BS Zoology (4-Years/8 Semesters)

Semester I

ZOL-301	Zoology – I (Principles of Animal Life-I)	4(3-1)
BOT-301	Diversity of Plants	4(3-1)
CHM-321	Introductory Chemistry	4(3-1)
ENG-321	Functional English	3(3-0)
ISL-321	Islamic Studies/Ethics	2(2-0)
	Total	**17**

Semester II

ZOL-302	Zoology-II (Principles of Animal Life-II)	4(3-1)
MTH-321	Mathematics-I	3(3-0)
CHM-322	Inorganic Chemistry – I	4(3-1)
ENG-322	English Comprehension and Composition	3(3-0)
PST-322	Pakistan Studies	2(2-0)
	Total	**16**

Semester III

ZOL-401	Zoology-III (Animal Diversity-I: Invertebrates)	4(3-1)
ZOL-403	Zoology-IV (Animal Diversity-II: Chordates)	4(3-1)
BOT-302	Systematics, Anatomy and Development	4(3-1)
CHM-421	Physical Chemistry –I	4(3-1)
ENG-421	Communication Skills	3(3-0)
	Total	**19**

Semester IV

ZOL-402	Zoology-V (Animal Form & Function-I)	4(3-1)
ZOL-404	Zoology-VI (Animal Form & Function-II)	4(3-1)
BOT-401	Cell Biology, Genetics and Evolution	4(3-1)
PSY-422	Introduction to Psychology	3(3-0)
CSI-422	Introduction to Computer Application	3(3-0)
	Total	**19**

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	4(3-1)
ZOL-507	Animal Behaviour	2(2-0)
ZOL-509	General and Molecular Genetics	4(3-1)
	Total	**17**

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 of Coordination and Animal Behavior	4(3-1)
	Total	**20**

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-656	Aquatic Toxicology	3(2-1)
*Special paper 1	in lieu of thesis	3(2-1)
	Total	**17**

Semester VIII

BNB-402	Basic Bioinformatics	3(2-1)
ZOL-606	Wildlife of Pakistan	3(2-1)
ZOL-608	Bioremediation and Bio-processing	3(2-1)
ZOL-692	Biodiversity	3(2-1)
*Special paper 2	in lieu of thesis	3(2-1)
	Total	**15**
	Grand Total	**140**

*Two special papers will be offered in lieu of thesis (ZOL-630: Thesis 6(0-6)) in 7^{th} and 8^{th} semester

*Two special papers will be offered in lieu of thesis (ZOL-680: Thesis 6(0-6)) in 3rd and 4th semester

***Two courses Special Subject/ Optional will be opted in lieu of research for BS**

ZOL-660	Fundamentals of Entomology	3(2-1)
ZOL-662	Endocrinology – A	3(2-1)
ZOL-664	Ornithology	3(2-1)
ZOL-665	Mammology	3(2-1)
ZOL-666	Aqua Culture Health Management	3(2-1)
ZOL-667	Insect Pest of Agriculture and their Management	3(2-1)
ZOL-668	Biology of Birds and Mammals in Pakistan	3(2-1)
ZOL-669	Proto-Zoology	3(2-1)
ZOL-670	Fundamentals of Limnology	3(2-1)
ZOL-671	Applied Limnology	3(2-1)
ZOL-672	Applied Entomology	3(2-1)
ZOL-673	Endocrinology – B	3(2-1)
ZOL-674	Applied Microbiology	3(2-1)
ZOL-675	Fish Physiology and Breeding	3(2-1)
ZOL-676	Aquatic Biology	3(2-1)
ZOL-677	Integrated Aqua Culture	3(2-1)
ZOL-678	Sea Food Technology	3(2-1)
ZOL-679	Seminar	3(2-1)
ZOL-680	Thesis	3(2-1)
ZOL-681	Project	3(2-1)
ZOL-682	Internship	3(2-1)
ZOL-683	Principles of Fish Biology	3(2-1)
ZOL-684	Immunology and Hematology	3(2-1)
ZOL-685	Vector Biology	3(2-1)
ZOL-686	Aquatic Environmental Management	3(2-1)
ZOL-687	Molecular Biology	3(2-1)
ZOL-688	Fish Ecology	3(2-1)
ZOL-689	Ichthyology	3(2-1)
ZOL-690	Bio-Physical Methods in Life Sciences	3(2-1)
ZOL-691	Comparative Anatomy of Vertebrates	3(2-1)

***** Due to various research groups in department; many courses cannot be accommodated in the limit of 652-698 codes. Therefore, the department will follow its own course codes for opted courses.

BS Courses: (Semester-wise)

Course Title	PRINCIPLES OF ANIMAL LIFE – I
Course Code	ZOL-301
Credit Hours	4(3-1)
Theory	3
Practical	1
Follow up	**BS**
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 organellae 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	**Course Contents** 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. 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. 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. 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. 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. 6. Ecology I: Individuals and Populations Animals and their abiotic environment; populations; interspecific interactions. 7. Ecology II: Communities and Ecosystems Community structure and diversity; ecosystems; ecosystems of the earth; ecological problems; human population growth, pollution, resource depletion and biodiversity.

	Practicals 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. 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). *Note*: *Prepared microscopic and/or projection slides and/or CD ROM computer projections must be used.* 3. Plasmolysis and deplasmolysis in blood. 4. Protein digestion by pepsin. 5. Ecological notes on animals of a few model habitats. 6. Field observation and report writing on animals in their ecosystem (a terrestrial and an aquatic ecosystem study). Books Recommended 1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 12th Edition (International), 2004. Singapore: McGraw Hill. 2. Miller, S.A. and Harley, J.B. ZOOLOGY, 6th Edition (International), 2005. Singapore: McGraw Hill. 3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 5th Edition (International), 2000. Singapore: McGraw Hill. 4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES, 2001. New York: McGraw Hill. 5. Campbell, N.A. BIOLOGY, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc. 6. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5th Edition (International), 2002. Singapore: McGraw Hill. 7. Hickman, C.P. and Kats, H.L., LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill. 8. Molles, M.C. ECOLOGY: CONCEPTS AND APPLICATIONS. 6th Edition. 2005. McGraw Hill, New York, USA. 9. Odum, E. P. FUNDAMENTALS OF ECOLOGY. 3rd Edition. 1994. W.B. Saunders.Philadelphia. 10. Slingby, D. and Cook, C., PRACTICAL ECOLOGY. 1986. McMillan Education Ltd. UK.

Course Title	PRINCIPLES OF ANIMAL LIFE – II
Course Code	ZOL-302
Credit Hours	4(3-1)
Theory	3
Practical	1
Follow up	**BS**
Aims and Objectives	The course imparts knowledge and understanding of: 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.
Learning Outcomes	
Syllabus in Brief	Course Contents 1. Cell Division Mitosis, cytokinesis, and the cell cycle: an overview; control of the cell cycle; meiosis: the basis of sexual reproduction; gamete formation. 2. Inheritance Patterns The birth of modern genetics; Mendelian inheritance patterns; other inheritance patterns; environmental effects and gene expression. 3. Chromosomes and Gene Linkage Eukaryotic chromosomes; linkage relationships; changes in chromosome number and structure. 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. 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. 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. 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. Books Recommended 1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11th Edition (International), 2004. Singapore: McGraw Hill. 2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5th Edition (International), 2002. Singapore: McGraw Hill. 3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4th Edition (International), 2000. Singapore: McGraw Hill. 4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2000. New York: McGraw Hill. 5. Campbell, N.A. BIOLOGY, 6th Edition. Menlo Park, California: 2002. Benjamin/Cummings Publishing Company, Inc. Practicals 1. Study of mitosis in onion root tip. 2. Study of meiosis in grasshopper testis (students should prepare the slide). *Note for 1-2: Prepared microscopic and/or projection slides and/or CD ROM computer projections must be used).* 3. Problem based study of Mendelian ratio in animals. 4. Multiple alleles study in blood groups. 5. Survey study of a genetic factor in population and its frequency.

	6. Study of karyotypes of *Drosophila*, mosquito. 7. Study of cytochemical detection of DNA in protozoa and avian blood cell. 8. Study to demonstrate nervous or endocrine basis of behaviour (conditioned reflex or aggression or parental behavior). 9. Study to demonstrate social behaviour (documentary film be shown, honey bee, monkey group in a zoo). Books Recommended 1. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5th Edition (International), 2002. Singapore: McGraw Hill. 2. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.

Course Title	**Animal Diversity -1 (Invertebrates Diversity)**
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	Theory 1. Introduction fication of organisms; evolutionary relationships and tree diagrams; patterns of organization. 2. Animal-Like Protists: The Protozoa ionary perspective; life within a single plasma membrane; symbiotic life-styles. Protozoan taxonomy: (up to phyla, subphyla and super classes, wherever applicable). Pseudopodia and amoeboid locomotion; cilia and other pellicular structures; nutrition; genetic control and reproduction; symbiotic ciliates; further phylogenetic considerations. 3. Multicellular and Tissue Levels of Organization ionary 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. 4. Triploblastics and Acoelomate Body Plan ionary perspective; phylum platyhelminthes: classification up to class; the free-living flatworms and the tapeworms; phylum nemertea; phylum gastrotricha; further phylogenetic considerations. 5. Pseudocoelomate Body Plan: Aschelminths ionary perspective; general characteristics; classification up to phyla with 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. 6. Molluscan Success

ionary 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.

7. Annelida: The Metameric Body Form

ionary 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.

8. Arthropods: Blueprint for Success

ionary perspective: classification and relationships to other animals; metamerism and tagmatization; the exoskeleton; metamorphosis; classification up to class; further phylogenetic considerations.

9. Hexapods and Myriapods: Terrestrial Triumphs

ionary 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.

Practicals

1. Study of *Euglena, Amoeba, Entamoeba, Plasmodium, Trypanosoma, Paramecium* as representative of animal like protists. (Prepared slides and from fresh water).
2. Study of sponges and their various body forms (prepared slides).
3. Study of principal representative classes of phylum Cnidaria.
4. Study of principal representative classes of phylum Platyhelminthes.
5. Study of representative of phylum Rotifera, phylum Nematoda.
6. Study of principal representative classes of phylum Mollusca.
7. Study of principal representative classes of phylum Annelida.
8. Study of principal representative classes of groups of phylum Arthropoda.
9. Brief notes on medical/economic importance of the following: *Plasmodium, Entamoebahistolitica, Leishmania,* Liverfluke, Tapeworm, Earthworm, Silkworm, Citrus butterfly.
10. Preparation of permanent stained slides of the following: *Obelia, Daphnia,* Cestode, Parapodia of *Nereis.*

Reference Books

1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11th Edition (International), 2004. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. ZOOLOGY, 9th Edition (International), 2009. Singapore: McGraw Hill.
3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4th Edition (International), 2000. Singapore: McGraw Hill.
4. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.
5. Miller, S.A., GENERAL ZOOLOGY LABORATORY MANUAL. 5th Edition (International), 2002. Singapore: McGraw Hill.
6. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.

Course Title	ANIMAL DIVERSITY-II (*CLASSIFICATION, PHYLOGENY AND ORGANIZATION)*
Course Code	ZOL-403
Credit Hours	4(3-1)
Theory	3
Practical	1
Follow up	**BS**
Category	
Aims and Objectives	The course provides knowledge and understanding about the different animal groups, emphasizing their phylogenetic relationships.
Learning Outcomes	
Syllabus in Brief	Course Contents 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. 2. Hemichordates and Invertebrate Chordates Evolutionary Perspective: Phylogenetic Relationships; Classification up to subphylum or class where applicable; Further Phylogenetic Considerations. 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. 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. 5. Reptiles: The First Amniotes Evolutionary perspective: cladistic interpretation of the amniotic lineage; survey of order testudines or chelonia, rhynchocephalia, squamata, and crocodilia; evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations. 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.

	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. Books Recommended 1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11th Edition (International), 2004. Singapore: McGraw Hill. 2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5th Edition (International) 2002. Singapore: McGraw Hill. 3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4th Edition (International), 2000. Singapore: McGraw Hill. 4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill. 5. Campbell, N.A. BIOLOGY, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc. Practicals 1. Study of a representative of Hemichordate and Invertebrate Chordate. 2. Study of representative groups of class Fishes. 3. Study of representative groups of class Amphibia. 4. Study of representative groups of class Reptilia. 5. Study of representative groups of class Aves. 6. Study of representative groups of class Mammalia. 7. Field trips to study animal diversity in an ecosystem. *Note*: *Preserved specimen and/or colored projection slide and/or CD ROM projection of computer must be used.* Books Recommended 1. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill. 2. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5th Edition (International), 2002. Singapore: McGraw Hill.
Course Title	**ANIMAL FORM AND FUNCTION-I** (A COMPARATIVE PERSPECTIVE)
Course Code	ZOL-402
Credit Hours	4(3-1)
Theory	3
Practical	1
Follow up	**BS**
Category	
Aims and Objectives	The course deals with the: a. Basis of structure and functions of animal nutrition, digestion, homeostasis and temperature regulation. b. It introduces the basic concepts in reproduction and development in animal kingdom. c. Provides knowledge about the development of chordate body plan and fate of germinal layers.
Learning Outcomes	

Syllabus in Brief	Course Contents 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. 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. 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. 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. Books Recommended 1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11th Edition (International), 2004. Singapore: McGraw Hill. 2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5th Edition (International), 2002. Singapore: McGraw Hill. 3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4th Edition (International), 2000. Singapore: McGraw Hill. 4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill. 5. Campbell, N.A. BIOLOGY, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc. Practicals 1. Study of excretory system in an invertebrate and a vertebrate representative (Model). 2. Study of nutritive canal in an invertebrate and a vertebrate representative (Dissection). 3. Study of male reproductive system in an invertebrate and a vertebrate representative (Dissection).

