on

DEPARTMENT OF ZOOLOGY

REVISED CURRICULUM M.SC (2YEARS) PROGRAM

SESSION: 2017-19 and 2018-2020

(EX POST FECTO APPROVAL)

Submitted by
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SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

Serial no.	Title	Page No.
1	Introduction	3
2	M.Sc Program objectives	4
4	Revised Scheme of study M.Sc (2Years) Program Session 2017-2019 and 2018-2020	5
5	List of compulsory course	6
6	List of optional courses	7
7	Detail of compulsory Courses with course contents	8
8	Detail of optional courses with course contents	31

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DEPARTMNT OF ZOOLOGY

INTRODUCTION

Zoology as a subject is multidisciplinary in nature, involving study of organisms and their genetic, morphological and physiological attributes, their surrounding environment, and their role in conservation of environment. Zoology is a combination of various disciplines such as Genetics, Physiology, Ecology, Developmental Biology, Microbiology, Parasitology, Entomology, Freshwater Biology, Fisheries, and Wildlife etc. This subject has significant role in human resources development, food security, environmental conservation, sustainable development and ultimately in alleviation of poverty.

Eligibility Criteria:

M.Sc. (2years): B.Sc (Zoology and Botany)

VISION STATEMENT OF DEPARTMENT

The department aims to be among the leading departments of Zoology country wide and to be a cradle of quality, up-to-date source of education and research which has relevance to local, regional and national needs. The department looks forward to launch post graduate, M.Phil/Ph.D programs in future as well.

MISSION STATEMENT OF DEPARTMENT

The mission of the department of Zoology is to utilize our knowledge and expertise in order to train students in Zoological science and to prepare students with problem solving attitude, humanistic outlook, critical thinking and the ability to respond to socio-economic challenges.

We aim to provide those professional skills and ethical practices relevant to Zoology to apply them meaningfully in those areas/fields requiring Zoological expertise and also awaken an awareness of the need to explore, understand and conserve animal diversity. To create an attractive and research based innovative department where students want to come for study and contributes their role in the welfare of humanity by finding ways to increase the food production, to preserve rare animal species by improving their habitat and to find different Zoonotic and other disorders and their solution.

MISSION STATEMENT OF M.SC (2YEARS) PROGRAM

The mission of the M.Sc program is to educate and prepare graduate students to understand the scope and limitations of the subject along with practical application requiring Zoological expertise for the development of human resource in the various disciplines of Zoology.

PROGRAM OBJECTIVES

The M.Sc program objectives are;

- ✓ To impart knowledge about various disciplines of Zoology.
- ✓ To enhance students presentation skills.
- ✓ To equip the students with professional skills.
- ✓ To establish culture of scientific research.
- ✓ To educate students about animal diseases, their causes, vectors, life cycles and treatment
- ✓ To improve the quality and quantity of animal based food through research
- ✓ To train students for better planning and management of animal resources and environment.

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR
DEPARTMENT OF ZOOLOGY
SCHEEME OF STUDY M.SC ZOOLOGY (SESSION 2017-2019 AND 2018-2020)

S.NO	Semester	COURSE TITLE	COURSE CODE	Theory	Practical	CREDIT HOURS
1.	1st	Principles of Biochemistry	ZOL-511	2	1	3
2.		Cell biology	ZOL-512	2	1	3
3.		General Genetics	ZOL-513	3	1	4
4.		Biostatistics and Computation	STAT-401	2	1	3
5.		Introduction to Evolution	ZOL-515	2	0	2
6.		Functional English-I	FENG-510	2	0	2
				Total Credit Hours		**17**
S.NO	**Semester**	**COURSE TITLE**	**COURSE CODE**	**Theory**	**Practical**	**CREDIT HOURS**
7.	2nd	Zoogeography and Paleontology	ZOL-521	2	0	2
8.		Animal Ecology	ZOL-522	3	1	4
9.		Developmental Biology	ZOL-523	3	1	4
10.		Animal Physiology	ZOL-524	3	1	4
11.		Wild life, Management and Conservation	ZOL-525	3	1	4
12.		Functional English-II	FENG-520	2	2	2
				Total Credit Hours		**20**
S.NO	**Semester**	**COURSE TITLE**	**COURSE CODE**	**Theory**	**Practical**	**CREDIT HOURS**
13.	3rd	Entomology	ZOL-631	3	1	4
14.		Functional Morphology of Invertebrates	ZOL-632	3	1	4
15.		Functional Morphology of vertebrates	ZOL-633	3	1	4
16.		General and Comparative Endocrinology	ZOL-634	2	1	3
17.		Synopsis and Research Methodology	ZOL-635	3	0	3
				Total Credit Hours		**18**
S.NO	**Semester**	**COURSE TITLE**	**COURSE CODE**	**Theory**	**Practical**	**CREDIT HOURS**
18.	4th	Parasitology	ZOL-641	3	1	4
19.		Fundamental Microbiology	ZOL-642	3	1	4
20.		Animal Behavior	ZOL-643	3	0	3
21.		Optional Course + internship OR	List ZOL-690	2+1	1+3	3+3
		Research Project	ZOL- 699	0	6	6
			Total Credit Hours			**17**

