

*Department of Zoology*  
**Government College University, Faisalabad**



**CURRICULUM 2016**

**UNDERGRADUTAE/GRADUATE/POSTGRADUATE**

**BS/MSc/MS/MPhil/PhD**

**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)
	<b>Total</b>	<b>17</b>

**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)
	<b>Total</b>	<b>16</b>

**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)
	<b>Total</b>	<b>19</b>

**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)
	<b>Total</b>	<b>19</b>

**Semester V**

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

**Semester VI**

ZOL-502	Biostatistics	3(3-0)
ZOL-504	Developmental Biology	4(3-1)
ZOL-506	Ecology	3(3-0)
ZOL-508	Principles of Zoogeography	3(2-1)
ZOL-510	Biochemistry – II (Metabolism)	3(2-1)
ZOL-512	Physiology of Coordination and Animal Behavior	4(3-1)
	<b>Total</b>	<b>20</b>

**Semester VII**

ZOL-601	Evolution and Principals of Systematics	4(3-1)
ZOL-605	Fisheries	3(2-1)
ZOL-607	Research Methodology	1(1-0)
ZOL-609	Principles of Paleontology	3(3-0)
ZOL-656	Aquatic Toxicology	3(2-1)
*Special paper 1	in lieu of thesis	3(2-1)
	<b>Total</b>	<b>17</b>

**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)
	<b>Total</b>	<b>15</b>
	<b>Grand Total</b>	<b>140</b>

\*Two special papers will be offered in lieu of thesis (ZOL-630: Thesis 6(0-6)) in 7<sup>th</sup> and 8<sup>th</sup> semester

## M.Sc. Zoology (2 Years/4 Semesters)

### Semester I

Course Code	Course Title	Credit Hours
ZOL-551	Biochemistry – I (Structure and Functions of Macro molecules)	3(2-1)
ZOL-553	Developmental Biology	4(3-1)
ZOL-555	Advanced Environmental Biology	3(2-1)
ZOL-557	Animal Physiology	4(3-1)
ZOL-559	Advanced Cell Biology	3(2-1)
ZOL-561	Research Methodology	1(1-0)
	<b>Total</b>	<b>18</b>

### Semester II

ZOL-552	Biochemistry – II (Metabolism)	3(2-1)
ZOL-554	Physiology of Coordination and Animal Behavior	4(3-1)
ZOL-556	Evolution and Principles of Systematics	3(2-1)
ZOL-558	General and Molecular Genetics	4(3-1)
ZOL-560	Principles of Zoogeography	3(2-1)
ZOL-562	Fundamentals of Microbiology	3(2-1)
	<b>Total</b>	<b>20</b>

### Semester III

ZOL-651	Principles of Paleontology	3(2-1)
ZOL-655	Biostatistics	3(3-0)
ZOL-657	Fish Culture	3(2-1)
ZOL-661	Introduction to Biotechnology	4(3-1)
ZOL-663	Biological and Chemical Control of Pests	3(2-1)
*Special paper 1	in lieu of thesis	3(2-1)
	<b>Total</b>	<b>19</b>

### Semester IV

ZOL-652	Wildlife of Pakistan	2(1-1)
ZOL-654	Bioremediation and Bio-processing	3(2-1)
ZOL-656	Aquatic Toxicology	3(2-1)
BIN-662	Basic Bioinformatics	3(2-1)
ZOL-692	Biodiversity	3(2-1)
*Special paper 2	in lieu of thesis	3(2-1)
	<b>Total</b>	<b>17</b>
	<b>Grand Total</b>	<b>74</b>

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

**\*Two courses Special Subject/ Optional will be opted in lieu of research for BS and M.Sc.**

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.

**LIST OF COURSES FOR MS/MPhil/PhD DEGREE PROGRAMMES**

<b>No.</b>	<b>Course Code</b>	<b>Course Title</b>	<b>Credit Hours</b>
1	ZOL – 701	Quantitative Zoology	3(2-1)
2	ZOL – 702	Advances in Biodiversity	3(2-1)
3	ZOL – 703	Immunology	3(2-1)
4	ZOL – 704	Advances in Recombinant DNA Technology	3(2-1)
5	ZOL – 705	Biotechnology	3(2-1)
6	ZOL – 706	Reproductive Physiology	3(2-1)
7	ZOL – 707	Population Genetics	3(2-1)
8	ZOL – 708	Comparative Vertebrate Endocrinology	3(2-1)
9	ZOL – 709	Biostatistics	3(3-0)
10	ZOL – 710	Biochemistry of Drug Action	3(2-1)
11	ZOL – 711	Helminthology	3(2-1)
12	ZOL – 712	Human Genetics	3(2-1)
13	ZOL – 713	Human Embryology and Teratology	3(2-1)
14	ZOL – 714	Molecular Biology	3(2-1)
15	ZOL – 715	Molecular Physiology	3(2-1)
16	ZOL – 716	Environmental Biotechnology	3(2-1)
17	ZOL – 717	Advances in Aquatic Toxicology	3(2-1)
18	ZOL – 718	Medical Microbiology	3(2-1)
19	ZOL – 719	Behavioural Ecology	3(2-1)
20	ZOL – 720	Principles of Toxicology	3(2-1)
21	ZOL – 721	Chalk Talk/Assignment Presentation	2(2-0)
22	ZOL – 722	Limnology	3(2-1)
23	ZOL – 723	Special Problem	1(1-0)
24	ZOL – 724	Term Paper (Review Article, Special problem)	3(3-0)
25	ZOL – 725	Advances in Aquaculture – I	3(2-1)
26	ZOL – 726	Journal Club	2(2-0)
27	ZOL – 727	Applied Fisheries	3(2-1)
28	ZOL – 731	Advances in Aquaculture – II	3(2-1)
29	ZOL – 732	Advances in Fish Genetics	3(2-1)
30	ZOL – 733	Biotechnology in Aquaculture	3(2-1)
31	ZOL – 734	Fish Biology	3(2-1)
32	ZOL – 735	Fish Ecology	3(2-1)
33	ZOL – 736	Fish Bioenergetics	3(2-1)
34	ZOL – 737	Fisheries Management	3(2-1)
35	ZOL – 738	Environmental Biology of Fishes	3(2-1)
36	ZOL – 739	Chemical Biology of Fishes	3(2-1)
37	ZOL – 740	Techniques in Fisheries Management	3(2-1)
38	ZOL – 741	Fisheries resources and development	2(2-0)
39	ZOL – 742	Nutrients requirement and metabolism in fish	4(3-1)
40	ZOL – 743	Bio-economics of fisheries resources	2(2-0)
41	ZOL – 744	Fish biotechnology/Aquaculture biology	3(2-1)

42	ZOL – 745	Fish Hatchery Management	3(2-1)
43	ZOL – 746	Molecular Entomology	3(2-1)
44	ZOL – 747	Medical Entomology	3(2-1)
45	ZOL – 748	Economic Entomology	3(2-1)
46	ZOL – 749	Environmental Entomology	3(2-1)
47	ZOL – 750	Animal Pest and disease producing organisms	3(2-1)
48	ZOL – 751	Advanced integrated pest management-I	3(2-1)
49	ZOL – 752	Advanced integrated pest management-II	3(2-1)
50	ZOL – 753	Insects and Wildlife-I	3(2-1)
51	ZOL – 754	Insects and Wildlife-II	3(2-1)
52	ZOL – 755	Biology and Control of Vertebrate Pests	3(2-1)
53	ZOL – 756	Vector Biology	3(2-1)
54	ZOL – 757	Mammalogy	3(2-1)
55	ZOL – 761	Applied Population Ecology	3(3-0)
56	ZOL – 762	Geographical Information System in Wildlife Management	3(3-0)
57	ZOL – 763	Wildlife Conservation Biology	3(3-0)
58	ZOL – 764	Wildlife Diseases and their Management	3(2-1)
59	ZOL – 765	Parasitic Diseases of Wild Mammals	3(2-1)
60	ZOL – 766	Wildlife Management-I (Wetlands)	3(2-1)
61	ZOL – 767	Wildlife Management-II (Terrestrial)	3(2-1)
62	ZOL – 768	Wildlife Food and Foraging	3(3-0)
63	ZOL – 769	Wild Fish Fauna of Pakistan	3(3-0)
64	ZOL – 770	Eco-Tourism Planning and Management	3(3-0)
65	ZOL – 771	Range Management	3(2-1)
66	ZOL – 772	Park Management	2(2-0)
67	ZOL – 773	Protected Areas and their Management	3(3-0)
68	ZOL – 774	Advances in Ichthyology	3(2-1)
69	ZOL – 775	Fish Nutrition-I	3(3-0)
70	ZOL – 776	Fish Nutrition-II	3(2-1)
71	ZOL – 777	Andrology	3(2-1)
72	ZOL – 778	Fishing Gear Technology	3(2-1)
73	ZOL – 779	Ornithology	3(2-1)
74	ZOL – 780	Herpetology	3(2-1)
75	ZOL – 781	Wildlife Damage Management	3(3-0)

#### **Other Mandatory Courses for MS/MPhil**

1	STA-795	Statistics for Research	3(2-1)
2	ZOL-728	Seminar (General)	1(1-0)
3	ZOL-729	Seminar (Research)	1(1-0)
4	ZOL-730	Thesis	6(0-6)

#### **Other Mandatory Courses for PhD**

1	STA-797	Experimental and Inferential statistics for Research	3(2-1)
2	ZOL-758	Seminar (General)	1(1-0)
3	ZOL-759	Seminar (Research)	1(1-0)

4	ZOL-760	Thesis	6(0-6)
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**BS Courses: (Semester-wise)**

<b>Course Title</b>	PRINCIPLES OF ANIMAL LIFE – I
Course Code	ZOL-301
Credit Hours	4(3-1)
Theory	3
Practical	1
Follow up	<b>BS</b>
Aims and Objectives	<p>The course aims to impart knowledge and understanding of:</p> <ol style="list-style-type: none"> <li>The concept and status of Zoology in life sciences.</li> <li>The common processes of life through its chemistry, biochemical and molecular processes.</li> <li>The structure and function of cell organellae and how common animal cell diversified in various tissues, organs and organ systems.</li> <li>Biochemical mechanisms eventually generating energy for animal work.</li> <li>Animals and their relationship with their environment.</li> </ol>
Learning Outcomes	
Syllabus in Brief	<p><b>Course Contents</b></p> <ol style="list-style-type: none"> <li>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.</li> <li>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.</li> <li>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.</li> <li>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.</li> <li>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.</li> <li>Ecology I: Individuals and Populations Animals and their abiotic environment; populations; interspecific interactions.</li> <li>Ecology II: Communities and Ecosystems Community structure and diversity; ecosystems; ecosystems of the earth; ecological problems; human population growth, pollution, resource depletion and biodiversity.</li> </ol>



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

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

	<p>6. Study of karyotypes of <i>Drosophila</i>, mosquito.</p> <p>7. Study of cytochemical detection of DNA in protozoa and avian blood cell.</p> <p>8. Study to demonstrate nervous or endocrine basis of behaviour (conditioned reflex or aggression or parental behavior).</p> <p>9. Study to demonstrate social behaviour (documentary film be shown, honey bee, monkey group in a zoo).</p> <p>Books Recommended</p> <p>1. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5<sup>th</sup> Edition (International), 2002. Singapore: McGraw Hill.</p> <p>2. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.</p>
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<b>Course Title</b>	<b>Animal Diversity -1 (Invertebrates Diversity)</b>
Course Code	ZOL – 401
Credit Hours	4
Theory	3
Practical	1
Follow up	Animal Diversity -1 (Vertebrates)
Category	BS (Hons)
Aims and Objectives	The students will be able to make comparison from simple unicellular to complex multicellular organization along with phylogenetic relationship
Learning Outcomes	The students will be able to achieve the aims and objectives of the course
Syllabus in Brief	<p>Theory</p> <p>1. Introduction Classification of organisms; evolutionary relationships and tree diagrams; patterns of organization.</p> <p>2. Animal-Like Protists: The Protozoa Evolutionary perspective; life within a single plasma membrane; symbiotic life-styles. Protozoan taxonomy: (up to phyla, subphyla and super classes, wherever applicable). Pseudopodia and amoeboid locomotion; cilia and other pellicular structures; nutrition; genetic control and reproduction; symbiotic ciliates; further phylogenetic considerations.</p> <p>3. Multicellular and Tissue Levels of Organization Evolutionary perspective: origins of multicellularity; animal origins. Phylum porifera: cell types, body wall, and skeletons; water currents and body forms; maintenance functions; reproduction. Phylum cnidaria (coelenterata) the body wall and nematocysts; alternation of generations; maintenance functions; reproduction and classification up to class. Phylum ctenophora; further phylogenetic considerations.</p> <p>4. Triploblastics and Acoelomate Body Plan Evolutionary perspective; phylum platyhelminthes: classification up to class; the free-living flatworms and the tapeworms; phylum nemertea; phylum gastrotricha; further phylogenetic considerations.</p> <p>5. Pseudocoelomate Body Plan: Aschelminths Evolutionary 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.</p> <p>6. Molluscan Success</p>

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, 11<sup>th</sup> Edition (International), 2004. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. ZOOLOGY, 9<sup>th</sup> Edition (International), 2009. Singapore: McGraw Hill.
3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4<sup>th</sup> 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. 5<sup>th</sup> 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.

<b>Course Title</b>	ANIMAL DIVERSITY-II ( <i>CLASSIFICATION, PHYLOGENY AND ORGANIZATION</i> )
Course Code	ZOL-403
Credit Hours	4(3-1)
Theory	3
Practical	1
Follow up	<b>BS</b>
Category	
Aims and Objectives	The course provides knowledge and understanding about the different animal groups, emphasizing their phylogenetic relationships.
Learning Outcomes	
Syllabus in Brief	<p>Course Contents</p> <p>1. Echinoderms Evolutionary perspective: relationships to other animals; echinoderm characteristics; classification up to class. Maintenance functions, regeneration, reproduction, and development in asteroidea, ophiuroidea, echinoidea, holothuroidea and crinoidea; further phylogenetic considerations; some lesser-known invertebrates: the lophophorates, entoprocts, cycliophores, and chaetognaths.</p> <p>2. Hemichordates and Invertebrate Chordates Evolutionary Perspective: Phylogenetic Relationships; Classification up to subphylum or class where applicable; Further Phylogenetic Considerations.</p> <p>3. Fishes: Vertebrate Success in Water Evolutionary perspective: phylogenetic relationships; survey of super class agnatha and gnathostomata; evolutionary pressures: adaptations in locomotion, nutrition and the digestive system, circulation, gas exchange, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations.</p> <p>4. Amphibians: The First Terrestrial Vertebrates Evolutionary perspective: phylogenetic relationships; survey of order caudata, gymnophiona, and anura. Evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction, development, and metamorphosis; further phylogenetic considerations.</p> <p>5. Reptiles: The First Amniotes Evolutionary perspective: cladistic interpretation of the amniotic lineage; survey of order testudines or chelonia, rhynchocephalia, squamata, and crocodilia; evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations.</p> <p>6. Birds: Feathers, Flight, and Endothermy Evolutionary perspective: phylogenetic relationships; ancient birds and the evolution of flight; diversity of modern birds; evolutionary pressures: adaptation in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and regulation, nervous and sensory systems, excretion and osmoregulation, reproduction and development; migration and navigation.</p>

	<p>7. Mammals: Specialized Teeth, Endothermy, Hair, and Viviparity  Evolutionary perspective: diversity of mammals; evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, behavior, reproduction and development.</p> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11<sup>th</sup> Edition (International), 2004. Singapore: McGraw Hill.</li> <li>2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5<sup>th</sup> Edition (International) 2002. Singapore: McGraw Hill.</li> <li>3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4<sup>th</sup> Edition (International), 2000. Singapore: McGraw Hill.</li> <li>4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill.</li> <li>5. Campbell, N.A. BIOLOGY, 6<sup>th</sup> Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.</li> </ol> <p>Practicals</p> <ol style="list-style-type: none"> <li>1. Study of a representative of Hemichordate and Invertebrate Chordate.</li> <li>2. Study of representative groups of class Fishes.</li> <li>3. Study of representative groups of class Amphibia.</li> <li>4. Study of representative groups of class Reptilia.</li> <li>5. Study of representative groups of class Aves.</li> <li>6. Study of representative groups of class Mammalia.</li> <li>7. Field trips to study animal diversity in an ecosystem.</li> </ol> <p><i>Note: Preserved specimen and/or colored projection slide and/or CD ROM projection of computer must be used.</i></p> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>1. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.</li> <li>2. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5<sup>th</sup> Edition (International), 2002. Singapore: McGraw Hill.</li> </ol>
<b>Course Title</b>	<b>ANIMAL FORM AND FUNCTION-I (A COMPARATIVE PERSPECTIVE)</b>
Course Code	ZOL-402
Credit Hours	4(3-1)
Theory	3
Practical	1
Follow up	<b>BS</b>
Category	
Aims and Objectives	<p>The course deals with the:</p> <ol style="list-style-type: none"> <li>a. Basis of structure and functions of animal nutrition, digestion, homeostasis and temperature regulation.</li> <li>b. It introduces the basic concepts in reproduction and development in animal kingdom.</li> <li>c. Provides knowledge about the development of chordate body plan and fate of germinal layers.</li> </ol>
Learning Outcomes	

Syllabus in Brief	<p><b>Course Contents</b></p> <p><b>1. Nutrition and Digestion</b>  Evolution of nutrition; the metabolic fates of nutrients in heterotrophs; digestion; animal strategies for getting and using food, diversity in digestive structures of invertebrates and vertebrates; the mammalian digestive system: gastrointestinal motility and its control, oral cavity, pharynx and esophagus, stomach, small intestine: main site of digestion; large intestine; role of the pancreas in digestion; and role of the liver and gallbladder in digestion.</p> <p><b>2. Temperature and Body Fluid Regulation</b>  Homeostasis and Temperature Regulation; The Impact of Temperature on Animal Life; Heat Gains and Losses; Some Solutions to Temperature Fluctuations; Temperature Regulation in Invertebrates, Fishes, Amphibians, Reptiles, Birds and Mammals; Heat Production in Birds and Mammals; Control of Water and Solutes (Osmoregulation and Excretion); Invertebrate and Vertebrate Excretory Systems; How Vertebrates Achieve Osmoregulation; Vertebrate Kidney Variations; Mechanism in Metanephric Kidney Functions.</p> <p><b>3. Reproduction and Development</b>  Asexual reproduction in invertebrates; advantages and disadvantages of asexual reproduction; sexual reproduction in invertebrates; advantages and disadvantages of sexual reproduction; sexual reproduction in vertebrates; reproductive strategies; examples of reproduction among various vertebrate classes; the human male reproductive system: spermatogenesis, transport and hormonal control, reproductive function; the human female reproductive system: folliculogenesis, transport and hormonal control, reproductive function; hormonal regulation in gestation; prenatal development and birth: the placenta; milk production and lactation.</p> <p><b>4. Descriptive Embryology</b>  Fertilization; embryonic development: cleavage, and egg types; the primary germ layers and their derivatives; echinoderm embryology; vertebrate embryology: the chordate body plan, amphibian embryology, development in terrestrial environments, avian embryology, the fate of mesoderm.</p> <p><b>Books Recommended</b></p> <ol style="list-style-type: none"> <li>Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11<sup>th</sup> Edition (International), 2004. Singapore: McGraw Hill.</li> <li>Miller, S.A. and Harley, J.B. ZOOLOGY, 5<sup>th</sup> Edition (International), 2002. Singapore: McGraw Hill.</li> <li>Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4<sup>th</sup> Edition (International), 2000. Singapore: McGraw Hill.</li> <li>Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill.</li> <li>Campbell, N.A. BIOLOGY, 6<sup>th</sup> Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.</li> </ol> <p><b>Practicals</b></p> <ol style="list-style-type: none"> <li>Study of excretory system in an invertebrate and a vertebrate representative (Model).</li> <li>Study of nutritive canal in an invertebrate and a vertebrate representative (Dissection).</li> <li>Study of male reproductive system in an invertebrate and a vertebrate representative (Dissection).</li> </ol>
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	<p>4. Study of female reproductive system in an invertebrate and a vertebrate representative (Dissection).</p> <p>5. Study of hormonal influence of a reproductive function (Model).</p> <p>6. Study of preserved advanced stages of avian and mammalian development for amniotic membranes and placenta (Model).</p> <p>7. Study of stages in the development of an Echinoderm.</p> <p>8. Study of early stages in the development of a frog, chick and a mammal.</p> <p><i>Note for 9-10: Prepared slides and preserved specimen and/or projection slides and/or CD ROM computer projections may be used.</i></p> <p>Books Recommended</p> <p>1. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.</p> <p>2. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5<sup>th</sup> Edition (International), 2002. Singapore: McGraw Hill.</p>
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<b>Course Title</b>	<b>ANIMAL FORM AND FUNCTION-II (A COMPARATIVE PERSPECTIVE)</b>
Course Code	ZOL-404
Credit Hours	4(3-1)
Theory	3
Practical	1
Follow up	<b>BS</b>
Category	
Aims and Objectives	<p>The course aims to teach the students about:</p> <p>a. Animals diversity adapted in different ways for their functions through modifications in body parts.</p> <p>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.</p> <p>c. Organ systems, their specialization and coordination with each other and constantly changing internal and external environment, inside and outside the animal's body.</p> <p>d. The basic structure of each system that determines its particular function.</p>
Learning Outcomes	
Syllabus in Brief	<p>Course Contents</p> <p>1. Protection, Support, and Movement Protection: the integumentary system of invertebrates and vertebrates; movement and support: the skeletal system of invertebrates and vertebrates; movement: non-muscular movement; an introduction to animal muscles; the muscular system of invertebrates and vertebrates.</p> <p>2. Communication I: Nerves Neurons: structure and function; neuron communication: introductory accounts of resting membrane potential, action potential (nerve impulse) and transmission of the action potential between cells; invertebrate and vertebrate nervous systems: the spinal cord, spinal nerves, the brain, cranial nerves and the autonomic nervous system.</p> <p>3. Communication II: Senses Sensory reception: baroreceptors, chemoreceptors, georeceptors, hygroreceptors,</p>



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, 11<sup>th</sup> Edition (International), 2004. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5<sup>th</sup> Edition (International), 2002. Singapore: McGraw Hill.
3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4<sup>th</sup> 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, 6<sup>th</sup> 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

	<p>representative (Model).</p> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>1. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.</li> <li>2. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5<sup>th</sup> Edition (International), 2002. Singapore: McGraw Hill.</li> </ol>
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<b>Course Title</b>	<b>Cell and Molecular Biology</b>
Course Code	ZOL-501
Credit Hours	4
Theory	3
Practical	1
Follow up	Not Applicable
Category	BS Zoology, 04-Years Programme
Aims and Objectives	This course is designed to impart knowledge about the animal cell and its complex organization of architecture and the unified role it plays for the ultimate sustainability of the organisms. In this course, the students will be able to learn about the ultra-structural, molecular and functional aspects of the cell.
Learning Outcomes	The students will be able to achieve the aims and objectives of this course.
Syllabus in Brief	<p><u>Theory</u></p> <p>Overview of prokaryotic and eukaryotic cell. Structure, chemical composition and functions of Plasma Membrane (including Permeability, Active Transport, Endocytosis), Mitochondria (including its role in respiration and its status as semi-autonomous organelle), Golgi Apparatus (including glycosylation), Endoplasmic Reticulum (including role in protein synthesis and drug metabolism), Lysosomes, Ribosomes, Peroxisomes, glyoxysomes, Cytoplasm, cytoskeleton. <u>Nucleus: Chromatin, heterochromatin, euchromatin, chromosome structure with reference to coiling and nucleosome during different phases of cell cycle.</u></p> <p>Significance of genetic material. Structure of DNA –A, B and Z forms. DNA replication mechanisms in prokaryotes and eukaryotes, DNA polymerases and other enzymes and DNA binding proteins involved in DNA replication, DNA repair mechanisms. Cell Cycle and its regulation. Central dogma: Transcription, RNA polymerases, transcriptional control in prokaryotes and eukaryotes. Post-transcriptional processing of mRNA, rRNA and tRNA. Genetic Code (point mutations), genetic code in mitochondrial DNA, Translation: Protein synthesis, post-translational processing of proteins. Regulation of Gene Expression: Lac Operon, Trp Operon. Recombinant DNA technology: Cloning vectors, restriction endonucleases, Southern blotting, Northern blotting, western blotting, DNA sequencing, Site directed mutagenesis.</p> <p><u>Practicals</u></p> <ol style="list-style-type: none"> <li>1. Culturing and staining of bacteria and yeast.</li> <li>2. Counting of bacterial cells and preparation of growth curves.</li> <li>3. Counting of blood cell types by haemocytometer.</li> <li>4. Detection (in protozoan culture and blood cells) and quantitative determination of chromosomal DNA and RNA.</li> <li>5. Isolation and plasmid DNA from bacterium and demonstration on agarose gel.</li> <li>6. Isolation and fractionation of proteins from blood sera by polyacrylamide gel</li> </ol>

	<p>electrophoresis.</p> <p><u>Books Recommended</u></p> <ol style="list-style-type: none"> <li>1. Darnell Jr., J., Lodisch, H. and Baltimore D., 1990. <i>Molecular Cell Biology</i>. Scientific American, New York.</li> <li>2. Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K and Walter, P., 2002. <i>Molecular Biology of Cell</i>. Garland Science, New York.</li> <li>3. DeRobertis, E.D.P. and DeRobertis Jr. E.N.F., 1987. <i>Cell and Molecular Biology</i>. Lea and Febiger, New York.</li> <li>4. Karp, G., 2002. <i>Cell and Molecular Biology. Concepts &amp; Experiments</i>. John Wiley &amp; Sons, New York.</li> <li>5. Stryer, L., 1995. <i>Biochemistry</i>. W.H. Freeman, New York.</li> </ol>
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<b>Course Title</b>	Biochemistry-I (Structure and Functions of Macromolecules)
Course Code	ZOL-503
Credit Hours	3
Theory	2
Practical	1
Follow up	Biochemistry-II (Metabolism)
Category	
Aims and Objectives	To provide knowledge regarding structural / storage components of basic unit of life at molecular level also. It will also enable the students to understand Biochemistry of major food stuffs.
Learning Outcomes	This course will enable the students to study the working of life processes at molecular level.
Syllabus in Brief	<p>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.</p> <p>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.</p> <p>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.</p> <p>Lipids: Fatty acids, their types. Storage Lipids: Acylglycerols; Structural Lipids of membranes: Glycerophospholipids; Sphingolipids their role and degradation. Sterols, Cholesterol, Testosterone, Estadiole. Major functions of Lipids. Lipoproteins, their types and major functions. Lipid analysis: GLC as an example.</p> <p>Vitamins as Cofactors: Occurrence, Structure and Biochemical function of Riboflavin.</p> <p>Nucleic acids: Types and structure.</p> <p><u>Books Recommended</u></p> <ol style="list-style-type: none"> <li>1. David I., Nelson, and Michael M, Cox. 2000, Lehninger Principles of Biochemistry, 3<sup>rd</sup> Edition, Macmillan Worth Pubslihers, New York.</li> </ol> <p><u>Additional Reading</u></p> <ol style="list-style-type: none"> <li>1. Murray, R.K., Granner, D.K., Mayer, P.A., and Rodwells, V.W., 2000.</li> </ol>