	4. Study of female reproductive system in an invertebrate and a vertebrate representative (Dissection). 5. Study of hormonal influence of a reproductive function (Model). 6. Study of preserved advanced stages of avian and mammalian development for amniotic membranes and placenta (Model). 7. Study of stages in the development of an Echinoderm. 8. Study of early stages in the development of a frog, chick and a mammal. *Note for 9-10: Prepared slides and preserved specimen and/or projection slides and/or CD ROM computer projections may be used.* Books Recommended 1. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill. 2. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5th Edition (International), 2002. Singapore: McGraw Hill.

Course Title	**ANIMAL FORM AND FUNCTION-II** (A COMPARATIVE PERSPECTIVE)
Course Code	ZOL-404
Credit Hours	4(3-1)
Theory	3
Practical	1
Follow up	**BS**
Category	
Aims and Objectives	The course aims to teach the students about: a. Animals diversity adapted in different ways for their functions through modifications in body parts. 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. c. Organ systems, their specialization and coordination with each other and constantly changing internal and external environment, inside and outside the animal's body. d. The basic structure of each system that determines its particular function.
Learning Outcomes	
Syllabus in Brief	Course Contents 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. 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. 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. 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, 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. 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. Books recommended 1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11th Edition (International), 2004. Singapore: McGraw Hill. 2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5th Edition (International), 2002. Singapore: McGraw Hill. 3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4th Edition (International), 2000. Singapore: McGraw Hill. 4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill. 5. Campbell, N.A. BIOLOGY, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc. Practicals 1. Study of insect chitin, fish scale, amphibian skin, reptilian scales, feathers and mammalian skin. 2. Study and notes of skeleton of *Labeo, Rana tigrina, Varanus,* fowl and rabbit. *Note*: *Exercises of notes on the adaptations of skeletons to their function must be done.* 3. Earthworm or leech; cockroach, freshwater mussel, *Channa* or *Catla catla* or *Labeo* or any other local fish, frog, pigeon and rat or mouse and rabbits are representative animals for study in dissections. 4. Study of models or preserved brains of representative animals and notes on adaptations. 5. Study of nervous system of earthworm and a fish. 6. Study of endocrine system in an insect and a rabbit. 7. Study of different types of blood cells in blood smear of rabbit. 8. Study of heart, principal arteries and veins in a representative vertebrate (dissection of representative fish/mammals). 9. Study of respiratory system in cockroach or locust and a vertebrate

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

Course Title	**Cell and Molecular Biology**
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	Theory 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, glyoxysomes, Cytoplasm, cytoskeleton. Nucleus: Chromatin, heterochromatin, euchromatin, chromosome structure with reference to coiling and nucleosome during different phases of cell cycle. 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. Practicals 1. Culturing and staining of bacteria and yeast. 2. Counting of bacterial cells and preparation of growth curves. 3. Counting of blood cell types by haemocytometer. 4. Detection (in protozoan culture and blood cells) and quantitative determination of chromosomal DNA and RNA. 5. Isolation and plasmid DNA from bacterium and demonstration on agarose gel. 6. Isolation and fractionation of proteins from blood sera by polyacrylamide gel

	electrophoresis. Books Recommended 1. Darnell Jr., J., Lodisch, H. and Baltimore D., 1990. *Molecular Cell Biology*. Scientific American, New York. 2. Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K and Walter, P., 2002. *Molecular Biology of Cell*. Garland Science, New York. 3. DeRobertis, E.D.P. and DeRobertis Jr. E.N.F., 1987. *Cell and Molecular Biology*. Lea and Febiger, New York. 4. Karp, G., 2002. *Cell and Molecular Biology. Concepts & Experiments*. John Wiley & Sons, New York. 5. Stryer, L., 1995. *Biochemistry*. W.H. Freeman, New York.

Course Title	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, Estiadiole. 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, 3rd Edition, Macmillan Worth Pubslihers, New York. Additional Reading 1. 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. 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, 4th Edition, Wm. C. Brown Publishers Inc. Oxford, England. 4. Lubert Stryer, 1995. Biochemistry, 4th Edition, W.H. Freeman & Company, New York. <u>Practicals</u> 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. 12. Various Qualitative Tests for detection of Lipids. 13. Determination of Acid value of Fats. <u>Books Recommended</u> 1. Plummer, David T., 1990. An Introduction to Practical Biochemistry, 4th Edition, McGraw-Hill Book Company, London. 2. Wilson, K & Walker, J., 1994. Practical Biochemistry: Principles of Techniques, 4th Edition, Cambridge University Press.

Course Title	Animal Physiology
Course Code	ZOL-505
Credit Hours	3
Theory	2
Practical	1
Follow up	None
Category	Physiology of Coordination and Animal Behaviour
Aims and Objectives	One is able to understand mechanisms and adaptations of physiological systems in animals.
Learning Outcomes	The students will be able to understand the working of various systems of organisms.
Syllabus in Brief	Central themes in Physiology: Structure-Function Relationship. Adaptations, Homeostasis. Conformity and Regulation. Exchange of Gases: Transport of O_2 and CO_2 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: Hypercapula in air breathing divers. Excretion and Osmoregulation: Osmoregulation in aquatic and terresterial 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. Nutrition: Regulation of digestive secretions: Physiological anatomy of digestive

	tract (mammalian model), Absorption of water, ions and nutrients. 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. Books Recommended 1. Randall. D.. Burggren. W.. French. K. and Fernald. R.. 2002. Eckert Animal Physiology: Mechanisms and Adaptations. 5th ed. W.H. Freeman and Company. New York. 2. Bullock. J.. Boyle. And Wang. M.B.. 2001. Physiology. 4th edition. Lippincott. Williams and Wilkins. Philadelphia. 3. Bame. F.M. and Levy. M.N.. 2000. Textbook of Medical Physiology. 3rd edition. St. Lions. Mosby. 4. Guyton and hall 2000 Text book of Medical Physiology 10th. Edition. 5. Withers1992 Comparative Animal Physiology. 6. Sdhmidt- Nelsen. K., 1997AnimalPhysiology.Adaptation and environment 5th. Edition Cambridge University Press Cambridge. *Practicals* Cardiovascular Activity: Normal cardiac activity, effect of temperature, effect of drug, heart block, tetanization of heart, Measurement of blood pressure. 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 altered by exercise. Book Recommended 1. Tharp. G. and Woodman. D. 2002. Experiments in Physiology. 8th Edition. Prentice Hall London.

Course Title	**Animal Behavior**
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	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, 2. Tinbergen's four questions: Importance of Niko Tinbergen presented proximate/causal and ultimate/ functional based questions to study the animal behavior, 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, 4. Basic components of animals behavior: nature and nurture, Mechanism of behavior; 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, 6. Endocrine control of behavior in vertebrates: explanation of milk-ejaculation reflex (MER) in goats, 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, 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, 9. Visual recognition of prey and predators: Classical conditioning, stimulus substitution theory and stimulus-response theory, types of responses and importance of reinforcement, 10. Fundamental aspects of habituation and extinctions: including phenomenon of external inhibition and disinhibition of conditional responses, Instrumental learning and law of effect, 11. Fundamental difference between classical conditioning and instrumental learning: types of reinforcement and its fundamental aspects. **Text Books:** 1. Graham Scott (2010) Essential Animal Behavior. Blackwell Publishing. 2. David McFarland (1985) Animal Behaviour: Psychobiology, Ethology and Evolution. Longman House, Burnt Mill, England. 3. Roland J. Siiter (1999) Introduction to Animal Behavior. Cole Publishing Company, CA, USA. 4. John Alcock (2001) Animal Behavior: An Evolutionary Approach. 7th Ed. Sinauer Associates, Inc., Massachusetts, USA. 5. David Randall, WarreBurggren and Kathleen French (2002) Eckert Animal Physiology: Mechanisms and Adaptations. W.H. Freeman and Company, New York, USA.

Course Title	**General and Molecular Genetics**
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	Theory 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). Practicals 1. Study of Mitosis and Meiosis. 2. Preparation of Drosophila culture. 3. Study of morphology and karyotype. 4. Study of Monohybrid and dihybrid ratio, sex-linked inheritance. 5. Pedigree Analysis 6. Detection of Blood Groups in humans. 7. Problem relating to theory. Books Recommended 1. Hartl, D. L. and E. W. Jones. 2009 Genetics: Analysis of Genes and Genomes. Seventh (7th) Edition. Jones and Bartlett Publishers. USA. 2. Snustard, D.P. and Simmon, M.J., 2003. Principles of Genetics. 3rd Edition. John Wiley and Sons, New York. 3. Muller, R.F. and Young, I.D., 2002. Emery's Elements of Medical Genetics. 11th Edition. Churchill Livingstone, Elsevier Science, Limited, UK. 4. Tammarin, R.M. 1999. Principles of Genetics. 6th Edition, WCB, McGraw Hill, New York. 5. Klug, Cummings et al., 2012, Concepts of Genetics 10th) edition, Pearson Publisher. Macmillan College Publishing Company, New York. 6. Strickberger, M.W. 1999. Genetics. 3rd Edition. Prentice Hall of India Private Ltd., New Delhi. 7. Herskowiez, I.H., 1985. Genetics. Little Brown, Boston, USA. 8. Lewin, B. 2003. Gene VII. Oxford, UK.

Course Title	**Biostatistics**
Course Code	ZOL-502
Credit Hours	3(3-1)
Theory	3
Practical	0
Follow up	**BS**
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	Course Contents 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. Books Recommended

	1. Geoffery, R. Norman, David L. Streiner BIOSTATISTICS: THE BARE ESSENTIALS. 2000. B.C. Decke Inc. 2. Gerry, P. Quinn, Michael J. Keough, EXPERIMENTAL DESIGN AND DATA ANALYSIS FOR BIOLOGISTS. 2002. Cambridge University Press. 3. Campbell, R. C. STATISTICS FOR BIOLOGISTS. 1989. Cambridge University Press.

Course Title	**Developmental Biology**
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	**Syllabus:Theory** Mitosis, Meiosis. Principle features of development; developmental patterns, mechanism of teratogenesis Spermatogenesis, Oogenesis, Fertilization; Recognition of sperm and egg, fusion of gametes. re- arrangement of egg 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. **Practical:** 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. **Text Books:** **Suggested Reading:** Books Recommended 1. An introduction to embryology 2013 by Balinsky .B.I. and Saunders 2. Developmental biology, 2000. by Gilbert, S. F. 3. Human Embryology and Developmental biology, By Carlson, B. M. 4. Introduction to Embryonic Developments by Oppenheimar, SS and Allen and Bacon 5. Developmental Biology by Saunders W.B. 6. Modern Embryology 1968 by Bodemer C.W 7. Mechanism of development 1980. by Ham.R.G., and Veomett, M. J. 8. The developing human 1982 by Moore K.L. 9. Medical Embryology 1981 by Largman, J. Clinical Embryology 1983 by

	Snell, R.S.,

Course Title	**Ecology**
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	Theory: 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. Practicals: Food chain, food web & ecological notes Methods and analysis of population dynamics Quadrate method Determining frequency of different species Determining density of species in habitat Measurement of pollutants levels In atmosphere (NO2, SO2, O3 and comparison with rural air) In soil (toxic chemical, fertilizer, insecticides, herbicides) Analysis of polluted and freshwater for Various pollutant; heavy metals,-CO3, -HCO3,NO3, BOD, COD, pH, EC, total soluble solids. Books Recommended: Books Recommended (Latest Edition) 1. E.P. Odum ,G. W. Barrett. Fundamentals of Ecology.(2004), 5th Edition 2. Miller, G.T. 2002. Living in the environment: Principles, Connections and Solutions. 12th Edition. Thomson Learning, Australia. 3. M.L. McKinney Enviromental Sciense: System and Solution (1999) Jones & Bartlett Publication, Boston. 4. M.C. Molles Ecology: Concepts and application (1999) WCB/McGraw Hill, New York. 5. Smith Ecology and Field Biology (1988) National Book Foundation

Course Title	**Principles of Zoogeography**

Course Code	ZOL-508
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	BS 04 Years/M.Sc. Zoology, 02-Years Programmee
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	**Theory:** 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 (Palaearctic 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. **Practicals:** Identification and classification of various invertebrates and vertebrates of Zoogeographical importance. **TextBook:** 1. Darlington, Zoogeography, John Wiely, 1963. 2. S.S. Ali, 1999. Palaeontology, Zoogeography and Wildlife Management. **RecommendedBooks:** 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.