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR
DEPARTMENT OF ZOOLOGY
LIST OF COMPULSORY COURSES M.SC (SESSION 2017-2019 AND 2018-2020)

Serial No.	COMPULSORY COURSES TITLES	COURSE CODE	CREDIT HOURS
1.	Principles of Biochemistry	ZOL-511	2+1
2.	Cell Biology	ZOL-512	2+1
3.	General Genetics	ZOL-513	3+1
4.	Biostatistics and Computation	ZOL-514	2+1
5.	Introduction to Evolution	ZOL-515	2
6.	Functional English-I	FENG-510	2
7.	Zoogeography and Paleontology	ZOL-521	2
8.	Animal Ecology	ZOL-522	3+1
9.	Developmental Biology	ZOL-523	3+1
10.	Animal Physiology	ZOL-524	3+1
11.	Wildlife, Management and Conservation	ZOL-525	3+1
12.	Functional English-II	FENG-520	2
13.	Entomology	ZOL-631	3+1
14.	Functional Morphology of Invertebrates	ZOL-632	3+1
15.	Functional Morphology of Vertebrates	ZOL-633	3+1
16.	General and Comparative Endocrinology	ZOL-634	2+1
17.	Synopsis and Research Methodology	ZOL-635	3
18.	Parasitology	ZOL-641	3+1
19.	Fundamental Microbiology	ZOL-642	3+1
20.	Animal Behavior	ZOL-643	3
21.	Research Project	ZOL-699	6
22.	One Optional course	List	2+1
23.	Internship	ZOL-690	3

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DEPARTMENT OF ZOOLOGY
LIST OF OPTIONAL COURSES M.SC (SESSION 2017-2019 AND 2018-2020)

Serial No.	OPTIONAL COURSES TITLE	COURSE CODE	CREDIT HOURS
1.	Ichthyology	ZOL- 651	3(2+1)
2.	Reproductive Physiology	ZOL- 652	3(2+1)
3.	Fish Nutrition And Health	ZOL- 653	3(2+1)
4.	Molecular Biology	ZOL- 654	3(2+1)
5.	Epidemiology of Animal Parasites	ZOL- 655	3(2+1)
6.	Introduction to Environmental Biology	ZOL- 656	3(2+1)
7.	Advances in aqua culture	ZOL- 657	3(2+1)
8.	Biomembranes and Signal Transduction	ZOL- 658	3(2+1)
9.	Radiobiology	ZOL- 659	3(2+1)
10.	Enzymology	ZOL- 670	3(2+1)
11.	Toxicology	ZOL- 671	3(2+1)
12.	Principles of Gene Manipulation	ZOL- 672	3(2+1)
13.	Clinical Biochemistry	ZOL- 673	3(2+1)
14.	Research Techniques & Instrumentation	ZOL- 674	3(2+1)
15.	Nucleic acids	ZOL- 675	3(2+1)
16.	Vitamins and Hormones	ZOL- 676	3(2+1)
17.	Medical Microbiology	ZOL- 677	3(2+1)
18.	Immunology	ZOL- 678	3(2+1)
19.	Aquaculture Systems Management	ZOL- 679	3(2+1)
20.	Herpetology	ZOL- 680	3(2+1)
21.	Mammology	ZOL- 681	3(2+1)
22.	Neurobiology	ZOL- 682	3(2+1)
23.	Protozoology	ZOL- 683	3(2+1)
24.	Ornithology	ZOL- 684	3(2+1)
25.	Freshwater fish culture	ZOL- 685	3(2+1)
26.	Introduction to Human Genetics	ZOL- 686	3(2+1)
27.	Vector biology	ZOL- 687	3(2+1)
28.	Epidemiology of animal parasites	ZOL- 688	3(2+1)
29.	Medical virology	ZOL- 689	3(2+1)
30.	Clinical bacteriology	ZOL- 690	3(2+1)

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DETAILS OF COURSES

CURRICULUM M.SC (2-YEARS) (SESSION 2017-2019 AND 2018-2020)

SEMESTER-I

Course Name: Principles of Biochemistry	Course Code: ZOL-511
Course Structure: Lectures: 2, Lab: 1	Credit Hours: 2+1

COURSE OUTLINE

Introduction and Importance, Hydrogen bonding in water, solvent properties of water, chemical equilibrium, pH, acids and bases, buffers, the Henderson-Hesselbach equation, bicarbonate buffer system of blood, Enzymes.

