

GC UNIVERSITY, FAISALABAD



# Scheme of Studies

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BS (Honors) Zoology

*8 Semesters / 4 years Degree Program  
for the year 2015 and onward*

**Department of Zoology**

**BS Zoology (4-Years/8 Semesters)****Semester I**

ZOL-301	Zoology – I	4(3-1)
BOT-301	Botany-I/subsidiary (Core)	4(3-1)
CHM-321	Chemistry-I/subsidiary	4(3-1)
ENG-321	English-I(English for Academic Purpose)(EPA)	3(3-0)
ISL-321	Islamic Studies	2(2-0)
	<b>Total</b>	<b>17</b>

**Semester II**

ZOL-302	Zoology-II	4(3-1)
BOT-302	Botany-II/subsidiary (Core)	4(3-1)
CHM-322	Chemistry-II/subsidiary (Core)	4(3-1)
ENG-322	English-II (Reading, Writing, Speaking and Listening)	3(3-0)
PST-322	Pak Studies	2(2-0)
	<b>Total</b>	<b>17</b>

**Semester III**

ZOL-401	Zoology-III	4(3-1)
ZOL-403	Zoology-IV	4(3-1)
BOT-401	Botany-III/subsidiary (Core)	4(3-1)
CHM-421	Chemistry-III/subsidiary (Core)	4(3-1)
ENG-421	English-III (Communication Skills)	3(3-0)
	<b>Total</b>	<b>19</b>

**Semester IV**

ZOL-402	Zoology-V	4(3-1)
ZOL-404	Zoology-VI	4(3-1)
PSY-422	Psychology / or any other elective outside of major	3(3-0)
CSI-422	Computer Application	2(2-0)
ENG-422	Communication Skills	2(2-0)
MTH-422	Math	3(3-0)
	<b>Total</b>	<b>18</b>

**Semester V**

ZOL-501	Cell and Molecular Biology	4(3-1)
ZOL-503	Biochemistry– I (Structure and Functions of Macromolecules)	3(2-1)
ZOL-505	Animal Physiology – I	4(3-1)
ZOL-507	Animal Behaviour	2(2-0)
ZOL-509	General and Molecular Genetics	4(3-1)
	<b>Total</b>	<b>17</b>

**Semester VI**

ZOL-502	Biostatistics	3(3-0)
ZOL-504	Developmental Biology	4(3-1)
ZOL-506	Ecology	3(3-0)

ZOL-508	Principles of Zoogeography	3(2-1)
ZOL-510	Biochemistry – II (Metabolism)	3(2-1)
ZOL-512	Physiology – II	4(3-1)
	<b>Total</b>	<b>20</b>

**Semester VII**

ZOL-601	Evolution and Principals of Systematics	4(3-1)
ZOL-605	Fisheries	3(2-1)
ZOL-607	Research Methodology	1(1-0)
ZOL-609	Principles of Paleontology	3(3-0)
ZOL-611	Fundamentals of Entomology	3(2-1)
ZOL-613	Aquatic Toxicology	3(2-1)
	<b>Total</b>	<b>17</b>

**Semester VIII**

ZOL-602	Basic Bioinformatics	3(2-1)
ZOL-606	Wildlife of Pakistan	3(2-1)
ZOL-608	Bioremediation and Bio-processing	3(2-1)
ZOL-630	Thesis	6(6-0)
To be offered	*Special paper 1 (in lieu of thesis)	3(2-1)
To be offered	*Special paper 2 (in lieu of thesis)	3(2-1)
	<b>Total</b>	<b>15</b>
	<b>Grand Total</b>	<b>140</b>

**BS Courses: (Semester-wise)**

<b>Course Title</b>	PRINCIPLES OF ANIMAL LIFE – I
Course Code	ZOL-301
Credit Hours	4(3-1)
Theory	3
Practical	1
Follow up	<b>BS</b>
Aims and Objectives	The course aims to impart knowledge and understanding of: a. The concept and status of Zoology in life sciences. b. The common processes of life through its chemistry, biochemical and molecular processes. c. The structure and function of cell organelles and how common animal cell diversified in various tissues, organs and organ systems. d. Biochemical mechanisms eventually generating energy for animal work. e. Animals and their relationship with their environment.
Learning Outcomes	
Syllabus in Brief	<p><b>Course Contents</b></p> <p>1. Place of Zoology in Science A one-world view: genetic unity, the fundamental unit of life, evolutionary oneness and the diversity of life, environment and world resources; what is Zoology? The classification of animals; the scientific method.</p> <p>2. The Chemical Basis of Animal Life Atoms and elements: building blocks of all matter; compounds and molecules: aggregates of atoms; acids, bases, and buffers; the molecules of animals: fractional account of carbohydrates, lipids, proteins, nucleotides and nucleic acids based on their structural aspects.</p> <p>3. Cells, Tissues, Organs, and Organ System of Animals Structure and functions of cell membranes; various movements across membranes; cytoplasm, organelles, and cellular components: functional account of ribosomes, endoplasmic reticulum, golgi apparatus, lysosomes, mitochondria, cytoskeleton, cilia and flagella, centrioles and microtubules, and vacuoles based on their structural aspects. The nucleus: nuclear envelope, chromosomes and nucleolus. Tissues: diversity in epithelial tissue, connective tissue, muscle tissue and nervous tissue to perform various functions. Structural integrations for functions in organs and organ systems.</p> <p>4. Energy and Enzymes: Life's Driving and Controlling Forces Energy and the laws of energy transformation; activation energy; enzymes: structure, function and factors affecting their activity; cofactors and coenzymes; ATP: how cells convert energy? An overview.</p> <p>5. How Animals Harvest Energy Stored in Nutrients: Glycolysis: the first phase of nutrient metabolism; fermentation: "life without oxygen"; aerobic respiration: the major source of ATP; metabolism of fats and proteins; control of metabolism; the metabolic pool.</p> <p>6. Ecology I: Individuals and Populations Animals and their abiotic environment; populations; interspecific interactions.</p> <p>7. Ecology II: Communities and Ecosystems Community structure and</p>

	<p>diversity; ecosystems; ecosystems of the earth; ecological problems; human population growth, pollution, resource depletion and biodiversity.</p> <p><b>Practicals</b></p> <ol style="list-style-type: none"> <li>1. Tests for different carbohydrates, proteins and lipids. Note: Emphasis on the concept that tests materials have been ultimately obtained from living organisms and constituted their body.</li> <li>2. Study of the prepared slides of epithelial tissue (squamous, cuboidal, columnar), connective tissue (adipose, cartilage, bone, blood), nervous tissue and muscle tissue (skeletal, smooth and cardiac). <i>Note: Prepared microscopic and/or projection slides and/or CD ROM computer projections must be used.</i></li> <li>3. Plasmolysis and deplasmolysis in blood.</li> <li>4. Protein digestion by pepsin.</li> <li>5. Ecological notes on animals of a few model habitats.</li> <li>6. Field observation and report writing on animals in their ecosystem (a terrestrial and an aquatic ecosystem study).</li> </ol> <p><b>Books Recommended</b></p> <ol style="list-style-type: none"> <li>1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 12<sup>th</sup> Edition (International), 2004. Singapore: McGraw Hill.</li> <li>2. Miller, S.A. and Harley, J.B. ZOOLOGY, 6<sup>th</sup> Edition (International), 2005. Singapore: McGraw Hill.</li> <li>3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 5<sup>th</sup> Edition (International), 2000. Singapore: McGraw Hill.</li> <li>4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES, 2001. New York: McGraw Hill.</li> <li>5. Campbell, N.A. BIOLOGY, 6<sup>th</sup> Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.</li> <li>6. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5<sup>th</sup> Edition (International), 2002. Singapore: McGraw Hill.</li> <li>7. Hickman, C.P. and Kats, H.L., LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.</li> <li>8. Molles, M.C. ECOLOGY: CONCEPTS AND APPLICATIONS. 6<sup>th</sup> Edition. 2005. McGraw Hill, New York, USA.</li> <li>9. Odum, E. P. FUNDAMENTALS OF ECOLOGY. 3<sup>rd</sup> Edition. 1994. W.B. Saunders. Philadelphia.</li> <li>10. Slingby, D. and Cook, C., PRACTICAL ECOLOGY. 1986. McMillan Education Ltd. UK.</li> </ol>
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<b>Course Title</b>	PRINCIPLES OF ANIMAL LIFE – II
Course Code	ZOL-302
Credit Hours	4(3-1)
Theory	3
Practical	1
Follow up	<b>BS</b>
Aims and Objectives	The course imparts knowledge and understanding of:

	<p>a. cell division and its significance in cell cycle.                  b. concepts and mechanisms of inheritance pattern, chromosome and gene linkage and molecular basics of genetics.                  c. animal behaviour and communication.                  d. theories of evolution, gene flow and mechanism of evolution with reference to animals and diversity.</p>
<p>Learning Outcomes</p>	
<p>Syllabus in Brief</p>	<p>Course Contents</p> <p>1. Cell Division                  Mitosis, cytokinesis, and the cell cycle: an overview; control of the cell cycle; meiosis: the basis of sexual reproduction; gamete formation.</p> <p>2. Inheritance Patterns                  The birth of modern genetics; Mendelian inheritance patterns; other inheritance patterns; environmental effects and gene expression.</p> <p>3. Chromosomes and Gene Linkage                  Eukaryotic chromosomes; linkage relationships; changes in chromosome number and structure.</p> <p>4. Molecular Genetics: Ultimate Cellular Control                  DNA: the genetic material; DNA replication in eukaryotes; genes in action; control of gene expression in eukaryotes; mutations; applications of genetic technologies; recombinant DNA.</p> <p>5. Animal Behaviour                  Four approaches to animal behaviour; proximate and ultimate causes; anthropomorphism; development of behavior; learning; control of behavior; communication; behavioral ecology; social behavior.</p> <p>6. Evolution: A Historical Perspective                  Pre-Darwinian theories of change; Lamarck: an early proponent of evolution; early development of Darwin's ideas of evolution and evidences; the theory of evolution by natural selection; evolutionary thought after Darwin; biogeography.</p> <p>7. Evolution and Gene Frequencies                  The modern synthesis: a closer look; the Hardy-Weinberg theorem; evolutionary mechanisms: population size, genetic drift, natural selection, gene flow, mutation, and balanced polymorphism; species and speciation; rates of evolution; molecular evolution; mosaic evolution.</p> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11<sup>th</sup> Edition (International), 2004. Singapore: McGraw Hill.</li> <li>Miller, S.A. and Harley, J.B. ZOOLOGY, 5<sup>th</sup> Edition (International), 2002. Singapore: McGraw Hill.</li> <li>Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4<sup>th</sup> Edition (International), 2000. Singapore: McGraw Hill.</li> <li>Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2000. New York: McGraw Hill.</li> <li>Campbell, N.A. BIOLOGY, 6<sup>th</sup> Edition. Menlo Park, California: 2002. Benjamin/Cummings Publishing Company, Inc.</li> </ol> <p>Practicals</p> <ol style="list-style-type: none"> <li>Study of mitosis in onion root tip.</li> <li>Study of meiosis in grasshopper testis (students should prepare the slide).</li> </ol> <p><i>Note for 1-2: Prepared microscopic and/or projection slides and/or CD</i></p>

	<p><i>ROM computer projections must be used).</i></p> <ol style="list-style-type: none"> <li>3. Problem based study of Mendelian ratio in animals.</li> <li>4. Multiple alleles study in blood groups.</li> <li>5. Survey study of a genetic factor in population and its frequency.</li> <li>6. Study of karyotypes of <i>Drosophila</i>, mosquito.</li> <li>7. Study of cytochemical detection of DNA in protozoa and avian blood cell.</li> <li>8. Study to demonstrate nervous or endocrine basis of behaviour (conditioned reflex or aggression or parental behavior).</li> <li>9. Study to demonstrate social behaviour (documentary film be shown, honey bee, monkey group in a zoo).</li> </ol> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>1. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5<sup>th</sup> Edition (International), 2002. Singapore: McGraw Hill.</li> <li>2. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.</li> </ol>
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<b>Course Title</b>	<b>Animal Diversity -1 (Invertebrates Diversity)</b>
Course Code	ZOL – 401
Credit Hours	4
Theory	3
Practical	1
Follow up	Animal Diversity -1 (Vertebrates)
Category	BS (Hons)
Aims and Objectives	The students will be able to make comparison from simple unicellular to complex multicellular organization along with phylogenetic relationship
Learning Outcomes	The students will be able to achieve the aims and objectives of the course
Syllabus in Brief	<p>Theory</p> <ol style="list-style-type: none"> <li>1. Introduction Classification of organisms; evolutionary relationships and tree diagrams; patterns of organization.</li> <li>2. Animal-Like Protists: The Protozoa Evolutionary perspective; life within a single plasma membrane; symbiotic lifestyles. Protozoan taxonomy: (up to phyla, subphyla and super classes, wherever applicable). Pseudopodia and amoeboid locomotion; cilia and other pellicular structures; nutrition; genetic control and reproduction; symbiotic ciliates; further phylogenetic considerations.</li> <li>3. Multicellular and Tissue Levels of Organization Evolutionary perspective: origins of multicellularity; animal origins. Phylum porifera: cell types, body wall, and skeletons; water currents and body forms; maintenance functions; reproduction. Phylum cnidaria (coelenterata) the body wall and nematocysts; alternation of generations; maintenance functions; reproduction and classification up to class. Phylum ctenophora; further phylogenetic considerations.</li> <li>4. Triploblastics and Acoelomate Body Plan Evolutionary perspective; phylum platyhelminthes: classification up to class; the free-living flatworms and the tapeworms; phylum nemertea; phylum gastrotricha; further phylogenetic considerations.</li> <li>5. Pseudocoelomate Body Plan: Aschelminths Evolutionary perspective; general characteristics; classification up to phyla with</li> </ol>

	<p>external features; feeding and the digestive system; other organ systems; reproduction and development of phylum rotifera and phylum nematoda; phylum kinorhyncha. Some important nematode parasites of humans; further phylogenetic considerations.</p> <p>6. Molluscan Success          Evolutionary perspective: relationships to other animals; origin of the coelom; molluscan characteristics; classification up to class. The characteristics of shell and associated structures, feeding, digestion, gas exchange, locomotion, reproduction and development, other maintenance functions and diversity in gastropods, bivalves and cephalopods; further phylogenetic considerations.</p> <p>7. Annelida: The Metameric Body Form          Evolutionary perspective: relationship to other animals, metamerism and tagmatization; classification up to class. External structure and locomotion, feeding and the digestive system, gas exchange and circulation, nervous and sensory functions, excretion, regeneration, reproduction and development, in polychaeta, oligochaeta and hirudinea; further phylogenetic considerations.</p> <p>8. Arthropods: Blueprint for Success          Evolutionary perspective: classification and relationships to other animals; metamerism and tagmatization; the exoskeleton; metamorphosis; classification up to class; further phylogenetic considerations.</p> <p>9. Hexapods and Myriapods: Terrestrial Triumphs          Evolutionary perspective; classification up to class. External structure and locomotion, nutrition and the digestive system, gas exchange, circulation and temperature regulation, nervous and sensory functions, excretion, chemical regulation, reproduction and development in hexapoda; insect behavior; insects and humans; further phylogenetic considerations.</p> <p>Practicals</p> <ol style="list-style-type: none"> <li>1. Study of <i>Euglena</i>, <i>Amoeba</i>, <i>Entamoeba</i>, <i>Plasmodium</i>, <i>Trypanosoma</i>, <i>Paramecium</i> as representative of animal like protists. (Prepared slides <u>and from fresh water</u>).</li> <li>2. Study of sponges and their various body forms (<u>prepared slides</u>).</li> <li>3. Study of principal representative classes of phylum Cnidaria.</li> <li>4. Study of principal representative classes of phylum Platyhelminthes.</li> <li>5. Study of representative of phylum Rotifera, phylum Nematoda.</li> <li>6. Study of principal representative classes of phylum Mollusca.</li> <li>7. Study of principal representative classes of phylum Annelida.</li> <li>8. Study of principal representative classes of groups of phylum Arthropoda.</li> <li>9. Brief notes on medical/economic importance of the following: <i>Plasmodium</i>, <i>Entamoebahistolitica</i>, <i>Leishmania</i>, Liverfluke, Tapeworm, Earthworm, Silkworm, Citrus butterfly.</li> <li>10. Preparation of permanent stained slides of the following: <i>Obelia</i>, <i>Daphnia</i>, Cestode, Parapodia of <i>Nereis</i>.</li> </ol> <p>Reference Books</p> <ol style="list-style-type: none"> <li>1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11<sup>th</sup> Edition (International), 2004. Singapore: McGraw Hill.</li> <li>2. Miller, S.A. and Harley, J.B. ZOOLOGY, 9<sup>th</sup> Edition (International), 2009. Singapore: McGraw Hill.</li> <li>3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4<sup>th</sup> Edition</li> </ol>
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	<p>(International), 2000. Singapore: McGraw Hill.</p> <p>4. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.</p> <p>5. Miller, S.A., GENERAL ZOOLOGY LABORATORY MANUAL. 5<sup>th</sup> Edition (International), 2002. Singapore: McGraw Hill.</p> <p>6. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.</p>
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<b>Course Title</b>	ANIMAL DIVERSITY-II (CLASSIFICATION, PHYLOGENY AND ORGANIZATION)
Course Code	ZOL-403
Credit Hours	4(3-1)
Theory	3
Practical	1
Follow up	<b>BS</b>
Category	
Aims and Objectives	The course provides knowledge and understanding about the different animal groups, emphasizing their phylogenetic relationships.
Learning Outcomes	
Syllabus in Brief	<p>Course Contents</p> <p>1. Echinoderms Evolutionary perspective: relationships to other animals; echinoderm characteristics; classification up to class. Maintenance functions, regeneration, reproduction, and development in asteroidea, ophiuroidea, echinoidea, holothuroidea and crinoidea; further phylogenetic considerations; some lesser-known invertebrates: the lophophorates, entoprocts, cycliophores, and chaetognaths.</p> <p>2. Hemichordates and Invertebrate Chordates Evolutionary Perspective: Phylogenetic Relationships; Classification up to subphylum or class where applicable; Further Phylogenetic Considerations.</p> <p>3. Fishes: Vertebrate Success in Water Evolutionary perspective: phylogenetic relationships; survey of super class agnatha and gnathostomata; evolutionary pressures: adaptations in locomotion, nutrition and the digestive system, circulation, gas exchange, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations.</p> <p>4. Amphibians: The First Terrestrial Vertebrates Evolutionary perspective: phylogenetic relationships; survey of order caudata, gymnophiona, and anura. Evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction, development, and metamorphosis; further phylogenetic considerations.</p> <p>5. Reptiles: The First Amniotes Evolutionary perspective: cladistic interpretation of the amniotic lineage; survey of order testudines or chelonia, rhynchocephalia, squamata, and</p>