Course Title	Biochemistry-II (Metabolism)
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.
	Bioenergetics: Concept of Free Energy and Standard Free Energy change. Energy rich compounds: Phosphoryl group transfers and ATP; Acyl phosphates; Enol phosphates and Thioesters. 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,

	Glyceraldehyde and Glycerol. Phosphorolysis of Glycogen. Biosyntehsis of Glycogen. Regulation of Glycogen Metabolism. Pentose phosphate pathway of Glucose oxidation and its major role in the animal tissues. Anabolic role of citric acid cycle intermediates; Regulation of Citric acid cycle. 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. Nitrogen Metabolism: Metabolic fate of standard amino acids. Catabolism of Amino acids: Decarboxylation; Deamination and Transamination. Amino acid degradation showing entery 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. Books Recommended 1. David I., Nelson, and Michael M, Cox. 2000, Lehninger Principles of Biochemistry, 3rd Edition, Macmillan Worth Pubslihers, New York. Additional Reading 1. 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. 2. Voet. D., Voet. J.G., and Pratt. C.W., 1999. Fundamentals of Biochemistry, John Wiley and Sons Inc., New York. 3. Zubay. G., 2000. Biochemistry, 4th Edition, Wm. C. Brown Publishers Inc. Oxford, England. 4. Lubert Stryer, 2001. Biochemistry, 4th Edition, W.H. Freeman & Company, New York. Practicals 1. Demonstration of Acid Hydrolysis of Polysaccharide. 2. Determination of pKa values of an amino acid by preparation of titration curves. 3. Estimation of Free Amino Acids in Biological samples colorimetrically. 4. Separation and identification of various amino acids by Paper chromatography / PAGE. 5. Separation of various protein fractions by precipitation method. 6. Preparation of standard curve of proteins using Lowry's technique. 7. Estimation of tissue (liver) proteins using Lowry's technique. 8. Preparation of standard curve and Estimation of proteins by ultraviolet (UV) spectrophotometry. 9. Preparation of standard curve and Estimation of DNA by colorimetric analysis using Diphenylamine method. 10. Preparation of standard curve and Estimation of total RNA by colorimetric analysis using Bial's Orcinol method. 11. Quantitative analysis of Diastase activity on starch. 12. Study on the effect of temperature on the enzymatic rate of reaction. Books Recommended 1. Plummer, David T., 1990. An Introduction to Practical Biochemistry, 4th Edition, McGraw-Hill Book Company, London. 2. Wilson, K & Walker, J., 1994. Practical Biochemistry: Principles of Techniques,

	4th Edition, Cambridge University Press.

Course Title	**Physiology of coordination and animal behaviour**
Course Code	ZOL-512
Credit Hours	4
Theory	3
Practical	1
Follow up	Animal Physiology
Category	BS (H) 04-Years/ M.Sc. Zoology, 02-Years Programme
Aims and Objectives	To understand the physiology of coordination and animal behaviour
Learning Outcomes	The students will be able to understand different phenomena responsible for coordinated animal behaviour
Syllabus in Brief	**Physiological basis of Neuronal Function**: Mechanisms in Resting Membrane Potentials: Electrogenic ion pump. Donnan equilbrium. Ionic mechanisms in action potentials: Roles of ion channels. Properties of action potential. Propagation of Action Potential: Synaptic transmission: Structure and function of electrical synapse &chemical synapse: Neurotransmitters: Synaptic receptors: Excitatory postsynaptic potentials: Inhibitory postsynaptic potentials: Presynaptic inhibitions: Integration at synapses: Facilitation. Posttetanic Potentiation. **Photoreception:** Ultrastructure of photoreceptors. Photochemistry, Phototransduction and physiological basis of color vision: Physiological mechanisms in electroreception. **Chemical Messenger and Regulators/Endocrine Physiology**: An overview of invertebrate endocrine structures, their hormones and physiological roles. An overview of hormones, their chemistry and physiological roles of Hypothalamus. Pituitary, Thyroid, Parathyroid and associated structures, Endocrine pancreas, Gastropancreatic system, Adrenal medulla (Chromaffin Tissue), Adrenal cortex, Ovary, Testis and Placenta. Endocrine functions of kidneys & heart and pineal gland. A generalized model account of hormone synthesis, storage and secretion (a peptide hormone model and steroid hormones). General account of hormonal regulations, hormonal turnover, recognition: Mechanisms of hormonal interactions involving metabolic, developmental, membrane receptors and nuclear modulated gene expression: **The study of Animal Behaviour:** Introduction. History of animal Behaviour. Approaches and Methods. Mechanisms of Behavior**:** The Nervous System and Behaviour. Hormones and Behaviour and Learning Behaviour. Finding Food and Shelter: Migration. Orientation and Navigation. **Practicals** **Muscle and Neuromuscular Activity:** Nerve muscle preparation. Muscle twitch, Comparision of muscle and nerve irritability, effect of stimulus strength, effect of stimulus frequency (tetany), effect of load or stretch, effect of prolonged activity (fatigue), stimulation of motor points in human. **Excitability, Sensation and Behaviour:** Recording of action potential by oscilloscope and demonstration of its various features. Experiments to demonstrate characteristic of reflex arc, Experiment in human (students themselves) to demonstrate some aspect of sensory physiology. **Endocrine and Reproductive Mechanisms**: Effect of insulin on glycemia, study of stages in estrous cycle, mechanisms in regulations of contraction.Study of hibernation and biological rhythms.

	Books Recommended 1. Randall. D.Burggren. W.. French. K. and Fernald. R.. 2002. Eckert Animal Physiology: Mechanisms and Adaptations. 5th ed. W.H. Freeman and Company. New York. 2. Seeley. Rod. R., Stephens, D. Trent and Tate Philip. 2008. Anatomy & Physiology, 8th Edition. The McGraw-Hill, New York, USA. 3. Bullock. J.. Boyle. And Wang. M.B.. 2001. Physiology. 4th edition. Lippincott. Williams and Wilkins. Philadelphia. 4. Bame. F.M. and Levy. M.N.. 2000. Textbookof Medical Physiology. 3rd edition. St. Lions. Mosby. 5. Guyton and hall 2000 Text book of Medical Physiology 10th. Edition. 6. Sdhmidt- Nelsen. K., 1997AnimalPhysiology.Adaptation and environment 5th. Edition Cambridge University Press Cambridge. 7. Drickamer, L.C., Vessey, S.H., and Jacob, E., 2002. Animal Behviour: Mechanism, Ecology, Evolution. 5th Edition. 8. Manning, A. and Daekins, M.S., 1997. An introduction to animal behviour, 4th edition, Cambridge University Press, Cambridge. 9. Tharp. G. and Woodman. D. 2002. Experiments in Physiology. 8th Edition. Prentice Hall London.

Course Title	**Evolution and Principles of Systematics**
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	**Theory:**Contribution of systematic to Biology; History of Taxonomy (Downward classification, upward classification, impact of origin of species and their delimitation, population systematics, current trends); Microrta xonomy, 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.

	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. 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. **Practicals:** 1. Study of preserved invertebrate species and their classification up to class level. 2. Collection, Preservation and identification of common species with the help of keys. 3. Methods of statistical analysis of samples from populations. 4. Preparation of keys for the identification of specimens. **Text Books:** 1. Ridley, M. 1993. Evolution, Blackwell Scientific Publications. 2. Mayer, E. 1969. Principles of Systematic Zoology, McGraw Hill York. 3. Simpson, G.G., 1961. Principles of Animal Taxonomy, Columbia University Press, N.Y. **Recommended Books:** 1. Mayer, E. and Asblock, P.D., 1991. . Principles of Systematic Zoology, McGraw Hill York. 2. Mayr, E. 1963. Animal Species and Evolution, Harvard University Press. 3. Huxley, E., 1940. New Systematics, Oxford University Press. 4. Scheuk and McMaster, 1959. Procedure in Taxonomy, Stanford University Press. 5. Mayer, E. and Asblock, P.D., 1991. . Principles of Systematic Zoology, McGraw Hill York. 6. Ross, H.H., 1974. Biological Systematics, Addison-Wesley Publishing Co. Reading, Massachusetts. 7. Heywood, V.H., 1975. Taxonomy and Ecology, Aeademic Press, London. 8. Whili, M.J.D., 1978. Modes of Speciation, W.H. Freeman and Co., San Francisco. 9. Howard, R. and Moore, A., 1984. A complete Check-list of the Birds of the World, Macmillan, London. 10. Dobzhansky, T., Ayala, F.J., Stebbins, G.L., and Valentine, J.W., 1973. Evolution, W.H. Freeman and Company. 11. Dobzhansky, T., 1970. Genetics of the Evolution process, Columbia University Press, New York. 12. Sheppard, P.M., 1985. Natural Selection and Heredity, Hutchson University Library, London. 13. Dobzhansky, T., Genetics and the Origin of Species, Columbia University Press, New York. 14. Mayr, E. Pouplations. Species and Evolution, Harvard University Press. 15. Moody, P.A., 1989, Introduction to Evolution, Harper and Row Polishers, New York. 16. Cain, A.J., Animal species and their Evolution, Hutchson University Library, London. 17. Westoll, T.S., The Evolution of Living Things. 18. Ross, H.H., Understanding Evolution. 19. Simpson, G.G., Meaning of Evolution, Yale University Press. 20. Dodson, E.O., 1960. Evolution: Process and product, Chapman and Hall Ltd. 21. Wilson, E.O., 1999: The diversity of life, 17th edition W.W. Northern & Co. 22. Samiullah, K., 2014. An approach to evolution.

Course Title	**Fisheries**
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	Theory: 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. Practicals: 1. Study of various aquatic culture systems (fish farm, hatcheries and nurseries). 2. Weight length and condition factor in relation to different environment in fish spp. 3. Induced spawning. 4. Fish diseases, symptoms and treatment. Books Recommended: 1. Huet, M., 1986. Textbook of Fish Culture: Breeding and cultivation of fish. 2nd Edition. Fishing News Book Ltd. England. 2. Pillay, T.V.R. and Dill, W.M.A., 1976. Advances in Aquaculture. Published by Fishing News Books, Ltd., England. 3. Jhingran, V.G., 1983. Fish and Fisheries of India. 2nd Edition. Hindustan Publishing Corporation, New Delhi. Pillay, T.V.R. 1999. Aquaculture: Principles and practices. Fishing News Books, London.

Course Title	**Research Methodology**
Course Code	ZOl-607
Credit Hours	1(1-0)
Theory	1
Practical	0
Follow up	
Category	BS (Hons) Zoology, 04-Years Programme/ MSc 02 years
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	Theory: Introduction to Course, Important definitions, The aims, objectives, motivation and types of research, The research topic, Research design, characteristics of good research design, research problem and research issues, Sampling design, Population and sampling types, Data analysis, interpretation of results, role of computer and statistics in research, report writing, Synopsis and Thesis (Title, Abstract, Introduction, Materials & Methods, Literature Review, Results and Discussion, Summary, Literature cited and References), Ethical consideration on research **Text Books/Suggested Books:** Kothari, C.R., 2004. *Research methodology: Methods and techniques*. New Age International. Creswell, J.W. (1994). Research design : qualitative and quantitative approaches. -

	Thousand Oaks, Calif.; London : Sage Publications, ISBN 0803952546 Dawson, C. 2009.Introduction to research methods: A practical guide for anyone undertaking a research project. 4th Ed. Spring Hill House, Spring Hill Road, Begbroke, Oxford OX5 1RX. United Kingdom.

Course Title	**Principles of Paleontology**
Course Code	ZOl-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	**Theory:** The history of life; Earth, Shells of earth (Atmosphere, hydrosphere, biosphere and lithosphere); Development of life on earth; Rock, types of rocks (lgneous, 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, Geological concepts of fossilization); 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. **Practicals:** 1. General survey of Paleontological lab. 2. Study of various kinds of Rocks (Igneous, sedimentary and metamorphic rocks). 3. Study of various kinds of fossils (Petrified, pseudomorphs, mold, casts, Imprints, foot prints and Coprolites etc.). 4. Identification and classification invertebrate fossils like foraminifers, coelenterates, Brachiopodes, arthropods (Trilobites), Molluscs and Echinoderms. 5. Study of vertebrate fossils of evolutionary importance e.g. Horses, Elephants, Primates and Camels etc. **TextBooks:** 1. Brouwer, A., 1977. General Palaeontology. Oliver and Boyed, London. 2. Samiullah, K 2014. A hand book of Paleontology **RecommendedBooks:** 1. S.S. Ali, 1999. Palaeontology, Zoogeography and Wildlife Management. 2. Young J.Z., 1950. (3rd edition & 7th edition). Life of vertebrates. London, Oxford Univ. Press. 3. Dunbar C.o., 1969. Historical Geology, John willey and sons Inc. New York. 4. Gilbert, Colbert, E.H., 1980. Evolution of vertebrates. John Willey and Sons Inc. New York. 5. Moore, R.C. Lalicker, G.C., Fisher, A.G., 1952. Invertebrate Fossils. McGraw-Hill, New York. 6. Steven M. Stanley, 2008. Earth system History3rd addition. 7. Abu Bakr, 1981. Palaeontology.