The ATP cycle of bio-energies structure and biological function of carbohydrates, lipids, proteins and nucleic acids. Glycolysis, the citric acid cycle, electron transport, oxidative phosphorylation and regulation of ATP production. Oxidation of fatty acids and amino acids, urea cycle.

Laboratory Work Outline

1. Titration of a strong acid with a strong base.
2. The determination of pKa, preparation of buffers.
3. Titration curves of amino acids, determination of amino acids
4. Identification of an unknown carbohydrate
5. Determination of lipids in a given sample.

Books Recommended

1. Darnell Jr. J., Lodish, H. and Balimore, D., (2004). Molecular Cell Biology, Scientific American Inc. N.Y.
2. Voet, D. and Voet, J.G., (1990). Biochemistry, John Wiley & Sons.
3. Zubay, G.L., (1995). Principles of Biochemistry. McMillan Publishing Co.
4. Stryer, L. (1995). Biochemistry, W.H. Freeman & Co., New York.
5. Davlin, J. 1992. Textbook of Biochemistry with Clinical Correlations, John Wiley & Sons.
6. Lehninger, A.L., Nelson, D.L. and Co. N.M., (2000). Principles of Biochemistry. Worth Publishers, N.Y.
7. Wilson, K., and Goulding, K.H. (2000). A Biologist's Guide to Principles and Techniques of Practicals of Biochemistry. Edward Arnold.
8. Karp, G., (2002). Cell and Molecular Biology: Concepts & Experiments. 3rd Edition. John Wiley Sons, Inc., N.Y.

Course Name: Cell Biology	**Course Code: ZOL-512**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**

COURSE OUTLINE

Introduction to cell theory and structure; chemical composition of cell; types of cell organelles, structure and their functions; transport properties of cell membrane; cell cycle; mitosis; molecular organization and function role. The concept of the unit membrane, the fluid mosaic model, surface receptors and membrane mediated control the movement of substances across cell membranes. Lysosome, micro-bodies; Mitochondria and the conversion of chemical energy: mitochondrial structure and function, oxidation – reduction – potentials.

The chloroplast and photosynthesis: chloroplast structure and the mechanism of photosynthesis. Cell movements: structure and function of cytoskeleton, centriole, cilia and flagella, the mitotic apparatus; The nucleus, chromosomes the nature of gene: the cell cycle: mitosis, cytokinesis and furrowing; Introduction of special topics: Immune system, cancer, aging and cloning.

Laboratory Work Outline

1. Study of prokaryotic and eukaryotic cell.
2. Study of Human Blood Cells
3. Plasmolysis and deplasmosis in blood
4. Study of cell structure using compound microscope and elucidation of ultra-structure from electron microphotographs.
5. Cellular reproduction, mitosis: smear/squash preparation of onion roots/cheek cells.
6. Preparation of culture plates.
7. The chemical and theoretical bases for differential staining procedure.
8. Study of the chemical basis of Gram stain
9. Staining of any tissue.
10. Study of prepared slides.
11. Study and preparation of epithelial cells.

Books Recommended

1. Molecular Biology of the Cell, Bruce Alberts, Alexander Johnson, 4th Edition, 2002. Garland Sciences.
2. Molecular Biology and Biotechnology, J.M. Walker and E.B. Gingold, 3rd Edition, 1993. Royal Chemistry Society.
3. Molecular Cell Biology, Lodish, Berk, Zipursky, 4th Edition. 2000. W.H. Freeman.
4. Cell and Molecular Biology, Karp, 3rd Edition. 2002. John Wiley and Sons.

Course Name: General Genetics	**Course Code: ZOL-513**
Course Structure: Lectures: 3, Lab: 1	**Credit Hours: 3+1**

COURSE OUTLINE

Introduction, scope and brief history of genetics. Mendilian inheritance; Laws of segregation and independent assortment, back cross, test cross, dominance and incomplete dominance. Sex linked inheritance, sex linkage in Drosophila and man, XO, XY, WZ mechanism, sex limited and sex linked characters, sex determination. Linkage and crossing over: Definitions, linkage groups, construction of linkage maps, detection of linkage.

Chromosomal aberrations: Changes in the number of chromosomes. Aneuploidy and euploidy. Changes in the structure of chromosomes, deficiency, duplication, inversion and translocation. Molecular genetics: DNA replication. Nature of gene, genetic code, transcription, translation, protein synthesis, regulation of gene expression(e.g lac operon). Transmission of genetic material in Bacteria: Conjugation and gene recombination in E.coli, transduction and transformation. Principles of genetic engineering/biotechnology; basic genetic engineering techniques. Application of genetics in animalimprovement: Induction of genetic variability (gene mutation, recombination), physical and chemical mutagens.