	<p>crocodilia; evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations.</p> <p>6. Birds: Feathers, Flight, and Endothermy Evolutionary perspective: phylogenetic relationships; ancient birds and the evolution of flight; diversity of modern birds; evolutionary pressures: adaptation in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and regulation, nervous and sensory systems, excretion and osmoregulation, reproduction and development; migration and navigation.</p> <p>7. Mammals: Specialized Teeth, Endothermy, Hair, and Viviparity Evolutionary perspective: diversity of mammals; evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, behavior, reproduction and development.</p> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11<sup>th</sup> Edition (International), 2004. Singapore: McGraw Hill.</li> <li>2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5<sup>th</sup> Edition (International) 2002. Singapore: McGraw Hill.</li> <li>3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4<sup>th</sup> Edition (International), 2000. Singapore: McGraw Hill.</li> <li>4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill.</li> <li>5. Campbell, N.A. BIOLOGY, 6<sup>th</sup> Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.</li> </ol> <p>Practicals</p> <ol style="list-style-type: none"> <li>1. Study of a representative of Hemichordate and Invertebrate Chordate.</li> <li>2. Study of representative groups of class Fishes.</li> <li>3. Study of representative groups of class Amphibia.</li> <li>4. Study of representative groups of class Reptilia.</li> <li>5. Study of representative groups of class Aves.</li> <li>6. Study of representative groups of class Mammalia.</li> <li>7. Field trips to study animal diversity in an ecosystem.</li> </ol> <p><i>Note: Preserved specimen and/or colored projection slide and/or CD ROM projection of computer must be used.</i></p> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>1. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.</li> <li>2. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5<sup>th</sup> Edition (International), 2002. Singapore: McGraw Hill.</li> </ol>
<b>Course Title</b>	<b>ANIMAL FORM AND FUNCTION-II</b> (A COMPARATIVE PERSPECTIVE)
Course Code	ZOL-402
Credit Hours	4(3-1)

Theory	3
Practical	1
Follow up	<b>BS</b>
Category	
Aims and Objectives	The course deals with the: <ul style="list-style-type: none"> <li>a. Basis of structure and functions of animal nutrition, digestion, homeostasis and temperature regulation.</li> <li>b. It introduces the basic concepts in reproduction and development in animal kingdom.</li> <li>c. Provides knowledge about the development of chordate body plan and fate of germinal layers.</li> </ul>
Learning Outcomes	
Syllabus in Brief	<p>Course Contents</p> <p>1. Nutrition and Digestion Evolution of nutrition; the metabolic fates of nutrients in heterotrophs; digestion; animal strategies for getting and using food, diversity in digestive structures of invertebrates and vertebrates; 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; and role of the liver and gallbladder in digestion.</p> <p>2. Temperature and Body Fluid Regulation 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.</p> <p>3. 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.</p> <p>4. Descriptive Embryology Fertilization; embryonic development: cleavage, and egg types; the primary germ layers and their derivatives; echinoderm embryology; vertebrate embryology: the chordate body plan, amphibian embryology, development in terrestrial environments, avian embryology, the fate of mesoderm.</p> <p>Books Recommended</p> <p>1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11<sup>th</sup> Edition (International), 2004. Singapore: McGraw Hill.</p>

	<p>2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5<sup>th</sup> Edition (International), 2002. Singapore: McGraw Hill.</p> <p>3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4<sup>th</sup> Edition (International), 2000. Singapore: McGraw Hill.</p> <p>4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill.</p> <p>5. Campbell, N.A. BIOLOGY, 6<sup>th</sup> Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.</p> <p>Practicals</p> <ol style="list-style-type: none"> <li>1. Study of excretory system in an invertebrate and a vertebrate representative (Model).</li> <li>2. Study of nutritive canal in an invertebrate and a vertebrate representative (Dissection).</li> <li>3. Study of male reproductive system in an invertebrate and a vertebrate representative (Dissection).</li> <li>4. Study of female reproductive system in an invertebrate and a vertebrate representative (Dissection).</li> <li>5. Study of hormonal influence of a reproductive function (Model).</li> <li>6. Study of preserved advanced stages of avian and mammalian development for amniotic membranes and placenta (Model).</li> <li>7. Study of stages in the development of an Echinoderm.</li> <li>8. Study of early stages in the development of a frog, chick and a mammal.</li> </ol> <p><i>Note for 9-10: Prepared slides and preserved specimen and/or projection slides and/or CD ROM computer projections may be used.</i></p> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>1. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.</li> <li>2. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5<sup>th</sup> Edition (International), 2002. Singapore: McGraw Hill.</li> </ol>
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<b>Course Title</b>	<b>ANIMAL FORM AND FUNCTION-I (A COMPARATIVE PERSPECTIVE)</b>
Course Code	ZOL-404
Credit Hours	4(3-1)
Theory	3
Practical	1
Follow up	<b>BS</b>
Category	
Aims and Objectives	<p>The course aims to teach the students about:</p> <ol style="list-style-type: none"> <li>a. Animals diversity adapted in different ways for their functions through modifications in body parts.</li> <li>b. The diversity in integumentary, skeletal, muscular, nervous and sensory, endocrine, circulatory, respiratory, nutritive, excretory, osmoregulatory and reproductive systems according to strategies to survive in their specific conditions.</li> <li>c. Organ systems, their specialization and coordination with each other</li> </ol>

	<p>and constantly changing internal and external environment, inside and outside the animal's body.</p> <p>d. The basic structure of each system that determines its particular function.</p>
<p>Learning Outcomes</p>	
<p>Syllabus in Brief</p>	<p>Course Contents</p> <p>1. Protection, Support, and Movement 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.</p> <p>2. Communication I: Nerves Neurons: structure and function; neuron communication: introductory accounts of resting membrane potential, action potential (nerve impulse) and transmission of the action potential between cells; invertebrate and vertebrate nervous systems: the spinal cord, spinal nerves, the brain, cranial nerves and the autonomic nervous system.</p> <p>3. Communication II: Senses 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, hearing and equilibrium in water, skin sensors of damaging stimuli, skin sensors of heat and cold, skin sensors of mechanical stimuli, sonar, smell, taste and vision in vertebrates.</p> <p>4. Communication III: The Endocrine System and Chemical Messengers Chemical messengers: hormones chemistry; and their feedback systems; mechanisms of hormone action; some hormones of porifera, cnidarians, platyhelminthes, nemertean, nematodes, molluscs, annelids, arthropods, and echinoderms invertebrates; an overview of the vertebrate endocrine system; endocrine systems of vertebrates, endocrine systems of birds and mammals.</p> <p>5. Circulation, Immunity, and Gas Exchange 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; gas exchange: respiratory surfaces; invertebrate and vertebrate respiratory systems: cutaneous exchange, gills, lungs, and lung ventilation; human respiratory system: gas transport.</p> <p>Books recommended</p> <ol style="list-style-type: none"> <li>1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11<sup>th</sup> Edition (International), 2004. Singapore: McGraw Hill.</li> <li>2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5<sup>th</sup> Edition (International), 2002. Singapore: McGraw Hill.</li> <li>3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4<sup>th</sup> Edition (International), 2000. Singapore: McGraw Hill.</li> <li>4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF</li> </ol>

	<p>VERTEBRATES. 2001. New York: McGraw Hill.</p> <p>5. Campbell, N.A. BIOLOGY, 6<sup>th</sup> Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.</p> <p>Practicals</p> <ol style="list-style-type: none"> <li>1. Study of insect chitin, fish scale, amphibian skin, reptilian scales, feathers and mammalian skin.</li> <li>2. Study and notes of skeleton of <i>Labeo</i>, <i>Rana tigrina</i>, <i>Varanus</i>, fowl and rabbit.</li> </ol> <p><i>Note: Exercises of notes on the adaptations of skeletons to their function must be done.</i></p> <ol style="list-style-type: none"> <li>3. Earthworm or leech; cockroach, freshwater mussel, <i>Channa</i> or <i>Catla catla</i> or <i>Labeo</i> or any other local fish, frog, pigeon and rat or mouse and rabbits are representative animals for study in dissections.</li> <li>4. Study of models or preserved brains of representative animals and notes on adaptations.</li> <li>5. Study of nervous system of earthworm and a fish.</li> <li>6. Study of endocrine system in an insect and a rabbit.</li> <li>7. Study of different types of blood cells in blood smear of rabbit.</li> <li>8. Study of heart, principal arteries and veins in a representative vertebrate (dissection of representative fish/mammals).</li> <li>9. Study of respiratory system in cockroach or locust and a vertebrate representative (Model).</li> </ol> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>1. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.</li> <li>2. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5<sup>th</sup> Edition (International), 2002. Singapore: McGraw Hill.</li> </ol>
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<b>Course Title</b>	<b>Cell and Molecular Biology</b>
Course Code	ZOL-501
Credit Hours	4
Theory	3
Practical	1
Follow up	Not Applicable
Category	BS Zoology, 04-Years Programme
Aims and Objectives	This course is designed to impart knowledge about the animal cell and its complex organization of architecture and the unified role it plays for the ultimate sustainability of the organisms. In this course, the students will be able to learn about the ultra-structural, molecular and functional aspects of the cell.
Learning Outcomes	The students will be able to achieve the aims and objectives of this course.
Syllabus in Brief	<p><u>Theory</u></p> <p>Overview of prokaryotic and eukaryotic cell. Structure, chemical composition and functions of Plasma Membrane (including Permeability, Active Transport, Endocytosis), Mitochondria (including its role in respiration and its status as semi-autonomous organelle), Golgi Apparatus (including glycosylation), Endoplasmic Reticulum (including role in protein synthesis and drug metabolism), Lysosomes, Ribosomes, Peroxisomes,</p>