Course Title	**Aquatic Toxicology**
Course Code	ZOL-656
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	**Syllabus in Brief:** Introduction to aquatic toxicology, Short History of Aquatic Toxicology, Major classes of aquatic pollutants, Routs by which pollutants enter the aquatic ecosystems, The Aquatic Environment, The Factors that Affect the Environmental Concentration of Chemicals,Basic Toxicological Concepts and Principles, Factors that influence Toxicity,Toxic Agents and their effects, Examination of Concentration-Response Relationships, Toxicity Testing, Interpreting Toxicity Test Data, Biomonitoring, Toxicity data and Environmental Regulations, Bioindicators and Biomarkers, Genotoxicity, Oxidative Stress, Effects on reproduction, Neurotoxicity, Apoptosis and Necrosis, Immunotoxicology, Effects on Development, Behavioral Effects. **Practical:** Effects of toxicants on hematology of fish,Effects of toxicants on liver and kidney, Effects of toxicants on food intake in fishes **Text Books** Fundamentals of Aquatic Toxicology: Effects, Environmental Fate, and Risk Assessment, Edited by Gary M. Rand, PhD, Second Edition, 1995.CRC Press **Suggested Reading:** 1. Taylor and Francis: Fundamentals of Aquatic Toxicology: Effects, Environmental Fate and Risk Assessment. 2nd Edition, Philadelphia, London 2. An introduction to Aquatic Toxicology, by MikkoNikinmma (2014). Elsevier 3. Karen E. Stine and Thomas M. Brown (2015). Principles of Toxicology, CRC Press 4. Hyes A W. 1994. Principles and Method of Toxicology. 3rd Ed. Raven Press New York

Course Title	**Wildlife of Pakistan**
Course Code	ZOl-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	**Syllabus:** 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. **Practical:** 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. **Text Books:** **Suggested Reading:** 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. http://www.wildlifeofpakistan.com

Course Title	**Bio-remediation and Bioprocessing**
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	Theory Concept of bioremediation; Ex situ and In-situ Bioremediation. Degradation of natural substances; Biodegradation of xenobiotics; Industrial effluents, Dyes, Hazardous chemicals, TNT wastes, Introduction to different Bacterial and Fungal spec used in Bioremediation. Biosorption: Use of Bacteria, Algae and Fungi for it. Phytoremediation. Biotechnology for Air Pollution: Bioscrubbers, Trickling Filters etc. Use of enzymes. Muncipal and Industrial Waste Water Treatment: Primary, Secondary, Tertiary and Sewage Treatment including disinfection. Phosphorus and Nitrogen Removal. Biohydrometallargy: for extraction of Precious metals from their ores (Iron, Gold, Copper, Silver)

	Biofuel generation; Use of Algae, Alcohol etc for production of Biofuels. **Practicals** Isolation and studies of heavy metals tolerant/resistant microorganisms; Studies on bacterial capable of degrading xenobiotics; production of alchohol from decaying fruits. Books Recommended Practical Environmental Bioremediation the field guide, 1997. R. Barry King, Gilbert M. Long, John K. Sheldon, Lewis publishers. **Books:** General Microbiology, 1995. Schlegel, H.G., Cambridge University Press. Biotechnology, 1996. Smith, J.F., Cambridge University Press. Environmental Biotechnology Principals and applications, 2000. Pruce, R. Hmana, Parry McCarty, McGraw Hill. Biodegradation and Bioremediation, 1999. Martin Alexender academic press Inc.

Course Title	**Biodiversity**
Course Code	ZOL-692
Credit Hours	3
Theory	2
Practical	1
Follow up	B.Sc. Zoology
Category	M.Sc. Zoology, 02-Years Programme
Aims and Objectives	Study regarding the richness and evenness in animal kingdom.
Learning Outcomes	The students will be able to achieve the aims and objectives of this course.
Syllabus in Brief	Definition; Types; Levels; Status of Biodiversity; Importance of Biodiversity. Natural Resources and Biodiversity • Ecological aspects of Biodiversity • Impacts on Biodiversity • Loss of Biodiversity • Protection / Conservation of Biodiversity. Practicals 1. Critical account (phylogenetic controversies) of some important museums speciments with the help of literature. 2. Procedures for studying species richness, Simpson Index, Shannon and Weiner Function. 3. Population of some local subterranean animals. Books Recommended 1. Biodiversity, Principles and Conservation by Kumar & Asija, 2000. 2. The Diversity of Life by C. Mary Jenking and Ann Boyce, 1987.

M.Sc. Courses:

Course Title	Biochemistry-I (Structure and Functions of Macromolecules)
Course Code	ZOL-551
Credit Hours	3
Theory	2
Practical	1
Follow up	B.Sc. Zoology
Category	M.Sc. Zoology, 02-Years Programme
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, Estiadiole. 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. <u>Books Recommended</u> 1. David I., Nelson, and Michael M, Cox. 2000, Lehninger Principles of Biochemistry, 3rd Edition, Macmillan Worth Pubslihers, New York. Additional Reading 1. 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. 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, 4th Edition, Wm. C. Brown Publishers Inc. Oxford, England. 4. Lubert Stryer, 1995. Biochemistry, 4th Edition, W.H. Freeman & Company, New York. <u>Practicals</u> 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. 12. Various Qualitative Tests for detection of Lipids. 13. Determination of Acid value of Fats. Books Recommended 1. Plummer, David T., 1990. An Introduction to Practical Biochemistry, 4th Edition, McGraw-Hill Book Company, London. 2. Wilson, K & Walker, J., 1994. Practical Biochemistry: Principles of Techniques, 4th Edition, Cambridge University Press.

Course Title	Developmental Biology
Course Code	ZOL-553
Credit Hours	4
Theory	3
Practical	1
Follow up	B.Sc. Zoology
Category	M.Sc. Zoology, 02-Years Programme
Aims and Objectives	The students will be able to understand basic principles through the understanding morphology and anatomy of embryos.
Learning Outcomes	The students will be able to apply the basic principles of development to further research.
Syllabus in Brief	*Theory* Principle features of development, developmental patterns. Spermatogenesis, oogenesis, fertilization, Recognition of sperm and egg, Fusion of gemetes. Rearrangement of egg cytoplasm, cleavage, patterns of embryonic cleavage, mechanism of cleavage, gastrulation, Fate maps, Gastrulation in birds, mammals. Early vertebrate development, Neurulation, ectoderm, mesoderm and endoderm. Cellular basis of morphogenesis, Establishments of body axis and mechanism of teratogenesis; organogenesis, a brief account of origin and migration of germ cells in vertebrates, factors controlling growth and oncogenesis. Regeneration in vertebrates. Practicals Study of structure of gametes of fowl. Study of cleavage and subsequent development with the help of prepared slides or whole mounts of chick embryo. Preparation and study of serial sections of different tissues. Preparation and staining of histological slides. Books Recommended 6. Developmental biology, 2000. by Gilbert, S. F. 7. Human Embryology and Developmental biology, By Carlson, B. M.

	8. Introduction to Embryonic Developments by Oppenheimar, SS and Allen and Bacon 9. An introduction to embryology 1985 by Balinsky .B.I. and Saunders 10. Developmental Biology by Saunders W.B. 11. Modern Embryology 1968 by Bodemer C.W 12. Mechanism of development 1980. by Ham.R.G., and Veomett, M. J. 13. Development 1978 by Barril N.J and Karp G. 14. The developing human 1982 by Moore K.L. 15. Medical Embryology 1981 by Largman, J. Clinical Embryology 1983 by Snell, R.S.,

Course Title	Advanced Environmental Biology
Course Code	ZOL-555
Credit Hours	3
Theory	2
Practical	1
Follow up	B.Sc. Zoology + Botany
Category	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.
Syllabus in Brief	*Theory* Nature of Ecology, The earth's life support system, Ecosystem concepts and components, Food chains and food webs, 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, Man and Environment, Impact of human population growth: Air pollution: Atmosphere, Outdoor air pollution, Photochemical and industrial smog, Acid deposition, Global warming, Ozone depletion in the stratosphere, Types and sources of water pollution, Noise pollution. *Practicals* Food chain, food web & ecological notes Methods and analysis of population dynamics Quadrate method Determining frequency of different species Determining density of species in habitat Measurement of pollutants levels In atmosphere (NO_2, SO_2, O_3 and comparison with rural air) In soil (toxic chemical, fertilizer, insecticides, herbicides) Analysis of polluted and freshwater for Various pollutant; heavy metals,-CO_3, -HCO_3,NO_3, BOD, COD, pH, EC, total soluble solids. *Books Recommended (Latest Edition)* 1. Miller, G.T. 2002. Living in the environment: Principles, Connections and Solutions. 12th Edition. Thomson Learning, Australia. 2. M.L. McKinney Enviromental Sciense: System and Solution (1999) Jones & Bartlett Publication, Boston. 3. M.C. Molles Ecology: *Concepts and application* (1999) WCB/McGraw Hill, New York. 5. Smith Ecology and Field Biology (1988) National Book Foundation 6. E.P. Odum Fundamentals of Ecology. Latest Edition.

Course Title	**Animal Physiology**

Course Code	ZOL-557
Credit Hours	4
Theory	3
Practical	1
Follow up	
Category	BS(H) 4 years/ M. Sc 2 years
Aims and Objectives	One is able to understand mechanisms and adaptations of physiological systems in animals.
Learning Outcomes	The students will be able to understand the working of various systems of organisms.
Syllabus in Brief	**Central themes in Physiology:** Structure-Function Relationship. Adaptations, Homeostasis. Conformity and Regulation. **Cardiovascular Mechanisms:** Electrical activity of heart: Automaticity, Rhythmicity, Electrocardiography, Mechnical activity of heart: Cardiac output, stroke volume and heart rate, Hemodynamics: Blood flow, pressures and resistance and their interrelationships and peripheral circulation. **Exchange of Gases:** Transport of O_2 and CO_2 between respiratory surface (the lungs) and body cells. Regulation of respiration: Gas transfer in lung, air and water (gills) and its regulation. Respiratory responses in extreme conditions as hypoxia, hypercapnia and diving by air breathing divers. **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**.** **Nutrition:** Regulation of digestive secretions: Physiological anatomy of digestive tract (mammalian model), Absorption of water, ions and nutrients. **Movements and Muscles:** Structural basis of muscle contraction: molecular structures of contractile components and their interaction, sarcoplasmic reticulum, calcium and membrane. **Temperature Relations:** Temperature based classifications of animals, Temperature relations of ectotherms: Ectotherms in different environments, cost & benefits of ectothermy, temperature relations of heterotherms and endotherms: Dormancy: Sleep, Torpor, Hibernation, Estivation. **Practicals:** Cardiovascular Activity:Normal cardiac activity, effect of temperature, effect of drug, heart block, tetanization of heart by Kymography, Measurement of blood pressure. Respiration and Exercise:Oxygen consumption in fish and effect of temperature (by dissolved oxygen meter) and terrestrial animal (mouse). Heart rate, blood pressure and glycemic alterations by exercise. **Books Recommended:** 1. Randall. D. Burggren. W. French. K. and Fernald. R. 2002. Eckert Animal Physiology: Mechanisms and Adaptations. 5th ed. W.H. Freeman and Company. New York. 2. Seeley. Rod. R., Stephens.D. Trent and Tate Philip. 2008. Anatomy & Physiology, 8th Edition. The McGraw-Hill, New York, USA. 3. Bullock. J. Boyle. And Wang. M.B. 2001. Physiology. 4th edition. Lippincott. Williams and Wilkins. Philadelphia. 4. Bame. F.M. and Levy. M.N. 2000. Textbook of Medical Physiology. 3rd

	Edition. St. Lions. Mosby. 5. Guyton, Arthur C. and John E. Hall. 2000 Text book of Medical Physiology 10th Edition. W.B. Saunders Company. 6. Withers. 1992. Comparative Animal Physiology. 7. Sdhmidt- Nelsen. K., 1997. Animal Physiology.Adaptation and environment 5th Edition Cambridge University Press Cambridge. 8. Tharp. G. and Woodman. D. 2002. Experiments in Physiology. 8th Edition.Prentice Hall London

Course Title	**Advanced Cell Biology**
Course Code	ZOL-559
Credit Hours	3
Theory	2
Practical	1
Follow up	Not Applicable
Category	M.Sc. Zoology, 02-Years Programme
Aims and Objectives	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	Structure of prokaryotic and eukaryotic cell. 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. Transcription: RNA polymerases, transcriptional control in prokaryotes and eukaryotes. Post-transcriptional processing of RNA, Structure and function of ribosomes. Genetic Code, point mutations, genetic code, DNA sequencing. Translation, Regulation of Gene Expression: Lac Operon, Recombinant DNA technology: Cloning vectors, restriction endonucleases, Brief introduction on Southern blotting, Northern blotting, western blotting. Structure, chemical composition and functions of Plasma Membrane (Permeability, Active Transport, Endocytosis), Mitochondria (its role in respiration and its status as semi-autonomous organelle), Golgi Apparatus, Endoplasmic Reticulum, Lysosomes, Ribosomes, Peroxisomes, glyoxysomes, Cytoskeleton. **Practical:** 1. Culturing and staining of bacteria and yeast. 2. Counting of bacterial cells and preparation of growth curves. 3. Counting of blood cell types by haemocytometer. 4. DNA extraction and demonstration on agarose gel. 5. Detection (in protozoan culture and blood cells) and quantitative determination of chromosomal DNA and RNA. 6. Isolation and fractionation of proteins from blood sera by polyacrylamide gel electrophoresis. **Text Books:** 1. Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K and Walter, P., 2002. *Molecular Biology of Cell*. Garland Science, New York.Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Scott, M.P., Bretscher, A., Ploegh, H and Matsudaira, P. Molecular Cell Biology, 6th edition. Freeman & Comp. New York. 2. Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K and Walter, P. 2002. Molecular Biology of the Cell. Garland Science, New York.

	3. Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K and Walter, P. 2008. Molecular Biology of the Cell, 5th edition. Garland Science, New York. 4. Karp, G. 2002. Cell and Molecular Biology: Concepts & Experiments. John Wiley & Sons, New York.