Laboratory Work Outline

1. Genetical problems related to transmission and distribution of genetic material.
2. Identification of DNA in plant material. Carmine, orcein staining.
3. Study of salivary gland chromosomes of Drosophila.
4. Study of Human Chromosomes/models.
5. Polyploidy in plant cells

Books Recommended

1. Hoelzel, A.R. 2001. Conservation Genetics. Kluwar Academic Publishers.
2. Lodish. H. 2001. Molecular Cell Biology. W.H. Freeman and Co.
3. Sinha, U. and Sinha, S. (1988). Cytogenesis Plant Breeding and Evolution, Vini Educational Books, New Delhi.
4. Strickberger, M.V. (1988). Genetics, MacMillan Press Ltd., London.
5. Carroll, S.B., Grenier, J.K. and Welnerbee, S.d. 2001. From DNA to Diversity-Molecular Genetics and the Evolution of Animal Design. Blackwell Sciences.
6. Lewin, R. 1997. Principles of Human Evolution. Blackwell Science.
7. Smith, J. (1998). Evolutionary Genetics 2nd edition.
8. Snustad, D.P. (1997). Principles of Genetics. John Wiley & Sons, inc.
9. Griffiths, Anthony J.F., et. al. (2002). Modern genetic analysis: integrating genes and genomes. Editions 2nd W.H. Freeman, New York.
10. Schleif, R. (1993). Genetics and molecular biology. Edition 2nd Johns Hopkins University Press, Baltimore.
11. Miesfeld, Roger L. (1999). Applied molecular genetics. John Wiley, New York

Course Name: Biostatistics and Computation	**Course Code: ZOL-514**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**

COURSE OUTLINE

Introduction of Biostatistics. Data Analysis (Collection of Primary and Secondary data. Editing of data, Diagrammatic representation of data) Concept of probability. Measures of central tendencies and dispersion (Arithmetic mean, standard error of the mean, median, mode, range, variance and standard deviation). Standard distribution: Binominal, Poisson and normal distributions, properties and application. Test of significance (t-test, X2-test, F-test. L.S.D test, Duncan multiple Range Test, correlation coefficient, regression, Experimental Design.

Laboratory Work Outline

1. Manipulation of Data
2. Application of different statistical test
3. Experimental design.

Books Recommended:

1. Samuels, M.L. (1991). Statistics for the Life Science. Dellen Publishing Company.
2. Yule, G.U. and Kendall, M.G. (1991). Introduction to the Theory of Statistics, Charles Griffin & Co.
3. Stanton, A.G. (2001). Primer of Biostatistics. McGraw Hill.
4. Streiner, N., Norman, G.R (2000). Biostatistics: The Bare Essentials. B.C. Decker, Inc.
5. Rosner, B. (2000). Fundamentals of Biostatistics. Cole Pub. Co.
6. Fowler, J., Cohen, L. and Jarris, P., 1998. Practical Statistics for Field biology. John Wiley and Sons.
7. Zar, 1998. Biostatistical Analysis.
8. Campbell, R.C. Statistics for Biologists. Cambridge University Press.
9. Sokal, R.R. and Rohlaf, f.j., 1973. An Introduction toBiostatistics. Toppan.
10. Bailey, N.T.J., 1981. Statistical methods in Biology. English University Press.
11. Mead, R., Currow, R.N. and Hastod, A.M., 1993. Statistical Methods in Agriculture and Experimental Biology, 2nd edition. Chapman & Hall.

Course Name: Introduction to Evolution	**Course Code: ZOL-515**
Course Structure: Lectures: 2, Lab: 0	**Credit Hours: 2+0**

COURSE OUTLINE

Pre-Darwinian concept of evolution. Darwin's concept of natural selection, support and

challenges for Darwin. The nature of evaluation including evidences for evolution and history of modern evolutionary theory.

The origin of hereditary variation, the genetic structure of populations; races, subspecies; reproductive isolation. Role of mutations, migration, selection, and random genetic drift in evolution.

Gene frequencies and Hardy-Weinberg equilibrium. Origin of universe and earth, geological dating, origin of life.

Books Recommended

1. Strickberger, M. W. (2005). Evolution. Jones and Bartlett, USA
2. Dobzhansky, Th., F.J. Ayala, G.L. Stebbins and J.W. Valentine. (1977). Evolution, W.H. Freeman and Company, Saw Francisco.
3. Hall BK, Hallgrímsson B, Strickberger MW. (2008). Strickberger's evolution: Jones & Bartlett Learning.
4. Ridley, M. (2004). Evolution. Blackwell Science.
5. Barton NH. (2007). Evolution. CSHL Press, 2007. Hardcover 833 pages.
6. Hedrick PW. (2005). Genetics of populations. Jones & Bartlett Learning, Hardcover. 737 pages
7. Jarman, C. (1972). Evolution of Life. A Bantam Book/published by arrangement with Grosset and Dunlap, Inc.
8. Stebbins, G.L. (1971). Process of Organic Evolution. Prentice-Hall, Inc.
9. Ayala, f.J. (Editor) (1976). Molecular Evolution. Sinauer Associates, Inc.