	<p>Harper's Biochemistry, 25<sup>th</sup> Edition, McGraw-Hill Book Company, New York.</p> <ol style="list-style-type: none"> <li>Voet. D., Voet. J.G., and Pratt. C.W., 1999. Fundamentals of Biochemistry, John Wiley and Sons Inc., New York.</li> <li>Zubay. G., 1995. Biochemistry, 4<sup>th</sup> Edition, Wm. C. Brown Publishers Inc. Oxford, England.</li> <li>Lubert Stryer, 1995. Biochemistry, 4<sup>th</sup> Edition, W.H. Freeman &amp; Company, New York.</li> </ol> <p><u>Practicals</u></p> <ol style="list-style-type: none"> <li>Tests for detection of carbohydrates in acidic medium.</li> <li>Tests for detection of carbohydrates in alkaline medium.</li> <li>Detection of Non-Reducing sugars in the presence of Reducing sugars.</li> <li>Tests to demonstrate relative instability of glycosidic linkage in carbohydrates.</li> <li>Tests for detection of Disaccharides.</li> <li>Preparation of standard curve of glucose by ortho-Toluidine method.</li> <li>Estimation of glucose from blood serum or any other fluid using ortho-Toluidine technique.</li> <li>Biochemical tests for detection of different amino acid groups.</li> <li>Preparation of standard curve of proteins by Biuret method.</li> <li>Estimation of Blood serum proteins using Biuret technique.</li> <li>Demonstration of differential solubility of lipids in various solvents.</li> <li>Various Qualitative Tests for detection of Lipids.</li> <li>Determination of Acid value of Fats.</li> </ol> <p><u>Books Recommended</u></p> <ol style="list-style-type: none"> <li>Plummer, David T., 1990. An Introduction to Practical Biochemistry, 4<sup>th</sup> Edition, McGraw-Hill Book Company, London.</li> <li>Wilson, K &amp; Walker, J., 1994. Practical Biochemistry: Principles of Techniques, 4<sup>th</sup> Edition, Cambridge University Press.</li> </ol>
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<b>Course Title</b>	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	<p>Central themes in Physiology: Structure-Function Relationship. Adaptations, Homeostasis. Conformity and Regulation.</p> <p>Exchange of Gases: Transport of O<sub>2</sub> and CO<sub>2</sub> between respiratory surface (the lungs) and body cells. Regulation of lungs respiration: Gas transfer in water (gills) and its regulation. Respiratory responses in extreme conditions as hypoxia: Hypercapula in air breathing divers.</p> <p>Excretion and Osmoregulation: Osmoregulation in aquatic and terrestrial environment. Vertebrate nephron as osmoregulatory organ: Physiological anatomy. Glomerular filtration. Tubular absorption and secretion: Nitrogenous waste products: Patterns of nitrogenous excretion and their phylogenetic development.</p> <p>Nutrition: Regulation of digestive secretions: Physiological anatomy of digestive</p>

	<p>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.</p> <p><u>Books Recommended</u></p> <ol style="list-style-type: none"> <li>1. Randall. D., Burggren. W., French. K. and Fernald. R.. 2002. Eckert Animal Physiology: Mechanisms and Adaptations. 5<sup>th</sup> ed. W.H. Freeman and Company. New York.</li> <li>2. Bullock. J., Boyle. And Wang. M.B.. 2001. Physiology. 4<sup>th</sup> edition. Lippincott. Williams and Wilkins. Philadelphia.</li> <li>3. Bame. F.M. and Levy. M.N.. 2000. Textbook of Medical Physiology. 3<sup>rd</sup> edition. St. Lions. Mosby.</li> <li>4. Guyton and hall 2000 Text book of Medical Physiology 10th. Edition.</li> <li>5. Withers1992 Comparative Animal Physiology.</li> <li>6. Sdhmidt- Nelsen. K., 1997AnimalPhysiology.Adaptation and environment 5th. Edition Cambridge University Press Cambridge.</li> </ol> <p><u>Practicals</u></p> <p>Cardiovascular Activity: Normal cardiac activity, effect of temperature, effect of drug, heart block, tetanization of heart, Measurement of blood pressure.  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.</p> <p><u>Book Recommended</u></p> <ol style="list-style-type: none"> <li>1. Tharp. G. and Woodman. D. 2002. Experiments in Physiology. 8<sup>th</sup> Edition. Prentice Hall London.</li> </ol>
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<b>Course Title</b>	<b>Animal Behavior</b>
Course Code	ZOL-507
Credit Hours	3(3-0)
Theory	3
Practical	0
Follow up	Not Applicable
Category	BS Zoology, 04-Years Programme
Aims and Objectives	To understand the basic principles to study animal behavior and its application in modern world.
Learning Outcomes	To be able to design animal behavior explorative assignments, independently, and interpret outcomes effectively.
Syllabus in Brief	<ol style="list-style-type: none"> <li>1. Introduction to the animal behavior: definition of animal behavior and historical background, Fundamental research approaches, mechanistic, vitalistic and ethological, conventionally used in field of animal behavior,</li> <li>2. Tinbergen's four questions: Importance of Niko Tinbergen presented proximate/causal and ultimate/ functional based questions to study the animal behavior,</li> <li>3. Behavior as adaptation: Influence of types of selections (directional, stabilize and disruptive) on animal behavior, animal welfare and conservation aspects in animal behavior, Case studies of animal welfare to elaborate the problems in repertoire of animal behavior and importance of its study,</li> <li>4. Basic components of animals behavior: nature and nurture, Mechanism of behavior;</li> <li>5. Neuronal control of behavior: types of sensory receptors, sensory coordination and somesthetic systems, vertebrate and invertebrate nervous system, general anatomy and function in repertoire of behavior,</li> <li>6. Endocrine control of behavior in vertebrates: explanation of milk-ejaculation reflex (MER) in goats,</li> <li>7. Sensory judgments: including sensation and perception difference, difference in uncertainty interval and difference threshold, Weber fraction, Fechner's Law, signal-detection theory and yes-no criterion, explanation through payoff matrix, hypothetical</li> </ol>

	<p>effects of different decision criteria in signal detection theory,</p> <p>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,</p> <p>9. Visual recognition of prey and predators: Classical conditioning, stimulus substitution theory and stimulus-response theory, types of responses and importance of reinforcement,</p> <p>10. Fundamental aspects of habituation and extinctions: including phenomenon of external inhibition and disinhibition of conditional responses, Instrumental learning and law of effect,</p> <p>11. Fundamental difference between classical conditioning and instrumental learning: types of reinforcement and its fundamental aspects.</p> <p><b>Text Books:</b></p> <p>1. Graham Scott (2010) Essential Animal Behavior. Blackwell Publishing.</p> <p>2. David McFarland (1985) Animal Behaviour: Psychobiology, Ethology and Evolution. Longman House, Burnt Mill, England.</p> <p>3. Roland J. Siiter (1999) Introduction to Animal Behavior. Cole Publishing Company, CA, USA.</p> <p>4. John Alcock (2001) Animal Behavior: An Evolutionary Approach. 7<sup>th</sup> Ed. Sinauer Associates, Inc., Massachusetts, USA.</p> <p>5. David Randall, WarreBurggren and Kathleen French (2002) Eckert Animal Physiology: Mechanisms and Adaptations. W.H. Freeman and Company, New York, USA.</p>
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<b>Course Title</b>	<b>General and Molecular Genetics</b>
Course Code	ZOL-509
Credit Hours	4
Theory	3
Practical	1
Follow up	Biotechnology
Category	BS. Zoology, 04-Years Programme/ MSc ,02-years
Aims and Objectives	This course covers general genetic principles, DNA tools for genetic analysis, the molecular basis of genetic diseases, animal models, Molecular methods of analysis are emphasized. Prerequisites: All four core courses
Learning Outcomes	In this course students learn to use the tools of modern genomics to elucidate phenotypic variation within populations.
Syllabus in Brief	<p>Theory</p> <p>Introduction: classical genetics, molecular genetics, Reverse and forward genetics, The basic principles of Inheritance (Mendelism): Monohybrid and Dihybrid crosses. Multiple Alleles: ABO Blood system. Genetics of Rh factor and Erythroblastosis Foetalis. Gene Interaction: Epistasis, Lethality and Pleiotropism. Sex Linked gene in human beings. Sex Chromosome and Sex determination in human beings, Drosophila and other animals. Variation in chromosome number and structure: Polyploidy, Aneupolidy and rearrangement of chromosome structure. Genetics of Bacteria: Transformation, conjugation and Transduction. Techniques of molecular genetics: Basic techniques used to clone genes, construction and screening of DNA libraries, manipulation of cloned DNA sequences, molecular analysis of DNA, RNA and protein. Analysis of human pedigrees. Gene therapy. DNA Fingerprints: Paternity tests and Forensic</p>

	<p>applications. Inborn errors of Metabolism: Amino acid metabolism (Phenylketonuria, Alkaptonuria and Oculocutaneous albinism); Carbohydrate metabolism (Galactosaemia); Lipid Metabolism, Tay-Sachs; Purine/pyrimidine metabolism (Lech – Nyhan disease).</p> <p>Practicals</p> <ol style="list-style-type: none"> <li>1. Study of Mitosis and Meiosis.</li> <li>2. Preparation of Drosophila culture.</li> <li>3. Study of morphology and karyotype.</li> <li>4. Study of Monohybrid and dihybrid ratio, sex-linked inheritance.</li> <li>5. Pedigree Analysis</li> <li>6. Detection of Blood Groups in humans.</li> <li>7. Problem relating to theory.</li> </ol> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>1. <u>Hartl, D. L. and E. W. Jones. 2009 Genetics: Analysis of Genes and Genomes. Seventh (7th) Edition. Jones and Bartlett Publishers. USA.</u></li> <li>2. Snustard, D.P. and Simmon, M.J., 2003. Principles of Genetics. 3rd Edition. John Wiley and Sons, New York.</li> <li>3. Muller, R.F. and Young, I.D., 2002. Emery's Elements of Medical Genetics. 11th Edition. Churchill Livingstone, Elsevier Science, Limited, UK.</li> <li>4. Tammarin, R.M. 1999. Principles of Genetics. 6th Edition, WCB, McGraw Hill, New York.</li> <li>5. <u>Klug, Cummings et al., 2012, Concepts of Genetics 10th) edition, Pearson Publisher. Macmillan College Publishing Company, New York.</u></li> <li>6. Strickberger, M.W. 1999. Genetics. 3rd Edition. Prentice Hall of India Private Ltd., New Delhi.</li> <li>7. Herskowitz, I.H., 1985. Genetics. Little Brown, Boston, USA.</li> <li>8. Lewin, B. 2003. Gene VII. Oxford, UK.</li> </ol>
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<b>Course Title</b>	<b>Biostatistics</b>
Course Code	ZOL-502
Credit Hours	3(3-1)
Theory	3
Practical	0
Follow up	<b>BS</b>
Aims and Objectives	The course will provide knowledge about the importance and use of statistics in life sciences. It will help the students to understand the methods to analyze data pertaining to their research work and to assess the significance of their experimental designs.
Learning Outcomes	After this course students will be able to apply basic statistical procedures for analysis of data for practical and research.
Syllabus in Brief	<p>Course Contents</p> <p>Introduction and scope, use of statistics in biology. Population and sample. Stages of research, types of data and methods of data collection. Data arrangement and presentation, formation of tables and charts. Measures of central tendency computation of mean, median and mode from grouped and ungrouped data. Measures of dispersion, computation of variance, standard deviation, standard error and their coefficients. Probability rules. Binomial, Poisson and normal distributions. Hypothesis testing, Student 't' test, Chi square test, Analysis of variance and LSD. Correlation and regression. Experimental designing, planning of an experiment, replication and randomization.</p> <p>Books Recommended</p>

	<ol style="list-style-type: none"> <li>1. Geoffery, R. Norman, David L. Streiner <b>BIostatistics: THE BARE ESSENTIALS</b>. 2000. B.C. Decker Inc.</li> <li>2. Gerry, P. Quinn, Michael J. Keough, <b>EXPERIMENTAL DESIGN AND DATA ANALYSIS FOR BIOLOGISTS</b>. 2002. Cambridge University Press.</li> <li>3. Campbell, R. C. <b>STATISTICS FOR BIOLOGISTS</b>. 1989. Cambridge University Press.</li> </ol>
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<b>Course Title</b>	<b>Developmental Biology</b>
Course Code	ZOL-504
Credit Hours	4(3-1)
Theory	3
Practical	1
Follow up	
Category	B.S. Zoology, 04-Years Program/ M.Sc. Zoology, 02-Years Program
Aims and Objectives	The students will be able to understand and compare basic principles of embryology through understanding the developmental patterns with help of morphology and anatomy of embryos of different vertebrates.
Learning Outcomes	The students will be able to apply the basic principles of development to further research.
Syllabus in Brief	<p><b>Syllabus: Theory</b>  Mitosis, Meiosis. Principle features of development; developmental patterns, mechanism of teratogenesis Spermatogenesis, Oogenesis, Fertilization; Recognition of sperm and egg, fusion of gametes. <u>re- arrangement of egg cytoplasm</u>, Cleavage; patterns of embryonic cleavage, mechanism of cleavage. Gastrulation; Fate maps, gastrulation in birds, mammals. Early vertebrate development, Neurulation; ectoderm, mesoderm and endoderm formation. Cellular basis of morphogenesis; Establishments of body axis. Organogenesis, a brief account of origin and migration of germ cells in vertebrates, Factors controlling growth, Oncogenesis. Regeneration in vertebrates.</p> <p><b>Practical:</b>  Study of mitosis and meiosis with the slides.  Study of structure of gametes of fowl. Study of cleavage and subsequent development with the help of prepared slides and Whole mounts of chick embryo.  Preparation and study of serial sections of different tissues.  Preparation and staining of histological slides.</p> <p><b>Text Books:</b>  <b>Suggested Reading:</b>  <u>Books Recommended</u></p> <ol style="list-style-type: none"> <li>1. An introduction to embryology 2013 by Balinsky .B.I. and Saunders</li> <li>2. Developmental biology, 2000. by Gilbert, S. F.</li> <li>3. Human Embryology and Developmental biology, By Carlson, B. M.</li> <li>4. Introduction to Embryonic Developments by Oppenheimer, SS and Allen and Bacon</li> <li>5. Developmental Biology by Saunders W.B.</li> <li>6. Modern Embryology 1968 by Bodemer C.W</li> <li>7. Mechanism of development 1980. by Ham.R.G., and Veomett, M. J.</li> <li>8. The developing human 1982 by Moore K.L.</li> <li>9. Medical Embryology 1981 by Largman, J. Clinical Embryology 1983 by</li> </ol>



	Snell, R.S.,
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<b>Course Title</b>	<b>Ecology</b>
Course Code	ZOL-506
Credit Hours	3
Theory	2
Practical	1
Follow up	Applied Ecology+Molecular Ecology
Category	BS. Zoology 4 year Programme M.Sc. Zoology, 02-Years Programme
Aims and Objectives	This course will provide awareness regarding the environmental changes.
Learning Outcomes	The students will be able to study the Applied ecology and Molecular ecology.
Syllabus in Brief	<p><b>Theory:</b> Nature of Ecology, The earth's life support system, Ecosystem concepts and components, Energy flow in Ecosystem, Primary productivity of ecosystems, Matter cycling in ecosystem (Biogeochemical cycles). Ecological Niche, Major ecosystem of world: Marine, Estuarine, Freshwater, Tundra, Forest, Grassland and Desert. Population Ecology: Population structure, Factors affecting population growth, Factors controlling population growth. Community Ecology: Size and structure of community. Ecological succession: Communities in transition, Role and interaction of species in the ecosystem, Food chains and food webs, Impact of human intervention on the global ecosystem and its effects on man. Molecular aspects of the ecosystem, food chains and community interactions.</p> <p><b>Practicals:</b> Food chain, food web &amp; ecological notes Methods and analysis of population dynamics Quadrat method Determining frequency of different species Determining density of species in habitat Measurement of pollutants levels In atmosphere (NO<sub>2</sub>, SO<sub>2</sub>, O<sub>3</sub> and comparison with rural air) In soil (toxic chemical, fertilizer, insecticides, herbicides) Analysis of polluted and freshwater for Various pollutant; heavy metals, -CO<sub>3</sub>, -HCO<sub>3</sub>, NO<sub>3</sub>, BOD, COD, pH, EC, total soluble solids.</p> <p><b>Books Recommended:</b> Books Recommended (Latest Edition) 1. E.P. Odum, G. W. Barrett. Fundamentals of Ecology. (2004), 5<sup>th</sup> Edition 2. Miller, G.T. 2002. Living in the environment: Principles, Connections and Solutions. 12<sup>th</sup> Edition. Thomson Learning, Australia. 3. M.L. McKinney Environmental Science: System and Solution (1999) Jones &amp; 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</p>

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

<b>Course Title</b>	Biochemistry-II (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.
	<p>Bioenergetics: Concept of Free Energy and Standard Free Energy change. Energy rich compounds: Phosphoryl group transfers and ATP; Acyl phosphates; Enol phosphates and Thioesters.</p> <p>Carbohydrate Metabolism: Regulation and Anabolic role of Glycolysis. Fate of Pyruvate under Aerobic and Anaerobic conditions. Gluconeogenesis, its regulation. Feeder Pathways in Glycolysis i.e. Fructose, Galactose, Mannose, Glucose 1-phosphate,</p>

Glyceraldehyde and Glycerol. Phosphorolysis of Glycogen. Biosynthesis of Glycogen. Regulation of Glycogen Metabolism. Pentose phosphate pathway of Glucose oxidation and its major role in the animal tissues.

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 entry points in citric acid cycle. Nitrogen Excretion and Urea cycle with Regulation. Incorporation of Ammonia in Glutamate and Glutamine. Sources of various atoms in Purine and Pyrimidine synthesis.

Books Recommended

1. David I., Nelson, and Michael M, Cox. 2000, Lehninger Principles of Biochemistry, 3rd Edition, Macmillan Worth Publishers, 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.

<b>Course Title</b>	<b>Physiology of coordination and animal behaviour</b>
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	<p><b>Physiological basis of Neuronal Function:</b> Mechanisms in Resting Membrane Potentials: Electrogenic ion pump. Donnan equilibrium. 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 &amp; chemical synapse: Neurotransmitters: Synaptic receptors: Excitatory postsynaptic potentials: Inhibitory postsynaptic potentials: Presynaptic inhibitions: Integration at synapses: Facilitation. Posttetanic Potentiation.</p> <p><b>Photoreception:</b> Ultrastructure of photoreceptors. Photochemistry, Phototransduction and physiological basis of color vision: Physiological mechanisms in electroreception.</p> <p><b>Chemical Messenger and Regulators/Endocrine Physiology:</b> 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 &amp; 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:</p> <p><b>The study of Animal Behaviour:</b> 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.</p> <p><b>Practicals</b></p> <p><b>Muscle and Neuromuscular Activity:</b> Nerve muscle preparation. Muscle twitch, Comparison 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.</p> <p><b>Excitability, Sensation and Behaviour:</b> 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.</p> <p><b>Endocrine and Reproductive Mechanisms:</b> Effect of insulin on glycemia, study of stages in estrous cycle, mechanisms in regulations of contraction. Study of hibernation and biological rhythms.</p>

	<p>Books Recommended</p> <ol style="list-style-type: none"> <li>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.</li> <li>2. Seeley. Rod. R., Stephens, D. Trent and Tate Philip. 2008. Anatomy &amp; Physiology, 8<sup>th</sup> Edition. The McGraw-Hill, New York, USA.</li> <li>3. Bullock. J.. Boyle. And Wang. M.B.. 2001. Physiology. 4th edition. Lippincott. Williams and Wilkins. Philadelphia.</li> <li>4. Bame. F.M. and Levy. M.N.. 2000. Textbook of Medical Physiology. 3rd edition. St. Lions. Mosby.</li> <li>5. Guyton and hall 2000 Text book of Medical Physiology 10th. Edition.</li> <li>6. Sdhmidt- Nelsen. K., 1997 Animal Physiology. Adaptation and environment 5th. Edition Cambridge University Press Cambridge.</li> <li>7. Drickamer, L.C., Vessey, S.H., and Jacob, E., 2002. Animal Behaviour: Mechanism, Ecology, Evolution. 5th Edition.</li> <li>8. Manning, A. and Daekins, M.S., 1997. An introduction to animal behaviour, 4th edition, Cambridge University Press, Cambridge.</li> <li>9. Tharp. G. and Woodman. D. 2002. Experiments in Physiology. 8th Edition. Prentice Hall London.</li> </ol>
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<b>Course Title</b>	<b>Evolution and Principles of Systematics</b>
Course Code	ZOL-601
Credit Hours	4
Theory	3
Practical	1
Follow up	
Category	BS Zoology, 04-Years Programme/ M.Sc Zoology, 02-Years Programme
Aims and Objectives	This course will provide informations about origin, classification and evolution of fauna
Learning Outcomes	The students will be able to understand classification, philosophy of nomenclature, species concepts, phylogenetic inference and evolutionary perspectives of biodiversity.
Syllabus in Brief	<p><b>Theory:</b>Contribution of systematic to Biology; History of Taxonomy (Downward classification, upward classification, impact of origin of species and their delimitation, population systematics, current trends); Micror taxonomy, phenon, Taxon; Taxonomic categories; species category, infraspecies category, higher categories; species concepts (Typological concept; nominalistic concept, Biological concept, evolutionary concept). Species mate recognition concept; non-dimensional species concept; Multidimensional species concept; Cohesion species concept; Difficulties in the application of biological species; ploytypic species, subspecies, superspecies, sibling species; study of major type of variation within a single population, Macrotaxonomy; different kinds of Synonym, Homonym, Keys; Evolution of the theory of Nomenclature; interpretation and application of the code (stability, priority, first revisor principle) range of authority of code; concept of availability, type method formation of specific names, cladistics, Taxonomic characters and their kinds and weightage, Importance and application of biosystematics in biological studies. The nature and origin to life, Evidences of evolution. Theories to explain the diversity to life – Lamarckism, Darwinism and Special Creation. The present status of these theories, Modern synthetic theory.</p>

	<p>Factors initiating elementary evolutionary changes (micro-evolution) by changing gene frequencies, mutation pressure, selection pressure and immigration, genetic drift. Role of isolation in evolution. Factors of large evolutionary changes, (macro-evolution) Heterochrony, allometry, orthogenesis, adaptive radiation.</p> <p>Modern concept of Natural Selection; Level of selection, selection patterns, laboratory and field examples regarding action of Natural Selection. Action of Natural Selection leading to convergence, radiation, regression and extinction, Batesian mimicry, Mullerian mimicry, Sexual selection; Darwin's concept, Fisher's view, Zahavi's handicap theory. Trend and rates in evolution.</p> <p><b><u>Practicals:</u></b></p> <ol style="list-style-type: none"> <li>1. Study of preserved invertebrate species and their classification up to class level.</li> <li>2. Collection, Preservation and identification of common species with the help of keys.</li> <li>3. Methods of statistical analysis of samples from populations.</li> <li>4. Preparation of keys for the identification of specimens.</li> </ol> <p><b><u>Text Books:</u></b></p> <ol style="list-style-type: none"> <li>1. Ridley, M. 1993. Evolution, Blackwell Scientific Publications.</li> <li>2. Mayer, E. 1969. Principles of Systematic Zoology, McGraw Hill York.</li> <li>3. Simpson, G.G., 1961. Principles of Animal Taxonomy, Columbia University Press, N.Y.</li> </ol> <p><b><u>Recommended Books:</u></b></p> <ol style="list-style-type: none"> <li>1. Mayer, E. and Asblock, P.D., 1991. . Principles of Systematic Zoology, McGraw Hill York.</li> <li>2. Mayr, E. 1963. Animal Species and Evolution, Harvard University Press.</li> <li>3. Huxley, E., 1940. New Systematics, Oxford University Press.</li> <li>4. Scheuk and McMaster, 1959. Procedure in Taxonomy, Stanford University Press.</li> <li>5. Mayer, E. and Asblock, P.D., 1991. . Principles of Systematic Zoology, McGraw Hill York.</li> <li>6. Ross, H.H., 1974. Biological Systematics, Addison-Wesley Publishing Co. Reading, Massachusetts.</li> <li>7. Heywood, V.H., 1975. Taxonomy and Ecology, Academic Press, London.</li> <li>8. Whili, M.J.D., 1978. Modes of Speciation, W.H. Freeman and Co., San Francisco.</li> <li>9. Howard, R. and Moore, A., 1984. A complete Check-list of the Birds of the World, Macmillan, London.</li> <li>10. Dobzhansky, T., Ayala, F.J., Stebbins, G.L., and Valentine, J.W., 1973. Evolution, W.H. Freeman and Company.</li> <li>11. Dobzhansky, T., 1970. Genetics of the Evolution process, Columbia University Press, New York.</li> <li>12. Sheppard, P.M., 1985. Natural Selection and Heredity, Hutchison University Library, London.</li> <li>13. Dobzhansky, T., Genetics and the Origin of Species, Columbia University Press, New York.</li> <li>14. Mayr, E. Populations. Species and Evolution, Harvard University Press.</li> <li>15. Moody, P.A., 1989, Introduction to Evolution, Harper and Row Polishers, New York.</li> <li>16. Cain, A.J., Animal species and their Evolution, Hutchison University Library, London.</li> <li>17. Westoll, T.S., The Evolution of Living Things.</li> <li>18. Ross, H.H., Understanding Evolution.</li> <li>19. Simpson, G.G., Meaning of Evolution, Yale University Press.</li> <li>20. Dodson, E.O., 1960. Evolution: Process and product, Chapman and Hall Ltd.</li> <li>21. Wilson, E.O., 1999: The diversity of life, 17<sup>th</sup> edition W.W. Northern &amp; Co.</li> <li>22. Samiullah, K., 2014. An approach to evolution.</li> </ol>
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<b>Course Title</b>	<b>Fisheries</b>
Course Code	ZOL-605

Credit Hours	3
Theory	2
Practical	1
Follow up	Not Applicable
Category	BS Zoology, 04-Years Programme
Aims and Objectives	Culturing of fishes to meet the needs of protein of the country.
Learning Outcomes	Introduction to fish fauna, its culture and field application.
Syllabus in Brief	<p>Theory:</p> <p>Aims and evolution of Fish Culture, Requisite conditions for fish suitable for Fish Culture; Construction and layout of ponds; natural food and growth of cultivated fishes; Techniques and methods of fish cultivation, Breeding and cultivation of cyprinids, biological means of increasing production; Maintenance and improvement of ponds; Artificial feeding of fish; Enemies and diseases of fish; Harvesting the fish.</p> <p>Practicals:</p> <ol style="list-style-type: none"> <li>1. Study of various aquatic culture systems (fish farm, hatcheries and nurseries).</li> <li>2. Weight length and condition factor in relation to different environment in fish spp.</li> <li>3. Induced spawning.</li> <li>4. Fish diseases, symptoms and treatment.</li> </ol> <p>Books Recommended:</p> <ol style="list-style-type: none"> <li>1. Huet, M., 1986. Textbook of Fish Culture: Breeding and cultivation of fish. 2<sup>nd</sup> Edition. Fishing News Book Ltd. England.</li> <li>2. Pillay, T.V.R. and Dill, W.M.A., 1976. Advances in Aquaculture. Published by Fishing News Books, Ltd., England.</li> <li>3. Jhingran, V.G., 1983. Fish and Fisheries of India. 2<sup>nd</sup> Edition. Hindustan Publishing Corporation, New Delhi.</li> </ol> <p>Pillay, T.V.R. 1999. Aquaculture: Principles and practices. Fishing News Books, London.</p>