	<p>glyoxysomes, Cytoplasm, cytoskeleton. <u>Nucleus: Chromatin, heterochromatin, euchromatin, chromosome structure with reference to coiling and nucleosome during different phases of cell cycle.</u></p> <p>Significance of genetic material. Structure of DNA –A, B and Z forms. DNA replication mechanisms in prokaryotes and eukaryotes, DNA polymerases and other enzymes and DNA binding proteins involved in DNA replication, DNA repair mechanisms. Cell Cycle and its regulation. Central dogma: Transcription, RNA polymerases, transcriptional control in prokaryotes and eukaryotes. Post-transcriptional processing of mRNA, rRNA and tRNA. Genetic Code (point mutations), genetic code in mitochondrial DNA, Translation: Protein synthesis, post-translational processing of proteins. Regulation of Gene Expression: Lac Operon, Trp Operon. Recombinant DNA technology: Cloning vectors, restriction endonucleases, Southern blotting, Northern blotting, western blotting, DNA sequencing, Site directed mutagenesis.</p> <p><u>Practicals</u></p> <ol style="list-style-type: none"> <li>1. Culturing and staining of bacteria and yeast.</li> <li>2. Counting of bacterial cells and preparation of growth curves.</li> <li>3. Counting of blood cell types by haemocytometer.</li> <li>4. Detection (in protozoan culture and blood cells) and quantitative determination of chromosomal DNA and RNA.</li> <li>5. Isolation and plasmid DNA from bacterium and demonstration on agarose gel.</li> <li>6. Isolation and fractionation of proteins from blood sera by polyacrylamide gel electrophoresis.</li> </ol> <p><u>Books Recommended</u></p> <ol style="list-style-type: none"> <li>1. Darnell Jr., J., Lodisch, H. and Baltimore D., 1990. <i>Molecular Cell Biology</i>. Scientific American, New York.</li> <li>2. Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K and Walter, P., 2002. <i>Molecular Biology of Cell</i>. Garland Science, New York.</li> <li>3. DeRobertis, E.D.P. and DeRobertis Jr. E.N.F., 1987. <i>Cell and Molecular Biology</i>. Lea and Febiger, New York.</li> <li>4. Karp, G., 2002. <i>Cell and Molecular Biology. Concepts &amp; Experiments</i>. John Wiley &amp; Sons, New York.</li> <li>5. Stryer, L., 1995. <i>Biochemistry</i>. W.H. Freeman, New York.</li> </ol>
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<b>Course Title</b>	Biochemistry-I (Structure and Functions of Macromolecules)
Course Code	ZOL-503
Credit Hours	3
Theory	2
Practical	1
Follow up	Biochemistry-II (Metabolism)
Category	
Aims and Objectives	To provide knowledge regarding structural / storage components of basic unit of life at molecular level also. It will also enable the students to understand Biochemistry of major food stuffs.
Learning Outcomes	This course will enable the students to study the working of life processes at molecular level.
Syllabus in Brief	Amino acids: Peptides and Proteins: Standard Amino acids their structure, Classification, Acid/Base properties and Titration curves. Amino acid

sequencing of proteins and its significance. Macromolecular separation techniques in Biochemistry: Ion exchange chromatography; Polyacrylamide gel Electrophoresis (PAGE); Isoelectric Focusing.

Enzymes: How enzymes work. Enzyme rate of reaction and substrate concentration. How pH and temperature effect enzyme activity. Kinetics of Bisubstrate and Multisubstrate reactions. Enzyme inhibition, Irreversible and Reversible Regulatory Enzymes.

Carbohydrates: Classification of Carbohydrates. History of Developments in Structure of Glucose. Monosaccharides. Disaccharides their types structure and properties. Polysaccharides: Storage and Structural types; Structure and major functions of Glycogen, Chitin, Peptidoglycans of bacterial cell wall.

Lipids: Fatty acids, their types. Storage Lipids: Acylglycerols; Structural Lipids of membranes: Glycerophospholipids; Sphingolipids their role and degradation. Sterols, Cholesterol, Testosterone, Estriadiole. Major functions of Lipids. Lipoproteins, their types and major functions. Lipid analysis: GLC as an example.

Vitamins as Cofactors: Occurrence, Structure and Biochemical function of Riboflavin.

Nucleic acids: Types and structure.

#### Books Recommended

1. David I., Nelson, and Michael M, Cox. 2000, Lehninger Principles of Biochemistry, 3<sup>rd</sup> Edition, Macmillan Worth Publihers, New York.

#### Additional Reading

1. Murray, R.K., Granner, D.K., Mayer, P.A., and Rodwells, V.W., 2000. Harper's Biochemistry, 25<sup>th</sup> Edition, McGraw-Hill Book Company, New York.

2. Voet. D., Voet. J.G., and Pratt. C.W., 1999. Fundamentals of Biochemistry, John Wiley and Sons Inc., New York.

3. Zubay. G., 1995. Biochemistry, 4<sup>th</sup> Edition, Wm. C. Brown Publishers Inc. Oxford, England.

4. Lubert Stryer, 1995. Biochemistry, 4<sup>th</sup> Edition, W.H. Freeman & Company, New York.

#### Practicals

1. Tests for detection of carbohydrates in acidic medium.

2. Tests for detection of carbohydrates in alkaline medium.

3. Detection of Non-Reducing sugars in the presence of Reducing sugars.

4. Tests to demonstrate relative instability of glycosidic linkage in carbohydrates.

5. Tests for detection of Disaccharides.

6. Preparation of standard curve of glucose by ortho-Toluidine method.

7. Estimation of glucose from blood serum or any other fluid using ortho-Toluidine technique.

8. Biochemical tests for detection of different amino acid groups.

9. Preparation of standard curve of proteins by Biuret method.

10. Estimation of Blood serum proteins using Biuret technique.

11. Demonstration of differential solubility of lipids in various solvents.



	<p>12. Various Qualitative Tests for detection of Lipids. 13. Determination of Acid value of Fats.</p> <p><u>Books Recommended</u></p> <p>1. Plummer, David T., 1990. An Introduction to Practical Biochemistry, 4<sup>th</sup> Edition, McGraw-Hill Book Company, London.</p> <p>2. Wilson, K &amp; Walker, J., 1994. Practical Biochemistry: Principles of Techniques, 4<sup>th</sup> Edition, Cambridge University Press.</p>
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<b>Course Title</b>	Animal Physiology-I
<b>Course Code</b>	ZOL-505
<b>Credit Hours</b>	3
<b>Theory</b>	2
<b>Practical</b>	1
<b>Follow up</b>	None
<b>Category</b>	Physiology of Coordination and Animal Behaviour
<b>Aims and Objectives</b>	One is able to understand mechanisms and adaptations of physiological systems in animals.
<b>Learning Outcomes</b>	The students will be able to understand the working of various systems of organisms.
<b>Syllabus in Brief</b>	<p>Central themes in Physiology: Structure-Function Relationship. Adaptations, Homeostasis. Conformity and Regulation.</p> <p>Exchange of Gases: Transport of O<sub>2</sub> and CO<sub>2</sub> between respiratory surface (the lungs) and body cells. Regulation of lungs respiration: Gas transfer in water (gills) and its regulation. Respiratory responses in extreme conditions as hypoxia: Hypercapnia in air breathing divers.</p> <p>Excretion and Osmoregulation: Osmoregulation in aquatic and terrestrial environment. Vertebrate nephron as osmoregulatory organ: Physiological anatomy. Glomerular filtration. Tubular absorption and secretion: Nitrogenous waste products: Patterns of nitrogenous excretion and their phylogenetic development.</p> <p>Nutrition: Regulation of digestive secretions: Physiological anatomy of digestive tract (mammalian model), Absorption of water, ions and nutrients.</p> <p>Cardiovascular Mechanisms: Electrical activity of heart: Automaticity, Rhythmicity, Electrocardiography, Kymography: Hemodynamics, Blood flow, pressures and resistance and their interrelationships. Control of cardiac activity (cardiac output) and peripheral circulation.</p> <p><u>Books Recommended</u></p> <p>1. Randall. D., Burggren. W., French. K. and Fernald. R., 2002. Eckert Animal Physiology: Mechanisms and Adaptations. 5<sup>th</sup> ed. W.H. Freeman and Company. New York.</p> <p>2. Bullock. J., Boyle. And Wang. M.B., 2001. Physiology. 4<sup>th</sup> edition. Lippincott. Williams and Wilkins. Philadelphia.</p> <p>3. Bame. F.M. and Levy. M.N., 2000. Textbook of Medical Physiology. 3<sup>rd</sup> edition. St. Lions. Mosby.</p> <p>4. Guyton and hall 2000 Text book of Medical Physiology 10th. Edition.</p> <p>5. Withers 1992 Comparative Animal Physiology.</p> <p>6. Schmidt- Nelsen. K., 1997 Animal Physiology. Adaptation and environment 5th. Edition Cambridge University Press Cambridge.</p> <p><u>Practicals</u></p> <p>Cardiovascular Activity: Normal cardiac activity, effect of temperature, effect of drug, heart block, tetanization of heart, Measurement of blood pressure.</p> <p>Respiration and Exercise: Oxygen consumption in fish and effect of temperature (by dissolved oxygen meter) and terrestrial animal (mouse). Oxygen consumption (by respirometer), heart rate, blood pressure glycemia</p>