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

DETAILS OF COURSES

CURRICULUM FOR M.SC (2-YEARS) (SESSION 2017-2019 AND 2018-2020)

SEMESTER-II

Course Name: Zoogeography and Paleontology	**Course Code: ZOL-521**
Course Structure: Lectures: 2, Lab: 0	**Credit Hours: 2+0**

COURSE OUTLINE

Zoogeography: Branches of Zoogeography (descriptive, chorology, faunistics, systematic, bioceonotic, causal, ecological, historical experimental and applied zoogeography). Animal distribution (cosmopolitan distribution, discontinuous distribution, isolation distribution, bipolar distribution and endemic distribution). Barriers and dispersals. Zoogeographical regions (division, geographic ranges, physical features, climates, faunas and affinities of Holarctic (Palaearctic and Nearctic regions), Oriental, Ethiopian, Australian and Neotropical regions). Paleogeography (theories of continental drift and plate tectonics).

Principles of Paleontology: Earth, shells of earth (atmosphere, hydrosphere, biosphere and lithosphere). Rock, types of rocks (igneous rocks, sedimentary rocks and metamorphic rocks). Fossil, types and uses of fossils. Nature of fossils. Processes of fossilization. Geological time scale. Pre-Cambrian life. Post Cambrian life (Paleozoic life, Mesozoic life, Cenozoic life). A brief history of the Siwaliks. Geochronometry (Uranium/Lead dating, radiocarbon dating, Fission track dating and palaeomagnetism).

Books Recommended

ZOOGEOGRAPHY

1. Cox, C.B. and Moore, P.D. 2000. Biogeography. An ecological and evolutionary approach. Blackwell Science. Oxford.
2. Hugget, R.J. 2004. Fundamentals of Biogeography. 2nd edition. Routledge. London, UK.
3. Lomolino, M.V., Riddle, B.R. and Brown, J.H. 2006. Biogeography. 3rd Ed. Sinauer Associates, Inc. Publishers. Sunderland, Massachussets.
4. Lomolino, M.V., Sax, D.V. and Brown, J.H. 2004. Foundations of Biogeography. The University of Chicago Press. Chicago, Illinois, USA.
5. Darlington, P.J., Zoogeography, John Wiley. 1985.
6. Ali, S.S. 1999. Palaeontology, Zoogeography and Wildlife management.

PRINCIPLES OF PALEONTOLOGY

1. Romer, A. S. 1966. Vertebrate Paleontology. 3rd Ed. University of Chicago Press, Chicago.
2. Gilbert, C.E.H. 1980. Evolution of vertebrates, John Willey and Sons Inc. NY.

3. Benton, M.J. 2005. Vertebrate Palaeontology. 3rd Ed. Wiley-Blackwell.
4. Brouwer, A. 1977 General Palaeontology, Oliver and Boyed London.
5. Yadav, P.R. 2009. Understanding Palaeontology. Discovery Pub. Delhi.
6. Ali, S.S. 1999. Palaeontology, Zoogeography and Wildlife Management.

Course Name: Animal Ecology	**Course Code: ZOL-522**
Course Structure: Lectures: 3, Lab: 1	**Credit Hours: 3+1**

COURSE OUTLINE

Introduction: Its meaning and scope. The biosphere: atmosphere, hydrosphere and lithosphere. Ecosystem, biotic and a biotic component. Flow of energy and laws of thermodynamics. Primary productivity and secondary production. Trophic structures: food chains (grazing and detritus) food webs, ecological pyramids and ecological efficiencies. Communities: Biological structure, dominance, richness and evenness, index of diversity and similarity. Patterns in communities and community dynamics.

Population: properties, density, dispersion, age structure and pyramids, population growth, natality, mortality, survivorship curves, population fluctuations, intra specific population regulations, interspecific interactions: herbivory, predation, parasitism, mutualism, human interaction with natural population.

Biogeochemical cycles of C or O, N or P or S, chlorinated hydrocarbons, heavy metals. Global Environmental changes and their effects: Increase in greenhouse gases, ozone hole, acid rain, use of non-biodegradable substances. Pollution, Nuclear Power, Loss of Biodiversity and its conservation.

Laboratory Work Outline

1. Measurement of environmental factors on land, water and air.
2. Study of different ecosystems: pond, agricultural or grassland, forest.
3. Community analysis through different sampling techniques (quadrat, transect).
4. Population dynamic of grasshoppers.
5. Adaptive features of animals in relation to food and environment.
6. Food chain studies through analysis of the gut contents.
7. Analysis of polluted and fresh water for biotic and abiotic variations.
8. Field visits for study of selected terrestrial habitat and writing notes.
9. Development of an ecological management plan of some selected area.