<b>Course Title</b>	<b><u>Research Methodology</u></b>
Course Code	ZOI-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	<p>Theory:</p> <p>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 &amp; Methods, Literature Review, Results and Discussion, Summary, Literature cited and References), Ethical consideration on research</p> <p><b>Text Books/Suggested Books:</b></p> <p>Kothari, C.R., 2004. <i>Research methodology: Methods and techniques</i>. New Age International.</p> <p>Creswell, J.W. (1994). <i>Research design : qualitative and quantitative approaches</i>. -</p>

	Thousand Oaks, Calif.; London : Sage Publications, ISBN 0803952546 Dawson, C. 2009. Introduction to research methods: A practical guide for anyone undertaking a research project. 4 <sup>th</sup> Ed. Spring Hill House, Spring Hill Road, Begbroke, Oxford OX5 1RX. United Kingdom.
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<b>Course Title</b>	<b><u>Principles of Paleontology</u></b>
Course Code	ZOI-609
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	BS (Hons) Zoology, 04-Years Programme/ MSc 02 years
Aims and Objectives	This course will help to learn about the evolutionary history of major groups of animals, origin and diversification and extinction. This course also provides understanding of the history of fossil life on earth, major crises about individuals of remote past.
Learning Outcomes	After studying this course, the student will be able to understand evolutionary history of fossil record, processes of evolution, stratigraphic and environmental of contexts.
Syllabus in Brief	<p><b><u>Theory:</u></b> The history of life; Earth, Shells of earth (Atmosphere, hydrosphere, biosphere and lithosphere); Development of life on earth; Rock, types of rocks (Igneous, sedimentary and metamorphic rocks); Introduction to Paleontology; Fossil, types and Significance of fossils, Nature of fossils, Fossilization and Processes of fossilization (Study of process of dying and what processes occur to animals after their death, <u>Geological concepts of fossilization</u>); Geological time scale; Pre-Cambrian life, Post-Cambrian life (Paleozoic life, Mesozoic life, Cenozoic life); A brief history of the Siwaliks; Dating the rocks, Radio-activity methods (Uranium/Lead dating, radiocarbon dating, Fission track dating and palaeomagnetism); Evolutionary histories of camel, horse, elephant and man.</p> <p><b><u>Practicals:</u></b></p> <ol style="list-style-type: none"> <li>1. General survey of Paleontological lab.</li> <li>2. Study of various kinds of Rocks (Igneous, sedimentary and metamorphic rocks).</li> <li>3. Study of various kinds of fossils (Petrified, pseudomorphs, mold, casts, Imprints, foot prints and Coprolites etc.).</li> <li>4. Identification and classification invertebrate fossils like foraminifers, coelenterates, Brachiopodes, arthropods (Trilobites), Molluscs and Echinoderms.</li> <li>5. Study of vertebrate fossils of evolutionary importance e.g. Horses, Elephants, Primates and Camels etc.</li> </ol> <p><b><u>TextBooks:</u></b></p> <ol style="list-style-type: none"> <li>1. Brouwer, A., 1977. General Palaeontology. Oliver and Boyed, London.</li> <li>2. Samiullah, K 2014. A hand book of Paleontology</li> </ol> <p><b><u>RecommendedBooks:</u></b></p> <ol style="list-style-type: none"> <li>1. S.S. Ali, 1999. Palaeontology, Zoogeography and Wildlife Management.</li> <li>2. Young J.Z., 1950. (3rd edition &amp; 7th edition). Life of vertebrates. London, Oxford Univ. Press.</li> <li>3. Dunbar C.o., 1969. Historical Geology, John Willey and sons Inc. New York.</li> <li>4. Gilbert, Colbert, E.H., 1980. Evolution of vertebrates. John Willey and Sons Inc. New York.</li> <li>5. Moore, R.C. Lalicker, G.C., Fisher, A.G., 1952. Invertebrate Fossils. McGraw-Hill, New York.</li> <li>6. Steven M. Stanley, 2008. Earth system History 3rd addition.</li> <li>7. Abu Bakr, 1981. Palaeontology.</li> </ol>



Course Title	<b>Aquatic Toxicology</b>
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	<p><b>Syllabus in Brief:</b>  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.</p> <p><b>Practical:</b>  Effects of toxicants on hematology of fish,Effects of toxicants on liver and kidney, Effects of toxicants on food intake in fishes</p> <p><b>Text Books</b>  Fundamentals of Aquatic Toxicology: Effects, Environmental Fate, and Risk Assessment, Edited by Gary M. Rand, PhD, Second Edition, 1995.CRC Press</p> <p><b>Suggested Reading:</b></p> <ol style="list-style-type: none"> <li>1. Taylor and Francis: Fundamentals of Aquatic Toxicology: Effects, Environmental Fate and Risk Assessment. 2<sup>nd</sup> Edition, Philadelphia, London</li> <li>2. An introduction to Aquatic Toxicology, by MikkoNikinmma (2014). Elsevier</li> <li>3. Karen E. Stine and Thomas M. Brown (2015). Principles of Toxicology, CRC Press</li> <li>4. Hyes A W. 1994. Principles and Method of Toxicology. 3<sup>rd</sup> Ed. Raven Press New York</li> </ol>

<b>Course Title</b>	<b>Wildlife of Pakistan</b>
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	<p><b>Syllabus:</b> Wildlife, Wild life of Pakistan ( Province wise), identification, distribution, status, conservation and management of reptiles, birds and mammals of major importance in Pakistan. Philosophy and significance of wildlife conservation. Biodiversity and sustainability of wildlife. Endangered species of wildlife in Pakistan. Wildlife rules and regulations in Pakistan. National and International organizations involved in conservation and management of wildlife. Sanctuaries, Game Reserve and National Parks in Pakistan. Wetlands, endangered species of Pakistan.</p> <p><b>Practical:</b> Study of distribution description, biology, food, predators and status of wild animals of a zoo or Zoological park of Pakistan. Adaptive features of animals in relation to food and environment, Food chain of local birds in various seasons. Construction of food chain and food webs of wild animals.</p> <p><b>Text Books:</b></p> <p><b>Suggested Reading:</b></p> <ol style="list-style-type: none"> <li>1. Wildlife of Pakistan, 2002. Published by Punjab Wildlife Department, Lahore.</li> <li>2. Miller, G.T. 2002. Living in the Environment: Principles, Connections and Solution. 12th Edition. Thomson Learning Inc., Australia.</li> <li>3 Roberts, T.J., 1998. The Birds of Pakistan, Vol. II, Oxford.</li> <li>4. Roberts, T.J., 1992. The Birds of Pakistan, Vol. II, Oxford.</li> <li>5. Roberts, T.J., 1998. Mammals of Pakistan, Ernest Benon Ltd. London.</li> <li>6. Robinson, W.L. and Bolen, E.G., 1984. Wildlife Ecology and Management, McMillan, Cambridge.</li> <li>7. <a href="http://www.wildlifeofpakistan.com">http://www.wildlifeofpakistan.com</a></li> </ol>

<b>Course Title</b>	<b>Bio-remediation and Bioprocessing</b>
Course Code	ZOL-608
Credit Hours	3
Theory	2
Practical	1
Follow up	Not Applicable
Category	BS Zoology, 04-years Program /M.Sc. Zoology, 02-Years Program
Aims and Objectives	Bioremediation is to control of environmental pollution and to address other problems by using living organisms. This keeps the environment free of natural and manmade pollutants by using living or dead organisms, their metabolites, biochemicals and processes.
Learning Outcomes	This course will develop techniques to tackle with the environmental pollution by biological means.
Syllabus in Brief	<p>Theory</p> <p>Concept of bioremediation; <u>Ex situ and In-situ Bioremediation.</u></p> <p>Degradation of natural substances; Biodegradation of xenobiotics; <u>Industrial effluents, Dyes, Hazardous chemicals, TNT wastes, Introduction to different Bacterial and Fungal spec used in Bioremediation.</u></p> <p>Biosorption: <u>Use of Bacteria, Algae and Fungi for it.</u></p> <p><u>Phytoremediation.</u></p> <p><u>Biotechnology for Air Pollution:</u></p> <p><u>Bioscrubbers, Tricking Filters etc.</u></p> <p><u>Use of enzymes.</u></p> <p><u>Municipal and Industrial Waste Water Treatment: Primary, Secondary, Tertiary and Sewage Treatment including disinfection. Phosphorus and Nitrogen Removal.</u></p> <p><u>Biohydrometallurgy: for extraction of Precious metals from their ores (Iron, Gold, Copper, Silver)</u></p>

	<p><u>Biofuel generation; Use of Algae, Alcohol etc for production of Biofuels.</u></p> <p><b>Practicals</b> Isolation and studies of heavy metals tolerant/resistant microorganisms; Studies on bacterial capable of degrading xenobiotics; production of alcohol from decaying fruits.</p> <p>Books Recommended Practical Environmental Bioremediation the field guide, 1997. R. Barry King, Gilbert M. Long, John K. Sheldon, Lewis publishers.</p> <p><b>Books:</b> General Microbiology, 1995. Schlegel, H.G., Cambridge University Press. Biotechnology, 1996. Smith, J.F., Cambridge University Press. Environmental Biotechnology Principles and applications, 2000. Puce, R. Hmana, Parry McCarty, McGraw Hill. Biodegradation and Bioremediation, 1999. Martin Alexender academic press Inc.</p>
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<b>Course Title</b>	<b>Biodiversity</b>
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	<p>Definition; Types; Levels; Status of Biodiversity; Importance of Biodiversity.</p> <p>Natural Resources and Biodiversity</p> <ul style="list-style-type: none"> <li>• Ecological aspects of Biodiversity</li> <li>• Impacts on Biodiversity</li> <li>• Loss of Biodiversity</li> <li>• Protection / Conservation of Biodiversity.</li> </ul> <p>Practicals</p> <ol style="list-style-type: none"> <li>1. Critical account (phylogenetic controversies) of some important museums specimens with the help of literature.</li> <li>2. Procedures for studying species richness, Simpson Index, Shannon and Weiner Function.</li> <li>3. Population of some local subterranean animals.</li> </ol> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>1. Biodiversity, Principles and Conservation by Kumar &amp; Asija, 2000.</li> <li>2. The Diversity of Life by C. Mary Jenking and Ann Boyce, 1987.</li> </ol>

**M.Sc. Courses:**

<b>Course Title</b>	Biochemistry-I (Structure and Functions of Macromolecules)
<b>Course Code</b>	ZOL-551
<b>Credit Hours</b>	3
<b>Theory</b>	2
<b>Practical</b>	1
<b>Follow up</b>	B.Sc. Zoology
<b>Category</b>	M.Sc. Zoology, 02-Years Programme
<b>Aims and Objectives</b>	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.
<b>Learning Outcomes</b>	This course will enable the students to study the working of life processes at molecular level.
<b>Syllabus in Brief</b>	<p>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.</p> <p>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.</p> <p>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.</p> <p>Lipids: Fatty acids, their types. Storage Lipids: Acylglycerols; Structural Lipids of membranes: Glycerophospholipids; Sphingolipids their role and degradation. Sterols, Cholesterol, Testosterone, Estriadiol. Major functions of Lipids. Lipoproteins, their types and major functions. Lipid analysis: GLC as an example.</p> <p>Vitamins as Cofactors: Occurrence, Structure and Biochemical function of Riboflavin.</p> <p>Nucleic acids: Types and structure.</p> <p><u>Books Recommended</u></p> <ol style="list-style-type: none"><li>1. David I., Nelson, and Michael M, Cox. 2000, Lehninger Principles of Biochemistry, 3<sup>rd</sup> Edition, Macmillan Worth Pubslihers, New York.</li></ol> <p><u>Additional Reading</u></p> <ol style="list-style-type: none"><li>1. Murray, R.K., Granner, D.K., Mayer, P.A., and Rodwells, V.W., 2000. Harper's Biochemistry, 25<sup>th</sup> Edition, McGraw-Hill Book Company, New York.</li><li>2. Voet. D., Voet. J.G., and Pratt. C.W., 1999. Fundamentals of Biochemistry, John Wiley and Sons Inc., New York.</li><li>3. Zubay. G., 1995. Biochemistry, 4<sup>th</sup> Edition, Wm. C. Brown Publishers Inc. Oxford, England.</li><li>4. Lubert Stryer, 1995. Biochemistry, 4<sup>th</sup> Edition, W.H. Freeman &amp; Company, New York.</li></ol> <p><u>Practicals</u></p> <ol style="list-style-type: none"><li>1. Tests for detection of carbohydrates in acidic medium.</li></ol>

	<ol style="list-style-type: none"> <li>2. Tests for detection of carbohydrates in alkaline medium.</li> <li>3. Detection of Non-Reducing sugars in the presence of Reducing sugars.</li> <li>4. Tests to demonstrate relative instability of glycosidic linkage in carbohydrates.</li> <li>5. Tests for detection of Disaccharides.</li> <li>6. Preparation of standard curve of glucose by ortho-Toluidine method.</li> <li>7. Estimation of glucose from blood serum or any other fluid using ortho-Toluidine technique.</li> <li>8. Biochemical tests for detection of different amino acid groups.</li> <li>9. Preparation of standard curve of proteins by Biuret method.</li> <li>10. Estimation of Blood serum proteins using Biuret technique.</li> <li>11. Demonstration of differential solubility of lipids in various solvents.</li> <li>12. Various Qualitative Tests for detection of Lipids.</li> <li>13. Determination of Acid value of Fats.</li> </ol> <p><u>Books Recommended</u></p> <ol style="list-style-type: none"> <li>1. Plummer, David T., 1990. An Introduction to Practical Biochemistry, 4<sup>th</sup> Edition, McGraw-Hill Book Company, London.</li> <li>2. Wilson, K &amp; Walker, J., 1994. Practical Biochemistry: Principles of Techniques, 4<sup>th</sup> Edition, Cambridge University Press.</li> </ol>
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<b>Course Title</b>	<u>Developmental Biology</u>
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	<p><u>Theory</u></p> <p>Principle features of development, developmental patterns. Spermatogenesis, oogenesis, fertilization, Recognition of sperm and egg, Fusion of gametes. 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.</p> <p><u>Practicals</u></p> <p>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.</p> <p><u>Books Recommended</u></p> <ol style="list-style-type: none"> <li>6. Developmental biology, 2000. by Gilbert, S. F.</li> <li>7. Human Embryology and Developmental biology, By Carlson, B. M.</li> </ol>

	8. Introduction to Embryonic Developments by Oppenheimer, 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.,
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<b>Course Title</b>	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	<p><u>Theory</u>          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.</p> <p><u>Practicals</u>          Food chain, food web &amp; ecological notes              Methods and analysis of population dynamics                  Quadrat method                  Determining frequency of different species                  Determining density of species in habitat          Measurement of pollutants levels              In atmosphere (NO<sub>2</sub>, SO<sub>2</sub>, O<sub>3</sub> and comparison with rural air)              In soil (toxic chemical, fertilizer, insecticides, herbicides)          Analysis of polluted and freshwater for              Various pollutant; heavy metals, -CO<sub>3</sub>, -HCO<sub>3</sub>, NO<sub>3</sub>, BOD, COD, pH, EC, total soluble solids.</p> <p><u>Books Recommended (Latest Edition)</u>          1. Miller, G.T. 2002. Living in the environment: Principles, Connections and Solutions. 12<sup>th</sup> Edition. Thomson Learning, Australia.          2. M.L. McKinney Environmental Science: System and Solution (1999) Jones &amp; Bartlett Publication, Boston.          3. M.C. Molles Ecology: <i>Concepts and application</i> (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.</p>

<b>Course Title</b>	<b>Animal Physiology</b>
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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	<p><b>Central themes in Physiology:</b> Structure-Function Relationship. Adaptations, Homeostasis. Conformity and Regulation.</p> <p><b>Cardiovascular Mechanisms:</b> Electrical activity of heart: Automaticity, Rhythmicity, Electrocardiography, Mechanical activity of heart: Cardiac output, stroke volume and heart rate, Hemodynamics: Blood flow, pressures and resistance and their interrelationships and peripheral circulation.</p> <p><b>Exchange of Gases:</b> Transport of O<sub>2</sub> and CO<sub>2</sub> 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.</p> <p><b>Excretion and Osmoregulation:</b> Osmoregulation in aquatic and terrestrial environment. Vertebrate nephron as osmoregulatory organ: Physiological anatomy. Glomerular filtration. Tubular absorption and secretion: Nitrogenous waste products: Patterns of nitrogenous excretion and their phylogenetic development.</p> <p><b>Nutrition:</b> Regulation of digestive secretions: Physiological anatomy of digestive tract (mammalian model), Absorption of water, ions and nutrients.</p> <p><b>Movements and Muscles:</b> Structural basis of muscle contraction: molecular structures of contractile components and their interaction, sarcoplasmic reticulum, calcium and membrane.</p> <p><b>Temperature Relations:</b> Temperature based classifications of animals, Temperature relations of ectotherms: Ectotherms in different environments, cost &amp; benefits of ectothermy, temperature relations of heterotherms and endotherms: Dormancy: Sleep, Torpor, Hibernation, Estivation.</p> <p><b>Practicals:</b> 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.</p> <p><b>Books Recommended:</b></p> <ol style="list-style-type: none"> <li>1. Randall. D. Burggren. W. French. K. and Fernald. R. 2002. Eckert Animal Physiology: Mechanisms and Adaptations. 5<sup>th</sup> ed. W.H. Freeman and Company. New York.</li> <li>2. Seeley. Rod. R., Stephens.D. Trent and Tate Philip. 2008. Anatomy &amp; Physiology, 8<sup>th</sup> Edition. The McGraw-Hill, New York, USA.</li> <li>3. Bullock. J. Boyle. And Wang. M.B. 2001. Physiology. 4<sup>th</sup> edition. Lippincott. Williams and Wilkins. Philadelphia.</li> <li>4. Bame. F.M. and Levy. M.N. 2000. Textbook of Medical Physiology. 3<sup>rd</sup></li> </ol>

	<p>Edition. St. Lions. Mosby.</p> <p>5. Guyton, Arthur C. and John E. Hall. 2000 Text book of Medical Physiology 10<sup>th</sup> Edition. W.B. Saunders Company.</p> <p>6. Withers. 1992. Comparative Animal Physiology.</p> <p>7. Sdhmidt- Nelsen. K., 1997. Animal Physiology.Adaptation and environment 5<sup>th</sup> Edition Cambridge University Press Cambridge.</p> <p>8. Tharp. G. and Woodman. D. 2002. Experiments in Physiology. 8<sup>th</sup> Edition.Prentice Hall London</p>
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<b>Course Title</b>	<b>Advanced Cell Biology</b>
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	<p>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.</p> <p>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.</p> <p><b>Practical:</b></p> <ol style="list-style-type: none"> <li>1. Culturing and staining of bacteria and yeast.</li> <li>2. Counting of bacterial cells and preparation of growth curves.</li> <li>3. Counting of blood cell types by haemocytometer.</li> <li>4. DNA extraction and demonstration on agarose gel.</li> <li>5. Detection (in protozoan culture and blood cells) and quantitative determination of chromosomal DNA and RNA.</li> <li>6. Isolation and fractionation of proteins from blood sera by polyacrylamide gel electrophoresis.</li> </ol> <p><b>Text Books:</b></p> <ol style="list-style-type: none"> <li>1. Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K and Walter, P., 2002. <i>Molecular Biology of Cell</i>. Garland Science, New York.Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Scott, M.P., Bretscher, A., Ploegh, H and Matsudaira, P. <i>Molecular Cell Biology</i>, 6<sup>th</sup> edition. Freeman &amp; Comp. New York.</li> <li>2. Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K and Walter, P. 2002. <i>Molecular Biology of the Cell</i>. Garland Science, New York.</li> </ol>



	<p>3. Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K and Walter, P. 2008. Molecular Biology of the Cell, 5<sup>th</sup> edition. Garland Science, New York.</p> <p>4. Karp, G. 2002. Cell and Molecular Biology: Concepts &amp; Experiments. John Wiley &amp; Sons, New York.</p>
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<b>Course Title</b>	<b><u>Research Methodology</u></b>
Course Code	ZOI-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	<p>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 &amp; Methods, Literature Review, Results and Discussion, Summary, Literature cited and References), Ethical consideration on research</p> <p><b>Text Books/Suggested Books:</b> Kothari, C.R., 2004. <i>Research methodology: Methods and techniques</i>. New Age International. Creswell, J.W. (1994). <i>Research design : qualitative and quantitative approaches</i>. - Thousand Oaks, Calif.; London : Sage Publications, ISBN 0803952546 Dawson, C. 2009. <i>Introduction to research methods: A practical guide for anyone undertaking a research project</i>. 4<sup>th</sup> Ed. Spring Hill House, Spring Hill Road, Begbroke, Oxford OX5 1RX. United Kingdom.</p>

<b>Course Title</b>	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	<p>Bioenergetics: Concept of Free Energy and Standard Free Energy change. Energy rich compounds: Phosphoryl group transfers and ATP; Acyl phosphates; Enol phosphates and Thioesters.</p> <p>Carbohydrate Metabolism: Regulation and Anabolic role of Glycolysis. Fate of Pyruvate under Aerobic and Anaerobic conditions. Gluconeogenesis, its regulation. Feeder Pathways in Glycolysis i.e. Fructose, Galactose, Mannose, Glucose 1-phosphate, Glyceraldehyde and Glycerol. Phosphorolysis of Glycogen. Biosynthesis of Glycogen. Regulation of Glycogen Metabolism. Pentose phosphate pathway of Glucose oxidation and its major role in the animal tissues.</p>

	<p>Anabolic role of citric acid cycle intermediates; Regulation of Citric acid cycle.</p> <p>Lipid metabolism: Digestion, mobilization and transport of Fats. Biosynthesis and Utilization of Triacylglycerol. Activation of Fatty acids and their transportation to mitochondria. Beta-Oxidation and its Bioenergetics. Oxidation of unsaturated Fatty acid. Biosynthesis of Saturated Fatty acid: As an example palmitic acid synthesis; Fatty acid synthetase (FAS) Models of FAS system in Bacteria, vertebrate tissue. Biosynthesis of unsaturated Fatty acids, Aerobic and Anaerobic pathways. Ketone bodies their Biosynthesis, utilization and role in the tissue. Cholesterol regulation.</p> <p>Nitrogen Metabolism: Metabolic fate of standard amino acids. Catabolism of Amino acids: Decarboxylation; Deamination and Transamination. Amino acid degradation showing entry points in citric acid cycle. Nitrogen Excretion and Urea cycle with Regulation. Incorporation of Ammonia in Glutamate and Glutamine. Sources of various atoms in Purine and Pyrimidine synthesis.</p> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>1. David I., Nelson, and Michael M, Cox. 2000, Lehninger Principles of Biochemistry, 3rd Edition, Macmillan Worth Pubshlers, New York.</li> <li>2. Additional Reading</li> <li>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.</li> <li>4. Voet. D., Voet. J.G., and Pratt. C.W., 1999. Fundamentals of Biochemistry, John Wiley and Sons Inc., New York.</li> <li>5. Zubay. G., 2000. Biochemistry, 4th Edition, Wm. C. Brown Publishers Inc. Oxford, England.</li> <li>6. Lubert Stryer, 2001. Biochemistry, 4th Edition, W.H. Freeman &amp; Company, New York.</li> </ol> <p>Practicals</p> <ol style="list-style-type: none"> <li>1. Demonstration of Acid Hydrolysis of Polysaccharide.</li> <li>2. Determination of pKa values of an amino acid by preparation of titration curves.</li> <li>3. Estimation of Free Amino Acids in Biological samples colorimetrically.</li> <li>4. Separation and identification of various amino acids by Paper chromatography / PAGE.</li> <li>5. Separation of various protein fractions by precipitation method.</li> <li>6. Preparation of standard curve of proteins using Lowry's technique.</li> <li>7. Estimation of tissue (liver) proteins using Lowry's technique.</li> <li>8. Preparation of standard curve and Estimation of proteins by ultraviolet (UV) spectrophotometry.</li> <li>9. Preparation of standard curve and Estimation of DNA by colorimetric analysis using Diphenylamine method.</li> <li>10. Preparation of standard curve and Estimation of total RNA by colorimetric analysis using Bial's Orcinol method.</li> <li>11. Quantitative analysis of Diastase activity on starch.</li> <li>12. Study on the effect of temperature on the enzymatic rate of reaction.</li> </ol> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>1. Plummer, David T., 1990. An Introduction to Practical Biochemistry, 4th Edition, McGraw-Hill Book Company, London.</li> <li>2. Wilson, K &amp; Walker, J., 1994. Practical Biochemistry: Principles of Techniques, 4th Edition, Cambridge University Press.</li> </ol>
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<b>Course Title</b>	<b>Physiology of coordination and animal behaviour</b>
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	<p><b>Physiological basis of Neuronal Function:</b> Mechanisms in Resting Membrane Potentials: Electrogenic ion pump. Donnan equilibrium. 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 &amp; chemical synapse: Neurotransmitters: Synaptic receptors: Excitatory postsynaptic potentials: Inhibitory postsynaptic potentials: Presynaptic inhibitions: Integration at synapses: Facilitation. Posttetanic Potentiation.</p> <p><b>Photoreception:</b> Ultrastructure of photoreceptors. Photochemistry, Phototransduction and physiological basis of color vision: Physiological mechanisms in electroreception.</p> <p><b>Chemical Messenger and Regulators/Endocrine Physiology:</b> 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 &amp; 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:</p> <p><b>The study of Animal Behaviour:</b> 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.</p> <p><b>Practicals</b></p> <p><b>Muscle and Neuromuscular Activity:</b> Nerve muscle preparation. Muscle twitch, Comparison 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.</p> <p><b>Excitability, Sensation and Behaviour:</b> 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.</p> <p><b>Endocrine and Reproductive Mechanisms:</b> Effect of insulin on glycemia, study of stages in estrous cycle, mechanisms in regulations of contraction. Study of hibernation and biological rhythms.</p> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>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.</li> <li>2. Seeley. Rod. R., Stephens, D. Trent and Tate Philip. 2008. Anatomy &amp; Physiology, 8<sup>th</sup> Edition. The McGraw-Hill, New York, USA.</li> <li>3. Bullock. J.. Boyle. And Wang. M.B.. 2001. Physiology. 4th edition. Lippincott. Williams and Wilkins. Philadelphia.</li> <li>4. Bame. F.M. and Levy. M.N.. 2000. Textbook of Medical Physiology. 3rd edition. St. Lions. Mosby.</li> </ol>