	altered by exercise. Book Recommended 1. Tharp. G. and Woodman. D. 2002. Experiments in Physiology. 8 <sup>th</sup> Edition. Prentice Hall London.
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<b>Course Title</b>	<b>Animal Behavior</b>
Course Code	ZOL-507
Credit Hours	3(3-0)
Theory	3
Practical	0
Follow up	Not Applicable
Category	BS Zoology, 04-Years Programme
Aims and Objectives	To understand the basic principles to study animal behavior and its application in modern world.
Learning Outcomes	To be able to design animal behavior explorative assignments, independently, and interpret outcomes effectively.
Syllabus in Brief	<ol style="list-style-type: none"> <li>1. Introduction to the animal behavior: definition of animal behavior and historical background, Fundamental research approaches, mechanistic, vitalistic and ethological, conventionally used in field of animal behavior,</li> <li>2. Tinbergen's four questions: Importance of Niko Tinbergen presented proximate/causal and ultimate/ functional based questions to study the animal behavior,</li> <li>3. Behavior as adaptation: Influence of types of selections (directional, stabilize and disruptive) on animal behavior, animal welfare and conservation aspects in animal behavior, Case studies of animal welfare to elaborate the problems in repertoire of animal behavior and importance of its study,</li> <li>4. Basic components of animals behavior: nature and nurture, Mechanism of behavior;</li> <li>5. Neuronal control of behavior: types of sensory receptors, sensory coordination and somesthetic systems, vertebrate and invertebrate nervous system, general anatomy and function in repertoire of behavior,</li> <li>6. Endocrine control of behavior in vertebrates: explanation of milk-ejaculation reflex (MER) in goats,</li> <li>7. Sensory judgments: including sensation and perception difference, difference in uncertainty interval and difference threshold, Weber fraction, Fechner's Law, signal-detection theory and yes-no criterion, explanation through payoff matrix, hypothetical effects of different decision criteria in signal detection theory,</li> <li>8. Stimulus filtering and sign stimulus: innate releasing mechanism (IRM), discrimination learning of animal, experimentation on complex stimuli, examples of herring gull and eggs shape, size and color, law of heterogeneous summation,</li> <li>9. Visual recognition of prey and predators: Classical conditioning, stimulus substitution theory and stimulus-response theory, types of responses and importance of reinforcement,</li> <li>10. Fundamental aspects of habituation and extinctions: including phenomenon of external inhibition and disinhibition of conditional responses, Instrumental learning and law of effect,</li> <li>11. Fundamental difference between classical conditioning and instrumental learning: types of reinforcement and its fundamental</li> </ol>

	<p>aspects.</p> <p><b>Text Books:</b></p> <ol style="list-style-type: none"> <li>1. Graham Scott (2010) Essential Animal Behavior. Blackwell Publishing.</li> <li>2. David McFarland (1985) Animal Behaviour: Psychobiology, Ethology and Evolution. Longman House, Burnt Mill, England.</li> <li>3. Roland J. Siiter (1999) Introduction to Animal Behavior. Cole Publishing Company, CA, USA.</li> <li>4. John Alcock (2001) Animal Behavior: An Evolutionary Approach. 7<sup>th</sup> Ed. Sinauer Associates, Inc., Massachusetts, USA.</li> <li>5. David Randall, WarreBurggren and Kathleen French (2002) Eckert Animal Physiology: Mechanisms and Adaptations. W.H. Freeman and Company, New York, USA.</li> </ol>
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<b>Course Title</b>	<b>General and Molecular Genetics</b>
Course Code	ZOL-509
Credit Hours	4
Theory	3
Practical	1
Follow up	Biotechnology
Category	BS. Zoology, 04-Years Programme/ MSc ,02-years
Aims and Objectives	This course covers general genetic principles, DNA tools for genetic analysis, the molecular basis of genetic diseases, animal models, Molecular methods of analysis are emphasized. Prerequisites: All four core courses
Learning Outcomes	In this course students learn to use the tools of modern genomics to elucidate phenotypic variation within populations.
Syllabus in Brief	<p>Theory</p> <p>Introduction: classical genetics, molecular genetics, Reverse and forward genetics, The basic principles of Inheritance (Mendelism): Monohybrid and Dihybrid crosses. Multiple Alleles: ABO Blood system. Genetics of Rh factor and Erythroblastosis Foetalis. Gene Interaction: Epistasis, Lethality and Pleiotropism. Sex Linked gene in human beings. Sex Chromosome and Sex determination in human beings, Drosophila and other animals. Variation in chromosome number and structure: Polyploidy, Aneupolidy and rearrangement of chromosome structure. Genetics of Bacteria: Transformation, conjugation and Transduction. Techniques of molecular genetics: Basic techniques used to clone genes, construction and screening of DNA libraries, manipulation of cloned DNA sequences, molecular analysis of DNA, RNA and protein. Analysis of human pedigrees. Gene therapy. DNA Fingerprints: Paternity tests and Forensic applications. Inborn errors of Metabolism: Amino acid metabolism (Phenylketonuria, Alkaptonuria and Oculocutaneous albinism); Carbohydrate metabolism (Galactosaemia); Lipid Metabolism , Tay-Sachs; Purine/pyrimidine metabolism (Lech – Nyhan disease).</p> <p>Practicals</p> <ol style="list-style-type: none"> <li>1. Study of Mitosis and Meiosis.</li> <li>2. Preparation of Drosophila culture.</li> <li>3. Study of morphology and karyotype.</li> <li>4. Study of Monohybrid and dihybrid ratio, sex-linked inheritance.</li> </ol>

	<ol style="list-style-type: none"> <li>5. Pedigree Analysis</li> <li>6. Detection of Blood Groups in humans.</li> <li>7. Problem relating to theory.</li> </ol> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>1. <u>Hartl, D. L. and E. W. Jones. 2009 Genetics: Analysis of Genes and Genomes. Seventh (7th) Edition. Jones and Bartlett Publishers. USA.</u></li> <li>2. Snustard, D.P. and Simmon, M.J., 2003. Principles of Genetics. 3rd Edition. John Wiley and Sons, New York.</li> <li>3. Muller, R.F. and Young, I.D., 2002. Emery's Elements of Medical Genetics. 11th Edition. Churchill Livingstone, Elsevier Science, Limited, UK.</li> <li>4. Tammarin, R.M. 1999. Principles of Genetics. 6th Edition, WCB, McGraw Hill, New York.</li> <li>5. <u>Klug, Cummings et al., 2012, Concepts of Genetics 10th) edition, Pearson Publisher. Macmillan College Publishing Company, New York.</u></li> <li>6. Strickberger, M.W. 1999. Genetics. 3rd Edition. Prentice Hall of India Private Ltd., New Delhi.</li> <li>7. Herskowitz, I.H., 1985. Genetics. Little Brown, Boston, USA.</li> <li>8. Lewin, B. 2003. Gene VII. Oxford, UK.</li> </ol>
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<b>Course Title</b>	<b>Biostatistics</b>
Course Code	ZOL-502
Credit Hours	3(3-1)
Theory	3
Practical	0
Follow up	<b>BS</b>
Aims and Objectives	The course will provide knowledge about the importance and use of statistics in life sciences. It will help the students to understand the methods to analyze data pertaining to their research work and to assess the significance of their experimental designs.
Learning Outcomes	After this course students will be able to apply basic statistical procedures for analysis of data for practical and research.
Syllabus in Brief	<p>Course Contents</p> <p>Introduction and scope, use of statistics in biology. Population and sample. Stages of research, types of data and methods of data collection. Data arrangement and presentation, formation of tables and charts. Measures of central tendency computation of mean, median and mode from grouped and ungrouped data. Measures of dispersion, computation of variance, standard deviation, standard error and their coefficients. Probability rules. Binomial, poissons and normal distributions. Hypothesis testing, Student 't' test, Chi square test, Analysis of variance and LSD. Correlation and regression. Experimental designing, planning of an experiment, replication and randomization.</p> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>1. Geoffery, R. Norman, David L. Streiner BIostatistics: THE BARE ESSENTIALS. 2000. B.C. Decker Inc.</li> <li>2. Gerry, P. Quinn, Michael J. Keough, EXPERIMENTAL DESIGN AND DATA ANALYSIS FOR BIOLOGISTS. 2002. Cambridge University Press.</li> </ol>

	3. Campbell, R. C. STATISTICS FOR BIOLOGISTS. 1989. Cambridge University Press.
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<b>Course Title</b>	<b>Developmental Biology</b>
Course Code	ZOL-504
Credit Hours	4(3-1)
Theory	3
Practical	1
Follow up	
Category	B.S. Zoology, 04-Years Program/ M.Sc. Zoology, 02-Years Program
Aims and Objectives	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.
Learning Outcomes	The students will be able to apply the basic principles of development to further research.
Syllabus in Brief	<p><b>Syllabus: Theory</b> Mitosis, Meiosis. Principle features of development; developmental patterns, mechanism of teratogenesis Spermatogenesis, Oogenesis, Fertilization; Recognition of sperm and egg, fusion of gametes. <u>re-arrangement of egg</u> cytoplasm, Cleavage; patterns of embryonic cleavage, mechanism of cleavage. Gastrulation; Fate maps, gastrulation in birds, mammals. Early vertebrate development, Neurulation; ectoderm, mesoderm and endoderm formation. Cellular basis of morphogenesis; Establishments of body axis. Organogenesis, a brief account of origin and migration of germ cells in vertebrates, Factors controlling growth, Oncogenesis. Regeneration in vertebrates.</p> <p><b>Practical:</b> Study of mitosis and meiosis with the slides. Study of structure of gametes of fowl. Study of cleavage and subsequent development with the help of prepared slides and Whole mounts of chick embryo. Preparation and study of serial sections of different tissues. Preparation and staining of histological slides.</p> <p><b>Text Books:</b> <b>Suggested Reading:</b> <u>Books Recommended</u></p> <ol style="list-style-type: none"> <li>1. An introduction to embryology 2013 by Balinsky .B.I. and Saunders</li> <li>2. Developmental biology, 2000. by Gilbert, S. F.</li> <li>3. Human Embryology and Developmental biology, By Carlson, B. M.</li> <li>4. Introduction to Embryonic Developments by Oppenheimer, SS and Allen and Bacon</li> <li>5. Developmental Biology by Saunders W.B.</li> <li>6. Modern Embryology 1968 by Bodemer C.W</li> <li>7. Mechanism of development 1980. by Ham.R.G., and Veomett, M. J.</li> <li>8. The developing human 1982 by Moore K.L.</li> <li>9. Medical Embryology 1981 by Largman, J. Clinical Embryology 1983 by Snell, R.S.,</li> </ol>