Course Title	**Research Methodology**
Course Code	ZOl-561
Credit Hours	1(1-0)
Theory	1
Practical	0
Follow up	
Category	BS (Hons) Zoology, 04-Years Programme/ MSc 02 years
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	Theory: Introduction to Course, Important definitions, The aims, objectives, motivation and types of research, The research topic, Research design, characteristics of good research design, research problem and research issues, Sampling design, Population and sampling types, Data analysis, interpretation of results, role of computer and statistics in research, report writing, Synopsis and Thesis (Title, Abstract, Introduction, Materials & Methods, Literature Review, Results and Discussion, Summary, Literature cited and References), Ethical consideration on research **Text Books/Suggested Books:** Kothari, C.R., 2004. *Research methodology: Methods and techniques*. New Age International. Creswell, J.W. (1994). Research design : qualitative and quantitative approaches. - Thousand Oaks, Calif.; London : Sage Publications, ISBN 0803952546 Dawson, C. 2009.Introduction to research methods: A practical guide for anyone undertaking a research project. 4th Ed. Spring Hill House, Spring Hill Road, Begbroke, Oxford OX5 1RX. United Kingdom.

Course Title	Biochemistry-II
Course Code	ZOL-552
Credit Hours	3
Theory	2
Practical	1
Follow up	Biochemistry-I (Structure and Functioning of Macromolecules)
Category	M.Sc. Zoology, 02-Years Programme
Aims and Objectives	To provide knowledge regarding molecular interpretation of problems and processes of life.
Learning Outcomes	This course will enable the students to comprehend all the current related courses in Zoology.
Syllabus in Brief	Bioenergetics: Concept of Free Energy and Standard Free Energy change. Energy rich compounds: Phosphoryl group transfers and ATP; Acyl phosphates; Enol phosphates and Thioesters. 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, Glyceraldehyde and Glycerol. Phosphorolysis of Glycogen. Biosyntehsis of Glycogen. Regulation of Glycogen Metabolism. Pentose phosphate pathway of Glucose oxidation and its major role in the animal tissues.

	Anabolic role of citric acid cycle intermediates; Regulation of Citric acid cycle. 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. Nitrogen Metabolism: Metabolic fate of standard amino acids. Catabolism of Amino acids: Decarboxylation; Deamination and Transamination. Amino acid degradation showing entery 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. Books Recommended 1. David I., Nelson, and Michael M, Cox. 2000, Lehninger Principles of Biochemistry, 3rd Edition, Macmillan Worth Pubslihers, New York. 2. Additional Reading 3. 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. 4. Voet. D., Voet. J.G., and Pratt. C.W., 1999. Fundamentals of Biochemistry, John Wiley and Sons Inc., New York. 5. Zubay. G., 2000. Biochemistry, 4th Edition, Wm. C. Brown Publishers Inc. Oxford, England. 6. Lubert Stryer, 2001. Biochemistry, 4th Edition, W.H. Freeman & Company, New York. Practicals 1. Demonstration of Acid Hydrolysis of Polysaccharide. 2. Determination of pKa values of an amino acid by preparation of titration curves. 3. Estimation of Free Amino Acids in Biological samples colorimetrically. 4. Separation and identification of various amino acids by Paper chromatography/ PAGE. 5. Separation of various protein fractions by precipitation method. 6. Preparation of standard curve of proteins using Lowry's technique. 7. Estimation of tissue (liver) proteins using Lowry's technique. 8. Preparation of standard curve and Estimation of proteins by ultraviolet (UV) spectrophotometry. 9. Preparation of standard curve and Estimation of DNA by colorimetric analysis using Diphenylamine method. 10. Preparation of standard curve and Estimation of total RNA by colorimetric analysis using Bial's Orcinol method. 11. Quantitative analysis of Diastase activity on starch. 12. Study on the effect of temperature on the enzymatic rate of reaction. Books Recommended 1. Plummer, David T., 1990. An Introduction to Practical Biochemistry, 4th Edition, McGraw-Hill Book Company, London. 2. Wilson, K & Walker, J., 1994. Practical Biochemistry: Principles of Techniques, 4th Edition, Cambridge University Press.

Course Title	**Physiology of coordination and animal behaviour**
Course Code	ZOL-554
Credit Hours	4
Theory	3
Practical	1
Follow up	Animal Physiology
Category	BS (H) 04-Years/ M.Sc. Zoology, 02-Years Programme

Aims and Objectives	To understand the physiology of coordination and animal behaviour
Learning Outcomes	The students will be able to understand different phenomena responsible for coordinated animal behaviour
Syllabus in Brief	**Physiological basis of Neuronal Function**: Mechanisms in Resting Membrane Potentials: Electrogenic ion pump. Donnan equilbrium. Ionic mechanisms in action potentials: Roles of ion channels. Properties of action potential. Propagation of Action Potential: Synaptic transmission: Structure and function of electrical synapse &chemical synapse: Neurotransmitters: Synaptic receptors: Excitatory postsynaptic potentials: Inhibitory postsynaptic potentials: Presynaptic inhibitions: Integration at synapses: Facilitation. Posttetanic Potentiation. **Photoreception:** Ultrastructure of photoreceptors. Photochemistry, Phototransduction and physiological basis of color vision: Physiological mechanisms in electroreception. **Chemical Messenger and Regulators/Endocrine Physiology**: An overview of invertebrate endocrine structures, their hormones and physiological roles. An overview of hormones, their chemistry and physiological roles of Hypothalamus. Pituitary, Thyroid, Parathyroid and associated structures, Endocrine pancreas, Gastropancreatic system, Adrenal medulla (Chromaffin Tissue), Adrenal cortex, Ovary, Testis and Placenta. Endocrine functions of kidneys & heart and pineal gland. A generalized model account of hormone synthesis, storage and secretion (a peptide hormone model and steroid hormones). General account of hormonal regulations, hormonal turnover, recognition: Mechanisms of hormonal interactions involving metabolic, developmental, membrane receptors and nuclear modulated gene expression: **The study of Animal Behaviour:** Introduction. History of animal Behaviour. Approaches and Methods. Mechanisms of Behavior**:** The Nervous System and Behaviour. Hormones and Behaviour and Learning Behaviour. Finding Food and Shelter: Migration. Orientation and Navigation. **Practicals** **Muscle and Neuromuscular Activity:** Nerve muscle preparation. Muscle twitch, Comparision of muscle and nerve irritability, effect of stimulus strength, effect of stimulus frequency (tetany), effect of load or stretch, effect of prolonged activity (fatigue), stimulation of motor points in human. **Excitability, Sensation and Behaviour:** Recording of action potential by oscilloscope and demonstration of its various features. Experiments to demonstrate characteristic of reflex arc, Experiment in human (students themselves) to demonstrate some aspect of sensory physiology. **Endocrine and Reproductive Mechanisms**: Effect of insulin on glycemia, study of stages in estrous cycle, mechanisms in regulations of contraction.Study of hibernation and biological rhythms. Books Recommended 1. Randall. D.Burggren. W.. French. K. and Fernald. R.. 2002. Eckert Animal Physiology: Mechanisms and Adaptations. 5th ed. W.H. Freeman and Company. New York. 2. Seeley. Rod. R., Stephens, D. Trent and Tate Philip. 2008. Anatomy & Physiology, 8th Edition. The McGraw-Hill, New York, USA. 3. Bullock. J.. Boyle. And Wang. M.B.. 2001. Physiology. 4th edition. Lippincott. Williams and Wilkins. Philadelphia. 4. Bame. F.M. and Levy. M.N.. 2000. Textbook of Medical Physiology. 3rd edition. St. Lions. Mosby.

	5. Guyton and hall 2000 Text book of Medical Physiology 10th. Edition. 6. Sdhmidt- Nelsen. K., 1997AnimalPhysiology.Adaptation and environment 5th. Edition Cambridge University Press Cambridge. 7. Drickamer, L.C., Vessey, S.H., and Jacob, E., 2002. Animal Behviour: Mechanism, Ecology, Evolution. 5th Edition. 8. Manning, A. and Daekins, M.S., 1997. An introduction to animal behviour, 4th edition, Cambridge University Press, Cambridge. 9. Tharp. G. and Woodman. D. 2002. Experiments in Physiology. 8th Edition. Prentice Hall London.

Course Title	**Evolution and Principles of Systematics**
Course Code	ZOL-556
Credit Hours	3
Theory	2
Practical	1
Follow up	B.Sc. Zoology + Botany
Category	M.Sc. Zoology, 02-Years Programme
Aims and Objectives	To classify fauna of the Universe and their origin.
Learning Outcomes	Application of knowledge to elaborate the different research techniques and apply it to explain the results.
Syllabus in Brief	Theory Contribution of systematic to Biology; History of Taxonomy (Downward classification, upward classification, impact of origin of species, population systematics, current trends); Micrortaxonomy, 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. 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. Factors initiating elementary evolutionary changes (micro-evolution) by changing gene frequencies, mutation pressure, selection pressure, immigration and croobreeding, genetic drift. Role of isolation in evolution. Factors of large evo- lutionary changes (macro-evolution) – allometry, orthogenesis, adaptive radiation. 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. Practicals Study of preserved invertebrate species and their classification up to class level. Collection. Preservation and identification of common species with the help of keys. Methods of statistical analysis of samples from populations. Preparation of keys for the identification of specimens. Books Recommended Mayer, E. 1969. Principles of Systematic Zoology, McGraw Hill York. Mayer, E. and Asblock, P.D., 1991. . Principles of Systematic Zoology, McGraw Hill York.

	Huxley, E., 1940. New Systematics, Oxford University Press. Mayr, E. 1963. Animal Species and Evolution, Harvard University Press. Scheuk and McMaster, 1959. Procedure in Taxonomy, Stanford University Press. Simpson, G.G., 1961. Principles of Animal Taxonomy, Columbia University Press, N.Y. Mayer, E. and Asblock, P.D., 1991. . Principles of Systematic Zoology, McGraw Hill York. Ross, H.H., 1974. Biological Systematics, Addison-Wesley Publishing Co. Reading, Massachusetts. Heywood, V.H., 1975. Taxonomy and Ecology, Aeademic Press, London. Whili, M.J.D., 1978. Modes of Speciation, W.H. Freeman and Co., San Francisco. Howard, R. and Moore, A., 1984. A complete Check-list of the Birds of the World, Macmillan, London. 12. Ridley, M. 1993. Evolution, Blackwell Scientific Publications Dobzhansky, T., Ayala, F.J., Stebbins, G.L., and Valentine, J.W., 1973. Evolution, W.H. Freeman and Company. Dobzhansky, T., 1970. Genetics of the Evolution process, Columbia University Press, New York. Sheppard, P.M., 1985. Natural Selection and Heredity, Hutchson University Library, London. Dobzhansky, T., Genetics and the Origin of Species, Columbia University Press, New York. Mayr, E. Pouplations. Species and Evolution, Harvard University Press. Moody, P.A., 1989, Introduction to Evolution, Harper and Row Polishers, New York. Cain, A.J., Animal species and their Evolution, Hutchson University Library, London. Westoll, T.S., The Evolution of Living Things. Ross, H.H., Understanding Evolution. Simpson, G.G., Meaning of Evolution, Yale University Press. Dodson, E.O., 1960. Evolution: Process and product, Chapman and Hall Ltd.

Course Title	**General and Molecular Genetics**
Course Code	ZOL-558
Credit Hours	4
Theory	3
Practical	1
Follow up	Biotechnology
Category	M.Sc. Zoology, 02-Years Programme
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	Introduction: classical genetics, molecular genetics, Reverse and forward genetics, basic principles of Inheritance (Mendelism): Monohybrid and Dihybrid crosses. Model organism used for genetic studies, 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. recombination and chromosome mapping in eukaryotes, 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 Gene cloning, construction and screening of DNA libraries, cDNA Library, molecular analysis of DNA, RNA and protein through blotting techniques. 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 (Familial hypercholesterolaemia, Tay-Sachs disease); Purine/pyrimidine metabolism (Lech – Nyhan disease). **Practical:** 8. Study of Mitosis and Meiosis. 9. Preparation of Drosophila culture. 10. Study of morphology and karyotype. 11. Study of Monohybrid and dihybrid ratio, sex-linked inheritance. 12. Pedigree Analysis 13. Detection of Blood Groups in humans. 14. Problem relating to theory. **Books:** 9. Hartl, D. L. and E. W. Jones. 2009 Genetics: Analysis of Genes and Genomes. Seventh (7th) Edition. Jones and Bartlett Publishers. USA. 10. Snustad, D.P. and Simmon, M.J., 2003. Principles of Genetics. 3rd Edition. John Wiley and Sons, New York. 11. Muller, R.F. and Young, I.D., 2002. Emery's Elements of Medical Genetics. 11th Edition. Churchill Livingstone, Elsevier Science, Limited, UK. 12. Tammarin, R.M. 1999. Principles of Genetics. 6th Edition, WCB, McGraw Hill, New York. 13. Klug, Cummings et al., 2012, Concepts of Genetics 10th edition, Pearson Publisher. Macmillan College Publishing Company, New York. 14. Strickberger, M.W. 1999. Genetics. 3rd Edition. Prentice Hall of India Private Ltd., New Delhi. 15. Lewin, B. 2003. Gene VII. Oxford, UK.