	<p>5. Guyton and hall 2000 Text book of Medical Physiology 10th. Edition.</p> <p>6. Schmidt- Nelsen. K., 1997 Animal Physiology. Adaptation and environment 5th. Edition Cambridge University Press Cambridge.</p> <p>7. Drickamer, L.C., Vessey, S.H., and Jacob, E., 2002. Animal Behaviour: Mechanism, Ecology, Evolution. 5th Edition.</p> <p>8. Manning, A. and Daekins, M.S., 1997. An introduction to animal behaviour, 4th edition, Cambridge University Press, Cambridge.</p> <p>9. Tharp. G. and Woodman. D. 2002. Experiments in Physiology. 8th Edition. Prentice Hall London.</p>
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<b>Course Title</b>	<b>Evolution and Principles of Systematics</b>
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	<p>Theory</p> <p>Contribution of systematic to Biology; History of Taxonomy (Downward classification, upward classification, impact of origin of species, population systematics, current trends); Microtaxonomy, phenon, Taxon; Taxonomic categories; species category, infraspecies category, higher categories; species concepts (Typological concept; nominalistic concept, Biological concept, evolutionary concept). Species mate recognition concept; non-dimensional species concept; Multidimensional species concept; Cohesion species concept; Difficulties in the application of biological species; ploytypic species, subspecies, superspecies, sibling species; study of major type of variation within a single population, Macrotaxonomy; different kinds of Synonym, Homonym, Keys; Evolution of the theory of Nomenclature; interpretation and application of the code (stability, priority, first revisor principle) range of authority of code; concept of availability, type method formation of specific names.</p> <p>The nature and origin to life, Evidences of evolution. Theories to explain the diversity to life – Lamarckism, Darwinism and Special Creation. The present status of these theories, Modern synthetic theory.</p> <p>Factors initiating elementary evolutionary changes (micro-evolution) by changing gene frequencies, mutation pressure, selection pressure, immigration and croobreeding, genetic drift. Role of isolation in evolution. Factors of large evo- lutionary changes (macro-evolution) – allometry, orthogenesis, adaptive radiation.</p> <p>Modern concept of Natural Selection; Level of selection, selection patterns, laboratory and field examples regarding action of Natural Selection. Action of Natural Selection leading to convergence, radiation, regressin and extinction, Batesian mimicry, Mullerian mimicry, Sexual selection; Darwin’s concept, Fisher’s view, Zahavi’s handicap theory. Trend and rates in evolution.</p> <p>Practicals</p> <p>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.</p> <p>Books Recommended</p> <p>Mayer, E. 1969. Principles of Systematic Zoology, McGraw Hill York.</p> <p>Mayer, E. and Asblock, P.D., 1991. . Principles of Systematic Zoology, McGraw Hill York.</p>

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

	<p>Oculocutaneous albinism); Carbohydrate metabolism (Galactosaemia); Lipid Metabolism (Familial hypercholesterolaemia, Tay-Sachs disease); Purine/pyrimidine metabolism (Lech – Nyhan disease).</p> <p><b>Practical:</b></p> <ol style="list-style-type: none"> <li>8. Study of Mitosis and Meiosis.</li> <li>9. Preparation of Drosophila culture.</li> <li>10. Study of morphology and karyotype.</li> <li>11. Study of Monohybrid and dihybrid ratio, sex-linked inheritance.</li> <li>12. Pedigree Analysis</li> <li>13. Detection of Blood Groups in humans.</li> <li>14. Problem relating to theory.</li> </ol> <p><b>Books:</b></p> <ol style="list-style-type: none"> <li>9. Hartl, D. L. and E. W. Jones. 2009 Genetics: Analysis of Genes and Genomes. Seventh (7th) Edition. Jones and Bartlett Publishers. USA.</li> <li>10. Snustad, D.P. and Simmon, M.J., 2003. Principles of Genetics. 3rd Edition. John Wiley and Sons, New York.</li> <li>11. Muller, R.F. and Young, I.D., 2002. Emery’s Elements of Medical Genetics. 11th Edition. Churchill Livingstone, Elsevier Science, Limited, UK.</li> <li>12. Tammarin, R.M. 1999. Principles of Genetics. 6th Edition, WCB, McGraw Hill, New York.</li> <li>13. Klug, Cummings et al., 2012, Concepts of Genetics 10th edition, Pearson Publisher. Macmillan College Publishing Company, New York.</li> <li>14. Strickberger, M.W. 1999. Genetics. 3rd Edition. Prentice Hall of India Private Ltd., New Delhi.</li> <li>15. Lewin, B. 2003. Gene VII. Oxford, UK.</li> </ol>
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<b>Course Title</b>	<b>Principles of Zoogeography</b>
Course Code	ZOL-560
Credit Hours	3
Theory	2
Practical	1
Follow up	B.Sc. Zoology
Category	M.Sc. Zoology, 02-Years Programme
Aims and Objectives	This course provides information on the distribution of animals and their association in different zoological regions of world.
Learning Outcomes	After studying this course, the student will be able to recognize extant fauna of world distributed in different climatic regions.
Syllabus in Brief	<p><b>Theory:</b> Introduction and history of Zoogeography, Branches of Zoogeography. Barriers to distribution and means of dispersal in Marine, Freshwater and Terrestrial environment. Division of world into various zoogeographical regions. Geographical limits, Physical, climatic features and faunas of Holarctic (Palearctic and Nearctic), Oriental, Ethiopian, Australian, and Neotropical regions. Insular fauna [continental islands {Recent (British Isles, Borneo, Java, Japan, Formosa and Philippines, and Sri Lanka islands)}, {Ancient (New Zealand and Madagascar Island)}]. [Oceanic Islands, (Azores, Bermuda, Galapagos, St. Helena and Karakatau Island)], Wallace’s line, Weber’s line and Wallacea. Continental drift theory and discontinuous distribution of animals.</p> <p><b>Practicals:</b> Identification and classification of various invertebrates and vertebrates of Zoogeographical importance.</p> <p><b>TextBook:</b></p> <ol style="list-style-type: none"> <li>3. Darlington, Zoogeography, John Wiely, 1963.</li> <li>4. S.S. Ali, 1999. Palaeontology, Zoogeography and Wildlife Management.</li> </ol> <p><b>RecommendedBooks:</b></p>

	<p>7. Hesse, Ecological Animal Geography, John Wiely, 1963.</p> <p>8. DeBeaufort, Zoogeography of the Land Inland Waters, Sidgwick and Jackson. 1951.</p> <p>9. Ekman, Zoogeography of the sea. Sidgwick and Jackson. 1953.</p> <p>10. Lillies, Introduction to Zoogeography, London, 1974.</p> <p>11. Muller, Aspects of Zoogeography, Hague, 1974.</p> <p>12. Jafri, Land Zoogeography of World, 1977.</p>
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<b>Course Title</b>	<b>Fundamentals of Microbiology</b>
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	<p>Theory:</p> <p>The history and scope of Microbiology. Microbial structure. <u>Taxonomy</u> and characterization of Microorganisms. Nutritional requirements and microbiological Media. <u>Growth kinetics of microorganisms</u>. 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. <u>Major groups and Taxonomy</u>, Microorganisms as components of Ecosystems. Industrial applications of Microbiology.</p> <p>Practicals:</p> <p>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 (<u>from fresh water as well</u>).</p> <p>Reference Books</p> <ol style="list-style-type: none"> <li>1. <u>Pommerville, J. C. 2014. Fundamentals of Microbiology. 9th edition, Published by Jones &amp; Bartlett, USA</u></li> <li>2. Batzing, B.L. 2001. Microbiology: An Introduction. Books / Cole Thomson Learning, USA.</li> <li>3. Tortora, G.J., Funke, B.R. and Case, C.L., 2001. Microbiology: An Introduction. 7th edition. Benjamin Cummins, New York.</li> <li>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.</li> <li>5. Benson, H.J., 1998. Microbiological Applications: Laboratory Manual in General Microbiology. 7th edition. WCB McGraw Hill.</li> <li>6. <u>Stanier, Y. Roger, John L. Ingrahm, Mark L. Wheelis and Page R. Painter. 2003. General Microbiology. V Ed. MacMillan Press Ltd. New Jersey.</u></li> </ol>

<b>Course Title</b>	<b>Principles of Palaeontology</b>
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	<p><b>Theory:</b> The history of life; Earth, Shells of earth (Atmosphere, hydrosphere, biosphere and lithosphere); Development of life on earth; Rock, types of rocks (Igneous, sedimentary and metamorphic rocks); Introduction to Paleontology; Fossil, types and Significance of fossils, Nature of fossils, Fossilization and Processes of fossilization (Study of process of dying and what processes occur to animals after their death, 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.</p> <p><b>Practicals:</b></p> <ol style="list-style-type: none"> <li>1. General survey of Paleontological lab.</li> <li>2. Study of various kinds of Rocks (Igneous, sedimentary and metamorphic rocks).</li> <li>3. Study of various kinds of fossils (Petrified, pseudomorphs, mold, casts, Imprints, foot prints and Coprolites etc.).</li> <li>4. Identification and classification invertebrate fossils like foraminifers, coelenterates, Brachiopodes, arthropods (Trilobites), Molluscs and Echinoderms.</li> <li>5. Study of vertebrate fossils of evolutionary importance e.g. Horses, Elephants, Primates and Camels etc.</li> </ol> <p><b>TextBooks:</b></p> <ol style="list-style-type: none"> <li>1. Brouwer, A., 1977. General Palaeontology. Oliver and Boyed, London.</li> <li>2. Samiullah, K 2014. A hand book of Paleontology</li> </ol> <p><b>RecommendedBooks:</b></p> <ol style="list-style-type: none"> <li>1. S.S. Ali, 1999. Palaeontology, Zoogeography and Wildlife Management.</li> <li>2. Young J.Z., 1950. (3rd edition &amp; 7th edition). Life of vertebrates. London, Oxford Univ. Press.</li> <li>3. Dunbar C.o., 1969. Historical Geology, John Willey and sons Inc. New York.</li> <li>4. Gilbert, Colbert, E.H., 1980. Evolution of vertebrates. John Willey and Sons Inc. New York.</li> <li>5. Moore, R.C. Lalicker, G.C., Fisher, A.G., 1952. Invertebrate Fossils. McGraw-Hill, New York.</li> <li>6. Steven M. Stanley, 2008. Earth system History 3rd addition.</li> <li>7. Abu Bakr, 1981. Palaeontology.</li> </ol>

<b>Course Title</b>	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,



	<p>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.</p> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>1. Simpson, G.G., Roe, A. and Lewontin R.C. 1960. Quantitative Zoology, Harcourt, Brace &amp; World Inc. New York.</li> <li>2. Steel, R.G.D. and Torrie, J.H., 1980. Principles and procedures of statistics. McGraw Hill International Editions.</li> <li>3. Fowler, J., Cohen, L. and Jarris, P., 1998. Practical statistics for field biology. John Wiley and Sons.</li> <li>4. Zar, 1998. Biostatistics Analysis.</li> <li>5. Campbell, R.C. Statistics for Biologists. Cambridge University Press.</li> <li>6. Sokal, R.R. and Rohlf, F.J., 1973. An Introduction to Biostatistics, Troppan.</li> <li>7. Bailey, N.T.J., 1981. Statistics Methods in Biology, English University Press.</li> <li>8. Mead, R., Currow, R.N. and Hastod, A.M., 1993. Statistics methods in agriculture and experimental biology, 2th edition. Chapman &amp; Hall.</li> </ol>
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<b>Course Title</b>	<b>Fish Culture</b>
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	<p>Theory:</p> <p>Aims and evolution of Fish Culture, Requisite conditions for fish suitable for Fish Culture; Construction and layout of ponds; natural food and growth of cultivated fishes; Techniques and methods of fish cultivation, Breeding and cultivation of cyprinids, biological means of increasing production; Maintenance and improvement of ponds; Artificial feeding of fish; Enemies and diseases of fish; Harvesting the fish.</p> <p>Practicals:</p> <ol style="list-style-type: none"> <li>1. Study of various aquatic culture systems (fish farm, hatcheries and nurseries).</li> <li>2. Weight length and condition factor in relation to different environment in fish spp.</li> <li>3. Induced spawning.</li> </ol> <p>Books Recommended:</p> <ol style="list-style-type: none"> <li>1. Huet, M., 1986. Textbook of Fish Culture: Breeding and cultivation of fish. 2nd Edition. Fishing News Book Ltd. England.</li> <li>2. Pillay, T.V.R. and Dill, W.M.A., 1976. Advances in Aquaculture. Published by Fishing News Books, Ltd., England.</li> <li>3. Jhingran, V.G., 1983. Fish and Fisheries of India. 2nd Edition. Hindustan Publishing Corporation, New Delhi.</li> <li>4. Pillay, T.V.R. 1999. Aquaculture: Principles and practices. Fishing News Books, London.</li> </ol>

<b>Course Title</b>	<b>Introduction to Biotechnology</b>
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, Agriculture 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	<p>Theory:</p> <p>Introduction to Biotechnology, <u>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.</u> <u>Recombinant DNA Technology: Cloning Vectors, Transformation Techniques, Selection and Expression.</u> <u>Large Scale Production of Biotechnological Products: Batch, Fed Batch, Continuous Fermentation System, Maximizing efficiency, Bioreactors, Product Harvesting, Purification and Ultra Purification.</u> 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.</p> <p>Practicals</p> <p>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.</p> <p><b>Books Recommended</b></p> <p>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.</p>

<b>Course Title</b>	<b>Biological and Chemical Control of Insects</b>
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	<p>Theory</p> <p>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.</p> <p>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.</p> <p>Practicals</p> <p>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.</p> <p>Books Recommended (Latest Editions)</p> <p>De bach, P., (1964). Biological control of insect pests and Weeds. Chapman and Hall, London.</p> <p>Pedigo, L.P., 1991. Entomology and Pest Management. MaxMillan.</p> <p>Metcalf, C.L. and Flint. Destructive and Useful Insects, McGraw hill Co., N Y.</p> <p>Martin, H. Insecticide and Fungicide, Handbook for Corp Protectin, Blackwell, Oxford.</p>

<b>Course Title</b>	<b>Wildlife of Pakistan</b>
Course Code	ZOI-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	<p><b>Syllabus:</b> Wildlife, Wild life of Pakistan ( Province wise), identification, distribution, status, conservation and management of reptiles, birds and mammals of major importance in Pakistan. Philosophy and significance of wildlife conservation. Biodiversity and sustainability of wildlife. Endangered species of wildlife in Pakistan. Wildlife rules and regulations in Pakistan. National and International organizations involved in conservation and management of wildlife. Sanctuaries, Game Reserve and National Parks in Pakistan. Wetlands, endangered species of Pakistan.</p> <p><b>Practical:</b></p> <p>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</p>

	<p>food webs of wild animals.</p> <p><b>Text Books:</b></p> <p><b>Suggested Reading:</b></p> <ol style="list-style-type: none"> <li>1. Wildlife of Pakistan, 2002. Published by Punjab Wildlife Department, Lahore.</li> <li>2. Miller, G.T. 2002. Living in the Environment: Principles, Connections and Solution. 12th Edition. Thomson Learning Inc., Australia.</li> <li>3 Roberts, T.J., 1998. The Birds of Pakistan, Vol. II, Oxford.</li> <li>4. Roberts, T.J., 1992. The Birds of Pakistan, Vol. II, Oxford.</li> <li>5. Roberts, T.J., 1998. Mammals of Pakistan, Ernest Benon Ltd. London.</li> <li>6. Robinson, W.L. and Bolen, E.G., 1984. Wildlife Ecology and Management, McMillan, Cambridge.</li> <li>7. <a href="http://www.wildlifeofpakistan.com">http://www.wildlifeofpakistan.com</a></li> </ol>
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<b>Course Title</b>	<b>Bioremediation and Bioprocessing</b>
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	<p>Theory</p> <p>Concept +++9+96+855of bioremediation; <u>Ex situ and In-situ Bioremediation.</u></p> <p>Degradation of natural substances; Biodegradation of xenobiotics; <u>Industrial effluents, Dyes, Hazardous chemicals, TNT wastes, Introduction to different Bacterial and Fungal spec used in Bioremediation.</u></p> <p>Biosorption: <u>Use of Bacteria, Algae and Fungi for it.</u></p> <p><u>Phytoremediation.</u></p> <p><u>Biotechnology for Air Pollution:</u></p> <p><u>Bioscrubbers, Tricking Filters etc.</u></p> <p><u>Use of enzymes.</u></p> <p><u>Municipal and Industrial Waste Water Treatment: Primary, Secondary, Tertiary and Sewage Treatment including disinfection. Phosphorus and Nitrogen Removal.</u></p> <p><u>Biohydrometallurgy: for extraction of Precious metals from their ores (Iron, Gold, Copper, Silver)</u></p> <p><u>Biofuel generation; Use of Algae, Alcohol etc for production of Biofuels.</u></p> <p><b>Practicals</b></p> <p>Isolation and studies of heavy metals tolerant/resistant microorganisms; Studies on bacterial capable of degrading xenobiotics; production of alcohol from decaying fruits.</p> <p>Books Recommended</p> <p>Practical Environmental Bioremediation the field guide, 1997. R. Barry King, Gilbert M. Long, John K. Sheldon, Lewis publishers.</p> <p><b>Books:</b></p> <p>General Microbiology, 1995. Schlegel, H.G., Cambridge University Press.</p> <p>Biotechnology, 1996. Smith, J.F., Cambridge University Press.</p> <p>Environmental Biotechnology Principals and applications, 2000. Pruce, R. Hmana, Parry McCarty, McGraw Hill.</p>

<b>Course Title</b>	<b>Aquatic Toxicology</b>
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	<p>Introduction to aquatic toxicology, Major classes of aquatic pollutants, Routes by which pollutants enter the aquatic ecosystem, Determination of toxicity; toxicity testing, trial and tribulation, Toxicity assessment; end points in toxicity (acute vs chronic, lethal vs physiological), Behavioral responses to toxicants, Physiological responses to toxicants, Biochemical responses to toxicants, Cellular and Molecular responses to toxicants, Molecular mechanism of interaction of Inorganics (Metallothioneins), Molecular mechanism of interaction of Organics (Cytochrome P-450), Endocrine disrupters, Genotoxicity, Immunotoxicity, Ecotoxicity.</p> <p><b>Practical:</b> Effects of toxicants on erythrocytes and leukocytes counts and ratio in fish, Effects of toxicants on hemoglobin and glucose in the blood of fish, Effects of toxicants on liver and kidney functions, Effects of toxicants on food intake in fishes, Effects of toxicants on growth (length &amp; weight) in fish, Effects of toxicants on gonadal development in fish, Effects of toxicants on endocrine disruption in fish</p> <p><b>Text Books</b> Aquatic Toxicology: Molecular, Biochemical and Cellular Perspective Donald, C. Malins and Gary, K. 1993, Lewis Publishers USA, 520 pp ISBN 0-87371-545-4</p> <p><b>Suggested Reading:</b></p> <ol style="list-style-type: none"> <li>1. Taylor and Francis: Fundamentals of Aquatic Toxicology: Effects, Environmental Fate and Risk Assessment. 2<sup>nd</sup> Edition, Philadelphia, London</li> <li>2. Landis W G and Yu M H. 1999. Introduction to Environmental Toxicology; Impact of chemicals upon ecological system. 2<sup>nd</sup> Ed. Lewis Publisher Boston, London</li> <li>3. Hyes A W. 1994. Principles and Method of Toxicology. 3<sup>rd</sup> Ed. Raven Press New York</li> <li>4. Crosby D G. 1980. Environmental Toxicology and Chemistry. Oxford University Press, New York</li> </ol>

<b>Course Title</b>	<b>Biodiversity</b>
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	<p>Definition; Types; Levels; Status of Biodiversity; Importance of Biodiversity.  Natural Resources and Biodiversity</p> <ul style="list-style-type: none"> <li>• Ecological aspects of Biodiversity</li> <li>• Impacts on Biodiversity</li> <li>• Loss of Biodiversity</li> <li>• Protection / Conservation of Biodiversity.</li> </ul> <p>Practicals</p> <ol style="list-style-type: none"> <li>4. Critical account (phylogenetic controversies) of some important museums specimens with the help of literature.</li> <li>5. Procedures for studying species richness, Simpson Index, Shannon and Weiner Function.</li> <li>6. Population of some local subterranean animals.</li> </ol> <p>Books Recommended</p> <ol style="list-style-type: none"> <li>3. Biodiversity, Principles and Conservation by Kumar &amp; Asija, 2000.</li> <li>4. The Diversity of Life by C. Mary Jenking and Ann Boyce, 1987.</li> </ol>

## Optional Courses for M.Sc

<b>Course Title</b>	<b>Fundamentals of Entomology</b>
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	<p>General characteristics of insects, Relationship with other Arthropod's, Reasons for success of the insects in diverse environment, General segmentation, Tagmatosis and organization; Detailed structure of cuticle and its biochemistry, Epidermal layer, its structure and function, basement membrane; cuticular outgrowths and appendages; sclerotization, Head sclerites, Antennae, Different modes of ingestion, Different parts and types of mouth parts; Sclerites of neck, Thorax sclerites, legs, its modifications and functions; Wings: origin, different regions, development, basal attachments, main veins and their branches, wing coupling; Secondary appendages and external genitalia, Structure and function of Muscular, Digestive, excretory, respiratory; Incubatory and nervous system, Reproductive organs, different types of reproduction in insects; Egg fertilization and maturation. Embryology up to dorsal closure; Different types of metamorphosis, insect communication.</p> <p><b>Practical:</b> Preparation of permanent slides, all the hard parts (terminal segments, wings, and antennae. Legs, mouth parts and genitalia). Different systems, especially digestive, reproductive of the following insects. American cockroach, Ak grasshopper, Housefly, Butterfly, Mosquito, Red cotton bug, Wasp and honey bee. Mouth-parts of Red cotton bug and Honey bee.</p> <p><b>Books Recommended</b> Text Books: Entomology and Pest management by Pidego,I, 1991.</p> <p><b>Suggested Reading</b></p> <ol style="list-style-type: none"> <li>1. The Insects, an outline of Entomology by Penny J. Gullan and Peter S. Cranston, 2010.</li> <li>2. The Principles of Insect Physiology, 1977, by Wigglesworth</li> </ol>

<b>Course Title</b>	<b>Endocrinology-A</b>
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	<p><b>Syllabus:</b></p> <ol style="list-style-type: none"> <li>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.</li> <li>2. Neuroendocrinology: neural control of glandular secretion, Hypothalamic-pituitary</li> </ol>

	<p>unit, hypophysiotropic neuronal system, hypophysiotropic hormones and neuroendocrine axis. Thyrotropin-releasing hormone, corticotrophin-releasing hormone, growth hormone-releasing hormones, somatostatin, prolactin-regulating factor, GnRH.</p> <ol style="list-style-type: none"> <li>3. Pituitary hormones: adenohypophysis and neurohypophysis hormones and their chemistry, synthesis and release.</li> <li>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.</li> <li>5. Calcitropic and mineral metabolism hormones: chemistry, physiological actions and metabolism of parathyroid hormones, calcitonin and calciferols, homeostasis of calcium, phosphate and magnesium.</li> <li>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.</li> <li>7. Reproductive endocrinology: Testicular and ovarian structure and function, hypothalamic-pituitary-gonadal axis and control of germ cells production.</li> <li>8. Endocrinology of pregnancy: Hormones in conception and implantation, growth factors in implantation, hormonal action and adaptation in pregnancy and parturition.</li> <li>9. Endocrinology of lactation: hormones in lactation</li> <li>10. Overview of endocrine mechanisms in invertebrates</li> </ol> <p><b>Practical:</b>          Demonstration of endocrine glands and associated structures in mouse/ rat dissection.          Histological and immunohistochemical procedures to study the endocrine glands, experiments to demonstrate 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.</p> <p><b>Text Books:</b>          Larsen PR, Konenbergh 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 &amp; Carr 2013 Vertebrate Endocrinology, 5th Edition. Academic Press. US</p>
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<b>Course Title</b>	<b>Ornithology</b>
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	<b>Origin and evolution of birds:</b> The evolutionary origins and evolution of flight,



	<p>Taxonomy and systematic (species and evolution).</p> <p><b>Adaptations for flight:</b> Anatomy and morphology, Feathers (kinds, molt, color), Skeletons, musculature and flight, advantages of flight.</p> <p><b>Adaptations for various environments:</b> Foraging, Physiology, Senses, Migration, Navigation and musculature.</p> <p><b>Ethology:</b> Behaviour, innate vs. learning, Communication, Territory, Flocking, Songs, Courtship, Mating systems, Nest building, Incubation and egg laying.</p> <p><b>Ecology of birds:</b> Predation, Seed dispersal, Pollination, Relations to habitat.</p> <p><b>Biodiversity and Conservation:</b> Threats to biodiversity, Causes and patterns of extinction, Human efforts to conserve biodiversity.</p> <p><b><u>Practical:</u></b></p> <p>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.</p> <p><b><u>Books:</u></b></p> <p>Sandy Podulka, Ronald W. Rohrbaugh, Rick Bonney. 2004. Hand book of Bird Biology. 2<sup>nd</sup> Edition Cornell Lab of Ornithology, ISBN-093802762X, 9780938027621.</p> <p>Gill, F.B. 2007. Ornithology; New York: W.H. Freeman &amp; Company</p> <p>B. Peterson, R.T. 1998. Field Guide to the Birds of Eastern and Central North America: Peterson's Field Guide Series; Boston: Houghton Mifflin.</p>
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<b>Course Title</b>	<b><u>Mammalogy</u></b>
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	<p><b><u>Theory:</u></b></p> <p>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.</p> <p><b><u>Practicals:</u></b></p> <ol style="list-style-type: none"> <li>1. General survey and classification up to species of Mammals of Pakistan</li> <li>2. Skeleton and skull of Cat and Rabbit.</li> <li>3. The vertebral column and appendicular skeleton.</li> </ol> <p><b><u>TextBooks:</u></b></p> <ol style="list-style-type: none"> <li>1. Davis, D., 1963. Principles in Mammalogy. Reinhold Publishers Corporation, New York.</li> <li>2. Gelder, 1969. Biology of mammals. Reinhold Publishers Corporation, New York.</li> </ol> <p><b><u>Recommended Books:</u></b></p>

	<ol style="list-style-type: none"> <li>1. Miller and Harly, 2005. Zoology (6<sup>th</sup> Edition). McGraw Hill, New York.</li> <li>2. Hickman, Roberts, and Larsen, 2005 &amp; 2008. Integrated principles of Zoology (13<sup>th</sup>&amp;14<sup>th</sup> Editions). McGraw Hill, New York.</li> <li>3. George C. Kent and Robert K. Carr, 2001. Comparative Anatomy of the Vertebrates. (9<sup>th</sup> Edition.) Boston: McGraw Hill, New York.</li> <li>4. Vauchan, T.A., Ryan, J.M., Czaplenski, N.J., 2011. Mammalogy. 5<sup>th</sup> Edition, Johns and Bartlett publisher USA.</li> </ol>
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<b>Course Title</b>	<b>Aquaculture Health Management</b>
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	<p>Theory:</p> <p>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.</p> <p>Practicals:</p> <ol style="list-style-type: none"> <li>1.Visit to Government and Private fish Farms.</li> <li>2.Fish diseases, their identification and control measures.</li> </ol> <p>Books Recommended:</p> <ol style="list-style-type: none"> <li>1.Templeton, R.G. 1995. Freshwater Fisheries Management (2<sup>nd</sup> Ed.) Fishing News Books, Blackwell Science, USA.</li> <li>2.Jacques, A. 1999. Management of freshwater Fisheries. Technique et Documentation, Lavoisier, Paris.</li> <li>3.Rounsefell, G.A. and Everhart, W.H. 1963. Fishery Science its methods and application. John Wiley &amp; Sons. Inc., New York.</li> <li>4.Arrignon, J. 1999. Management of Freshwater Fisheries. Oxford &amp; IBH Pu</li> </ol>