<b>Course Title</b>	<b>Ecology</b>
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Course Code	ZOL-506
Credit Hours	3
Theory	2
Practical	1
Follow up	Applied Ecology+Molecular Ecology
Category	BS. Zoology 4 year Programme M.Sc. Zoology, 02-Years Programme
Aims and Objectives	This course will provide awareness regarding the environmental changes.
Learning Outcomes	The students will be able to study the Applied ecology and Molecular ecology.
Syllabus in Brief	<p>Theory:</p> <p>Nature of Ecology, The earth's life support system, Ecosystem concepts and components, Energy flow in Ecosystem, Primary productivity of ecosystems, Matter cycling in ecosystem (Biogeochemical cycles). Ecological Niche, Major ecosystem of world: Marine, Estuarine, Freshwater, Tundra, Forest, Grassland and Desert. Population Ecology: Population structure, Factors affecting population growth, Factors controlling population growth. Community Ecology: Size and structure of community. Ecological succession: Communities in transition, Role and interaction of species in the ecosystem, Food chains and food webs, Impact of human intervention on the global ecosystem and its effects on man. Molecular aspects of the ecosystem, food chains and community interactions.</p> <p>Practicals:</p> <p>Food chain, food web &amp; ecological notes Methods and analysis of population dynamics Quadrat method Determining frequency of different species Determining density of species in habitat Measurement of pollutants levels In atmosphere (NO<sub>2</sub>, SO<sub>2</sub>, O<sub>3</sub> and comparison with rural air) In soil (toxic chemical, fertilizer, insecticides, herbicides) Analysis of polluted and freshwater for Various pollutant; heavy metals, -CO<sub>3</sub>, -HCO<sub>3</sub>, NO<sub>3</sub>, BOD, COD, pH, EC, total soluble solids.</p> <p>Books Recommended:</p> <p>Books Recommended (Latest Edition)</p> <ol style="list-style-type: none"> <li>1. E.P. Odum, G. W. Barrett. Fundamentals of Ecology. (2004), 5<sup>th</sup> Edition</li> <li>2. Miller, G.T. 2002. Living in the environment: Principles, Connections and Solutions. 12<sup>th</sup> Edition. Thomson Learning, Australia.</li> <li>3. M.L. McKinney Environmental Science: System and Solution (1999) Jones &amp; Bartlett Publication, Boston.</li> <li>4. M.C. Molles Ecology: Concepts and application (1999) WCB/McGraw Hill, New York.</li> <li>5. Smith Ecology and Field Biology (1988) National Book Foundation</li> </ol>

<b>Course Title</b>	<b>Principles of Zoogeography</b>
Course Code	ZOL-508
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	BS 04 Years/M.Sc. Zoology, 02-Years Programme
Aims and Objectives	This course provides information on the distribution of animals and their association in different zoological regions of world
Learning Outcomes	After studying this course, the student will be able to recognize extant fauna of world distributed in different climatic regions.
Syllabus in Brief	<p><b>Theory:</b> Introduction and history of Zoogeography, Branches of Zoogeography. Barriers to distribution and means of dispersal in Marine, Freshwater and Terrestrial environment. Division of world into various zoogeographical regions. Geographical limits, Physical, climatic features and faunas of Holarctic (Palaeartic and Nearctic), Oriental, Ethiopian, Australian, and Neotropical regions. Insular fauna [continental islands {Recent (British Isles, Borneo, Java, Japan, Formosa and Philippines, and Sri Lanka islands)}, {Ancient (New Zealand and Madagascar Island)}]. [Oceanic Islands, (Azores, Bermuda, Galapagos, St. Helena and Karakatau Island)], Wallace's line, Weber's line and Wallacea. Continental drift theory and discontinuous distribution of animals.</p> <p><b>Practicals:</b> Identification and classification of various invertebrates and vertebrates of Zoogeographical importance.</p> <p><b>TextBook:</b> 1. Darlington, Zoogeography, John Wiely, 1963. 2. S.S. Ali, 1999. Palaeontology, Zoogeography and Wildlife Management.</p> <p><b>RecommendedBooks:</b> 1. Hesse, Ecological Animal Geography, John Wiely, 1963. 2. DeBeaufort, Zoogeography of the Land Inland Waters, Sidgwick and Jackson. 1951. 3. Ekman, Zoogeography of the sea. Sidgwick and Jackson. 1953. 4. Lillies, Introduction to Zoogeography, London, 1974. 5. Muller, Aspects of Zoogeography, Hague, 1974. 6. Jafri, Land Zoogeography of World, 1977.</p>

<b>Course Title</b>	Biochemistry-II
Course Code	ZOL-510
Credit Hours	3
Theory	2
Practical	1
Follow up	Biochemistry-I (Structure and Functioning of Macromolecules)
Category	Not Applicable
Aims and Objectives	M.Sc. Zoology, 02-Years Programme
Learning Outcomes	To provide knowledge regarding molecular interpretation of problems and processes of life.
Syllabus in Brief	This course will enable the students to comprehend all the current related

	courses in Zoology.
	<p>Bioenergetics: Concept of Free Energy and Standard Free Energy change. Energy rich compounds: Phosphoryl group transfers and ATP; Acyl phosphates; Enol phosphates and Thioesters.</p> <p>Carbohydrate Metabolism: Regulation and Anabolic role of Glycolysis. Fate of Pyruvate under Aerobic and Anaerobic conditions. Gluconeogenesis, its regulation. Feeder Pathways in Glycolysis i.e. Fructose, Galactose, Mannose, Glucose 1-phosphate, Glycereraldehyde and Glycerol. Phosphorolysis of Glycogen. Biosynthesis of Glycogen. Regulation of Glycogen Metabolism. Pentose phosphate pathway of Glucose oxidation and its major role in the animal tissues.</p> <p>Anabolic role of citric acid cycle intermediates; Regulation of Citric acid cycle.</p> <p>Lipid metabolism: Digestion, mobilization and transport of Fats. Biosynthesis and Utilization of Triacylglycerol. Activation of Fatty acids and their transportation to mitochondria. Beta-Oxidation and its Bioenergetics. Oxidation of unsaturated Fatty acid. Biosynthesis of Saturated Fatty acid: As an example palmitic acid synthesis; Fatty acid synthetase (FAS) Models of FAS system in Bacteria, vertebrate tissue. Biosynthesis of unsaturated Fatty acids, Aerobic and Anaerobic pathways. Ketone bodies their Biosynthesis, utilization and role in the tissue. Cholesterol regulation.</p> <p>Nitrogen Metabolism: Metabolic fate of standard amino acids. Catabolism of Amino acids: Decarboxylation; Deamination and Transamination. Amino acid degradation showing entry points in citric acid cycle. Nitrogen Excretion and Urea cycle with Regulation. Incorporation of Ammonia in Glutamate and Glutamine. Sources of various atoms in Purine and Pyrimidine synthesis.</p> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>David I., Nelson, and Michael M, Cox. 2000, Lehninger Principles of Biochemistry, 3rd Edition, Macmillan Worth Pubslihers, New York.</li> </ol> <p>Additional Reading</p> <ol style="list-style-type: none"> <li>Murray, R.K., Granner, D.K., Mayer, P.A., and Rodwells, V.W., 2000. Harper's Biochemistry, 25th Edition, McGraw-Hill Book Company, New York.</li> <li>Voet. D., Voet. J.G., and Pratt. C.W., 1999. Fundamentals of Biochemistry, John Wiley and Sons Inc., New York.</li> <li>Zubay. G., 2000. Biochemistry, 4th Edition, Wm. C. Brown Publishers Inc. Oxford, England.</li> <li>Lubert Stryer, 2001. Biochemistry, 4th Edition, W.H. Freeman &amp; Company, New York.</li> </ol> <p>Practicals</p> <ol style="list-style-type: none"> <li>Demonstration of Acid Hydrolysis of Polysaccharide.</li> <li>Determination of pKa values of an amino acid by preparation of titration curves.</li> <li>Estimation of Free Amino Acids in Biological samples colorimetrically.</li> </ol>



	<p>4. Separation and identification of various amino acids by Paper chromatography / PAGE.</p> <p>5. Separation of various protein fractions by precipitation method.</p> <p>6. Preparation of standard curve of proteins using Lowry's technique.</p> <p>7. Estimation of tissue (liver) proteins using Lowry's technique.</p> <p>8. Preparation of standard curve and Estimation of proteins by ultraviolet (UV) spectrophotometry.</p> <p>9. Preparation of standard curve and Estimation of DNA by colorimetric analysis using Diphenylamine method.</p> <p>10. Preparation of standard curve and Estimation of total RNA by colorimetric analysis using Bial's Orcinol method.</p> <p>11. Quantitative analysis of Diastase activity on starch.</p> <p>12. Study on the effect of temperature on the enzymatic rate of reaction.</p> <p>Books Recommended</p> <p>1. Plummer, David T., 1990. An Introduction to Practical Biochemistry, 4th Edition, McGraw-Hill Book Company, London.</p> <p>2. Wilson, K &amp; Walker, J., 1994. Practical Biochemistry: Principles of Techniques, 4th Edition, Cambridge University Press.</p>
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<b>Course Title</b>	Physiology – II
Course Code	ZOL-512
Credit Hours	3
Theory	2
Practical	1
Follow up	Animal Physiology
Category	Not Applicable
Aims and Objectives	M.Sc. Zoology, 02-Years Programme
Learning Outcomes	To understand basic mechanism and adaptations of various physiological processes in different animals.
Syllabus in Brief	The students will be able to understand different phenomena in animal physiology.