Books Recommended

1. Krohne, D. T. (2001). General Ecology. 2nd Ed. Books and Cole Thomson Learning
2. Manuel L. Mouls Jr. (2002). Ecology, concepts and applications. 2nd Ed. McGraw Hill Co.
3. Stiting, P. (2002). Ecology: Theories and Applications. 4rth Ed. Prentice Hall of India

4. Towsend, U. R.., Harper, J. L. and Begon, M. (2000). Essentials of Ecology. Ist Ed. Blackwell Science.
5. Smith, R. L. and Smith, T. M. (1998). Elements of Ecology. 4rth Ed. The Benjamin/Cummings Publishing Co.
6. Mackenzie, A., Ball, A. Virde, S. R. (1998). Instant notes in Ecology. Ist Ed. BIOS Scientific Publishers.
7. Odum, E.P., 1994. Fundamentals of Ecology. W.B. Saunders.
8. Moles, M.C., 2002. Ecology: Concepts and Applications. McGraw Hill, Boston.
9. Dodson, S.I., Allen, T.F.N., Carpenter, S.R., Ives, A., Jeanne, R.L., Kitchell, J.F., Langston, N.E. and Turner, M.G., 1998. Ecology. Oxford Univ. Press, Oxford.
10. Singby, D. and Cork, D., 1986. Practical Ecology. McMillan Education Ltd., London.
11. Chapman, J.L. and Reiss, M.J., 1997. Ecology. Principles and Application. Cambridge Univ. Press, Cambridge.
12. Smith, R.L. 1996. *Ecology and Field Biology*, Harper and Row.
13. Southwick, C.H., 1976. *Ecology and Quality of our Environment*. D. Van Norstrand Co, New York.
14. Boyd, C.E. 1981. *Water quality in warm water fish ponds*. Craft Master Printers Incorporation, Alabama.

Course Name: Developmental Biology	**Course Code: ZOL-523**
Course Structure: Lectures: 3, Lab: 1	**Credit Hours: 3+1**

COURSE OUTLINE

Study of mechanism of development. Historical development, morphogenesis and cell adhesion, fertilization: structure of gametes, sperm, and egg.
An introduction to early developmental process: cleavage, blastulation and gastrulation, patterns of cleavage; cleavage in sea urchin, amphibians, fish, bird and mammals.
Later embryonic development: formation of neural tube, primary and secondary neurolation, neural crest cells, emphasis on morphological, biochemical and physiological factor, induction, evocation and primary organizer concepts, competence, prospective fates and potency, mosaic and regulatory development, and implantation, role of cytoplasm, egg cortex and nuclei in development and differentiation; analysis of mechanisms during organogenesis; Cytodifferentiation and stem cell concept.

Laboratory Work Outline

1. Study of structure of gametes in some representative cases i.e frog, fowl etc.
2. Study of cleavage and subsequent development from prepared slides and/or whole mounts in various animals i.e chick, fish, frog etc.,
3. preparation of whole mount slides of chick embryo at different developmental stages,
4. early development of frog/toad through induced spawning under laboratory conditions. Application of microsurgical techniques on chick embryos in vitro.

5. Preparation and staining of histological slides.

Books Recommended:

1. Gilbert, S.F., 2004. *Developmental Biology*, Sinauer Associates, Sunderland, MA.
2. Balinsky, B.I., 1985. *An Introduction to Embyrology*, Saunders.
3. Saunders, J.W., 1982. *Development Biology*, McMillan.
4. Oppenheimer, S.S., 1984. *Introduction to Embryonic Development*, Allen and Bacon.
5. Bodemer, C.W.,1968. *Modern embryology*. Holt, Rinehart and Winston.
6. Ham, R.G. and Veomett, M.J., 1980. *Mechanism of development*. C.V. Mosby Co.
7. Berril, N.J. and Karp, G., 1978. *Development*. McGraw Hill.
8. Wilt, F. H. and Hake, S. C. (2004). Principles of Developmental Biology. W. W. Norton and Company, Inc.
9. Sadler, T. W. (2000). Langman's Medical Embryology. 8th Ed. Lippincott Williams and Wilkins.
10. Moore, K. C. and Persaud, T. V. N. (2003). The developing human. 7th Ed. Saunder

Course Name: Animal Physiology	**Course Code: ZOL-524**
Course Structure: Lectures: 3, Lab: 1	**Credit Hours: 3+1**

COURSE OUTLINE

Central themes in physiology: Methods and tools used in the study of physiology: Structure- function Relationship, Adaptations, Homeostasis,