<b>Course Title</b>	<b>Insect Pest of Agriculture and their Management</b>
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	<p><b>Syllabus:</b> 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;</p> <p><b>Practical:</b> 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 field visits.</p> <p><b>Text Books:</b></p> <ol style="list-style-type: none"> <li>1. Pedigo, L.P. &amp; M.E. Rice. 2009. Entomology and Pest Management, 6th Edition. Prentice Hall. Upper Saddle River, NJ.</li> <li>2. Ciancio A, Mukerji KG (2010) Integrated Management of Arthropod Pests and Insect Borne Diseases (1<sup>st</sup> edition). Springer., London, UK.</li> <li>3. Radcliffe EB, Hutchison WD, Cancelado RE (2009) Integrated Pest Management: Concepts, Tactics, Strategies and Case Studies (1<sup>st</sup> edition); Cambridge University Press., New York, USA.</li> <li>4. Louis M, Schoonhoven, van Loon JJA, Marcel D (2006) Insect-Plant Biology (2nd edition). Oxford University Press, USA.</li> <li>5. Dhaliwal, G.S. and R. Arora. 2003. Principles of insect pest management. Kalyani Publishers, New Delhi, India.</li> <li>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.</li> <li>7. M. R. Binns, J.P. Nyooop and W. Van der Werf, 2000. Sampling and monitoring in crop protection CABI Publisher</li> </ol> <p><b>Suggested Reading:</b></p> <ol style="list-style-type: none"> <li>1. Pedigo, L.P. &amp; M.E. Rice. 2009. Entomology and Pest Management, 6th Edition. Prentice Hall. Upper Saddle River, NJ.</li> </ol>

<b>Course Title</b>	<b>Biology of Birds and Mammals in Pakistan</b>
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	<p>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.</p> <p>Classification, distribution, life history, evolution, distribution, ecology, behavior, anatomy, and classification of mammals, with emphasis on mammalian species of Pakistan.</p> <p><b>Practical:</b> 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.</p>

	<p><b>Books</b></p> <p>Sandy Podulka, Ronald W. Rohrbaugh, Rick Bonney. 2004. Hand book of Bird Biology. 2<sup>nd</sup> Edition Cornell Lab of Ornithology, ISBN-093802762X, 9780938027621.</p> <p>Vaughan, T. A., J. M. Ryan, and N. J. Czaplewski. 2014. <i>Mammalogy</i>. 6h edition Jones and Bartlett; ISBN-13: 9781284032093.</p>
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<b>Course Title</b>	<b>Fundamentals of Limnology</b>
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	<p>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</p> <p><b>Text Books:</b></p> <ol style="list-style-type: none"> <li>1. Boyd, C.E. and G.S. Tucker. 2009. Pond Aquaculture Water Quality Management. Rashtriya Printers, Delhi. 700p. (ISBN: 978-81-8489-186-7)</li> <li>2. Huet, M., 1986. Text book of fish culture: Breeding and cultivation of fish. 2<sup>nd</sup> Edition. Fishing News Book Ltd. England</li> <li>3. Jhingran, V.G., 1983. Fish and fisheries in India. 2<sup>nd</sup> Edition. Hindustan Publishing Corporation, New Dehli.</li> </ol> <p>Welch, P.S. 1952. Limnology 2<sup>nd</sup> Ed. Mcgraw-Hill Book Company, Inc. New York, 538p.</p>

<b>Course Title</b>	<b>Applied Entomology 3(2-1)</b>
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, Orthoptera, Dictyoptera, Isoptera, Hemiptera, Lepidoptera, Diptera, Hymenoptera, Coleopter. Only diagnostic

	<p>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</p> <p><b>Practical:</b> 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</p> <p><b>Text Books:</b> Entomology and Pest management, 1991 by Pidego,I.</p> <p><b>Suggested Reading</b></p> <ol style="list-style-type: none"> <li>1. The Insects, an outline of Entomology, 2010 by Penny J. Gullan and Peter S. Cranston</li> <li>2. The Principles of Insect Physiology, 1977, by Wigglesworth</li> </ol>
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<b>Course Title</b>	<b>Endocrinology-B</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	<p><b>Syllabus:</b></p> <ol style="list-style-type: none"> <li>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.</li> <li>2. Mechanism of action of 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</li> <li>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.</li> <li>4. Poly endocrine disorders</li> <li>5. Endocrine responsive cancer</li> </ol> <p><b>Practical:</b> 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 anorexia, Studies of hormonal status in puberty and aging.</p> <p><b>Text Books:</b> Larsen PR, Konenbergh HM, Melmed S and Polonsky KS. 2012. Williams</p>

	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
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<b>Course Title</b>	<b>Applied Microbiology</b>
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	<p>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. <u>Microarrays technology</u>, Microbiology of domestic water and sewage. Microbiology of food, milk and milk products. Industrial Microbiology: Scope of industrial microbiology in food production, <u>Metals in yeast fermentation processes</u>, control of insects, human therapy, petroleum, mining and bioremediation, Biotechnology and its role in modern human comforts, <u>Biotechnology and leather industry</u>.</p> <p>Practicals <u>Bacteriological examination of fresh ponds, canal, domestic water</u> Isolation and identification of coliform bacteria Isolation of pathogens Normal throat microflora and its reaction with blood agar Enumeration and identification <u>wounds</u> microorganisms <u>Enumeration and identification of common carp skin microbes</u> Eradication of microbes through physical agents <u>Eradication of microbes</u> through chemical agents Inhibitory zone formation(Bacterial sensitivity tests) Survey of industries based on microbial activities</p> <p>Reference Books 1. <u>Durieux, A and J-P. Simon. 2001. Applied Microbiology. Boston : Kluwer Academic Publishers, Database: WorldCat</u> 2. Nester, E.W., Anderson, D.G., Roberts, C.E., Pearsall, N.N. and Nester, M.T., 2004. <u>Microbiology: A human perspective. McGraw Hill, Higher Education, New York.</u> 3. <u>Kale, V. V. 2007. Applied Microbiology. Publisher: Mumbai : Himalaya Pub. House, Database: WorldCat</u> 4. <u>Hans G. Schlegel. 2002. General Microbiology. VII Ed. Cambridge University Press. UK.</u> 5. <u>James. G. Cappucino. And Natabe Sherman, (2004). Microbiology – A Laboratory Manual, VI Ed., (I Indian Reprint). Pearson Education (Singapore) Pvt. Ltd., India.</u></p>

<b>Course Title</b>	<b>Aquatic Biology</b>
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	<p>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.</p> <p><b>Practical:</b> 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.</p> <p>Text Books: 1: McShaffrey, D. 1992. Comparative functional morphology of larval <i>Stenacron interpunctatum</i> and <i>Rhithrogena pellucida</i> (Ephemeroptera: Heptageniidae) and <i>Ephemerella needhami</i> (Ephemeroptera: Ephemerellidae) with applications in mayfly taxonomy and ecology. Proceedings of the VII International Conference on Ephemeroptera.</p> <p>Suggested Reading: 1: McShaffrey, D. and W.P. McCafferty. 1987. The behavior and form of <i>Psephenus herricki</i> (DeKay) (Coleoptera: Psephenidae) in relation to water flow. <i>Freshwater Biology</i>. 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. <i>Aquatic Conservation: Marine and Freshwater Ecosystems</i> 9:159-178.</p>

<b>Course Title</b>	<b>Sea Food Technology</b>
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

	<p>seafood and their importance in determining food methods of arresting them. Methods of quality evaluation. Preservation methods. Public health aspects of fish products. <u>Biochemical techniques in fish analysis. Technology of fish freezing and fish storage. Thermal processing fish products.</u></p> <p><b>Practical:</b></p> <p><b>1:</b> Evaluation of fish / fishery products for organoleptic, chemical and microbial quality.</p> <p><b>2:</b> Methods for analysis for bacterial quality parameters, chemical parameters and filth.</p> <p><b>3:</b> Evaluation of sanitary conditions in fish processing units.</p> <p><b>4:</b> Analysis of typical hazards. Study of correction and corrective action.</p> <p><b>Text Books:</b></p> <p><b>1:</b> Advances in Fish processing Technology, Sen D. P., Pub. Allied Publishers Pvt. Ltd. New Delhi (2005).</p> <p><b>Suggested Reading:</b></p> <p><b>1:</b> Assessment and Management of Seafood Safety and Quality. (2003) Free aminoacids Technical Paper No. 444.</p> <p><b>2:</b> Fish Processing Technology (1992) G. M. Hull. (Ed), Blackie Academic and Professional, London.</p> <p><b>3:</b> Food borne Disease Handbook. IInd Edn. (2001) Vol.4:Seafood and Environmental Toxins, Marcel Dekker Inc New York.</p>
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<b>Course Title</b>	<b>Ichthyology</b>
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	<p><b>Syllabus:</b> 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.</p> <p><b>Practical:</b></p> <p>1: Study of external features of a bony fish</p> <p>2: Dissection of fish to study various systems.</p> <p>3: Study of scales.</p> <p>4: Study of prepared slides.</p> <p>5: Study of museum.</p> <p><b>Text Books:</b></p> <p><b>1:</b> Lagler, KF. Ichthyology 1984.</p> <p><b>Suggested Reading:</b></p>



	<p>1 Norman J.R. &amp; Greenwood P.H. A history of fishes 1975.</p> <p>2: Ashely and Chiassion. Laboratory Anatomy of Shark and Perch.</p> <p>3: Nikol'skii, Special Ichthyology, 1991.</p> <p>4: B. Collette, Douglas E. Facey, and Brian W. Bowen 2008. 2<sup>nd</sup> Edition ISBN-10: 1405124946</p>
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<b>Course Title</b>	<b>Bio-Physical Methods in Life Sciences</b>
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	<p><b>Syllabus:</b> 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</p> <p><b>Practical:</b> 1: Biomolecular interaction analysis 2: Chromatography techniques 3: Use of spectroscopy technique in lab.</p> <p><b>Text Books:</b> 1: Mary.L. 2013. Membrane Structural Biology. Cambridge University Press</p> <p><b>Suggested Reading:</b> 1: Tapan K. Das. 2014. Biophysical Methods for Biotherapeutics: Discovery and Development Applications. 1<sup>st</sup> Edt. Wiley-Blackwell.</p>

MS/MPhil/PhD Courses:

<b>Course Title</b>	<b><u>Quantitative Zoology</u></b>
Course Code	ZOL-701
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p>Introduction to techniques used for obtaining quantitative information on morphological, anatomical, ecological and ethological variates of animal populations, handling and interpretation of numerical data, application of statistical techniques used in current ZOLogical research.</p> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>1. Simpson, G. G., J. Roe and R.C. Lowenting, 1960. Quantitative Zoology. Harcourt, Brace and World Inc.</li> <li>2. Magurran, A.E.,1988. Ecological Diversity and its Measurements. New Fetter Lane, London.</li> <li>3. Southwood, T.R.E.,1987. Ecological Methods (2<sup>nd</sup> Ed.). Croon Helm, New Fetter Lane, London.</li> </ol>

<b>Course Title</b>	<b><u>Advances in Biodiversity</u></b>
Course Code	ZOL-702
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b>Biodiversity science:</b> Definition, scope and constraints.</p> <p><b>Genetic diversity:</b> Introduction, Nature and origin of genetic variations, measurement of genetic diversity, genetic diversity verses transgenic organisms.</p> <p><b>Species diversity:</b> Introduction, species inventory, history and origin of species diversity, diversity indices based on species, future of species diversity studies.</p> <p><b>Ecosystem diversity:</b> Introduction, Classification, major ecosystem types of World.</p> <p><b>Values and uses of biodiversity:</b> Introduction, biodiversity values, ethical and aesthetic values, precautionary principle, methods for valuation of biodiversity, uses of plants, uses of microbes.</p> <p><b>Loss of biodiversity:</b> Introduction, loss of genetic, species and ecosystem diversity, related factors and processes that cause the loss,</p> <p><b>Conservation of biodiversity:</b> Why conservation and conservation biology, current practices in conservation, conservation of genetic species and ecosystem diversity, top-down and bottom-up protocols for conservation, In-situ and ex-situ conservation, social approaches to conservation, role of Universities and other</p>

	<p>educational institutions in biodiversity conservation, sustainable development.</p> <p><b>Agrobiodiversity and cultivated taxa:</b> Introduction, origin and evolution of cultivated species diversity, diversity in domesticated species, feral plants, domesticated microbes.</p> <p><b>Management of biodiversity:</b> Introduction, organizations associated with biodiversity management, biodiversity Legislation and Conventions.</p> <p><b>Biodiversity and biotechnology:</b> Introduction, biotechnology and its role in assessment of biodiversity and bioresources, adverse impacts of biotechnology on biodiversity.</p> <p><b>Practicals:</b> Critical account of some important museum specimens, Procedures to determine the species richness, Review of diversity indices (Simpson's index Shannon and Wiener function), Procedures to determine the subterranean animal population, Population estimation procedures.</p> <p><b>Text Books:</b></p> <ol style="list-style-type: none"> <li>1. Biodiversity, Principles and Conservation by Kumar and Asija, 2000.</li> <li>2. The Diversity of Life by C. Mary Jenking and Ann Boyce, 1987.</li> <li>3. An Advanced textbook on Biodiversity, Principles and Practices by K.V. Krishnamurthy, 2007.</li> </ol>
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<b>Course Title</b>	<b><u>Immunology</u></b>
Course Code	ZOL-703
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b></p> <p>Overview of the immune system Historical perspective, innate and acquired immunity. Cells and organs of immune systems Hematopoiesis, lymphatic cells, Mononuclear cells Dendritic cells, primary lymphatic organs, leukocyte recrudescences. Antigens: immunologic properties of Antigens factors affecting antigenicity, epitopes, Haptens, and study of antigenicity, viral and bacterial antigens, mitogens, Immunoglobulin structure and function basic structure, sequencing studies, fine structure, receptor complex, Antigenic determinations, Isotype and super family, Antigen antibody interactions strength, cross reactivity, precipitation, agglutination reaction RIA and ELISA, western blotting, immunofluorescence. Organization and expression of immunoglobulin genes genetic models compatible with immunoglobulin structure. Multigene organization of Ig genes variable region rearrangement, regulation of Ig gene transcription, generation of Ab diversity, class switching among constant region genes. Expression of Ig genes, Major histocompatibility complex (MHC). General organization and inheritance of MHC. Class I MHC molecules and genes, Polymorphism of class I and II MHC genes, class III MHC molecules, mapping of MHC and its expression. Antigen processing and presentation: self MHC restriction of T-cells role of Ag presenting cells, receptor complex, T-cell receptor Organization and rearrangement of TCR genes T-cell receptor complex, TCR (i) 3 T-cell accessory membrane molecules TCR-MHC-Antigen interaction. Cytokines: General properties discovery and purification, structure and function, receptors,</p>

	<p>antagonists, recreation and Biological activity of TH-1 and TH-2 subsets. Generation of humoral immune responses, Kinetics, experimental systems, identification of cells required for induction of humoral immunity, Cell mediated immunity, Direct and delayed type cytotoxic and hypersensitivity responses. Transplantation immunology graft reflection. Immunodeficiency diseases. Classification, phagocytic humoral, cell mediated and combined humoral and cell mediated deficiencies, complement mediated deficiencies.</p> <p><b><u>PRACTICALS</u></b></p> <p>Detection of Ab, Primary immune response, Secondary immune response, Demonstration of Ab specificity, Estimation of antibodies, Separation of various types of immunoglobulins, Microscopic study of various organs of immune system, Immune responses in stress, Estimation of globulins, Demonstration of enzyme linked immunosorbent assay, Demonstration of radioimmuno assays.</p> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>1. KUBY'S IMMUNOLOGY, 2000. 4<sup>th</sup> ed. Richard, A., Goldsby, Thomas, J. Kindt and Barbara, A. Osborn, W.H. Freeman &amp; Company, New York.</li> <li>2. CELLULAR AND MOLECULAR IMMUNOLOGY, 1994, 2<sup>th</sup> ed. Abbas Lichtman &amp; Pober, W.B. Saunders Co. Biotechnology. ASM, Washington DC, USA.</li> </ol>
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<b>Course Title</b>	<b>Advances in Recombinant DNA Technology</b>
Course Code	ZOL-704
Credit Hours	3(2-1)
Theory	2
Practical	1
Follow up	
Category	MPhil Zoology, 02-Years Programme
Aims and Objectives	<p>The course will provide to:</p> <ol style="list-style-type: none"> <li>1. Study the advanced applications of molecular biology.</li> <li>2. Study the role of the genes, enzymes, proteins and their modifications by genetic engineering techniques.</li> <li>3. Construct the transgenic plants and animals for research, diagnosis, medicine and health for the advanced applications of recombinant DNA technology in industry, Food, agriculture and environment.</li> </ol>
Learning Outcomes	<p>On completion of this course student will have improved ability:-</p> <ol style="list-style-type: none"> <li>1. To know the importance of recombinant DNA technology to understand the mechanism of construction the genes to understand the regulation and function of biomolecules.</li> <li>2. To gain the knowledge in modification of genes and their function by constructing the transgenic plants and animals for research, Health and medicine.</li> <li>3. To know the significance of recombinant DNA technology and its wide applications in various fields-- industry, Food, agriculture and environment.</li> </ol>
Syllabus in Brief	<b>Introduction to Recombinant DNA technology:</b> Introduction and importance of recombinant DNA technology. Vectors: Structure and function of cloning and expression vectors. Regulatory sequences of prokaryotic and eukaryotic genes. Different host systems for cloning and expression. Transformation techniques:

physical, chemical and biological.

**Important enzymes used in the recombinant DNA technology:** nucleases, restriction endonucleases, RNases, DNA and RNA polymerases, ligases, DNA methylases, phosphatases, kinases, topoisomerases. Construction and screening of genomic and cDNA libraries.

**Advanced techniques used in recombinant DNA technology:** Isolation of DNA and RNA. Estimation of purity and quantity of nucleic acids, Polymerase chain reaction (PCR), Autoradiography, DNA sequencing. Detection of DNA, RNA and proteins by Southern blotting, Northern blotting, western blotting and *in situ* hybridization techniques. Site specific mutagenesis, Gene mapping and Microarrays.

**Applications of recombinant DNA technology in Medicine and Health**

Genetically modified microbes and animals (Recombinant bacteria for the production of commercial scale production of proteins and pharmaceuticals, antibiotics, enzymes, insulin, growth hormones, monoclonal antibodies).

Applications of rDNA in diagnosis of pathogens and abnormal genes. Genetically modified insect cells for the production of commercially important bioproducts.

**Applications of recombinant DNA technology in agriculture, industry and environment:** Industrial production of specialty chemicals and proteins: organic molecules and commercially important proteins. Biosafety regulations and evaluation of genetically modified microorganisms (GMOs) and animals.

**Practicals**

1) Introduction to recombinant DNA technology tools.

2) Cell disruption

3) Isolation of plasmid and chromosomal DNA from bacteria and yeast.

4) Protein precipitation by  $\text{NH}_4\text{SO}_4$  by solvent methods and its recovery

5) Protein purification by chromatography.

6) Cloning: transfer a gene into plasmid vector and transformation into bacteria.

7) Screening and characterization of transformed cells.

8) Estimation and Isolation of total DNA from tissues/cells

9) Characterization of DNA by AGE/Southern blot

10) Detection of recombinant proteins by Western blotting

11) Amplification of target DNA by PCR

12) Isolation and quantification of RNA

**Recommended Books:**

1. Russell, David W, Sambrook, Joseph (2001). Molecular cloning: a laboratory manual. volumes I - III. Cold Spring Harbor laboratory Press, USA.

2. Channarayappa (2006) Molecular Biotechnology: Principles and Practices. Universities Press (India) Pvt. Ltd. Worldwide publishing: CRC Press, Taylor and Francis.

3. David S Latchman (1994) From Genetics to Gene Therapy – the molecular pathology of human disease by, BIOS scientific publishers, sixth edition.

4. Old RW and Primrose SB (1993) Principles of gene manipulation, an introduction to genetic engineering. Blackwell Scientific Publications.

5. Benjamin Lewis (2008) Genes VIII. Oxford University & Cell Press

6. Channarayappa (2010) Cell Biology. Universities Press (India) Private Limited.

7. Setlow J.K., Genetic Engineering; Principles and Methods. Kluwer Academic Publishers. 2000.

8. Nicholl D.S.T., An Introduction to Genetic Engineering, Cambridge University Press, 2002.

9. Hartl, D. L. and E. W. Jones. 2009 Genetics: Analysis of Genes and Genomes. Seventh (7th) Edition. Jones and Bartlett Publishers. USA.

<b>Course Title</b>	Biotechnology
<b>Course Code</b>	ZOL-705
<b>Credit Hours</b>	3
<b>Theory</b>	2
<b>Practical</b>	1
<b>Follow up</b>	
<b>Category</b>	MS/PhD Zoology, 02-Years Programme
<b>Aims and Objectives</b>	
<b>Learning Outcomes</b>	
<b>Syllabus in Brief</b>	<p><b><u>Theory</u></b>  Application of biotechnology in industry; biotechnology of raw ore processing (bleaching of sulphides, carbonates, silicates etc.), accumulation of metals by microbial cells, biopulping, biofuels, microbial enhanced oil recovery; application in agriculture, food and livestock products; biofertilization, crop improvement, biocontrol of noxious plants and animals, production of cheese, probiotics, bread, single cell protein, citric acid, amino acid, acetic acid, production of drinks; application related to environmental concerns: various types of environmental pollutants, waste management and bioremediation; microbial enzymes in industry, enzyme immobilization, application of recombinant DNA technology with comprehensive theoretical know-how macromolecules of desired characters for transgenic.</p> <p><b><u>PRACTICALS</u></b>  Experimental design, Techniques in biotechnology: cell lysate preparation, gradient and zonal centrifugation, gel-electrophoresis, HPLC, Southern, Northern and Western blotting, PCR technology; screening of enzymes of industrial significance, enzyme immobilization; Case studies: production of cheese, yogurt, citric acid, amino acid, acetic acid.</p> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>1. Rehm, J.J., 1988. Biotechnology Fundamentals, VCH Publishers, N. Y.</li> <li>2. Lee, B.H., 1996. Fundamentals of Food Biotechnology, VCH Publishers, N. Y.</li> <li>3. Pirt, J.B., 1975. Microbes and Cell Cultivation, Blackwell scientific Publishers, London.</li> <li>4. Bailey, J.E., and Ollis, D.F., 1986. Biochemical Engineering Fundamentals, McGraw Hills.</li> <li>5. Watson, J.D., Tooze, J. and Kurtz, D.T., 1983. Recombinant DNA- A short course, Scientific American Books, New York.</li> <li>6. Old, R.W. and Primrose, S.B., 1989. Principles of gene manipulation. 4<sup>th</sup> edition, Blackwell scientific Publishers, London.</li> <li>7. Molecular cloning, 1989. A Laboratory manual, 2<sup>th</sup> edition, Cold Spring Harbor Laboratory.</li> <li>8. Higgins, I.J., Best, D.J. and Jones, J., 1988. Biotechnology Principles and Applications. Blackwell scientific Publishers, London.</li> <li>9. Rehm, J.J., 1988. Biotechnology: Special Microbial Process, Vol. 6b, VCH Publishers, N. Y.</li> <li>10. Demain, A.L. and Solomon, N.A., 1986. Manual of Industrial Microbiology and</li> </ol>

<b>Course Title</b>	<b>Reproductive Physiology</b>
Course Code	ZOL – 706
Credit Hours	3(2+1)
Theory	2
Practical	1
Follow up	Developmental Biology
Category	Mphil/PhD
Aims and Objectives	<ul style="list-style-type: none"> <li>• To develop the knowledge of general morphological aspects of male and female reproductive systems</li> <li>• To develop the insight on molecular basis of development of male and female reproductive machinery including spermatogenesis and oogenesis</li> <li>• To understand the endocrine control of reproductive systems</li> <li>• To develop the ability to assess the abnormal reproductive systems</li> <li>• To polish the intellectual and comprehension skills to address the human or animal reproduction related problems and modern trends to secure fertility</li> </ul>
Learning Outcomes	
Syllabus in Brief	<p><b>1.Introduction</b>  Brief outline with its current trends and anticipated outcomes</p> <p><b>2.Genetic and cellular differentiation basis of two sexes</b>  Genetic and development of internal and external genitalia  and postnatal growth of testis and ovary</p> <p><b>3.Testicular and ovarian structures and functional organization</b>  Differentiation of spermatozoa  Events in Spermatogenesis, spermiogenesis, spermatogenic cycle and wave  of follicular growth, preovulatory growth, ovulation  Corpus luteum formation, maintenance and luteolysis  Overview of ovarian cycle</p> <p><b>4.Endocrine regulation of gonadal function</b>  Hypothalamic-Hypophysial axis  Steroid hormone regulation and pituitary-Leydig cell axis  Regulation of Follicular and luteal phases in menstrual cycle</p> <p><b>5.Fertilization, implantation and placenta establishment</b>  Transport of spermatozoa in female tract  Fertilization and activation  Embryo establishment and development initiation  Molecular basis of embryo implantation  Development of fetus and fetal membranes</p> <p><b>6.Maternal endocrine support of pregnancy</b>  Role of progesterone, oestrogens and hCG</p> <p><b>7.Lactation</b>  Endocrine systems in mammary glands of mammals  Somatosensory pathways in suckling-induced reflex release of prolactin and oxytocin</p> <p><b>Practical:</b></p> <ul style="list-style-type: none"> <li>• Demonstration of male and female reproductive systems in mice or rat through dissection</li> <li>• Fundamental approaches for histology and staining of cross sections</li> <li>• Cellular dissection of testicular cross sections</li> <li>• Recognition of spermatogenic stages on the basis of cellular architecture in seminiferous tubule</li> </ul>

	<ul style="list-style-type: none"> <li>• Determination of estrus cycle's stages by vaginal smear technique</li> <li>• Primordial, preantral, antral and preovulatory follicles</li> <li>• identification in ovarian cross section of adult mice</li> <li>• Introduction to assisted reproductive techniques (ART) for male with infertility problems</li> <li>• Fundamental parameters of semen analysis in Andrology lab</li> <li>• Sperm morphology criteria and indices of multiple sperm defects</li> <li>• Sperm preparation techniques for IUI, IVF and ICSI</li> <li>• General techniques of sperm function tests such as reactive oxygen species and infertility</li> <li>• Assessment of acrosome reaction</li> </ul> <p><b>.Text Books:</b></p> <ol style="list-style-type: none"> <li>1. Knobil, E. and Neill, J.D., et al., 1994. The Physiology of Reproduction, Vol. 1&amp;2; 2<sup>nd</sup> Edition, Raven Press, New York.</li> <li>2. Wilson, J.D., Foster, D.W., Kronenberg, H.M. and Larsen, P.R., 1998. William's Textbook of Endocrinology, 9<sup>th</sup> Edition, W.B. Saunders Company, Philadelphia</li> <li>3. Johnson, M.H. and Everitt, B.J. 2000. Essential Reproduction, 5<sup>th</sup> Edition. Blackwell Sciences Inc., Oxford.</li> <li>4. World Health Organization 1999. WHO Laboratory Manual for the examination of human semen and sperm –cervical mucus interaction. 4th Edition, Cambridge University Press, UK.</li> <li>5. Grinnell A. and Barber A.A. 1976. Laboratory Experiments in Physiology, 9th edition, CV Mosby company USA</li> <li>6. Nieschlag, E., Behre, H.M., and Nieschlag, S. 2010. Andrology: Male Reproductive Health and Dysfunction, 3<sup>rd</sup> Edition. Springer-Verlag Berlin Heidelberg, Germany.</li> </ol>
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<b>Course Title</b>	<b>Population Genetics</b>
Course Code	ZOL-707
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	M.Phil Zoology, 02-Years Programme
Aims and Objectives	To acquaint the students to the principles of genetics and statistics that's relevant to population studies, and to the forces affecting genetic variation from the molecular to the organismic level. Further it deals with evolutionary forces of mutation, migration, natural selection in all its varieties, and genetic drift. Quantitative genetics is covered from the standpoint of genetic variance and covariance components.
Learning Outcomes	The students will be able to achieve the aims and objectives of this course.
Syllabus in Brief	Theory <u>Introduction</u> to Population Genetics; Scope and Premises of Population Genetics; Types of population genetics; <u>Population Structure</u> : Basic concepts of population genetics; Definitions (population Genetics, Phenotype and phenotypic variation, Gene and allele, Allele frequencies; Genotype and genotypic variation, Polymorphism, Ecological and genetical differentiation of Population, Population structure- levels of population structure-individual population, subpopulation and total population); The Hardy-Weinberg principle and linkage equilibrium; Hardy-Weinberg equilibrium for