Course Title	**Principles of Zoogeography**
Course Code	ZOL-560
Credit Hours	3
Theory	2
Practical	1
Follow up	B.Sc. Zoology
Category	M.Sc. Zoology, 02-Years Programmee
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	**Theory:** 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 (Palaearctic 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. **Practicals:** Identification and classification of various invertebrates and vertebrates of Zoogeographical importance. **TextBook:** 3. Darlington, Zoogeography, John Wiely, 1963. 4. S.S. Ali, 1999. Palaeontology, Zoogeography and Wildlife Management. **RecommendedBooks:**

	7. Hesse, Ecological Animal Geography, John Wiely, 1963. 8. DeBeaufort, Zoogeography of the Land Inland Waters, Sidgwick and Jackson. 1951. 9. Ekman, Zoogeography of the sea. Sidgwick and Jackson. 1953. 10. Lillies, Introduction to Zoogeography, London, 1974. 11. Muller, Aspects of Zoogeography, Hague, 1974. 12. Jafri, Land Zoogeography of World, 1977.

Course Title	**Fundamentals of Microbiology**
Course Code	ZOL – 562
Credit Hours	3
Theory	2
Practical	1
Follow up	Applied Microbiology
Category	M.Sc. Zoology, 02-Years Programme
Aims and Objectives	In this course, the students will be able to learn the basic microbial knowledge about structure, function; culturing techniques, and its applications in various industries making the foundations for the further future research.
Learning Outcomes	The students will be able to apply basic information in order to achieve the aims and objectives of the course.
Syllabus in Brief	Theory: The history and scope of Microbiology. Microbial structure. Taxonomy and characterization of Microorganisms. Nutritional requirements and microbiological Media. Growth kinetics of microorganisms. Control of microorganisms by physical and chemical agents. Microbial metabolism; microbes and genetic engineering, microbiology of soil, water and atmosphere. Viruses, Morphology, Characteristics and Replications. Major groups and Taxonomy, Microorganisms as components of Ecosystems. Industrial applications of Microbiology. Practicals: Simple staining, Negative staining, Smear preparation, Capsular staining, Gram staining, Culture Media preparation, Study of bacteria in Stale Milk, Study of Protozoa, Algae and Cyanobacteria (from fresh water as well). Reference Books 1. Pommerville, J. C. 2014. Fundamentals of Micrbiology. 9th edition, Published by Jones & Bartlett, USA 2. Batzing, B.L. 2001. Microbiology: An Introduction. Books / Cole Thomson Learning, USA. 3. Tortora, G.J., Funke, B.R. and Case, C.L., 2001. Microbiology: An Introduction. 7th edition. Benjamin Cummins, New York. 4. Nester, E.W., Anderson, D.G., Roberts, C.E., Pearsall, N.N. and Nester, M.T., 2004. Microbiology: A human perspective. McGraw Hill, Higher Education, New York. 5. Benson, H.J., 1998. Microbiological Applications: Laboratory Manual in General Microbiology. 7th edition. WCB McGraw Hill. 6. Stanier, Y. Roger, John L. Ingrahm, Mark L. Wheelis and Page R. Painter. 2003.General Microbiology. V Ed. MacMillan Press Ltd. New Jersey.

Course Title	**Principles of Palaeontology**
Course Code	ZOl-651
Credit Hours	3
Theory	2
Practical	1
Follow up	B.Sc. Zoology
Category	M.Sc. Zoology, 02-Years Programme

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	**Theory:** The history of life; Earth, Shells of earth (Atmosphere, hydrosphere, biosphere and lithosphere); Development of life on earth; Rock, types of rocks (lgneous, 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, Geological concepts of fossilization); 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. **Practicals:** 1. General survey of Paleontological lab. 2. Study of various kinds of Rocks (Igneous, sedimentary and metamorphic rocks). 3. Study of various kinds of fossils (Petrified, pseudomorphs, mold, casts, Imprints, foot prints and Coprolites etc.). 4. Identification and classification invertebrate fossils like foraminifers, coelenterates, Brachiopodes, arthropods (Trilobites), Molluscs and Echinoderms. 5. Study of vertebrate fossils of evolutionary importance e.g. Horses, Elephants, Primates and Camels etc. **TextBooks:** 1. Brouwer, A., 1977. General Palaeontology. Oliver and Boyed, London. 2. Samiullah, K 2014. A hand book of Paleontology **RecommendedBooks:** 1. S.S. Ali, 1999. Palaeontology, Zoogeography and Wildlife Management. 2. Young J.Z., 1950. (3rd edition & 7th edition). Life of vertebrates. London, Oxford Univ. Press. 3. Dunbar C.o., 1969. Historical Geology, John willey and sons Inc. New York. 4. Gilbert, Colbert, E.H., 1980. Evolution of vertebrates. John Willeyand Sons Inc. New York. 5. Moore, R.C. Lalicker, G.C., Fisher, A.G., 1952. Invertebrate Fossils. McGraw-Hill, New York. 6. Steven M. Stanley, 2008. Earth system History3rd addition. 7. Abu Bakr, 1981. Palaeontology.

Course Title	Biostatistics
Course Code	ZOL-655
Credit Hours	1
Theory	0
Practical	1
Follow up	None
Category	M.Sc. Zoology, 02-Years Programme
Aims and Objectives	To aware the students about the application of statistics in the field of life sciences.
Learning Outcomes	The students will be able to apply statistical formulae to analyze the research data.
Syllabus in Brief	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 and distribution. Binomial, poisson and normal distributions. Hypothesis testing, student's 't' test. Chi-square test. Analysis of variance and LSD. Correlation and regression. Experimental designing, planning of an experiment replication and randomization. Books Recommended 1. Simpson, G.G., Roe, A. and Lewontin R.C. 1960. Quantitative Zoology, Harcourt, Brace & World Inc. New York. 2. Steel, R.G.D. and Torrie,J.H.,1980. Principels and procedures of statistics. McGraw Hill International Editions. 3. Fowler, J., Cohen, L. and Jarris, P., 1998. Practical statistics for field biology. John Wiley and Sons. 4. Zar, 1998. Biostatistics Analysis. 5. Campbell, R.C. Statistics for Biologists. Cambridge University Press. 6. Sokal, R.R. and Rohlf, F.J., 1973. An Intriduction to Biostatistics, Troppan. 7. Bailey,N.T.J., 1981. Statistics Methods in Biology, English University Press. 8. Mead, R., Currow, R.N. and Hastod, A.M., 1993. Statistics methods in agriculture and experimental biology, 2th edition. Chapman & Hall.

Course Title	**Fish Culture**
Course Code	ZOL-657
Credit Hours	3
Theory	2
Practical	1
Follow up	Not Applicable
Category	M.Sc. Zoology, 02-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	Theory: 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. Practicals: 1. Study of various aquatic culture systems (fish farm, hatcheries and nurseries). 2. Weight length and condition factor in relation to different environment in fish spp. 3. Induced spawning. Books Recommended: 1. Huet, M., 1986. Textbook of Fish Culture: Breeding and cultivation of fish. 2nd Edition. Fishing News Book Ltd. England. 2. Pillay, T.V.R. and Dill, W.M.A., 1976. Advances in Aquaculture. Published by Fishing News Books, Ltd., England. 3. Jhingran, V.G., 1983. Fish and Fisheries of India. 2nd Edition. Hindustan Publishing Corporation, New Delhi. 4. Pillay, T.V.R. 1999. Aquaculture: Principles and practices. Fishing News Books, London.

Course Title	**Introduction to Biotechnology**
Course Code	ZOL-661
Credit Hours	4

Theory	3
Practical	1
Follow up	Not Applicable
Category	M.Sc. Zoology, 02-Years Program BS Zoology, 04-years Program
Aims and Objectives	Biotechnology aims at integrated use of biochemistry, microbiology and engineering sciences in order to achieve technological application of the capabilities of microorganisms, cultured tissue, cells and plants thereof. Its main objective is the application of biochemistry, microbiology and chemical engineering to industrial process and products for the benefit of mankind in the fields of environment, Health, Agricultures and Industry.
Learning Outcomes	This course will develop the understanding of Biotechnology. And learners will develop technical know how to deal with environmental problems, Health care, Agriculture and Industrial applications. After learning students can have basic knowledge of Biotechnology so that they can opt as special subject in the future.
Syllabus in Brief	Theory: Introduction to Biotechnology, Different products of Biotechnology in the Health, Agriculture, Industrial and Environmental Sector, Emergence of Biotechnology, Up Stream Down Stream Processes. Biological systems E coli, Saccharomyces etc. Recombinant DNA Technology: Cloning Vectors, Transformation Techniques, Selection and Expression. Large Scale Production of Biotechnological Products: Batch, Fed Batch, Continuous Fermentation System, Maximizing efficiency, Bioreactors, Product Harvesting, Purification and Ultra Purification. Molecular-Biotechnology for Health care: Insulin hormone, human growth hormone (somatotropin), somatostatin and human interferon, Vaccines, Antibodies. Fermentation Biotechnology: Cultures of microorganisms, production of organic compounds by microbial fermentation (ethanol, acetone, butanol, amino acids, cheese, wine, beer, cider, and vinegar) and their improvement using Molecular Biotechnology. Single Cell Protein (SCP): Microorganisms, nutritional value of SCP, production of algal biomass and production of yeast biomass. Transgenic plants: Insect resistant transgenic plants, virus resistance. Biotechnology of Nitrogen Fixation: Understanding Nitrogen Fixation, Genetic Engineering in Nitrogenase gene. Enzyme Biotechnology: Methods of enzyme production, immobilization of enzymes and uses of enzymes. Practicals Screening of enzymes of industrial significance. Enzyme immobilization Screening and selection of microorganisms of Industrial significance from local environment. Development and preservation of pure cultures of the microorganisms of industrial significance. Development of typical microbial growth curve using different substrate systems. **Books Recommended** Glick, B.R. and Pasternak, J.J. 2003. Molecular Biotechnology. Third Edition. ASM Press, Washington D.C., USA. Philopose, P.M. 2004. A Textbook of Biotechnology. First Edition. Dominant Publishers and Distributors. New Delhi, India. Chirikjian, J.G. 1999. Biotechnology-Theory and Techniques. Jones and Bartlett Publishers, Inc., USA.

Course Title	**Biological and Chemical Control of Insects**
Course Code	ZOL-663

Credit Hours	3
Theory	2
Practical	1
Follow up	B.Sc. Zoology
Category	M.Sc. Zoology, 02-Years Programme
Aims and Objectives	To provide knowledge about various biological and chemical methods to control insect pest for better production of food.
Learning Outcomes	The course will provide the execution of biological and chemical methods to handle insect pest.
Syllabus in Brief	Theory Historical development of biological control, Steps in establishing biological control programme, Concept and significance of natural control. Attributes of an effective natural enemy. Superparasitism and multiple parasitism. Importance of systematics of biological control. Methods of colonization, recovery and evaluation of natural enemies. Importance of chemical control: Classification of insecticides, stomach poison, control poison, fumigants. Biology, life histories and control measures of insects attacking paddy, sugar cane, cotton, apple and some forest, trees. Integrated pest management. Practicals Collection and identification of insect pests of agricultural crops and forest trees. Demonstration of effects of some insecticides on the survival of insect pests in the Laboratory. Books Recommended (Latest Editions) De bach, P., (1964). Biological control of insect pests and Weeds. Chapman and Hall, London. Pedigo, L.P., 1991. Entomology and Pest Management. MaxMillan. Metcalf, C.L. and Flint. Destructive and Useful Insects, McGraw hill Co., N Y. Martin, H. Insecticide and Fungicide, Handbook for Corp Protectin, Blackwell, Oxford.

Course Title	**Wildlife of Pakistan**
Course Code	ZOl-652
Credit Hours	2
Theory	1
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	**Syllabus:** 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. **Practical:** 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. **Text Books:** **Suggested Reading:** 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. http://www.wildlifeofpakistan.com

Course Title	**Bioremediation and Bioprocessing**
Course Code	ZOL-654
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	Theory Concept +++9+96+855of bioremediation; Ex situ and In-situ Bioremediation. Degradation of natural substances; Biodegradation of xenobiotics; Industrial effluents, Dyes, Hazardous chemicals, TNT wastes, Introduction to different Bacterial and Fungal spec used in Bioremediation. Biosorption: Use of Bacteria, Algae and Fungi for it. Phytoremediation. Biotechnology for Air Pollution: Bioscrubbers, Trickling Filters etc. Use of enzymes. Muncipal and Industrial Waste Water Treatment: Primary, Secondary, Tertiary and Sewage Treatment including disinfection. Phosphorus and Nitrogen Removal. Biohydrometallargy: for extraction of Precious metals from their ores (Iron, Gold, Copper, Silver) Biofuel generation; Use of Algae, Alcohol etc for production of Biofuels. **Practicals** Isolation and studies of heavy metals tolerant/resistant microorganisms; Studies on bacterial capable of degrading xenobiotics; production of alchohol from decaying fruits. Books Recommended Practical Environmental Bioremediation the field guide, 1997. R. Barry King, Gilbert M. Long, John K. Sheldon, Lewis publishers. **Books:** General Microbiology, 1995. Schlegel, H.G., Cambridge University Press. Biotechnology, 1996. Smith, J.F., Cambridge University Press. Environmental Biotechnology Principals and applications, 2000. Pruce, R. Hmana, Parry McCarty, McGraw Hill.

	Biodegradation and Bioremediation, 1999. Martin Alexender academic press Inc.