Membrane physiology, mechanism in Resting Membrane Potential: Donnan equilibrium, ion channels, electrochemical potential difference, Membrane receptors, Action potential generation and propagation innerves and muscles; Structure and function of electrical and chemical synapse. Molecular basis of muscle contraction; myoneural junction; skeletal and smooth muscle, Neurotransmitters;

Receptors Physiology: Mechanoreception, Photoreception, Auditory, Vestibular and Chemical sensory system; Motor system with in brain system, Cortical, Cerebeller and basal ganglia control of posture and movements; Autonomic system and its control; Higher function of nervous system including state of consciousness, learning , memory. Blood and its consumption, transport of oxygen and CO2;

Cardiovascular System: Physiology of cardiac muscles; cardiac cycle action potentials, Electrocardiography, Control of cardiac activity (cardiac out put) and peripheral circulation. Nervous and hormonal regulation of heart activity; Blood and homeostasis; Hemodynamics; Blood flow, pressures and resistance and their interrelationships. Arterial system; Microcirculation and lymphatics;

Overview of respiratory system; Exchange of Gases: Transport of O_2 and CO_2 between respiratory surface (the lungs) and body cells. Regulation of lungs respiration; Regulation of ventilation. Oxygen dissociation; Mechanical aspects of breathing; Respiratory responses in extreme conditions.

Excretion and Osmoregulation: in aquatic and terrestrial environment. Problems of osmoregulation; Obligatory exchange of ions and water; Vertibrate nephron

asosmoregulatory organ: Physiological anatomy of kidney and nephron; Glomerular filteration, Tubular absorption and secretion; water and electrolyte balance,urine formation; Control of body fluid volume and osmolality; Potassium, Calcium and Phosphate homeostasis; Role of kidney in acid-base balance. Nitrogeous waste products; Patterns of nitrogenous excretion and their phylogenetic development. **Nutrition and physiology of digestion:** Regulation of digestive secretions; Physiology anatomy of digestive tract (mammalian model), Absorption of water, ions and nutrients; Potential and movements in Gastrointestinal tract; Control of Motility. Gastrointestinal secretions and their control: Salivary, gastric, pancreatic and liver; Digestion and absorption of carbohydrates, proteins, lipids, vitamins, ions and water; Motility of gastrointestinal tract: Functional anatomy, regulation and motility in various segments. **Temperature relations of heterotherms and endothermes;** Dormancy: Sleep, Torpor, Hibernation, Estivation. Environmental Challenges: Temperature and animal energetic; Temperature relation of Ectotherms, Heterotherms and Endotherms.

Laboratory Work Outline

1. Recording of action potentials on oscilloscope and effects of various factors on its characters;
2. Study of synaptic activity with neuromuscular preparations; Sciatic nerve compound action potential.
3. Demonstration of nervous system organization while studying brain, cranial nerve, spinal cord and spinal nerves.
4. Experiments on sensory organs study.
5. Experiments on characteristics of skeletal muscle contractions; Responses of intestinal muscles and effect of drugs.
6. Demonstration of endocrine glands in a mammal (mouse). Effect of hormones on glycemia and calcemia; Effect of thyroxine on oxygen consumption; Effect of androgen on accessory sex organs and of estrogens on target tissues; Study of estrous cycle and effects of the hormones.
7. Experiments on the study of heart in prepared frogs
8. Study of blood pressure in various physiological states
9. Study of electrocardiograms
10. Blood coagulation study
11. Determination of oxygen consumption in fish and mouse and effects of factors

Demonstration of respiratory volume and pulmonary function tests. Experiments on digestion on nutrients by enzymes and effects of factors; Study of exocrine secretion in stomach or pancreas and effects of factors. Experiments on kidney regulation of osmolality; Urine analysis; Study of osmoregulatory adaptations in animals inhabiting various environments; Demonstration of effect of temperature on several physiological responses; Study of animals in various types of dormancy.

Books Recommended:

1. Schmidt-Nielsen, K. (2002). Animal Physiology. 5th Ed. Cambridge Univ. Press.
2. Randall, D., Burggren, W and French, K. (2001). Animal Physiology. 5th Ed. W. H. Freeman and Co.
3. Sherwood, L. (2004). Human Physiology. 5th Ed. Thomson Learning, Inc.

4. Costanzo, L. S. (2002). Physiology. 2nd Ed. Elsevier Science. USA.
5. Randall, D., Burggren, W., French, K. and Fernald, R., 2002. Eckert Animal Physiology: Mechanisms and Adaptations, 6th ed. W.H. Freeman and Company, New York.
6. Berne, R.M. and Levy, M.N., 2000. Principles of Physiology, 3rd edition. St. Lious, Mosby.
7. Guyton, A.C. and Hall, J.E., 2000. Textbook of Medical Physiology, 10th Edition. W.B. Saunders Company, Philadelphia.
8. Withers, P.C., 1992. Comparative Animal Physiology. Saunders College Publishing, Philadelphia.
9. Schmidt-Nelsen, K., 1997. Animal Physiology, Adaptation and Environment, 5th edition. Cambridge University Press, Cambridge.
10. Tharp, G. and Woodman, D., 2002. Experiments in Physiology, 8th Edition. Prentice Hall, London.