	<p>multiple alleles and loci; Demonstration of Hardy-Weinberg Equilibrium in laboratory population and natural populations. Assumption and expectation; calculating allele frequencies ; Forces shaping genetic diversity – Mutation, Migration, Recombination, Selection, Drift, Effective population size, decreasing population and its consequences; Reproduction and mating systems: outbreeding, inbreeding, random and non-random mating-classified and inbreeding; Calculation of inbreeding coefficients, Inbreeding depression, mating system evolution</p> <p><u>Phenotypes and Genotypes: Quantitative Genetics</u> -Population means, average effects, breeding value, dominance deviation, interaction deviation. Genotypic components of variance; Genetic variation in space and time; Environmental variance; Natural variation in population; Measuring genetic variance, Types of genetic variance; The unmeasured Genotype Approach-familial aggregation, relative risk, family studies, twin studies, adoption studies,</p> <p><b>Practicals:</b></p> <ul style="list-style-type: none"> <li>• Problems on changes in gene frequencies under migration, mutation, selection and genetic drift.</li> <li>• Demonstration of Hardy-Weinberg Equilibrium in laboratory population and natural populations.</li> <li>• Estimation of phenotypic, genotypic and environmental variances.</li> <li>• Partitioning of genetic variance into additive, dominance and epistatic components, and estimation of heritability in broad and narrow sense.</li> <li>• Calculation of inbreeding coefficients through pedigrees</li> <li>• Estimations of genetic covariance through pedigrees.</li> </ul> <p><b>Recommended Books:</b></p> <ul style="list-style-type: none"> <li>• Hartl D.L., and Andrew G. Clark (1997). Principles of Population Genetics, Sinauer Assoc; 1997</li> <li>• Lynch M. and Walsh, B. (2002). Evolution and Selection of Quantitative Traits, Sinauer Associates.</li> <li>• Kang M.S. (2002). Quantitative Genetics, Genomics, and Plant Breeding, CABI Publishing, CAB International.</li> <li>• Falconer D. S. and Trudy MacKay, F. C. (1996). Introduction to Quantitative Genetics, 4th edition, Addison-Wesley Pub Co.</li> <li>• Kearsley M.J. and Pooni, H. S. (1996). Genetical Analysis of Quantitative Traits, Stanley Thornes Pub Ltd.</li> <li>• Weir B. (2002) Genetic Data Analysis III, Sinauer Assoc.</li> <li>• Hedrick P.W. (2000). Genetics of Populations, Jones and Bartlett Pub.</li> </ul>
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<b>Course Title</b>	<b>Comparative vertebrate endocrinology</b>
Course Code	ZOL-708
Credit Hours	3(2+1)
Theory	2
Practical	1
Follow up	Endocrinology A &B
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	To understand the evolutionary aspects of endocrine gland and their secretions in vertebrates
Learning Outcomes	To nurture the students knowledge of endocrine systems and their significance in normal body function
Syllabus in Brief	1. Introduction: neural versus humoral coordination, what is comparative

	<p>endocrinology?, Occurrence of vertebrate hormones in other organism, diversity of vertebrate hormones</p> <ol style="list-style-type: none"> <li>2. Comparative morphology of endocrine tissue: comparative morphology of the pituitary, hypothalamus, thyroid, parathyroid and ultimobranchial bodies, adrenals, hormones of gut and gonads putative endocrine glands</li> <li>3. Life history of hormones: Synthesis, release of hormones, concentration of hormones in circulation, transport of hormones, mechanism of action of hormones</li> <li>4. Structural and functional Heterogeneity and evolution in hormones: Function of Pituitary secreting hormones, Hormonal stimulation and inhibition of the pituitary via hormones of the endocrine hypothalamus (TRH, SRIH, GHRH, GnRH, CRH), origin and evolution of hormones and hormone receptors</li> <li>5. Role of thyroid hormones in development and metabolism,</li> <li>6. Hormonal control of calcium homeostasis: parathyroid hormone, cholecalciferol derivatives, calcitonin, stanniocalcin Hormones of the adrenal medulla (catecholamines) and the adrenal cortex (glucocorticoids, mineralocorticoids)</li> <li>7. Hormones involved in reproductive physiology and sex differentiation (androgens, oestrogens, progestagens, AMH, inhibins/activins)</li> <li>8. Endocrinology of Pregnancy: Hormones in conception and implantation; Hormonal actions and adaptation in pregnancy and parturition.</li> <li>9. Endocrinology of Lactation: Hormones in lactation.</li> <li>10. Other hormonal systems (renine-angiotensine-system, natriuretic peptides, hormones of the urofysis, melatonin) Interaction between hormones and pheromones in endocrine processes</li> </ol> <p><b>Practical:</b> Demonstration of endocrine glands and associated structures in mouse/ rat dissection. Histological and immunohistochemical procedures to study the endocrine glands, Perform experiments on animals or on animal tissues to investigate the function of a specific hormone. Examples are the effect of insulin on circulating glucose levels and the effect of oxytocin on uterus contractions and the way this is influenced by neurotransmitters. Hormone assessment techniques including RIA and ELISA with standard curve preparation.</p> <p><b>Text Books:</b> Comparative Endocrinology" by A. Gorbman et al. (1983) Vertebrate Endocrinology by D. O. Norris (2007, 4th Edition), Comparative Vertebrate Endocrinology" by P.J. Bentley (1988, 3rd Edition) Hadley, M.E. and Levine J.E. 2007. Endocrinology, 6th n. Pearson Prentice-Hall, Pearson Education Inc., New Jersey. ms textbook of endocrinology, 9<sup>th</sup> Edition, W.D. Saunders Company, Philadelphia.</p>
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<b>Course Title</b>	<b>Biochemistry of Drug Action</b>
Course Code	ZOL-710
Credit Hours	3(2+1)
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	

**Theory**

Introduction: Drug sources, drug and active principle, drug development. Principles routes of drug administration, intestinal mucosa and blood barriers, bioavailability of a drug, first pass metabolism, drug distribution, blood tissue barriers, binding of drug to plasma proteins. Biotransformation of drugs, drug elimination, cellular and metabolic tolerance to a drug. Drugs acting on the sympathetic nervous system: Structure and function of sympathetic nervous system, adrenoceptor subtypes and catecholamine actions, direct and indirect sympathomimetics and sympatholytics, drugs used in hypertension, angina, cardiac arrhythmias and heart failure. Drugs acting on parasympathetic and motor nervous system: Structure and function of parasympathetic and motor nervous system, cholinergic synapse, neuromuscular blocking agents, neuromuscular stimulants, parasympathomimetics, parasympatholytics. Drugs used in hyperlipoproteinemias: lipoprotein metabolism, hyperlipoproteinemias, drug treatment. Drugs acting on the central nervous system: neurotransmission in the brain, dopaminergic and serotonergic synapse. CNS stimulants, CNS depressants, anxiolytics, neuroleptics, antidepressants, opiates, addiction, Hallucinogens, antiparkinsonians, antiepileptics. Antihistaminergic drugs: Allergens, IgE, histamine, histamine receptors, asthma, hay fever and anaphylaxis, peptic ulcer, drugs for the treatment. Analgesics and antipyretic analgesics: pain mechanism and pathways, thermoregulation and antipyretics, drugs used for analgesic anti-inflammatory and antipyretic activity. Diuretics: NaCl reabsorption in the kidney, osmotic diuretics, diuretics of the sulphonamide type, carbonic anhydrase inhibitors, loop diuretics, thiazide diuretics, potassium sparing diuretics. Antibacterial drugs: Bacterial infection, bactericidal and bacteriostatic effects, bacterial resistance, inhibitors of cell wall synthesis, inhibitors of tetrahydrofolate synthesis, inhibitors of DNA function, inhibitors of protein synthesis.

**PRACTICALS**

To estimate salicylate in the blood of sodium salicylate injected rabbits and in an aspirin tablet. To determine half life and AUC of a drug. To study the effect of time on biological response of a drug. To determine biological response of a drug at various doses and plot dose response curve. Determination of ED<sub>50</sub> and efficacy of a drug. To study the effect of an antagonist on agonist-induced biological response. To monitor stimulatory effects of a CAN stimulant in rats. To monitor sedative effects of a CNS depressant in rats.

**BOOKS RECOMMENDED**

1. Hardman, J.G., Limberd, L.E., Molinoff, P.B., Ruddon, R.W., Goodman, L.S. and Gilman, A., 1996. Goodman & Gilman's The Pharmacological basis of Therapeutics, 9<sup>th</sup> ed. The McGraw Hill Companies.
2. Smith, C.M. and Reynard, A.M., 1995. Essentials of Pharmacology. WB Saunders Company.
3. Lullmann, H., Mohr, K., Ziegler, A. and Bieger, D., 1993. Pocket Atlas of Pharmacology. Thieme Medical Publishers, Inc. New York.
4. Haleem, D.J., 1994. Neurochemistry of Drug Action. BCC & T Press Karachi Univ.
5. Walker, R., 1994. Clinical Pharmacy and Therapeutics. Longman Singapore Publishers.
6. Eadie, M.J., 1992. Drug Therapy in Neurology. Longman Group UK Limited.
7. Rose, K.M., Rosenfeld, G.C. and Loose-Mitchell, D.S., 1991. Pharmacology, William and Wilkins, New York.
8. Rayall, R.W., 1989. Mechanism of drug action on the central nervous

	<p>system. Cambridge University Press.</p> <p>9. Neal, M.J.,1997. Medical Pharmacology at a glance. Blackwell Scientific Publication, Oxford, Londong.</p> <p>10. Katzung, B.G., 1995. Basic and Clinical Pharmacology. Lange Medical Publications, California.</p> <p>11. Harvey, R.A. and Champe, P.C., 2000. Pharmacology (Lippincott Illustated Reviews). J.P. Lippincott and Company.</p>
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<b>Course Title</b>	<b>Helminthology</b>
Course Code	ZOL-711
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b>  Introduction to the phylum platyhelminthes, Trematoda, Aspidothria, Trematoda, Form, Function, Life cycle and Classification of digeneans, Digenians, strigeiformes, <i>Schistosoma haematobium</i>, <i>S. japonicum</i>, <i>S. mansoni</i> (Schistosomiasis); Digeneans Echinostomiformes; Fasciola hepatica, F gigantia, Paramphistomum cervi.</p>

<b>Course Title</b>	<b>Human Genetics</b>
Course Code	ZOL-712
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	M.Phil Zoology, 02-Years Programme
Aims and Objectives	This course attempts to walk the students through classical genetics and molecular genetics with a cautionary endnote on range of ethical, legal and social issues which are also the logical consequences of such unparalleled scientific progress.
Learning Outcomes	To impart the full command over the subject starting with application of a variety of conventional and modern tools limitations of genetic methodology when applied to humans would be discussed. Application of mapping tools and current knowledge on genetic variations in health and disease across populations and their clinical/diagnostic implications would be dealt subsequently
Syllabus in Brief	Theory: Introduction to Human Genetics: History; Early perception, development and documentation; Genome organization; Genetic variation in health and disease: Chromosome structure, function and implications for disease. Study tools in Human Genetics: Pedigree analysis- Mendelian inheritance and exceptions; Chromosomal analysis (in vitro, in vivo), Biochemical analysis; Somatic cell genetics (somatic cell hybrids, monochromosome hybrid panels), gene mapping: deletion mapping and duplication mapping, Genetical basis of cancer, Eugenics, Twin studies. Human genetic diversity: Tracing human migrations with autosomal, Y-chromosomal and mitochondrial markers. Ethical, legal and social issues in Human genetics:

	<p><b>PRACTICALS</b></p> <ol style="list-style-type: none"> <li>1. Study of different qualitative and quantitative traits.</li> <li>2. Pedigree analysis (Screening of metabolic and other disorders).</li> <li>3. Analysis of sex chromosomes in Inter-phase nuclei.</li> <li>4. Karyotyping of normal and abnormal human chromosomes.</li> <li>5. Dermatology of normal and mentally retarded individuals.</li> <li>6. Problems solving on genetic counselling.</li> </ol> <p><b>BOOKS RECOMMENDED:</b></p> <ul style="list-style-type: none"> <li>• Falconer, D.S.,(1989). Introduction to Quantitative Genetics, Longman, London.</li> <li>• Li., C.C. (1963). Population Genetics, University of Chicago Press.</li> <li>• Crow, J.F., and Kimura (1970). An Introduction to Population Genetics Theory, Harper &amp; Row, New York.</li> <li>• Strachan, T. and Andrew P. (1999). Human Molecular Genetics, 2nd Edition, Wiley-Liss</li> <li>• Ehrilch P.R. (2002). Human Natures: Genes, Cultures, and the Human Prospect, 1st Edition, Penguin USA Paper,</li> <li>• Relethford J.H.(2001). Genetics and the Search for Modern Human Origins, Wiley-Liss.</li> <li>• Annual Review of Genomics and Human Genetics (2001) (Annual Review of Genomics and Human Genetics, Vol 2, Annual Reviews.</li> <li>• Dennis C., Gallagher, R. and Watson, J. (2002). The Human Genome, 1st Edition, Palgrave.</li> </ul> <p><b>Suggested readings:</b></p> <ul style="list-style-type: none"> <li>• TVogel F. and. Motulsky A. GT, (1997). Human Genetics: Problems and Approaches. Springer Verlag</li> <li>• Pasternak J . (1999). An Introduction to Human Molecular Genetics: Mechanism of Inherited Diseases. Fitzgerald Science Press</li> <li>• Bickmore W. A.(2006) Chromosome Structural analysis: A Practical Approach (Ed.) 3rd edition. Oxford University Press</li> <li>• Barch MJ, Knutsen T and Spurbeck JL (eds) (1997) The AGT. Cytogenetics Laboratory Manual, 3rd ed. Raven publications.</li> <li>• Rooney D. E. Human Cytogenetics: Constitutional analysis (Ed) . Oxford University Press</li> </ul>
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<b>Course Title</b>	<b><u>Human Embryology and Teratology</u></b>
Course Code	ZOL-713
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b></p> <p>Formation of normal and abnormal gametes and their relation to age, gastrulation and implantation. Formation of basic organ rudiments. Development of fetal membranes and formation of the placenta. Embryonic and fetal growth. Brief description of development of various body systems. Congenital malformations and their causes.</p> <p><b><u>PRACTICALS</u></b></p>

	<p>Study of mammalian gonads and gametes. Study of whole mounts and sections of various mammalian embryos. Experimental manipulation of live embryos.</p> <p><b><u>BOOKS RECOMMENDED (LATEST EDITIONS)</u></b></p> <ol style="list-style-type: none"> <li>1. Moore, K.L., 1982. <i>The Developing Human</i>, Saunders.</li> <li>2. Largman, J., 1981. <i>Medical Embryology</i>, William and Wilkins.</li> <li>3. Snell, R.S., 1983. <i>Clinical Embryology</i>, Little Brown.</li> </ol>
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<b>Course Title</b>	<b>Molecular Biology</b>
Course Code	ZOL-714
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD
Aims and Objectives	To impart knowledge about the molecular biology of animal cell and the unified role of macromolecules for the ultimate sustainability of the organisms
Learning Outcomes	The students will be able to achieve the aims and objectives of this course.
Syllabus in Brief	<p>Prokaryotic and eukaryotic structure and classification particularly with reference to DNA. Nucleus: Chromatin, heterochromatin, euchromatin, DNA, RNA physical and chemical structure, DNA replication (mechanism, DNA replication in prokaryotes specially with reference to variety of DNA polymerases and other proteins involved, DNA replication in Eukaryotes with special reference to DNA polymerases, DNA repair, Transcription, posttranscriptional processing of RNA, Genetic code, point mutations, Translation (with reference to the specific role of Ribosomes, various factors, and posttranslational processing), Regulation of Gene Expression, role of promoter and operator, Lac operon, Gene Regulation in Eukaryotes; role of promoter and diverse transcription factors involved, Recombinant DNA technology, molecular tools involved: vectors, enzymes, expression system; DNA sequencing, PCR techniques, Molecular biology of DNA and RNA viruses and yeast. Molecular immunology, Cell cycle regulation, Oncogenes and cancer.</p> <p><b>Practical:</b></p> <ol style="list-style-type: none"> <li>1. Quantitative estimation of various macromolecules (DNA, RNA, Protein).</li> <li>2. Demonstration of properties of these macromolecules.</li> <li>3. Methods of bacterial culture.</li> </ol> <p><b>Text Books:</b></p> <ol style="list-style-type: none"> <li>1. Allison, L.A. 2007. <i>Fundamental Molecular Biology</i>. Blackwell Pub. Comp.</li> <li>2. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Scott, M.P., Bretscher, A., Ploegh, H and Matsudaira, P. 2008. <i>Molecular Cell Biology</i>, 6<sup>th</sup> edition. Freeman &amp; Comp. New York.</li> <li>3. Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K and Walter, P. 2002. <i>Molecular Biology of the Cell</i>. Garland Science, New York.</li> <li>4. Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K and Walter, P. 2008. <i>Molecular Biology of the Cell</i>, 5<sup>th</sup> edition. Garland Science, New York.</li> <li>5. Karp, G. 2002. <i>Cell and Molecular Biology: Concepts &amp; Experiments</i>. John Wiley &amp; Sons, New York.</li> </ol>

<b>Course Title</b>	<b>Molecular Physiology</b>
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Course Code	ZOL-715
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b></p> <p>Overview of resting membrane, action potential and synaptic transmission; Structure and mechanisms in ion channels; Biosynthesis of neurotransmitters; Neurotransmitters actions at synaptic receptors. Neurosecretions and neurotransmitters in higher nervous system activity.</p> <p>Molecular mechanisms in transduction of sensory stimuli into impulse; photochemistry and transduction of photoreceptor; Color vision.</p> <p>Overview of endocrine glands, their hormones and roles; Chemistry and biosynthesis of hormones of adenohipophysis, thyroid, parathyroid, endocrine pancreas, adrenal medulla and steriodogenic tissues; Metabolism of thyroid and steriodogenic tissues; Structure of hormone receptors; Mechanisms of action of a protein/peptide, a steroid and thyroid hormone; Hormonal regulation of metabolism; Molecular basis of muscular contraction; Molecular interaction at neuromuscular level; Molecular structure of cilia and flagella and mechanisms in movements.</p> <p>Automicity and rythmicity of myogenic heart; Regulation of cardiac activity; Humoral regulation of circulation: Vasoconstriction and vasodilation. Exchange of respiratory gases; Chemical regulation of respiration. Nature and formation of various nitrogenous waste product; Glomerular filtration, reabsorption and secretion mechanisms; Concentration of urine. Regulation of digestive secretions; Digestion and absorption of nutrients.</p> <p>Molecular mechanisms in adaptation to temperature extremes.</p> <p><b><u>PRACTICALS</u></b></p> <p>Study of post synaptic receptor mechanisms in neuromuscular preparation of frogs; Experiments to study molecular responses to hormones. Study of hormones receptors in differing hormonal circulation levels; Ultra-structure study of muscle structure for muscle contraction. Effect of chemicals and drugs on cardiac activity of prepared frogs; Study of drugs on reflexes and local circulation models. Respiratory function and oxygen consumption in acidosis and alkalosis in mouse. Study of nature of nitrogenous wastes of animals inhabiting different environment. Urine analysis in different physiological states. Absorption of glucose in inverted intestinal sac, effect of drugs on intestinal movements. Muscular responses to Pyrexia.</p> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>1. Randall, D., Burggren, W., French, K. and Femald, R., 2002. Eckert Animal Physiology: Mechanisms and Adaptations, 6<sup>th</sup> ed.W.H. Freeman and Company, New York.</li> <li>2. Berne, R.M. and Levy, M.N., 2000. Principles of Physiology, 3<sup>rd</sup> Edition. St. Lious, Mosby.</li> <li>3. Guyton, A.C. and Hall, J.E., 2000. Textbook of Medical Physiology, 10<sup>th</sup> Edition. W.B. Saunders Company, Philadelphia.</li> <li>4. Withers, P.C., 1992. Comparative Animal Physiology, Saunders College Publishing, Philadelphia.</li> </ol>

	<p>5. Schmidt-Nelsen, K., 1997. Animal Physiology, Adaptation and Environment, 5<sup>th</sup> Edition. Cambridge University Press, Cambridge.</p> <p>6. Tharp, G. and Woodman, D., 2002. Experiments in Physiology, 8<sup>th</sup> Edition, Prentice Hall, London.</p>
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<b>Course Title</b>	<b>Environmental Biotechnology</b>
Course Code	ZOL-716
Credit Hours	3
Theory	2
Practical	1
Follow up	Not Applicable
Category	M.Sc. Zoology, 02-Years Programme
Aims and Objectives	To learn and assess the environmental problems and monitor the environmental factors to make sustainable and suitable one for living beings and receive benefits through their applications in different fields of life
Learning Outcomes	The students will be able to understand the importance of biotechnology in order to resolve environmental problems and play an innovative roles for the further research
Syllabus in Brief	<p><u>Environmental Biotechnology and its applications in daily life.</u> Role of Biotechnology for a better Environment. Environmental Pollutants: Heavy metals (Cu, Cd, Zn, Hg, Cd, Bi, Co, etc.). Aromatic hydrocarbons (mononuclear and polynuclear), pesticides, solvent and gases. Hazardous and toxic effects of pollutants. Health problems. Biotechnology for pollution monitoring Biosensors, development and use for monitoring. Biotechnological processes involved in reducing pollution.</p> <ol style="list-style-type: none"> <li>1. Biosorption, bioaccumulation, bioprecipitation, bioreduction and solubilization of heavy metals. Mechanisms involved.</li> <li>2. Biodegradation of aromatic hydrocarbons, pesticides and solvents pathway and genes involved.</li> <li>3. Biopolymers, polyhydroxyalkanoates, gums, polysaccharides etc., process involved.</li> </ol> <p>nitrogen fixers and use of plant growth promoting bacteria. Immobilization and biofilm formation support systems (economical aspects) and efficiency of biofilm. Bioreactors: types, construction flow rate and performance, Economic feasibility. GEMS; construction and their use in cleaning, Release of GEMs in the environment guide lines and risk assessment. Case studies of use of biotechnology for environmental cleaning. Commercial aspects of biotech products for having cleaner environment.</p> <p><b><u>TICALS</u></b></p> <p>Environment for bacteria involved in the Sulfur Cycle using a Winogradsky column. Isolation of Bioluminescent bacteria from soil samples. Isolation of Magnetotactic bacteria. Mutualism between Algae and Cyanobacteria. Symbiotic relationship between Rhizobium and Leguminous plants (Field study). Biodegradation of wastes and pollutants: a) Cellulose decomposition, b) The biodegradation of petroleum. Bioleaching.</p> <p><b><u>RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>1. Peacock, K. W. 2010. Biotechnology and Genetic Engineering. An imprint of Infobase Publishing. 132 West 31<sup>st</sup> Street, New York.</li> <li>2. Evans, G. G. and J. Furlong. 2011. Environmental Biotechnology: Theory and Application. 2<sup>nd</sup> Ed. John Wiley &amp; Sons Ltd. USA.</li> <li>3. Baveye, Ph., Block, J.C. and Goncharuk, V.V., 1999. Bioavailability of Organic</li> </ol>



	<p>Xenobiotics in the Environment – Practical Consequences for the Environment. Kluwer Academic Publishers, Dordrecht.</p> <p>4. Saylor, G.S., Sanseverino, J. and Davis, K.L., 1997. Biotechnology in the Sustainable Environment. Plenum Press, New York.</p> <p>5. Verstreet, W., Debeer, D., Pena, M., Lettinga, G. and Lens, P., 1996. Anaerobic Bioprocessing of organic wastes. World J. Microbial. Biotechnol., 12:221-238.</p>
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<b>Course Title</b>	<b>Advances in Aquatic Toxicology</b>
Course Code	ZOL-717
Credit Hours	3(2-1)
Theory	2
Practical	1
Category	MS/MPhil Zoology, 02 Years Programme
Aims and Objectives	The major objectives of this course are to introduce students to the diverse array of stressors and toxicants in aquatic environment effecting aquatic life at molecular, physiological and genetic level.
Learning Outcomes	By the end of the semester students will be able to apply their acquired knowledge to better understand the interactions between toxicants and the environment. They will be able to distinguish between different classes of toxicants and their general and specific effects on aquatic life at physiological and molecular levels. They will be able to demonstrate knowledge of aquatic toxicology principles, laboratory procedures and interpret data pertaining to the behavior of the individual organism in its natural environment; to the structure and function of populations, communities, and ecosystems; and to human impacts on these systems and the environment.
Syllabus in Brief	<p>Biological Indicators of Aquatic Ecosystem Stress: Introduction and Overview. Biochemical Responses as Indicators of Aquatic Ecosystem Health: Biochemical Markers of Exposure Cytochrome P450 1A, Phase II Enzymes, Oxidative Stress, Metallothioneins, Porphyrins, Cholinesterases.</p> <p>Molecular Biomarkers in Aquatic Organisms: DNA Damage, Micronucleus Analysis, Flow Cytometry, Gene Expression Assays, Northern, Slot and Dot Blots, Ribonuclease Protection Assay, Expression of multixenobiotic Defense mechanism, Vitellogenin Expression, Microarray Hybridizations: Gene Chips.</p> <p>Physiological and Condition-Related Indicators of Environmental Stress in Fish: Physiological Stress Indicators, Condition-Based Stress Indicators, Measuring and Interpreting Stress Responses.</p> <p>Genetic Responses as Population-Level Biomarkers of Stress in Aquatic Ecosystems: Factors Influencing Genetic Diversity in Populations, Approaches to quantify Genetic Diversity</p> <p>Biomarkers and Bioindicators in Monitoring and Assessment</p> <p><b>Practical:</b></p> <p>Introduction, Basic Water Quality Parameters, Analytical Equipments ; Serial Dilutions, Standard Curves, Data Manipulation; 10 – 48-hour Acute Toxicity Test – <i>Oreochromis mossambicus</i>; 24 - hour Acute Toxicity Test, Data Analysis; 03 – 48-h Unknown Toxicity Test; Toxicity Amelioration, Short-term Chronic Toxicity Test - <i>Oreochromis mossambicus</i>, Data Analysis - Short-term Chronic Toxicity Toxicity Identification, Evaluation, Sediment Toxicity Assessment .</p> <p><b>Text Books</b></p> <p>1. An Introduction to Aquatic Toxicology, 1st Edition. M Nikinmaa, 2014. ISBN: 9780124115743. Academic Press.</p> <p>2. Biological Indicators of Aquatic Ecosystem Stress, Adam, S.M., 2002. American Fisheries Society, Bethesda, Maryland.</p>