Course Title	**Aquatic Toxicology**
Course Code	ZOL-656
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	Introduction to aquatic toxicology, Major classes of aquatic pollutants, Routs 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. **Practical:** 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 & weight) in fish, Effects of toxicants on gonadal development in fish, Effects of toxicants on endocrine disruption in fish **Text Books** Aquatic Toxicology: Molecular, Biochemical and Cellular Perspective Donald, C. Malins and Gary, K. 1993, Lewis Publishers USA, 520 pp ISBN 0-87371-545-4 **Suggested Reading:** 1. Taylor and Francis: Fundamentals of Aquatic Toxicology: Effects, Environmental Fate and Risk Assessment. 2nd Edition, Philadelphia, London 2. Landis W G and Yu M H. 1999. Introduction to Environmental Toxicology; Impact of chemicals upon ecological system. 2nd Ed. Lewis Publisher Boston, London 3. Hyes A W. 1994. Principles and Method of Toxicology. 3rd Ed. Raven Press New York 4. Crosby D G. 1980. Environmental Toxicology and Chemistry. Oxford University Press, New York

Course Title	**Biodiversity**
Course Code	ZOL-692
Credit Hours	3
Theory	2
Practical	1

Follow up	B.Sc. Zoology
Category	M.Sc. Zoology, 02-Years Programme
Aims and Objectives	Study regarding the richness and evenness in animal kingdom.
Learning Outcomes	The students will be able to achieve the aims and objectives of this course.
Syllabus in Brief	Definition; Types; Levels; Status of Biodiversity; Importance of Biodiversity. Natural Resources and Biodiversity • Ecological aspects of Biodiversity • Impacts on Biodiversity • Loss of Biodiversity • Protection / Conservation of Biodiversity. Practicals 4. Critical account (phylogenetic controversies) of some important museums speciments with the help of literature. 5. Procedures for studying species richness, Simpson Index, Shannon and Weiner Function. 6. Population of some local subterranean animals. Books Recommended 3. Biodiversity, Principles and Conservation by Kumar & Asija, 2000. 4. The Diversity of Life by C. Mary Jenking and Ann Boyce, 1987.

Optional Courses for M.Sc

Course Title	**Fundamentals of Entomology**
Course Code	ZOL-660
Credit Hours	3
Theory	2
Practical	1
Follow up	Not Applicable
Category	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	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. **Practical:** 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. **Books Recommended** Text Books: Entomology and Pest management by Pidego,I, 1991. **Suggested Reading** 1. The Insects, an outline of Entomology by Penny J. Gullan and Peter S. Cranston, 2010. 2. The Principles of Insect Physiology, 1977, by Wigglesworth

Course Title	**Endocrinology-A**
Course Code	Zol-662
Credit Hours	4(3+1)
Theory	3
Practical	1
Follow up	Endocrinology-B
Category	MSc Course
Aims and Objectives	To overview the general scheme of endocrinology
Learning Outcomes	Awareness about importance of endocrine system in normal body functions
Syllabus in Brief	**Syllabus:** 1. An overview of general concepts and principles of endocrinology: types of hormones; endocrine and nervous system relationship; general principles in function, interaction, synthesis, secretion and transport of hormones; general concept of feedback; genetic control of peptide hormones; pathology and assessment of endocrine function; evolution of endocrine system. 2. Neuroendocrinology: neural control of glandular secretion, Hypothalamic-pituitary

	unit, hypophysiotropic neuronal system, hypophysiotropic hormones and neuroendocrine axis. Thyrotropin-releasing hormone, corticotrophin-releasing hormone, growth hormone-releasing hormones, somatostatin, prolactin-regulating factor, GnRH. 3. Pituitary hormones: adenohypophysis and neurohypophysis hormones and their chemistry, synthesis and release. 4. Thyroid gland: Anatomy and histology of gland, formulation and secretion of thyroid hormones, thyroid hormone in peripheral tissues, regulation and factors affecting thyroid hormones. 5. Calcitotrophic and mineral metabolism hormones: chemistry, physiological actions and metabolism of parathyroid hormones, calcitonin and calciferols, homeostasis of calcium, phosphate and magnesium. 6. Adrenal medulla and cortex: Chromaffin cell and organization, structure of adrenal medulla and cortex, biosynthesis, storage, release and metabolism, adrenergic receptors. regulation and metabolism of glucocorticoids, mineralocorticoids and adrenal sex steroids. 7. Reproductive endocrinology: Testicular and ovarian structure and function, hypothalamic-pituitary-gonadal axis and control of germ cells production. 8. Endocrinology of pregnancy: Hormones in conception and implantation, growth factors in implantation, hormonal action and adaptation in pregnancy and parturition. 9. Endocrinology of lactation: hormones in lactation 10. Overview of endocrine mechanisms in invertebrates **Practical:** Demonstration of endocrine glands and associated structures in mouse/ rat dissection. Histological and immunohistochemical procedures to study the endocrine glands, experiments to demonstrates physiological role of hormones from different endocrine glands Study the regulation of hormones, Experiments to demonstrate the functional diversity of hormones in different vertebrates, experiments on endocrine mechanism in vertebrates, Hormone assessment techniques including RIA and ELISA with standard curve preparation. **Text Books:** Larsen PR, Konenberg HM, Melmed S and Polonsky KS. 2012. Williams Textbook of Endocrinology. Saunders, Pennsylvania. Jameson JL and De Groot LJ 2010 Endocrinology, 2-Volume Set, 6th Edition Nussey S and Whitehead S. 2001 Endocrinology: An Integrated Approach. BIOS Scientific Publishers; Oxford. Norris & Carr 2013 Vertebrate Endocrinology, 5th Edition. Academic Press. US

Course Title	**Ornithology**
Course Code	ZOL-664
Credit Hours	3
Theory	2
Practical	1
Follow up	Not Applicable
Category	M.Sc. Zoology, 02-Years Programme
Aims and Objectives	To impart knowledge about the diversity, origin, evolution, threats and possible conservation strategies of the birds.
Learning Outcomes	The students will be able to achieve the aims and objectives of this course.
Syllabus in Brief	**Origin and evolution of birds:** The evolutionary origins and evolution of flight,

	Taxonomy and systematic (species and evolution). **Adaptations for flight: A**natomy and morphology, Feathers (kinds, molt, color), Skeletons, musculature and flight, advantages of flight. **Adaptations for various environments:** Foraging, Physiology, Senses, Migration, Navigation and musculature. **Ethology:** Behaviour, innate vs. learning, Communication, Territory, Flocking, Songs, Courtship, Mating systems, Nest building, Incubation and egg laying. **Ecology of birds:** Predation, Seed dispersal, Pollination, Relations to habitat. **Biodiversity and Conservation:** Threats to biodiversity, Causes and patterns of extinction, Human efforts to conserve biodiversity. **Practical:** Gross anatomy, bird watching tour in Pakistan, field techniques and specimen preparation, and systematic study of avian groups using the collections of the Museum specimens. **Books:** Sandy Podulka, Ronald W. Rohrbaugh, Rick Bonney. 2004. Hand book of Bird Biology. 2nd Edition Cornell Lab of Ornithology, ISBN-093802762X, 9780938027621. Gill, F.B. 2007. Ornithology; New York: W.H. Freeman & CompanyB. Peterson, R.T. 1998. Field Guide to the Birds of Eastern and Central North America: Peterson's Field Guide Series; Boston: Houghton Mifflin.

Course Title	**Mammalogy**
Course Code	ZOL-665
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MSc. (2 year programme)
Aims and Objectives	This course provides basic information about the Biodiversity of mammals.
Learning Outcomes	It will create awareness about the mammals, origin, classification and information about different orders of class Mammalia.
Syllabus in Brief	Theory: Introduction, Origins, evolution, biogeography of Mammals; Mammalian Characteristics;Prototheria, Matatheria and Eutheria; Trophic Ecology of mammals; Mammal Conservation, Population regulation, different types of mammals, Insectivores, Perissodactyla, Artiodactyla, Primates, Ungulates, Rodentia Cetaceans, Lagomorpha and Chiroptera. Practicals: 1. General survey and classification up to species of Mammals of Pakistan 2. Skeleton and skull of Cat and Rabbit. 3. The vertebral column and appendicular skeleton. TextBooks: 1. Davis, D., 1963. Principles in Mammalogy. Reinhold Publishers Corporation, New York. 2. Gelder, 1969. Biology of mammals. Reinhold Publishers Corporation, New York. Recommended Books:

	1. Miller and Harly, 2005. Zoology (6th Edition). McGraw Hill, New York. 2. Hickman, Roberts, and Larsen, 2005 & 2008. Integrated principles of Zoology (13th&14th Editions). McGraw Hill, New York. 3. George C. Kent and Robert K. Carr, 2001. Comparative Anatomy of the Vertebrates. (9th Edition.) Boston: McGraw Hill, New York. 4. Vauchan, T.A., Ryan, J.M., Czaplenski, N.J., 2011. Mammalogy. 5th Edition, Johns and Bartlett publisher USA.

Course Title	**Aquaculture Health Management**
Course Code	ZOL –666
Credit Hours	3
Theory	2
Practical	1
Follow up	Not applicable
Category	MSc 02 years Programme)
Aims and Objectives	To teach students the fish culturing practices in Pakistan and problems associated with it
Learning Outcomes	The students will have the practical approached regarding fish farming on commercial scale in Pakistan and their common diseases
Syllabus in Brief	Theory: Discusses the relevance of bacteria to disease outbreaks and as a cause of disease. Classification and causes of disease. Introduction to immunology. Methodology of fish diagnosis. Host responses to disease. Stress and predisposing factors of disease. Common disease conditions in fish. Anthropogenic activities and their impact of fishery, protection against hazards, improvement of habitat, age and growth. The use of antibiotics and probiotics. Practicals: 1. Visit to Government and Private fish Farms. 2. Fish diseases, their identification and control measures. Books Recommended: 1. Templeton, R.G. 1995. Freshwater Fisheries Management (2nd Ed.) Fishing News Books, Blackwell Science, USA. 2. Jacques, A. 1999. Management of freshwater Fisheries. Technique et Documentation, Lavoisier, Paris. 3. Rounsefell, G.A. and Everhart, W.H. 1963. Fishery Science its methods and application. John Wiley & Sons. Inc., New York. 4. Arrignon, J. 1999. Management of Freshwater Fisheries. Oxford & IBH Pu

Course Title	**Insect Pest of Agriculture and their Management**
Course Code	ZOL-667
Credit Hours	3(2-1)
Theory	2
Practical	1
Follow up	Not applicable
Category	M.Sc. Zoology, 02-Years Program
Aims and Objectives	An introduction to management of insect pests; to impart knowledge on concepts of integrated pest management using a combination of cultural, physical, mechanical, genetic, biological, and chemical control methods
Learning Outcomes	To let students to assess new approaches and to apply IPM techniques for better

	Integrated Pest Management in Pakistan.
Syllabus in Brief	**Syllabus:** Introduction to insect pest management:Pest Management Theories; Surveillance and sampling; general and new concepts of insect pest management; The utilization and integration of insect pest control methods (cultural methods, biological control, chemical, host resistance) for management of insects, Integrated Pest; Chemical control and its safe use with other techniques; Management of major insect pests of crops, fruits, and vegetables; Economic Thresholds- Concepts, Development and Application; Insecticide Resistance Management as a Component of IPM; Integration of GM Crops in IPM Programs; **Practical:** Collection, Mounting, Identification of different insect pests; Insect collection-box; data record of the life history of major insect pests of main crops, sampling, scouting and methods to detect their threshold levels; Lab and filed visits. **Text Books:** 1. Pedigo, L.P. & M.E. Rice. 2009. Entomology and Pest Management, 6th Edition. Prentice Hall. Upper Saddle River, NJ. 2. Ciancio A, Mukerji KG (2010) Integrated Management of Arthropod Pests and Insect Borne Diseases (1st edition). Springer., London, UK. 3. Radcliffe EB, Hutchison WD, Cancelado RE (2009) Integrated Pest Management: Concepts, Tactics, Strategies and Case Studies (1st edition); Cambridge University Press., New York, USA. 4. Louis M, Schoonhoven, van Loon JJA, Marcel D (2006) Insect-Plant Biology (2nd edition). Oxford University Press, USA. 5. Dhaliwal, G.S. and R. Arora. 2003. Principles of insect pest management. Kalyani Publishers, New Delhi, India. 6. Norris, R.F., E.P. Caswell-Chen and M. Kogan. 2002. Concepts in integrated pest management. Prentice Hall of India Private Limited New Delhi, India. 7. M. R. Binns, J.P. Nyoop and W. Van der Werf, 2000. Sampling and monitoring in crop protection CABI Publisher **Suggested Reading:** 1. Pedigo, L.P. & M.E. Rice. 2009. Entomology and Pest Management, 6th Edition. Prentice Hall. Upper Saddle River, NJ.

Course Title	**Biology of Birds and Mammals in Pakistan**
Course Code	ZOL-668
Credit Hours	3(2-1)
Theory	2
Practical	1
Follow up	Not applicable
Category	M.Sc. Zoology, 02-Years Program
Aims and Objectives	To impart knowledge about the biology of the birds and mammals of Pakistan.
Learning Outcomes	The students will be able to achieve the aims and objectives of this course.
Syllabus in Brief	Fossil record and theories for avian origins, taxonomy of birds, Anatomy and physiology, Adaptations and the physics of flight, Nesting and courtship behavior, Vocalizations, Mating systems and sexual selection, Cooperative breeding, Demography and conservation of birds of Pakistan. Classification, distribution, life history, evolution, distribution, ecology, behavior, anatomy, and classification of mammals, with emphasis on mammalian species of Pakistan. **Practical:** Gross anatomy, bird and mammals watching tour in Pakistan, field techniques and specimen preparation, and systematic study of avian and mammalian groups using the collections of the Museum specimens.

