesis of mRNA, rRNA and tRNA with special reference to enzymes involved; RNA processing; Split genes and concept of ribozymes; Genetic Code; Role of ribosomes; Mechanism of translation in prokaryotes and eukaryotes; Various factors, and post-translational processing; Types of mutations; Base-analogue mutagens; Chemical mutagens; Control of gene expression in prokaryotes; Inducible and repressible operons; Control of gene expression in eukaryotes.

Practical

Preparation of different stock solutions used in molecular biology (solution used in PCR, electrophoresis, DNA isolation, RNA isolation and Protein isolation; Isolation of DNA from human blood; Quantification of DNA and RNA through spectrophotometer; DNA amplification through polymerase chain reaction; Separation of different sized DNA fragments on agarose gel.

Suggested Readings

1. Alberts B. R. Heald, A. Johnson, D. Morgan, M. Raff, K. Roberts and P. Walter. 2022. Molecular Biology of the Cell. 7th Ed. W. W. Norton & Company, New York, USA.
2. Cooper G. and K. Adams. 2022. The Cell: A Molecular Approach. 9th Ed. Sinauer Associates, Inc. Massachusetts, USA.
3. De Robertis, E. D. P. 2017. Cell and Molecular Biology, 8th Ed. Lea & Febiger, New York, USA.
4. Harvey L., A. Berk, C. A. Kaiser, M. Krieger, A. Bretscher, H. Ploegh, K. C. Martin and A. Amon. 2021. Molecular Cell Biology. 9th Ed. W. H. Freeman and Company, New York USA.
5. Karp G. , J. Iwasa and W. Marshall. 2020. Karp's Cell and Molecular Biology. 9th Ed. John Wiley and Sons, Inc. New York, USA.

ZOOL-620	**SEMINAR**	**1(1-0)**	***(New Course)***
ZOOL-621	**INTERNSHIP**	**3(0-3)**	***(New Course)***
ZOOL-622	**TECHNICAL REPORT**	**3(0-3)**	