	<p>3. Aquatic Toxicology Research Focus. Elias P. Svensson, 2008. Nova Publishers.</p> <p><b>Suggested Reading:</b></p> <ol style="list-style-type: none"> <li>1. Fundamentals of Aquatic Toxicology: <i>Effects, Environmental Fate and Risk Assessment, 3rd Edition</i>, Gary M. Rand, 2008 by CRC Publishers.</li> <li>2. Aquatic Toxicology: Molecular, Biochemical and Cellular Perspective Donald, C. Malins and Gary K. Ostrander. 1994. CRC Press</li> <li>3. Landis W G and Yu M H. 1999. Introduction to Environmental Toxicology; Impact of chemicals upon ecological system. 2<sup>nd</sup> Ed. Lewis Publisher Boston, London.</li> </ol>
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<b>Course Title</b>	<b>Medical Microbiology</b>
Course Code	ZOL-718
Credit Hours	3(2-1)
Theory	2
Practical	1
Follow up	Not Applicable
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	In this course, the students will be able to learn about pathogens and their interactions with hosts, 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	<p>Theory</p> <p>Microbiology and Medicine, antimicrobial agents, mode of action. Bacterial pathogenicity, sources and spread of infection in the community, Immunological principles: antigens, antibodies, and antigen-antibody reactions.</p> <p>Bacterial pathogens and associated diseases. Staphylococcus, skin and wound infections. Streptococcus, sore throat, scarlet fever, glomerulo-nephritis. Pneumococcus, respiratory infections. <i>Corynebacterium</i>. <i>Erysipelothrix</i>: Listerial, Diphtheria. <i>Mycobacterium tuberculosis</i>: pulmonary and other tuberculosis infections. <i>Actinomyces</i>. <i>Neisseria</i>: Meningitis, Gonorrhoea. <i>Salmonella</i>, <i>Shigella</i>. <i>Escherichia coli</i>, <i>Klebsiella</i>, <i>Proteus</i>, <i>Providencia</i>. Anthrax bacillus. <i>Clostridium tetani</i>. Poxviruses. Herpes virus. Herpes simplex. Cytomegalo-virus infections. Adenoviruses. Influenza viruses. Miscellaneous viruses: Rubella, Corona, Arboviruses. Hepatitis viruses. Arboviruses. Rickettsia. Pathogenic Fungi. Protozoa. Infective syndromes and diagnostic procedures. Strategy of antimicrobial therapy. Prophylactic immunization.</p> <p><b><u>PRACTICALS</u></b></p> <p>Basic techniques. Widal test. Laboratory diagnosis and control of infections: <i>Streptococcus</i>, <i>Corynebacterium</i>, <i>Erysipelothrix</i> <i>Listeria</i>, and <i>Mycobacterium</i>. The Enterobacteriaceae: <i>Salmonella</i>, <i>Shigella</i>. <i>Escherichia</i>, <i>Klebsiella</i>, <i>Proteus</i> and other Enterobacteria. <i>Clostridium</i> I. <i>Clostridium</i> II. Protozoa. Blood tests: TLC, DLC, RBC.</p> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>1. <u>Kayser, F. H., K. A. Bienz., J. Eckert and R. M. Zinkernagel. (2011). Thieme 333 Seventh Avenue, New York NY 10001, USA</u></li> <li>2. Cruickshank, R., Duguid, J.P., Hermion, B.P. and Swain, R.H.A., (1975). <i>Medical Microbiology</i>, (Vol. 1 &amp; Vol. 2), Churchill Livingstone, N.Y.</li> <li>3. Turk, D.C. and Poster, I.A., (1978). A Short Textbook of <i>Medical Microbiology</i>, Hodder and Stoughton.</li> <li>4. Vollum, R.L., Jamison, and Cummins C.S. (1970). Fairbrother's Textbook of <i>Bacteriology</i>, William Heinemann, London. Collin's C.H. and Lyne P.M. <i>Microbiology Methods</i>.</li> </ol>

<b>Course Title</b>	<b>Behavioral Ecology</b>
Course Code	ZOL-719
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b> Prey-predator relations, sharing of food and space between species, temporal, ecological and behavioral diversification, acquired and learned behavior, building of constraints, action of acquired constraints, the role of territoriality and communication in foraging, defence and search for mates.</p> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>1. Kerbs, J.R. and N.B. Davies, 1981. An Introduction to Behavioural Ecology, Blackwell Scientific Publications, London.</li> <li>2. Lehner, P. 1978. The Hand Book of Ethological Methods. Garland STP Press, New York.</li> <li>3. Hansell, M. H. and J.J. Atkin, 1979. Experimental Animal Behaviour. Blackies &amp; Sons.</li> <li>4. Hazlett, B. A. 1977. Quantitative Methods in the study of Animal Behaviour. Academic Press, London.</li> </ol>

<b>Course Title</b>	<b>Principles of Toxicology</b>
Course Code	ZOL-720
Credit Hours	3(2-1)
Theory	2
Practical	1
Follow up	Not Applicable
Category	M.Phil. Zoology, 02-Years Program, PhD Zoology.
Aims and Objectives	Enabling the students to learn about mechanisms and scope of Toxicity, effects of Toxicity on the Physiology and different techniques for its calculation and Estimation.
Learning Outcomes	Students will understand Toxicity and will be able to perform Basic Toxicity Tests.
Syllabus in Brief	<p><b>Theory</b> Definition: Early development, Recent Development and Challenges. Absorption, distribution and Excretion of Toxicants Biotransformation of Toxicants, Phase I and Phase II reactions. <u>Effect of Toxicity: Spectrum of Toxic effects, Target organs, Mechanisms of Action, Molecular Targets including proteins and Co-enzymes.</u> <u>Modifying factors of Toxic effects: Host factors, Environmental effects, Chemical Interactions, Toxicity Studies: Acute and Chronic Toxicity Studies, Experimental Designs. Developmental Toxicity.</u> Mutagenesis: Mechanisms, Introduction to In vivo and In vitro tests utilizing Bacteria, yeast, Insects and Mammals. <u>Carcinogenesis: Mode of Action; Bioactivation, Interaction with other molecules. Categories; Genotoxic and Nongenotoxic carcinogens, Introduction to some human carcinogens. Introduction to different tests for carcinogenicity.</u> Detoxification: Host and Environmental factors, Introduction to antidotes and its mechanisms</p> <p><b>Practicals</b> 1. Determination of LD50 values of some pesticide against any insect pest.</p>

	<ol style="list-style-type: none"> <li>2. Determination of LD50 of any toxic compound in mammalian system.</li> <li>3. Effect of any toxicant on body weight in mice.</li> <li>4. Toxicity of some toxic compound on relative organ weight in mice.</li> <li>5. Effect of toxicant on food consumption in mice.</li> <li>6. Study of toxicity of any chemical on total leukocytes count.</li> <li>7. Effect of toxicant on total erythrocytic count in blood of mice.</li> <li>8. Effect of any toxicant on hemoglobin level in mice.</li> <li>9. Study of inhibition of cholinesterase enzyme activity by organophosphate insecticides in mice.</li> <li>10. <u>Mutagenicity tests using Ames Test.</u></li> <li>11. <u>Genotoxicity Testing using any genotoxicity assay</u></li> </ol> <p><b>Books Recommended</b></p> <ol style="list-style-type: none"> <li>1. KLAASSEN, CURTIS D., (1996). <i>Casarell and Doull's Toxicology; The Basic science of Poisons</i>; 5<sup>th</sup> Edition (International). McGraw-Hill, Health Professions Division, New York.</li> <li>2. Timbrel, J.A., 1995. <i>Introduction to Toxicology</i>, 2<sup>th</sup> Edition. Taylor and Francis Ltd., London.</li> </ol>
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<b>Course Title</b>	<b>Limnology</b>
Course Code	ZOL-722
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b> Introduction, Inland Water Bodies, Origin of Lakes, Organism in lotic series and lentic series; plants, animals, bacteria, other fungal and non-plankton algae, higher aquatic plants and their limnological importance, Physical Features of Water bodies, Dissolved gases and solids, pH, Thermal Stratification, Plankton Nekton. Adaptation of organisms in relation to various physical features of water and water bodies, Biological productivity and their influence on biota.</p> <p><b><u>PRACTICALS</u></b> Collection and study of rooted and submerged and free floating plants of various approachable water bodies; Collection and study of animal life both Plankton and Nekton. Study of aquatic adaptations in both plants and animals.</p> <p><b><u>BOOKS RECOMMENDED (LATEST EDITIONS)</u></b></p> <ol style="list-style-type: none"> <li>1. Welch, P.S., 1948. <i>Limnology</i>, McGraw Hill, New York.</li> <li>2. Ward &amp; Whipple. <i>Fresh Water Biology</i>.</li> <li>3. Stewart, E.A. <i>Chemical Analysis of Ecological Materials</i>, Scientific Publishers, London.</li> <li>4. Goldman, C.R. and Horne, A.J., 1983. <i>Limnology</i>. McGraw Hill, International Books Company, Japan.</li> <li>5. Welch, P.C., 1968. <i>Limnology</i>. 4<sup>th</sup> Ed. McGraw Hill Book Co. Inc. New York.</li> <li>6. Allen S.E., 1990. <i>Chemical Analysis of Ecological Materials</i>. Scientific Publishers, London.</li> </ol>

<b>Course Title</b>	<b>Advances in Aquaculture – I</b>
Course Code	ZOL-725
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b></p> <p>Physical problems in fish farm construction, hydrometrology in pond fish culture, application of lime and fertilizers in fish farm management, warm water fish seed production, enhancing production of carp fingerlings by the use of growth promoting substances, intensive and semi-intensive culture of major carps, polyculture v/s monoculture, flavour problem in fish culture, fish diseases and their control in aquaculture.</p> <p><b><u>PRACTICALS</u></b></p> <ol style="list-style-type: none"> <li>Submission of report after study the following farming systems: <ol style="list-style-type: none"> <li>Extensive fish farming</li> <li>Semi extensive farming</li> <li>Intensive farming of carps</li> <li>Ponds, reservoirs and raceway</li> <li>Integrated fish farming</li> </ol> </li> <li>Fish diseases, symptoms and treatment.</li> </ol> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>Meade, J. W. 1998, Aquaculture Management. Chapman &amp; Hall Inc. N. York.</li> <li>Pillay, T. V. R., 1999. Aquaculture: Principles and Practices. Fishing News Books, London.</li> <li>Parker, R. 1994. Aquaculture Science. Delmar Publishers, N. York.</li> <li>Deborah, A. T. 1989. Aquaculture , Mansell, N. York.</li> <li>Agrawal, V.v P. 1999. Recent Trends in Aquaculture. Society of Biosciences. India.</li> <li>Reddy, M. S. and K.R.S. SambasivaRao. 1999. A text book of Aquaculture. Discovery Publishing House, N. Delhi</li> </ol>

<b>Course Title</b>	<b>Applied Fisheries</b>
Course Code	ZOL-727
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b></p> <p><b><i>Basic Principles of fish culture:</i></b> Extensive fishn culture, Semi-intensive fish culture, Intensive fish culture. <b><i>Construction and management of fish farm:</i></b> Ponds for fingerlings, Ponds for yearlings, Rearing ponds, Nursery ponds, Fattening ponds, Stocking ponds, Farm for large-scale fish culture. <b><i>Construction</i></b></p>

	<p><b>and maintenance of fish seed hatchery:</b> Hatchery for Salmonids, Hatchery for cyprinids, Hatchery for Catfishes. <b>Natural food and feeding:</b> Phytoplankton, Zooplanktons, Crustaceans (cladocera), Arthropoda larvae, Annelids, Molluscs.</p> <p><b>Artificial feed and feeding:</b> Of plant origin, Of animal origin, Feed for Salmonids, Feed for Cyprinids, Feed pelleting. <b>Adaptation of fish on pelleted feed</b></p> <p><b>Breeding and cultivation of Salmonids</b> (rainbow trout &amp; brown trout): Natural breeding, Artificial breeding, induced spawning, Hormonal induced spawning. <b>Breeding and cultivation of Cyprinids</b> (major carps &amp; Chinese carps): Natural breeding, Artificial breeding, induced spawning, Hormonal induced spawning. <b>Fish diseases and their control:</b> Viral disease, Bacterial disease, Fungal disease, Parasitic (protozoan, helminthes, crustaceans, leeches, <i>Argulus</i> etc). <b>Fish enemies and their control:</b> Amphibians, Reptiles, Birds, Mammals, Chemicals and fertilizers. <b>Fish harvesting and marketing:</b> Netting, Transportation, Maintenance of flesh quality and price control.</p> <p><b><u>PRACTICALS</u></b></p> <ul style="list-style-type: none"> <li>• Morphological identification of important culturable fish species</li> <li>• Study of gut contents of culturable fish species</li> <li>• Diagnosis of important bacterial diseases in cyprinids</li> <li>• Study of important parasites of fish</li> <li>• Stripping of mature fish and artificial fertilization of eggs and sperms</li> <li>• Study of early development stages</li> <li>• Visit to various fish seed hatcheries during breeding season</li> </ul> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>1. Kestin Farmed Fish Quality (2001) Multiline Books</li> <li>2. Ruth Freshwater Aquaculture(2000) Multiline Books</li> <li>3. Bromage Broodstock Management and Egg &amp; Larval Quality (1995) Pak Book Corp</li> <li>4. Woo Fish Diseases and Disorder: Protozoan and Metazoan infections (1995) Pak Books Corp</li> <li>5. Brenabe Aquaculture Vol. I &amp; II (1992) Fishing News Books Ltd. England</li> <li>6. C. Maseke Fish Aquaculture (1987) Pergamon Press. Oxford</li> <li>7. M.Huet Text Book of Fish Culture: Breeding and Cultivation (1986) Fishing News Books Ltd. England.</li> </ol>
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<b>Course Title</b>	<b>Advances in Aquaculture - II</b>
Course Code	ZOL-731
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b></p> <p>Introduction to advanced Aquaculture. Culture of freshwater prawn shrimps and Oyster culture. Aquaculture in raceways, cages, enclosures and ponds with particulars. Advances in fish seed production technology. Fish flesh</p>

	<p>composition, Aquatic weeds</p> <p><b><u>PRACTICALS</u></b></p> <ol style="list-style-type: none"> <li>1. Study of various aquatic culture systems (fish farm, hatcheries and nurseries).</li> <li>2. Study of various installations and their functions. Submission of report.</li> <li>3. Study of spawning in freshwater fish.</li> </ol> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>1. Meade, J. W. 1998, Aquaculture Management. Chapman &amp; Hall Inc. N. York.</li> <li>2. Pillay, T. V. R., 1999. Aquaculture: Principles and Practices. Fishing News Books, London.</li> <li>3. Parker, R. 1994. Aquaculture Science. Delmar Publishers, N. York.</li> <li>4. Deborah, A. T. 1989. Aquaculture , Mansell, N. York.</li> <li>5. Agrawal, V.v P. 1999. Recent Trends in Aquaculture. Society of Biosciences. India.</li> <li>6. Reddy, M. S. and K.R.S. SambasivaRao. 1999. A text book of Aquaculture. Discovery Publishing House, N. Delhi.</li> </ol>
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<b>Course Title</b>	<b>Biotechnology in Aquaculture</b>
Course Code	ZOL-733
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b></p> <p>Introduction and history of aquaculture. Role of biotechnology in aquaculture, use of effective microorganisms in technology; paucity of fish geneticists, fish as an experimental animal, technical details and possibilities. Use of hormones for sex manipulation and growth promotion in cultivable fishes: hormonal manipulation of sex, gonadal sex manipulation, masculinization and sterilization by androgens, feminization by estrogens, duration and timing and method of administration of steroid hormones. Hormonal enhancement of growth. Genetic in enhancing productivity; phenotypic sex reversal, heterospecific in semination long-term preservation of gametes, selection of high directional growth rate, production of polyploids.</p> <p><b><u>PRACTICALS</u></b></p> <p>Study of chromosomes and DNA. Quantitative analyses of sex hormones. Artificial fecundity and induced breeding of cultivable fish. E.M. Techniques.</p> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>1. Sinha, C.R.P. and Srivastava, 1991. Biotechnology and Aquaculture Engineering. Session Oxford and IBH Publishing Co. (Pvt.) Ltd., New Delhi.</li> <li>2. Pimtani, M., 1992. Aquaculture Research Needs for 2000 A.D. Oxford and IBH Publishing Co. (Pvt.) Ltd., New Delhi.</li> <li>3. Gall, G.A. and Chen, H., 1994. Fish Bioenergetics. Chapman and Hall, London.</li> <li>4. Schreck, C.B. and Moyle, P.B., 1990. Methods for fish Biology, American Fisheries Soc. Bethesda Maryland, USA.</li> </ol>

	5. Matty, A.J., 1985. Fish Endocrinology. Timber Press, USA. 6. Pakin, J. and Lensen, E.B. [eds], 1993. Fish Ecophysiology. Chapman and Hall, London.
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<b>Course Title</b>	<b>Fish Biology</b>
Course Code	ZOL-734
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b>Theory:</b> Inter-relationships between biotic and abiotic environment of fish, recruitment natality and mortality, population dynamics, food and feeding behaviour, reproduction, fecundity and reproductive behaviour. Fundamental links in the life cycles of the fishes and their migration. Fishery statistics: Standard error, standard deviation, variance, analysis of variance, probability, correlation, regression, chi-square test and t-test.</p> <p><b><u>PRACTICALS</u></b> Analysis of gut contents of fish. Population estimation, determination of fecundity.</p> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>Gulland, J.A., Fish Population Dynamics, 1988.</li> <li>Lagler, K.F. Ichthyology, 1984. John Wiley &amp; Sons, USA.</li> <li>Ali, S.S. Freshwater Fisher Biology, 1999. Naseem Book Depot, Hyderabad.</li> <li>Schreck, C.B. and B.B. Moyle, Methods of Fish Biology, American Fisheries Society, 1990.</li> <li>Nikol's kii, Special Ichthyology, 1991.</li> <li>Yadev, B.N., Fish and Fisheries, 1990.</li> <li>Bome, Q., Biology of fishes. 1982.</li> <li>Gulland, J.A., Fish Population Dynamics, 1988.</li> </ol>

<b>Course Title</b>	<b>Fish Ecology</b>
Course Code	ZOL-735
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b> Inter-relationships between fishes and their abiotic and biotic environment; density and pressure of the water, salinity of the water, temperature of the water, salt contents of the water, gases in solution, light, bottom deposits and particles suspended in water, biotic inter-relationships among fishes and other animals,</p>



	<p>fundamental links in the life cycles of fishes and migration of fishes.</p> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>1. Moss, B. 1998. Ecology of Freshwaters: Man and Medium, Past to Future (3<sup>rd</sup> Ed.). Blackwell Science, USA.</li> <li>2. Jeffries, M. and D. Mills. 1992. Freshwater Ecology: Principles and Applications. CBS Publishers and Distributors, N. Delhi.</li> <li>3. Kaul, B.L. 1999. Advances in Fish and Wildlife Ecology and Biology. Daya Publishing House, N. Delhi.</li> </ol>
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<b>Course Title</b>	<b>Fish Bioenergetics</b>
Course Code	ZOL-736
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b></p> <p>Introduction to energetics and energy budgets . Fish feeds and their nutritional value. Metabolism and growth. Energy of waste products. Ecosystem energetics. Energy and food production. Energetics of Locomotion.</p> <p><b><u>PRACTICALS</u></b></p> <p>Energy budget. Qualitative assessment of fish feed. Oxygen consumption. Analysis of faeces.</p> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>1. Jobling, M., 1994. Fish Bioenergetics. Chapman and Hall, London.</li> <li>2. Hoar, W.S., Randall, D.J., and Brett, J.R., 1979. Fish Physiology, Vol. VIII. Academic Press, New York.</li> <li>3. Brafield, A.E. and Llewellyn, M.J., 1982. Animal Energetics. Blackie&amp;Sons, Glasgow.</li> <li>4. Tytler, P. and callow, P., 1985. Fish Energetics. New Perspectives. Croom Helm, Beckenham.</li> <li>5. Pandian, T.J. and vernberg, F.J., 1987. Animal Energetics, Vol. I &amp; II.</li> <li>6. Weatherley, A.H. and Gill, H.S., 1987. The biology of Fish Growth. Academics Press, London.</li> <li>7. Rankin, J.C. and Jensen, F.B., 1993. Fish Ecophysiology. Chapman and Hall, London. Publishing Co. N. Dehli.</li> </ol>

<b>Course Title</b>	<b>Fisheries Management</b>
Course Code	ZOL-737
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<b><u>Theory</u></b>

	<p>Road to management, natural populations, protection against hazards, improvement of habitat, age and growth, managing natural populations, the significance of fishes in the life of mankind and biological basis of natural fishery.</p> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>1. Templeton, R.G. 1995. Freshwater Fisheries Management (2<sup>nd</sup> Ed.) Fishing News Books, Blackwell Science, USA.</li> <li>2. Jacques, A. 1999. Management of freshwater Fisheries. Technique et Documentation, Lavoisier, Paris.</li> <li>3. Rounsefell, G.A. and Everhart, W.H. 1963. Fishery Science its methods and application. John Wiley &amp; Sons. Inc., New York.</li> <li>4. Arrignon, J. 1999. Management of Freshwater Fisheries. Oxford &amp; IBH Pu</li> </ol>
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<b>Course Title</b>	<b>Environmental Biology of Fishes</b>
Course Code	ZOL-738
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b></p> <p>Fish and their Environments. Feeding and Nutrition. Environmental Biology of Fish Growth. Osmoregulation and Ion Balance. Environmental Biology of Reproduction. Behaviour. Water Pollution. Waste management. Sustainability and environmental Issues.</p> <p><b><u>PRACTICALS</u></b></p> <p>Weight length and condition factor in relation to different environments. Gut contents of different fish species. Effect of temperature on fish growth. Effect of salinity on fish growth. Induce spawning. Effect of different pollutants on survival of fish. Assignment.</p> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>1. Weatherley, A.H.,1972. Growth and Ecology of Fish Poplations.</li> <li>2. Wootton, R.J., 1990. Ecology of Teleost Fishes. Chapman nd Hall, London.</li> <li>3. Wootton, R.J.,1998. Ecology of Teleost Fishes. 2<sup>nd</sup> Edition, Kluwer.</li> <li>4. Jobling, M., 1995. Environmental Biology of Fishes. Chapman &amp; Hall, U.K.</li> <li>5. Weatherley, A.H. and Gill, H.S.,1987. The Biology of Fish Growth. Chapman &amp; Hall, U.K.</li> <li>6. Evans, D.H.,1998. The Physiology of Fishes , 2<sup>nd</sup> Ed. CRC Press, Boca Raton, New York.</li> <li>7. Boyd. C.E. and Tucker , C.S., 1998. and Pond Aquaculture Water Quality management, Boston, Kluwer.</li> </ol>

<b>Course Title</b>	<b>Chemical Biology of Fishes</b>
Course Code	ZOL-739
Credit Hours	3

Theory	2
Practical	1
Follow up	
Category	
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b>  Proximate Body Composition – Protein, Lipid, Ash and Caloric Contents.  Proximate Body Composition – Reaction and Adaptations to Environment.  Proximate Body Composition – Major carps, Chinese carps and Salmonids in Pakistan.</p> <p><b><u>PRACTICALS</u></b>  Determination of Moisture contents, lipid content. Protein content, ash content, dry weight of culturable fish species. Effect of ad-lib feeding on body composition of fish.</p> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>Grodzinski, W., Kelkowski, R.Z. and Duncan, A. (Ed.), 1975. Methods for Ecological Bioenergetics. Blackwell, Oxford.</li> <li>Love, R.M., 1970. The Chemical Biology of Fishes, Vol. 1. Academic Press, London.</li> <li>Love, R.M., 1980. The Chemical Biology of Fishes, Vol.2. Academic Press, London.</li> </ol> <p>Weratherley, A.H. and Gill, H.S., 1987. The Biology of Fish Growth. Academic Press, London.</p>

<b>Course Title</b>	<b>Techniques in Fisheries Management</b>
Course Code	ZOL-740
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b>  The literature of fish and fisheries, a method of compiling bibliography, literature sources, general bibliography on fish, forms for recording data I fishery surveys, recording, length, weight, sex and age determination, preparation of impressions, photographs and slides of scales, scale reading, types of tags and information sought, techniques of tagging and recovery, fishery statistics.</p> <p><b><u>PRACTICALS</u></b>  Survey of literature, recording data, preparing and reading scales, tagging and population estimation.</p> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>Sinha, V.R.P. and Srivastava, H.C. 1991. Aquaculture Productivity, Oxford &amp; IBH Publishing Co. N. Delhi.</li> <li>Sheri, A.N. 1974. Selected Bibliography of Fishes and Fisheries of Pakistan (1864-1966). University of Agriculture, Faisalabad.</li> <li>Ricker, W.E. 1958. Hand Book of Computation for Biological Statistics of Fish Population. Fish Res. Bd. Of Canada. Bull. No. 119.</li> </ol>

<b>Course Title</b>	<b>Molecular Entomology</b>
Course Code	ZOL-746
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/MPhil/PhD. Zoology
Aims and Objectives	<ol style="list-style-type: none"> <li>1. To know different molecular approaches and research activities in Entomology</li> <li>2. To explain the use of different insects as model organisms with reference to human diseases.</li> <li>3. To assess the advance molecular approaches towards forensic sciences and criminology.</li> </ol>
Learning Outcomes	
Syllabus in Brief	<p>Insects as a model for molecular study; <i>Drosophila</i>, Red flour beetle, Mosquitoes, Army worm; DNA, Genes and Gene Structure in model insects; Genomics, Transcriptomics and Proteomics; Genome Browsers and Blast; Gene homology in insects with reference to the invertebrates; Role of barcoding and its application (Advantages and disadvantages); Study of different types of genetic variations in insects; Genetic identification of species and biotypes in insects. DNA and protein Alignments, DNA/RNA Isolation in insects; cDNA Synthesis, Primer Design and PCR; Use of molecular markers in insects; RAPD, SSR, RFLP, AFLP, Microsatellites, MLST; Southern blotting, Northern blotting, western blotting; Cloning with reference to insects; Genome Sequencing; Insect Transgenesis; Use of Transgenesis in Entomological Applications; RNA Interference technique and gene silencing, Use of insects for disease cure, i.e. Cancer, Tumor, Alzheimer, mental disorders, etc. Importance of molecular markers in forensic science; Any new developing technique.</p> <p><b>Practical:</b> Isolation of genomic DNA from insects for DNA fingerprinting by various methods; Comparison of different DNA extraction methods and use of different Molecular markers; Gel electrophoresis of insect DNA; DNA study from model and forensically important insects; Use of molecular information data base available for insects (homology, alignment, etc)</p> <p><b>Recommended Books:</b></p> <ol style="list-style-type: none"> <li>1. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Scott, M.P., Bretscher, A., Ploegh, H and Matsudaira, P. 2008 Molecular Cell Biology, 6<sup>th</sup> Edition. Freeman and Comp. New York.</li> <li>2. Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K and Walter, P. 2008. Molecular Biology of the Cell, 5<sup>th</sup> edition. Garland Science, New York.</li> <li>3. Genomes. 2nd edition. Brown TA. Oxford: Wiley-Liss; 2002.</li> <li>4. Old, R.W. and Primrose, S.B., 1989. Principles of gene manipulation. 4<sup>th</sup> edition, Blackwell scientific Publishers, London.</li> <li>5. Marjorie, A.H. 2003. Insect Molecular Genetics. Academic Press, USA.</li> <li>6. Blackman, R.L., G.M. Hemitt and M. Ashburner. 1980. Insect Cytogenetics. Black-Well Scientific Publications, Oxford, London.</li> <li>7. Gray, J. Blomquit, Richard. 2003. Insect pheromone biochemistry and molecular biology, (Elsevier Academic).</li> <li>8. Dnyansayer, V.R. 1992. Cytology and Genetics. Tata McGraw-Hill Publishing Co. New Delhi.</li> <li>9. John, C.A. 2004. Molecular Markers, Natural History, and Evolution. 2<sup>nd</sup> Ed., Sinauer associates, Inc. Publishers Sunderland, Massachusetts.</li> </ol>