<b>Course Title</b>	<b>Evolution and Principles of Systematics</b>
Course Code	ZOL-601
Credit Hours	4
Theory	3
Practical	1
Follow up	
Category	BS Zoology, 04-Years Programme/ M.Sc Zoology, 02-Years Programme
Aims and Objectives	This course will provide informations about origin, classification and evolution of fauna
Learning Outcomes	The students will be able to understand classification, philosophy of nomenclature, species concepts, phylogenetic inference and evolutionary perspectives of biodiversity.
Syllabus in Brief	<b>Theory:</b> Contribution of systematic to Biology; History of Taxonomy

	<p>(Downward classification, upward classification, impact of origin of species and their delimitation, population systematics, current trends); Microtaxonomy, phenon, Taxon; Taxonomic categories; species category, infraspecies category, higher categories; species concepts (Typological concept; nominalistic concept, Biological concept, evolutionary concept). Species mate recognition concept; non-dimensional species concept; Multidimensional species concept; Cohesion species concept; Difficulties in the application of biological species; ploytypic species, subspecies, superspecies, sibling species; study of major type of variation within a single population, Macrotaxonomy; different kinds of Synonym, Homonym, Keys; Evolution of the theory of 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, cladistics, Taxonomic characters and their kinds and weightage, Importance and application of biosystematics in biological studies. The nature and origin to life, Evidences of evolution. Theories to explain the diversity to life – Lamarckism, Darwinism and Special Creation. The present status of these theories, Modern synthetic theory.</p> <p>Factors initiating elementary evolutionary changes (micro-evolution) by changing gene frequencies, mutation pressure, selection pressure and immigration, genetic drift. Role of isolation in evolution. Factors of large evolutionary changes, (macro-evolution) Heterochrony, allometry, orthogenesis, adaptive radiation.</p> <p>Modern concept of Natural Selection; Level of selection, selection patterns, laboratory and field examples regarding action of Natural Selection. Action of Natural Selection leading to convergence, radiation, regressin and extinction, Batesian mimicry, Mullerian mimicry, Sexual selection; Darwin's concept, Fisher's view, Zahavi's handicap theory. Trend and rates in evolution.</p> <p><b><u>Practicals:</u></b></p> <ol style="list-style-type: none"><li>1. Study of preserved invertebrate species and their classification up to class level.</li><li>2. Collection, Preservation and identification of common species with the help of keys.</li><li>3. Methods of statistical analysis of samples from populations.</li><li>4. Preparation of keys for the identification of specimens.</li></ol> <p><b><u>Text Books:</u></b></p> <ol style="list-style-type: none"><li>1. Ridley, M. 1993. Evolution, Blackwell Scientific Publications.</li><li>2. Mayer, E. 1969. Principles of Systematic Zoology, McGraw Hill York.</li><li>3. Simpson, G.G., 1961. Principles of Animal Taxonomy, Columbia University Press, N.Y.</li></ol> <p><b><u>Recommended Books:</u></b></p> <ol style="list-style-type: none"><li>1. Mayer, E. and Asblock, P.D., 1991. . Principles of Systematic Zoology, McGraw Hill York.</li><li>2. Mayr, E. 1963. Animal Species and Evolution, Harvard University Press.</li><li>3. Huxley, E., 1940. New Systematics, Oxford University Press.</li><li>4. Scheuk and McMaster, 1959. Procedure in Taxonomy, Stanford University Press.</li></ol>
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	<ol style="list-style-type: none"> <li>5. Mayer, E. and Asblock, P.D., 1991. . Principles of Systematic Zoology, McGraw Hill York.</li> <li>6. Ross, H.H., 1974. Biological Systematics, Addison-Wesley Publishing Co. Reading, Massachusetts.</li> <li>7. Heywood, V.H., 1975. Taxonomy and Ecology, Academic Press, London.</li> <li>8. Whili, M.J.D., 1978. Modes of Speciation, W.H. Freeman and Co., San Francisco.</li> <li>9. Howard, R. and Moore, A., 1984. A complete Check-list of the Birds of the World, Macmillan, London.</li> <li>10. Dobzhansky, T., Ayala, F.J., Stebbins, G.L., and Valentine, J.W., 1973. Evolution, W.H. Freeman and Company.</li> <li>11. Dobzhansky, T., 1970. Genetics of the Evolution process, Columbia University Press, New York.</li> <li>12. Sheppard, P.M., 1985. Natural Selection and Heredity, Hutchison University Library, London.</li> <li>13. Dobzhansky, T., Genetics and the Origin of Species, Columbia University Press, New York.</li> <li>14. Mayr, E. Populations. Species and Evolution, Harvard University Press.</li> <li>15. Moody, P.A., 1989, Introduction to Evolution, Harper and Row Polishers, New York.</li> <li>16. Cain, A.J., Animal species and their Evolution, Hutchison University Library, London.</li> <li>17. Westoll, T.S., The Evolution of Living Things.</li> <li>18. Ross, H.H., Understanding Evolution.</li> <li>19. Simpson, G.G., Meaning of Evolution, Yale University Press.</li> <li>20. Dodson, E.O., 1960. Evolution: Process and product, Chapman and Hall Ltd.</li> <li>21. Wilson, E.O., 1999: The diversity of life, 17<sup>th</sup> edition W.W. Northern &amp; Co.</li> <li>22. Samiullah, K., 2014. An approach to evolution.</li> </ol>
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<b>Course Title</b>	<b>Fisheries</b>
Course Code	ZOL-605
Credit Hours	3
Theory	2
Practical	1
Follow up	Not Applicable
Category	BS Zoology, 04-Years Programme
Aims and Objectives	Culturing of fishes to meet the needs of protein of the country.
Learning Outcomes	Introduction to fish fauna, its culture and field application.
Syllabus in Brief	<p>Theory:</p> <p>Aims and evolution of Fish Culture, Requisite conditions for fish suitable for Fish Culture; Construction and layout of ponds; natural food and growth of cultivated fishes; Techniques and methods of fish cultivation, Breeding and cultivation of cyprinids, biological means of increasing production; Maintenance and improvement of ponds; Artificial feeding of fish; Enemies and diseases of fish; Harvesting the fish.</p> <p>Practicals:</p> <ol style="list-style-type: none"> <li>1. Study of various aquatic culture systems (fish farm, hatcheries and nurseries).</li> </ol>

	<p>2. Weight length and condition factor in relation to different environment in fish spp.</p> <p>3. Induced spawning.</p> <p>4. Fish diseases, symptoms and treatment.</p> <p>Books Recommended:</p> <p>1. Huet, M., 1986. Textbook of Fish Culture: Breeding and cultivation of fish. 2<sup>nd</sup> Edition. Fishing News Book Ltd. England.</p> <p>2. Pillay, T.V.R. and Dill, W.M.A., 1976. Advances in Aquaculture. Published by Fishing News Books, Ltd., England.</p> <p>3. Jhingran, V.G., 1983. Fish and Fisheries of India. 2<sup>nd</sup> Edition. Hindustan Publishing Corporation, New Delhi.</p> <p>Pillay, T.V.R. 1999. Aquaculture: Principles and practices. Fishing News Books, London.</p>
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<b>Course Title</b>	<b><u>Principles of Paleontology</u></b>
Course Code	ZOI-609
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	BS (Hons) Zoology, 04-Years Programme/ MSc 02 years
Aims and Objectives	This course will help to learn about the evolutionary history of major groups of animals, origin and diversification and extinction. This course also provides understanding of the history of fossil life on earth, major crises about individuals of remote past.
Learning Outcomes	After studying this course, the student will be able to understand evolutionary history of fossil record, processes of evolution, stratigraphic and environmental of contexts.
Syllabus in Brief	<p><b><u>Theory:</u></b></p> <p>The history of life; Earth, Shells of earth (Atmosphere, hydrosphere, biosphere and lithosphere); Development of life on earth; Rock, types of rocks (Igneous, sedimentary and metamorphic rocks); Introduction to Paleontology; Fossil, types and Significance of fossils, Nature of fossils, Fossilization and Processes of fossilization (Study of process of dying and what processes occur to animals after their death, <u>Geological concepts of fossilization</u>); Geological time scale; Pre-Cambrian life, Post-Cambrian life (Paleozoic life, Mesozoic life, Cenozoic life); A brief history of the Siwaliks; Dating the rocks, Radio-activity methods (Uranium/Lead dating, radiocarbon dating, Fission track dating and palaeomagnetism); Evolutionary histories of camel, horse, elephant and man.</p> <p><b><u>Practicals:</u></b></p> <ol style="list-style-type: none"> <li>1. General survey of Paleontological lab.</li> <li>2. Study of various kinds of Rocks (Igneous, sedimentary and metamorphic rocks).</li> <li>3. Study of various kinds of fossils (Petrified, pseudomorphs, mold, casts, Imprints, foot prints and Coprolites etc.).</li> <li>4. Identification and classification invertebrate fossils like foraminifers, coelenterates, Brachiopodes, arthropods (Trilobites), Molluscs and Echinoderms.</li> <li>5. Study of vertebrate fossils of evolutionary importance e.g. Horses, Elephants, Primates and Camels etc.</li> </ol>