	Books Sandy Podulka, Ronald W. Rohrbaugh, Rick Bonney. 2004. Hand book of Bird Biology. 2nd Edition Cornell Lab of Ornithology, ISBN-093802762X, 9780938027621. Vaughan, T. A., J. M. Ryan, and N. J. Czaplewski. 2014. *Mammalogy*. 6h edition Jones and Bartlett; ISBN-13: 9781284032093.

Course Title	**Fundamentals of Limnology**
Course Code	ZOL-670
Credit Hours	3
Theory	2
Practical	1
Follow up	Not Applicable
Category	M.Sc. Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	Definition, importance, inland waters, Sources of bottom Materials, Physical features of water, Temperature, light, Currents, density and water turbidity, Chemical features of water, Dissolved Oxygen, Dissolved solids, pH, Electrolytes, Alkalinity, Hardness , Salinity, Brief description of nitrogen cycles, Brief description of nitrogen cycles, Brief description of Phosphorous cycles, Brief description of Phosphorous cycles, Micronutrients, Paper Discussion **Text Books:** 1. Boyd, C.E. and G.S. Tucker. 2009. Pond Aquaculture Water Quality Management. Rashtriya Printers, Delhi. 700p. (ISBN: 978-81-8489-186-7) 2. Huet, M., 1986. Text book of fish culture: Breeding and cultivation of fish. 2nd Edition. Fishing News Book ltd. England 3. Jhingran, V.G., 1983. Fish and fisheries in India. 2nd Edition. Hinduston Publishing Corporation, New Dehli. Welch, P.S. 1952. Limnology 2nd Ed. Mcgraw-Hill Book Company, Inc. New York, 538p.

Course Title	**Applied Entomology 3(2-1)**
Course Code	ZOL-672
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	M.Sc. Zoology, 02-Years Programme
Aims and Objectives	The students will be able to identify different insects. They will understand and apply the basic principles of Taxonomy along with the applied side of Entomology.
Learning Outcomes	The students will be able to understand the basic principles of Taxonomy and applications of Entomology in the field.
Syllabus in Brief	General account on classification, Insect classification; Classification and characteristics of insect orders: Collembola, Orthroptera, Dictyoptera, Isoptera, Hemiptera, Lepidoptera, Diptera, Hymenoptera, Coleopter. Only diagnostic

	features of the remaining insect orders. Insects of economic importance; Biological control of Insects; Chemical control of Insects; Concept of IPM; Methods of IPM; Sampling techniques in insect pests **Practical:** Collection, preservations and identification of insects up-to families with the help of literature/keys; Identifications of important insect pests up to species level. Survey and Field visits. Pest monitoring of important insect pests in the field **Text Books:** Entomology and Pest management, 1991 by Pidego,I. **Suggested Reading** 1. The Insects, an outline of Entomology, 2010 by Penny J. Gullan and Peter S. Cranston 2. The Principles of Insect Physiology, 1977, by Wigglesworth

Course Title	**Endocrinology-B**
Course Code	Zol-673
Credit Hours	4(3+1)
Theory	3 hrs/ week
Practical	2 hrs/ week
Follow up	Endocrinology-A
Category	MSc Course
Aims and Objectives	To overview the therapeutic approach of general scheme of endocrinology
Learning Outcomes	Awareness about importance of endocrine system in normal and abnormal body functions
Syllabus in Brief	**Syllabus:** 1. General Mechanism in Molecular endocrinology: general mechanism of cellular secretion, genetic control of peptide hormone formation, recombinant DNA technology and molecular genetics in diagnosis and treatment of endocrine diseases. 2. Mechanism of actionof hormones: Hormones acting on the nuclear receptors, Nuclear receptor signaling mechanism, Nuclear localization, Hormone binding, Target gene recognition, receptor dimerization and receptor regulation of gene transcription, Hormones acting on cell surface, Receptor tyrosine kinases, receptors that signal through associated tyrosine kinases and protein-coupled receptors 3. Functional pathology in endocrine glands: thyrotoxicosis, hyperthyroidism, non toxic goiter, adrenal cortex and hypertension, sexual dysfunction in men and women, Puberty disorders, disorders of carbohydrate and lipid metabolism. 4. Poly endocrine disorders 5. Endocrine responsive cancer **Practical:** Studies on recognition and response of receptors, Studies of disorders of pituitary by observing anatomical and histological features, Studies of thyroid status in deficient and excess hormone functions, Studies of type 1 and type 2 diabetes mellitus, epidemiology of the types in population, Studies of management of the type 2 diabetes, Model studies of disorder of ovarian and testicular disorders, Model studies of obesity and aneroxia, Studies of hormonal status in puberty and aging. **Text Books:** Larsen PR, Konenberg HM, Melmed S and Polonsky KS. 2012. Williams

	Textbook of Endocrinology. Saunders, Pennsylvania. Jameson JL and De Groot LJ 2010 Endocrinology, 2-Volume Set, 6th Edition Nussey S and Whitehead S. 2001 Endocrinology: An Integrated Approach. BIOS Scientific Publishers; Oxford. Norris & Carr 2013 Vertebrate Endocrinology, 5th Edition. Academic Press. US

Course Title	**Applied Microbiology**
Course Code	ZOL -674
Credit Hours	3
Theory	2
Practical	1
Follow up	Not Applicable
Category	M. Sc. Zoology, 02-Years Programme
Aims and Objectives	To learn about the harmful and beneficial microbes for living beings and their applications in different fields of life
Learning Outcomes	The students will be able how to prevent and control pathogenic diseases and their applications in different industries
Syllabus in Brief	Theory: Microorganisms and diseases. Control of Microorganisms, antibiotics and other chemotherapeutic agents, Host-microbial interactions, Resistance and Immunity, food and water-borne human infections. Human contact diseases. Infectious diseases of animals, sick building syndrome, Control of Diseases. Microarrays technology, Microbiology of domestic water and sewage. Microbiology of food, milk and milk products. Industrial Microbiology: Scope of industrial microbiology in food production, Metals in yeast fermentation processes, control of insects, human therapy, petroleum, mining and bioremediation, Biotechnology and its role in modern human comforts, Biotechnology and leather industry. Practicles Bacteriological examination of fresh ponds, canal, domestic water Isolation and identification of coliform bacteria Isolation of pathogens Normal throat microflora and its reaction with blood agar Enumeration and identification wounds microorganisms Enumeration and identification of common carp skin microbes Eradication of microbes through physical agents Eradication of microbes through chemical agents Inhibitory zone formation(Bacterial sensitivity tests) Survey of industries based on microbial activities Reference Books 1. Durieux, A and J-P. Simon. 2001. Applied Microbiology. Boston : Kluwer Academic Publishers, Database: WorldCat 2. Nester, E.W., Anderson, D.G., Roberts, C.E., Pearsall, N.N. and Nester, M.T., 2004. Microbiology: A human perspective. McGraw Hill, Higher Education, New York. 3. Kale, V. V. 2007. Applied Microbiology. Publisher: Mumbai : Himalaya Pub. House, Database: WorldCat 4. Hans G. Schlegel. 2002. General Microbiology. VII Ed. Cambridge University Press. UK. 5. James. G. Cappucino. And Natabe Sherman, (2004). Microbiology – A Laboratory Manual, VI Ed., (I Indian Reprint). Pearson Education (Singapore) Pvt. Ltd., India.

Course Title	**Aquatic Biology**
Course Code	ZOL-676

Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MSc. Zoology, 02-Years Programme
Aims and Objectives	To study aquatic life under the influence of various abiotic and biotic factors of environment.
Learning Outcomes	This course will provide knowledge / techniques for improvements of aquatic habitat for life.
Syllabus in Brief	Diversity of life. Five kingdoms. Approaches used to study aquatic organisms. Introduction to aquatic ecosystems, Aquatic environments. Sedimentation processes. Ocean environments, waves, weather influences, currents and upwelling. Populations, communities and ecosystems. Structural organizations of aquatic animals. External and internal anatomy of commercially important aquatic invertebrates and fishes**.** Marine organisms and their distributions, biotic features of the oceans, organism-habitat and relationships and general ecological concepts influencing marine populations and communities. **Practical:** Study of temperature, DO, conductivity of pond water. Collect and identify specimen from pond water. Survey the structure, adaptations, and life styles of organisms found over the range of habitats in the pond, lakes and rivers. Text Books: 1: McShaffrey, D. 1992. Comparative functional morphology of larval Stenacron interpunctatum and Rhithrogena pellucida (Ephemeroptera: Heptageniidae) and Ephemerella needhami (Ephemeroptera: Ephemerellidae) with applications in mayfly taxonomy and ecology. Proceedings of the VII International Conference on Ephemeroptera. Suggested Reading: 1: McShaffrey, D. and W.P. McCafferty. 1987. The behavior and form of Psephenus herricki (DeKay) (Coleoptera: Psephenidae) in relation to water flow. Freshwater Biology. 18:319-324. 2: Kemp, JL, DM Harper, GA Crosa. 1999. Use of 'functional habitats' to link ecology with morphology and hydrology in river rehabilitation. Aquatic Conservation: Marine and Freshwater Ecosystems 9:159-178.

Course Title	**Sea Food Technology**
Course Code	ZOL-678
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MPhil. Zoology, 02-Years Programme
Aims and Objectives	This course deals with techniques involved to handle harvesting fish and shellfish and their processing and preservation of food products. It will teach quality effecting parameters.
Learning Outcomes	The students will be able to provide techniques to process and preserve the sea food for human consumption.
Syllabus in Brief	Introduction to post harvest handling of fish and shellfish. Processes of spoilage of seafood products and methods of arresting them. The sensory properties of

	seafood and their importance in determining food methods of arresting them. Methods of quality evaluation. Preservation methods. Public health aspects of fish products. Biochemical techniques in fish analysis. Technology of fish freezing and fish storage. Thermal processing fish products. **Practical:** **1:** Evaluation of fish / fishery products for organoleptic, chemical and microbial quality. **2**: Methods for analysis for bacterial quality parameters, chemical parameters and filth. **3**: Evaluation of sanitary conditions in fish processing units. **4:**Analysis of typical hazards. Study of correction and corrective action. **Text Books:** **1:** Advances in Fish processing Technology, Sen D. P., Pub. Allied Publishers Pvt. Ltd. New Delhi (2005). **Suggested Reading:** **1:** Assessment and Management of Seafood Safety and Quality. (2003) Free aminoacids Technical Paper No. 444. **2:** Fish Processing Technology (1992) G. M. Hull. (Ed), Blackie Academic and Professional, London. **3:** Food borne Disease Handbook. IInd Edn. (2001) Vol.4:Seafood and Environmental Toxins, Marcel Dekker Inc New York.

Course Title	**Ichthyology**
Course Code	ZOL-689
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MSc Zoology, 02-Years Programme
Aims and Objectives	This course will expose the major disciplines that make up the diverse science of Ichthyology including the evolution and adaptation, anatomy, taxonomy, behavior and ecology of fishes.
Learning Outcomes	Course will improve students understanding of the basic physiological and behavioral adaptations that fishes use to carry out their life cycle.
Syllabus in Brief	**Syllabus:** Morphology, skeletal, integumentary, digestive, respiratory, circulatory, urinogenital reproductive, nervous system and sense organs of Bony fish. Osmoregulation in fishes. Swimming and locomotion Breeding habits and parental care in fishes, types of eggs, Fish migration, Behaviour and communication. Feeding, digestion and nutrition. **Practical:** 1: Study of external features of a bony fish 2: Dissection of fish to study various systems. 3:Study of scales. 4:Study of prepared slides. 5: Study of museum**.** **Text Books:** **1:** Lagler, KF. Ichthyology 1984. **Suggested Reading:**

	1 Norman J.R. & Greenwood P.H. A history of fishes 1975. 2: Ashely and Chiassion. Laboratory Anatomy of Shark and Perch. 3: Nikol'skii, Special Ichthyology,1991. 4: B. Collette, Douglas E. Facey, and Brian W. Bowen 2008. 2nd Edition ISBN-10: 1405124946

Course Title	**Bio-Physical Methods in Life Sciences**
Course Code	ZOL-690
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MSc. Zoology, 02-Years Programme
Aims and Objectives	To know about biomacromolecules and transport activities of cell membranes.
Learning Outcomes	The students will be able to know about the functional status of cell membrane.
Syllabus in Brief	**Syllabus:** Biological macromolecules, excitable cell membranes and ion channel activities, molecular structure, cell structure. Macromolecular complex formation, protein folding, stability, interactions and enzymatic mechanisms. Spectroscopy. Microscopy and Single Molecules **Practical:** **1:** Biomolecular interaction analysis 2:Chromatography techniques 3: Use of spectroscopy technique in lab. **Text Books:** **1:** Mary.L.2013.Membrane Structural Biology. Cambridge University Press **Suggested Reading:** **1:** Tapan K. Das. 2014.Biophysical Methods for Biotherapeutics: Discovery and Development Applications.1st Edt. Wiley-Blackwell.