<b>Course Title</b>	<b>Medical Entomology</b>
Course Code	ZOL-747
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/MPhil/PhD. Zoology
Aims and Objectives	<ol style="list-style-type: none"> <li>1. To define and compare the insects of medical importance and also provide the management solutions</li> <li>2. To discuss the principles of vector-borne epidemiology</li> <li>3. To explain the reasons underlying the major diseases outbreaks in human history and;</li> <li>4. To relate why these outbreaks occasionally occur in today's modern world</li> </ol> <p>To assess the new approaches in solving vector-borne pathogen challenges</p>
Learning Outcomes	
Syllabus in Brief	<p>Introduction of medical entomology; Historical and global impact of insect-borne diseases; Epidemiology. Identification, Biology and Control of insects and other arthropods of medical importance. Insects and some other arthropod transmitted diseases, their symptoms and diagnosis; Morphological adaptations of parasitic insects; Envenomization and Allergens; Collembola, Blattaria, Coleoptera, Medical importance of Hemiptera (Psychodidae, Cimicidae); Sand fly (Leishmaniasis); Black flies (Onchocerciasis); Biting and sucking lice (Epidemic typhus); The biting flies; blood feeders and vectors; Mosquitoes: Biology, Mosquitoes as vectors (host-parasite interactions) (Malaria, Dengue, Filariasis); Horse flies, Deer flies and their relatives Muscoid blood feeders; Tsetse flies (African sleeping sickness), Non blood-feeding muscoid flies, Myiasis fleas, Plague (Bubonic, Septicemic, Pneumonic, Pharyngeal plague); Ticks and mites; DNA fingerprinting and criminal identification using insects; Use of insects in forensic science (Flies, Ants, Cockroaches, Mosquito, etc.)</p> <p><b>Practical:</b> Collection, mounting and identification of medically important insects (particularly Dipteran); Mouthpart morphology and blood feeding of hemaphagous insects; Review of Specimens (Cockroaches, Beetles, Lice, Bugs and others) in relation to diseases. Forensic Entomology field trips.</p> <p><b>Recommended Books:</b></p> <ol style="list-style-type: none"> <li>1. Service, M.W. 1996. Medical Entomology</li> <li>2. Metcalf, G.L. and W. P. Flint. 1980. Destructive and useful insects. Mc Graw Hill, New York.</li> <li>3. Metheson, R. 2003. Medical Entomology. Comstock Publishing Associates, New York.</li> <li>4. World Health Organization. 1984. Chemical methods for the control of Arthropod Vectors and pests of Public Health Importance Geneva..</li> <li>5. Walker, A. 1994. Arthropods of human and domestic animals. A Guide to Preliminary Identification. Chapman and Hall.</li> <li>6. Scèveice, M.W., 1980. A Guide to Medical Entomology. The MacMillan Company, New York.</li> <li>7. Herms, W.B. and James, M.T. 1960. Medical entomology. The MacMillan Company, New York.</li> <li>8. Busvine, J. R. 1980. Insects and Hygiene, 3<sup>rd</sup> Ed. Chapman and Hall, London.</li> </ol>

	<p>9. Harwood, R. F. and M. T. James. 1979. Entomology in Human and Animal Health, 7<sup>th</sup> Edition. Mcmillan Publishing Co. Inc., New York.</p> <p>10. Service, M. W. 1996. Medical Entomology for Students. Chapman and Hall, London</p> <p>11. Aldridge, B. 2004. Medical Entomology: Text Book of Public Health and Veterinary. Chapman and Hall, London.</p> <p>12. Lehane, S. 2005. Biology of Blood Sucking Insects, Printice, U.S.A.</p>
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<b>Course Title</b>	<b>Economic Entomology</b>
Course Code	ZOL-748
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/MPhil/PhD. Zoology
Aims and Objectives	This course will elaborate the key insects of economically-important groups; and also what kind of benefits the insects can provide to man. Moreover, the course will ensure what are their major identification features and damages they cause in the form of economic losses.
Learning Outcomes	To provide a solid foundation in traditional economic entomology, emphasizing insect pest population dynamics, economic decision levels and aspects of management with reference to the expenditures
Syllabus in Brief	<p>Cottage Industry; Beekeeping, Lac culture, Sericulture. Insects of Aesthetic value, Insect as food commodity (source of income as an export), Insect as commercial commodity in industry (colors, textile, etc.). Major insects of economic importance; Insect pests of Rice Wheat, Cotton and Sugarcane crops, their losses, identification, life histories, distribution and control. Major stored-grain insect pests and their losses. Comparison of the economic impact of insect pests in agricultural crops and forests with the social and economic value of insects.</p> <p><b>Practical:</b> Collection, Mounting, Identification of beneficial insects, Stored-grain and crop insect pests; Insect collection-box; Field visit.</p> <p><b>Books:</b></p> <ol style="list-style-type: none"> <li>1. Pedigo, L.P. and M.E. Rice. 2009. Entomology and Pest Management, 6th Edition. Prentice Hall. Upper Saddle River, NJ.</li> <li>2. Pedigo, L.P. 2002. Economic Decision Levels for Pest Populations in Entomology and Pest Management. 4<sup>th</sup> Edition. Prentice Hall, NJ.</li> <li>3. Ashfaq, M. and W. Akram. 1999. A Manual of Sericulture. Univ. of Agri., Faisalabad.</li> </ol>

<b>Course Title</b>	<b>Environmental Entomology</b>
Course Code	ZOL-749
Credit Hours	<b>3</b>
Theory	<b>2</b>
Practical	<b>1</b>
Follow up	
Category	MS/MPhil/PhD. Zoology
Aims and Objectives	Insect pest of urban areas, landscape, household, urban environments; diversity of insects

	in different ecosystems; Insects and the role of Society; industrial entomology; insects in aquatic habitats as bio indicator; use of insects as food in aquatic habitats; effect of pollution on insect population in a given environment; use of insects for a cleaner environment; Insects and related arthropods in residential and industrial buildings, nature of damage, and their control. Recognition, biology, behavior, economic importance, and management of insects in a given environment (Cockroaches, Crickets, Silverfish and Firebrats, Carpenter Ants, Fleas, Earwigs, Fabric Pests, Cluster Flies, House Flies, Mosquitoes, Human Lice, Stinging Insect Control, Mining Bees, Carpenter Bees); Insects important in management of forest resources including timber, wildlife, and recreation
Learning Outcomes	Studies of Insect pest of urban and industrial along with diversified environmental arena having impact on society. Insects in residential and industrial buildings, nature of damage and their control. Recognition, biology, behavior, economic importance, and management of insects in a given environment
Syllabus in Brief	Insect pest of urban areas, landscape, household, urban environments; diversity of insects in different ecosystems; Insects and the role of Society; industrial entomology; insects in aquatic habitats as bio indicator; use of insects as food in aquatic habitats; effect of pollution on insect population in a given environment; use of insects for a cleaner environment; Insects and related arthropods in residential and industrial buildings, nature of damage, and their control. Recognition, biology, behavior, economic importance, and management of insects in a given environment (Cockroaches, Crickets, Silverfish and Firebrats, Carpenter Ants, Fleas, Earwigs, Fabric Pests, Cluster Flies, House Flies, Mosquitoes, Human Lice, Stinging Insect Control, Mining Bees, Carpenter Bees); Insects important in management of forest resources including timber, wildlife, and recreation. <b>Practical:</b> Collection, mounting and the Identification; data record of the life history of the different urban insect pest species, methods to detect their presence, and management strategies. Field trips during the semester to different sites (landscape area, industrial area, aquatic/canal area and sanctuaries etc.). <b>Recommended Books:</b> 1. Pedigo, L.P. and M.E. Rice. 2009. Entomology and Pest Management, 6th Edition. Prentice Hall. Upper Saddle River, N.J. 2. Ahmad, M. 1990. Agricultural Entomology of Pakistan. Nalt. Long Auth, Islamabad. 3. Choudhry, G.U., 1970. Survey of Insect fauna of forests of Pakistan.Vol II, CABI Direct. 4. Ghani, M.A. and Cheema, M.A., 1973. Biology, Ecology and Behavior of Principal Natural Enemies of major Insects Pests of Forests of Pakistan. CABI, England. 5. Perry, A.S. 1998. Insecticides in Agriculture and Environment: Retrospect's and Prospects. Eslvier, New York. 6. Huffaker, C.B 1999, Ecological Entomology. John Wiley Sons. 7. Saleem. M.A. and M. Ashfaq. 2004. Environmental pollution. Pak Book Empire, Lahore.

Course Title	Animal Pest and disease producing organisms
Course Code	ZOL-750
Credit Hours	3

Theory	2
Practical	1
Follow up	
Category	
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b> Nature and mechanism of damages caused by animals pest injuries to cash crops, vegetables and fruit plants, stored grains and forest plants, with brief description of their biology, ecology and control. Role of insects, helminthes, nematodes, protozoans and other pathogens in disease transmission and myiasis,. Insects and mites of medical and veterinary importance in Pakistan. Study of important birds and mammals causing injuries to corps. Biology and ecology of common avian and mammalian pests of Pakistan.</p> <p><b><u>PRACTICALS</u></b> Collection, mounting studying and identification of important animal pests. Endo and ecto-parasite of various animals. Mounting of slides after processing the parasites.</p> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>Ahmad, M., 1990. Agricultural Entomology of Pakistan. Nalt. Long Auth, Islamabad.</li> <li>Choudhry, G.U., 1970. Survey of Insect fauna of forests of Pakistan.</li> <li>Ghani, M.A. and Cheema, M.A., 1973. Biology, ecology and behaviour of principal natural enemies of major insects pests of forests of Pakistan.</li> <li>USDA, 1956. Year Book of Agriculture, Insects.</li> </ol>

<b>Course Title</b>	<b>Advanced Integrated Pest Management-I 3(2-1)</b>
Course Code	ZOL-751
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/MPhil/PhD. Zoology
Aims and Objectives	<ol style="list-style-type: none"> <li>To know about the concept of Integrated Pest Management and let students to apply IPM techniques in Pakistan.</li> <li>To assess the new approaches towards better management practices in IPM program.</li> </ol>
Learning Outcomes	
Syllabus in Brief	<p>Course Introduction and Management of Arthropods in Agricultural Systems: Pest Management Theories; Surveillance and sampling; Background, general and new concepts of integration; The utilization and integration of pest control tactics (cultural methods, biological control, chemical, host resistance) for management of insects, Study of pheromones and its applications; Integrated Pest Management of major pests of crops, fruits, and vegetables; Impact of Pesticide Residue/Food Safety Issues on Pest Management; Economic Thresholds- Concepts, Development and Application; Insecticide Resistance Management as a Component of IPM; Integration of GM Crops in IPM Programs; Environment safe</p>



	<p>and un-safe methods of IPM.</p> <p><b>Practical:</b> 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.</p> <p><b>Books:</b></p> <ol style="list-style-type: none"> <li>8. Pedigo, L.P. &amp; M.E. Rice. 2009. Entomology and Pest Management, 6th Edition. Prentice Hall. Upper Saddle River, NJ.</li> <li>9. Ciancio A, Mukerji KG (2010) Integrated Management of Arthropod Pests and Insect Borne Diseases (1<sup>st</sup> edition). Springer., London, UK.</li> <li>10. Radcliffe EB, Hutchison WD, Cancelado RE (2009) Integrated Pest Management: Concepts, Tactics, Strategies and Case Studies (1<sup>st</sup> edition); Cambridge University Press., New York, USA.</li> <li>11. Louis M, Schoonhoven, van Loon JJA, Marcel D (2006) Insect-Plant Biology (2nd edition). Oxford University Press, USA.</li> <li>12. Dhaliwal, G.S. and R. Arora. 2003. Principles of insect pest management. Kalyani Publishers, New Delhi, India.</li> <li>13. 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.</li> <li>14. M. R. Binns, J.P. Nyoop and W. Van der Werf, 2000. Sampling and monitoring in crop protection CABI Publisher.</li> </ol>
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<b>Course Title</b>	<b>Advanced Integrated Pest Management-II</b>	<b>3(2-1)</b>
Course Code	ZOL-752	
Credit Hours	3	
Theory	2	
Practical	1	
Follow up		
Category	MS/MPhil/PhD. Zoology	
Aims and Objectives	<ol style="list-style-type: none"> <li>1. To discuss the use of advanced methodologies and management strategies in IPM.</li> <li>2. To assess the advanced and scientific approaches to minimize the use of pesticides and make wards better use of available methodologies for IPM program.</li> </ol>	
Learning Outcomes		
Syllabus in Brief	<p>Concepts of Development of sustainable integrated pest management programme; Concepts of integration and development of different IPM techniques; Ecoomic decisions and risks in IPM; Crop diversification and pest regulation; Chemical control and its safe use with other techniques; Role of <i>Wolbachia</i>, Sterile Insect Techniques (SIT), Incompatible Insect Techniques (IIT), Remote sensing of insect pests in expediency of Pest management; Eradication of key pests- insect pests management in cotton, tobacco, soybean, tomato, corn crops; Biology, Ecology and Management; IPM for the future, sustainable agriculture and organic crop.</p> <p><b>Practical:</b> Collection, Mounting, Identification of different insect pests; Lab visits to demonstrate the use of different spraying equipments and latest facilities to detect pesticide residues in crops through HPLC; Field trips during the semester to different cropping areas. Pest scouting, survey and monitoring; damage</p>	

assessment, methods of insect records of major pests, stages of insects and plants; identification of alternate hosts, data collection and economic threshold levels); Selection of pesticides and their application (on the basis of mode of insect damage, group of insecticide, selection of application equipments on the basis of crop); Augmentation of bio-control agents (different methods, precautions and synchronization for releasing bio-control agents and follow up evaluations).Integration of different methods of IPM (cultural, physical, mechanical, biological, molecular, genetic and chemical methods)

**Recommended 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 BorneDiseases (1<sup>st</sup> edition). Springer., London, UK.
3. Gilbert LI, Gill SS (2010) Insect Control: Biological and Synthetic Agents. Academic Press., New York, USA.
4. Radcliffe EB, Hutchison WD, Cancelado RE (2009) Integrated Pest Management: Concepts, Tactics, Strategies and Case Studies (1<sup>st</sup> edition); Cambridge University Press., New York, USA.
5. Louis M, Schoonhoven, van Loon JJA, Marcel D (2006) Insect-Plant Biology (2nd edition). Oxford University Press, USA.
6. Mayer, C.D. 2004. Biotechnological Approach for the Integrated Management. Wiley Intersciences, London.
7. Opende, Koul, L.S. Dhaliwal, 2004. Transgenic crop protection, Oxford and IBH publisher.
8. Dhaliwal, G.S. and R. Arora. 2003. Principles of insect pest management. Kalyani Publishers, New Delhi, India.
9. 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.
10. Dhaliwal, G.S., R. Singh and B.S. Chhillar. 2006. Essentials of agricultural entomology. Kalyani Publishers, New Delhi, India.
11. Metcalf, P.I. (Ed.) 1990 -Todate. Advances in Pest Control Research, Vols. I-todate. Inter-sciences Publishers, N.Y.
12. M. R. Binns, J.P. Nyooop and W. Van der Werf, 2000. Sampling and monitoring in crop protection CABI Publisher.
13. Gray, J. Blomquit, Richard. 2003. Insect pheromone biochemistry and molecular biology, (Elsevier Academic).

<b>Course Title</b>	<b>Biology and Control of Vertebrate Pests</b>
Course Code	ZOL-755
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<u><b>Theory</b></u> Definition and general characteristics of pests with special reference to Pakistan. Identification and biology of important vertebrate pests. Methods of studying pests

	<p>population. Methods of damage survey and damage assessment. Diseases carries and public health importance. Control: Habitat manipulation and ecologically based integrated management, biological control, non-chemical/physical controls. Chemical Control; laboratory and field evolution of pesticides and materials, field application of pesticides baits. Evolution of control. Justification and ecological consideration.</p> <p><b><u>PRACTICALS</u></b></p> <ol style="list-style-type: none"> <li>1. Study of important taxonomic characteristics of different species of vertebrate pests (live animals/study skins)</li> <li>2. Identification of damage to crops by different vegetable pests i.e. rats, porcupines, wild boar and birds.</li> <li>3. Contamination and damage to stored products by commensal rodents.</li> <li>4. Methods of damage assessments.</li> <li>5. Selection and preparation of different bait materials for rats, porcupine, and wild boar.</li> <li>6. Field application of pesticides baits for control of rats, porcupine and wild boar.</li> </ol> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>1. Singelton, G.R., Hinds, L.A., Levis, H. and Zhang, Z. 1990. Ecologically-based management of rodent pests. Australisn Centre for International Agricultural Research, Canberra.</li> <li>2. Buckle, A.P. and Smith, R.H. 1994. Rodent pests and their control. CAB International, UK.</li> <li>3. Books, J. E., Ahmad, E., Hussain, L., Munir, s., and Khan, A.A. 1990. A training manual on vertebrate pest Management. A GOP/USAID/DWRC Vertebrate pest control project, NARC, Islamaabad.</li> <li>4. Chitty, D. and N.H. Southeren, 1964. The Control of Rats and Mice. Voi. I, II, III. Clarendon Press, Oxford.</li> <li>5. Murton, R.K. and E. N. Wright, 1968. The Problems of Birds as Pests. Academic Press, N. York.</li> <li>6. Dermott, W., 1982. Mammals and Birds Pests. Ministry of Agriculture, Fisheries and Food. Agricultural Science Service, London.</li> </ol>
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<b>Course Title</b>	<b>Vector Biology</b>
Course Code	ZOL-756
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b><u>Theory</u></b></p> <p>Details studies of systematic, Biology and Ecology of some vectors of medical importance (order Diptera)</p> <p>Mosquitoes: Anopheles mosquitoes, culicine mosquitoes, Black flies, sand flies, biting midges, horse flies, deer flies, and clegs, tsetse flies, house flies, myiasis producing flies, (blow flies, blue bottles, green bottles, flesh flies, warble flies and bot flies).</p> <p>The study will cover following aspects: Morphology, anatomy, distribution, breeding habits, life-cycle, pathogenesis and seasonal prevalence of the species. Brief account of diseases spread by these vectors, methods of control,</p>

	<p>modern trends in their biological and chemical control.</p> <p><b><u>PRACTICALS</u></b></p> <p>Methods of identification; Dissection of selected vectors i.e. mosquito, house flies, blue bottles, green bottles, and bot flies. Study of prepared slides of parasites. Epidemiological studies of Vector borne diseases (one e.g. malaria) including field studies of control methods and parasite evaluation.</p> <p><b><u>BOOKS RECOMMENDED</u></b></p> <ol style="list-style-type: none"> <li>1. William A. Riley. Medical Entomology. McGraw Hill book Co., Inc. London.</li> <li>2. McDonald, G. The Epidemiology and Control of Malaria, London Oxford Press.</li> <li>3. World Health Organization. Vector Control series, Training and information guide. The House fly.</li> <li>4. World Health Organization. Chemical methods for the control of Arthropod Vectors and pests of Public Health Importance Geneva, WHO, 1984.</li> <li>5. Walker, A. 1994. Arthropods of human and domestic animals. A guide to preliminary identification. Chapman &amp; Hall.</li> <li>6. Scevce, M.W., 1980. A guide to medical entomology. The MacMillan Company, New York.</li> <li>7. Herms, W.B. and James, M.T. 1960. Medical entomology. The MacMillan Company, New York.</li> </ol>
<b>Course Title</b>	<b>Wildlife Management – I</b>
Course Code	ZOL-766
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b>Theory</b></p> <p>Origin and processes of formation of wetlands. Functions and values of wetlands, Regulatory processes affecting wetlands: physical, chemical and biological processes. Common flora of wetlands and the vicinity and their importance for wildlife. Wetland flora and fauna, socio-economic linkages. Man and wildlife conflicts at wetlands and their management. Macro-invertebrates of wetlands and their eco-linkages. Problems associated with the conservation of wildlife in wetland environments. Factors governing the distribution, abundance, and diversity of freshwater organisms.</p> <p>Overview of coastal ecosystems, physical and biological elements and processes, and coastal zone dynamics, including sandy, rocky and muddy shorelines, estuaries, dunes, and coastal watersheds.</p> <p>Wetland systems and associated wildlife in Pakistan. Planning and Management of wetland systems for wildlife and other human needs, improving conservation through awareness and effective wetland policies &amp; legislation.</p> <p><b>Practical</b></p> <p>Measurement of pollutants levels in soil (toxic chemical, fertilizer, insecticides, herbicides) nearby wetlands</p> <p>Analysis of various pollutant; heavy metals, -CO<sub>3</sub>, -HCO<sub>3</sub>, NO<sub>3</sub>, BOD, COD, pH, EC, total soluble solids of the wetlands.</p>

	<p>Notes on threats to wetlands</p> <p><b>Books Recommended</b></p> <ol style="list-style-type: none"> <li>1. Dungan, P. J. 1990. Wetland Conservation: A Review of Current Issues and Required Action. The World Conservation Union (IUCN).</li> <li>2. Maitland, P. S. 1997. Conservation Management of Freshwater Habitats: Lakes, Rivers and Wetlands. Published by Springer.</li> <li>3. Weller, M. W. 1999. Wetland Birds: habitat resources and conservation implications. Cambridge University Press.</li> </ol> <p>Wong, M. H. 2004. Wetlands Ecosystems in Asia: Function and Management Published by Elsevier.</p>
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<b>Course Title</b>	<b>Wildlife Management – II</b>
Course Code	ZOL-767
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	
Aims and Objectives	
Learning Outcomes	
Syllabus in Brief	<p><b>Theory</b></p> <p>Introduction to terrestrial ecosystems and associated wildlife in Pakistan: mountains, rangelands, foothill forests, deserts, agro-ecosystems. Status and threats to wildlife in these ecosystems. Wildlife and farmlands (Farm crops as wildlife food, erosion, sedimentation and wildlife, agricultural chemicals and wildlife). Wildlife and rangelands (management of range vegetation, livestock grazing and wildlife, range fires and wildlife, fencing, game ranching). Forest management and wildlife (basics of forest management, clear cutting and wildlife, snags, deadwood and fuel wood, forest fire and wildlife). Urban wildlife (urban wildlife resources, urban monoculture, multiple use management in the city, urban wildlife as pest). Exotic wildlife (exotic species, concerns, guidelines and policies) Wildlife and water (ecological influences on wildlife, populations, physiological and behavioral responses, reservoir effect and management, water and raw sewage, water developments and wildlife). Wildlife and soils (relationship of soil &amp; wildlife, fertilization).</p> <p>Wildlife Management Planning. Management efforts by public sector agencies and departments, NGO's and Community organizations, major projects of wildlife conservation; concept of community based wildlife management, wildlife and ecotourism.</p> <p><b>Practical</b></p> <p>Visits of National Parks, wildlife Sanctuaries, Safari Parks to note the biology of wild animals</p> <p>Notes on endangered and threatened wild animals of Pakistan and World</p> <p><b>Books Recommended</b></p> <ol style="list-style-type: none"> <li>1. Bailey, J.A. 1984. Principles of Wildlife Management. John Wiley London.</li> <li>2. Bolen, E. G. and W. L. Robinson. 1995. Wildlife ecology and management. 3<sup>rd</sup> edition. Prentice Hall, Inc, New Jersey, USA. 620pp.</li> <li>3. Khan, M. S. 2006. Amphibians and Reptiles of Pakistan. Krieger Publishing</li> </ol>

	<p>Company. 311pp.</p> <ol style="list-style-type: none"> <li>4. Peine, John D. 1999. Ecosystem Management for Sustainability: Principles and Practices Illustrated by a Regional. CRC Press.</li> <li>5. Roberts, T. J. 1997. The Mammals of Pakistan. Oxford University Press. 525pp.</li> <li>6. Roberts. T. J. 1992. The Birds of Pakistan (Vol. I&amp; II). Oxford University Press. 598, 617pp.</li> <li>7. Teague, Richard. D. A. Manual of wildlife conservation, Colorado State University, Fort Collins, Colorado. The Wildlife Society Washington D.C.</li> <li>8. Tiwaei, P.C. and Bhagwati, J. 1997. Wildlife in the Himalayan Foothills: Conservation and Management. 376 pp.</li> </ol>
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<b>Course Title</b>	<b>Advances in Ichthyology</b>
Course Code	ZOL-774
Credit Hours	3
Theory	2
Practical	1
Follow up	
Category	MS/PhD Zoology, 02-Years Programme
Aims and Objectives	The objectives of the course is the study of the anatomy, morphology, physiology, age and growth, reproduction, and to provide the students with identification and curatorial skills necessary for working with fishes
Learning Outcomes	Familiarity with external morphology measurements, analysis of morphometric data, sample construction for age identification and calculation of fish fecundity, application of statistical and other methods for estimating growth parameters during practical skills.
Syllabus in Brief	<p>Introduction to Ichthyology, Morphology and Anatomy: Form and function of external/internal structures and basic physiology of a generalized fish including body shape and size; Skin; coloration, fins, spines, and scales, respiration, circulation, Digestion, skeletal, urinogenital, nervous and endocrine systems and reproduction, reproductive strategies of fish and their relative success, fecundity, osmoregulation, buoyancy and thermal regulation, Migrations. Sense organs, Evolutionary Perspectives: Agnathans and ancestor, parasitic sea Lampreys; Jaw; Evolutionary Innovation, Chondrichthyes-an evolutionary solution, Elasmobranchs; an overview, ostichthyes-a different solution, Teleosts-making sense of diversity, Ostariophysians; Success stories of freshwater Physiological mechanisms used by different fish to survive in aquatic habitats, important ecological and evolutionary processes that affect fish distribution and abundance today. Ichthyology-application and implications, conservation and managements.</p> <p><b>Practical:</b></p> <ol style="list-style-type: none"> <li>1. Collection and Identification of common fishes of Punjab/ Pakistan</li> <li>2. Study of external features of a bony fish and its dissection to study major anatomical features (digestive system, respiratory system, reproductive system and excretory system)</li> <li>3. key features for six (6) basic fish body shapes</li> <li>4. Study of fish scales, Age and growth, length-weight relationships &amp; growth parameters.</li> <li>5. Survey the major groups of fishes in the Pakistan, their distributions, and</li> </ol>

their defining characters and traits.

6. Study of prepared fish tissues

**Suggested Reading**

1. PAULY D., R. FROESE & M.L. PALOMARES & K.I. STERGIUO. 2009. Fish On Line: A guide to learning and teaching ichthyology 2. FishBase Publications. [www.fishbase.org](http://www.fishbase.org).
2. Collette, B., Douglas E. Facey, and Brian W. Bowen 2008. 2<sup>nd</sup> Edition ISBN-10: 1405124946
3. Pillay, T.V.R. 1993. Aquaculture, Principles & Practices. Fishing News Books, Oxford.
4. Jobling, M. 1995. Environmental Biology of Fishes. Chapman & Hall, London.
5. Evans, D.H. 1997. The Physiology of Fishes, 2nd ed. CRC Press, N.Y.
6. Wootton, R.J. 1990 Ecology of Teleost Fishes. Chapman & Hall, London.
7. Gene S. Helfman, Bruce B. Collette, Douglas E. Facey, and Brian W. Bowen. 2009. *The Diversity of Fishes*, 2<sup>nd</sup> Edition. Wiley-Blackwell, Chichester, West Sussex, UK.
8. Nelson, Joseph S. 2006. *Fishes of the World*, 4th Edition. John Wiley & Sons, Hoboken, New Jersey.