	<p><b><u>TextBooks:</u></b></p> <ol style="list-style-type: none"> <li>1. Brouwer, A., 1977. General Palaeontology. Oliver and Boyed, London.</li> <li>2. Samiullah, K 2014. A hand book of Paleontology</li> </ol> <p><b><u>RecommendedBooks:</u></b></p> <ol style="list-style-type: none"> <li>1. S.S. Ali, 1999. Palaeontology, Zoogeography and Wildlife Management.</li> <li>2. Young J.Z., 1950. (3rd edition &amp; 7th edition). Life of vertebrates. London, Oxford Univ. Press.</li> <li>3. Dunbar C.o., 1969. Historical Geology, John Willey and sons Inc. New York.</li> <li>4. Gilbert, Colbert, E.H., 1980. Evolution of vertebrates. John Willey and Sons Inc. New York.</li> <li>5. Moore, R.C. Lalicker, G.C., Fisher, A.G., 1952. Invertebrate Fossils. McGraw-Hill, New York.</li> <li>6. Steven M. Stanley, 2008. Earth system History 3rd addition.</li> <li>7. Abu Bakr, 1981. Palaeontology.</li> </ol>
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<b>Course Title</b>	<b>Fundamentals of Entomology</b>
Course Code	ZOL-611
Credit Hours	3
Theory	2
Practical	1
Follow up	Not Applicable
Category	BS Zoology 04years /M.Sc. Zoology, 02-Years Programme
Aims and Objectives	To let students learn basic structure functions and adjustment of insects with the environment. To understand and apply the fundamental principles of entomology.
Learning Outcomes	The students will be able to achieve the aims and objectives of this course.
Syllabus in Brief	<p>General characteristics of insects, Relationship with other Arthropod's, Reasons for success of the insects in diverse environment, General segmentation, Tagmatosis and organization; Detailed structure of cuticle and its biochemistry, Epidermal layer, its structure and function, basement membrane; cuticular outgrowths and appendages; sclerotization, Head sclerites, Antennae, Different modes of ingestion, Different parts and types of mouth parts; Sclerites of neck, Thorax sclerites, legs, its modifications and functions; Wings: origin, different regions, development, basal attachments, main veins and their branches, wing coupling; Secondary appendages and external genitalia, Structure and function of Muscular, Digestive, excretory, respiratory; Incubatory and nervous system, Reproductive organs, different types of reproduction in insects; Egg fertilization and maturation. Embryology up to dorsal closure; Different types of metamorphosis, insect communication.</p> <p><b>Practical:</b> Preparation of permanent slides, all the hard parts (terminal segments, wings, and antennae. Legs, mouth parts and genitalia). Different systems, especially digestive, reproductive of the following insects. American cockroach, Ak grasshopper, Housefly, Butterfly, Mosquito, Red cotton bug, Wasp and honey bee. Mouth-parts of Red cotton bug and Honey bee.</p> <p><b>Books Recommended</b></p> <p>Text Books: Entomology and Pest management by Pidego, I, 1991.</p> <p><b>Suggested Reading</b></p> <ol style="list-style-type: none"> <li>1. The Insects, an outline of Entomology by Penny J. Gullan and Peter</li> </ol>

	S. Cranston, 2010. 2. The Principles of Insect Physiology, 1977, by Wigglesworth
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Course Title	<b>Aquatic Toxicology</b>
Course Code	ZOL-613
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MSc/MPhil Zoology, 02 Years Programme
Aims and Objectives	The major objectives of this course are to introduce students to the diverse array of toxic chemicals that are currently found in aquatic environment effecting aquatic life.
Learning Outcomes	This course will provide hands-on experience with the techniques used in toxicological studies
Syllabus in Brief	<p>Introduction to aquatic toxicology, Major classes of aquatic pollutants, Routes by which pollutants enter the aquatic ecosystem, Determination of toxicity; toxicity testing, trial and tribulation, Toxicity assessment; end points in toxicity (acute vs chronic, lethal vs physiological), Behavioral responses to toxicants, Physiological responses to toxicants, Biochemical responses to toxicants, Cellular and Molecular responses to toxicants, Molecular mechanism of interaction of Inorganics (Metallothioneins), Molecular mechanism of interaction of Organics (Cytochrome P-450), Endocrine disrupters, Genotoxicity, Immunotoxicity, Ecotoxicity.</p> <p><b>Practical:</b> Effects of toxicants on erythrocytes and leukocytes counts and ratio in fish, Effects of toxicants on hemoglobin and glucose in the blood of fish, Effects of toxicants on liver and kidney functions, Effects of toxicants on food intake in fishes, Effects of toxicants on growth (length &amp; weight) in fish, Effects of toxicants on gonadal development in fish, Effects of toxicants on endocrine disruption in fish</p> <p><b>Text Books</b> Aquatic Toxicology: Molecular, Biochemical and Cellular Perspective Donald, C. Malins and Gary, K. 1993, Lewis Publishers USA, 520 pp ISBN 0-87371-545-4</p> <p><b>Suggested Reading:</b></p> <ol style="list-style-type: none"> <li>1. Taylor and Francis: Fundamentals of Aquatic Toxicology: Effects, Environmental Fate and Risk Assessment. 2<sup>nd</sup> Edition, Philadelphia, London</li> <li>2. Landis W G and Yu M H. 1999. Introduction to Environmental Toxicology; Impact of chemicals upon ecological system. 2<sup>nd</sup> Ed. Lewis Publisher Boston, London</li> <li>3. Hyes A W. 1994. Principles and Method of Toxicology. 3<sup>rd</sup> Ed. Raven Press New York</li> <li>4. Crosby D G. 1980. Environmental Toxicology and Chemistry. Oxford University Press, New York</li> </ol>

<b>Course Title</b>	<b>Wildlife of Pakistan</b>
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Course Code	ZOI-606
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	M.Sc. Zoology, 02-Years Programme
Aims and Objectives	To know what type of wildlife exist in Pakistan and what are the threats it is facing, moreover, how wildlife is being secured in Pakistan
Learning Outcomes	Students will become able to participate in conservation of Wildlife.
Syllabus in Brief	<p><b>Syllabus:</b> Wildlife, Wild life of Pakistan ( Province wise), identification, distribution, status, conservation and management of reptiles, birds and mammals of major importance in Pakistan. Philosophy and significance of wildlife conservation. Biodiversity and sustainability of wildlife. Endangered species of wildlife in Pakistan. Wildlife rules and regulations in Pakistan. National and International organizations involved in conservation and management of wildlife. Sanctuaries, Game Reserve and National Parks in Pakistan. Wetlands, endangered species of Pakistan.</p> <p><b>Practical:</b> Study of distribution description, biology, food, predators and status of wild animals of a zoo or Zoological park of Pakistan. Adaptive features of animals in relation to food and environment, Food chain of local birds in various seasons. Construction of food chain and food webs of wild animals.</p> <p><b>Text Books:</b> <b>Suggested Reading:</b> 1.Wildlife of Pakistan, 2002. Published by Punjab Wildlife Department, Lahore. 2.Miller, G.T. 2002. Living in the Environment: Principles, Connections and Solution. 12th Edition. Thomson Learning Inc., Australia. 3 Roberts, T.J., 1998. The Birds of Pakistan, Vol. II, Oxford. 4. Roberts, T.J., 1992. The Birds of Pakistan, Vol. II, Oxford. 5. Roberts, T.J., 1998. Mammals of Pakistan, Ernest Benon Ltd. London. 6. Robinson, W.L. and Bolen, E.G., 1984. Wildlife Ecology and Management, McMillan, Cambridge. 7.<a href="http://www.wildlifeofpakistan.com">http://www.wildlifeofpakistan.com</a></p>

<b>Course Title</b>	<b>Bio-remediation and Bioprocessing</b>
Course Code	ZOL-608
Credit Hours	3
Theory	2
Practical	1
Follow up	Not Applicable
Category	BS Zoology, 04-years Program /M.Sc. Zoology, 02-Years Program
Aims and Objectives	Bioremediation is to control of environmental pollution and to address other problems by using living organisms. This keeps the environment free of natural and manmade pollutants by using living or dead organisms, their metabolites, biochemicals and processes.

Learning Outcomes	This course will develop techniques to tackle with the environmental pollution by biological means.
Syllabus in Brief	<p>Theory</p> <p>Concept of bioremediation; <u>Ex situ and In-situ Bioremediation.</u></p> <p>Degradation of natural substances; Biodegradation of xenobiotics; <u>Industrial effluents, Dyes, Hazardous chemicals, TNT wastes, Introduction to different Bacterial and Fungal spec used in Bioremediation.</u></p> <p>Biosorption: <u>Use of Bacteria, Algae and Fungi for it.</u></p> <p><u>Phytoremediation.</u></p> <p><u>Biotechnology for Air Pollution:</u></p> <p><u>Bioscrubbers, Trickling Filters etc.</u></p> <p><u>Use of enzymes.</u></p> <p><u>Municipal and Industrial Waste Water Treatment: Primary, Secondary, Tertiary and Sewage Treatment including disinfection. Phosphorus and Nitrogen Removal.</u></p> <p><u>Biohydrometallurgy: for extraction of Precious metals from their ores (Iron, Gold, Copper, Silver)</u></p> <p><u>Biofuel generation; Use of Algae, Alcohol etc for production of Biofuels.</u></p> <p><b>Practicals</b></p> <p>Isolation and studies of heavy metals tolerant/resistant microorganisms; Studies on bacterial capable of degrading xenobiotics; production of alcohol from decaying fruits.</p> <p>Books Recommended</p> <p>Practical Environmental Bioremediation the field guide, 1997. R. Barry King, Gilbert M. Long, John K. Sheldon, Lewis publishers.</p> <p><b>Books:</b></p> <p>General Microbiology, 1995. Schlegel, H.G., Cambridge University Press.</p> <p>Biotechnology, 1996. Smith, J.F., Cambridge University Press.</p> <p>Environmental Biotechnology Principals and applications, 2000. Pruce, R. Hmana, Parry McCarty, McGraw Hill.</p> <p>Biodegradation and Bioremediation, 1999. Martin Alexander academic press Inc.</p>

**The End**