Course Name: Wild Life, Management and Conservation	**Course Code: ZOL-525**
Course Structure: Lectures: 3, Lab: 1	**Credit Hours: 3+1**

COURSE OUTLINE

Wildlife of Pakistan, identification, distribution, status, conservation and management (population estimate technology) of fishes, reptiles, birds and mammals of major importance in Pakistan. Philosophy and significance of wildlife conservation. Biodiversity and sustainability of wildlife. Wildlife rules and regulations in Pakistan. National and International agencies involved in conservation and management of wildlife. Sanctuaries, Game Reserves and National Parks in Pakistan. Ramsar convention, wetlands, endangered species of Pakistan.

Introducation to wildlife and their relationship with population. Concepts of wildlife conservation, sustainable development and ecosystem. Effects of Industrial and Agricultural development and urbanization on wildlife. National Parks. Wildlife sancturies and game reserves of Pakistan, their management and environmental problems. Modern techniques for control of environmental pollution in wildlife areas. Endangered species: causes and measures for the conservation. International Conventions. Study of ecosystems. Oceans or inland water bodies, forests, Tundras and deserts. Biological communities: primary producer. Primary, secondary and tertiary consumers of various environments. Interrelationship between components of the different food web. Ecosystem Management, Range management. Conservation methods for animals and plants.

Laboratory Work Outline

1. Visit to National Parks, Wildlife sanctuaries and game reserves.
2. Population studies of some reptiles, birds and small manuals.
3. Report on endangered species.

Books Recommended

1. Bailey, J.A., 1986. *Principles of Wildlife Management*, John Wiley.
2. Ali S. & Ripley S.D., 1973. *A Handbook of Birds of India & Pakistan*, Oxford University Press, London.
3. Roberts, T. J., 1998. *The Birds of Pakistan*, Vol. I. Oxford.
4. Roberts, T. J., 1992. *The Birds of Pakistan*, (Vol. II), Oxford.
5. Roberts, T.J., 1977. *Mammals of Pakistan*. Ernest Benon Ltd, London,
6. Robinson, W.L. and Bolen, E.G., 1984. *Wildlife Ecology and Management*. McMillan, Cambridge.
7. Magon, C.F. 1988. *Biology of freshwater pollution*. Longman and Scientific Publication.
8. Boyd, C.E. 1981. *Water quality in warm water fish ponds*. Craft Master Printers Incorporation, Alabama.
9. John Carius. 1995. Rehabilitating Demaged Ecosystem. Lawis Publishers.
10. M.C., Sharron. 1993 Pollution Ecology and Bio.Treatment. Longman House England.
11. R.G.H. Bunce, 1993.Landscap and Ecology and Agro Ecosystems. Lawis Publishers.
12. R.T.T., Forman and Godron, M. 1986. Landscaps Ecology. John Wiley and Sons, New York.
13. Russ. John. C. 1995. The Image Processing Handbook. Lawis Publisher.
14. Edgar Falkner. 1994. Aerial Mapping Methods & App;ications. Lawis Publisher.
15. Arlinghaus, Sandra Lach. 1994. Practical Handbook of Digital Mapping Terms and Concepts. Lawis Publisher.
16. Stephen Horn. 1993. Snboduetion to PCM Telemetering system. Lawis Publisher
17. Doughlas, Williem J. 1991. Environmental GIS Applications to Industrial Facilities.

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

DETAILS OF COURSES

CURRICULUM FOR M.SC (SESSION 2017-2019 AND 2018-2020)

SEMESTER-III

Course Name: Entomology	**Course Code: ZOL-631**
Course Structure: Lectures: 3, Lab: 1	**Credit Hours: 3+1**

COURSE OUTLINE

A general account including classification of insect order Collembola orthoptera Dictyoptera, Isoptera, Hemiptera, Lepidoptera, Diptera, Hymenoptera, Coleoptera. Only diagnostic characters of the remaining insect orders Thysanura, Diplura, Protura, Ephemeroptera, Odonata, Plecoptera Grylloblattoidea, Phasmida, Dermaptera, Embioptera, Zoraptera, Psocoptera, Mallophaga, Siphunculata Thysanoptera, Neuroptera Mecoptera, Trichoptera, Siphonaptera strepsiptera ,insects of economic importance.Integument Head of an orthopteroid insect Thorax sclerites of a typical wing bearing segment Hypothetical primitive venation pattern wing regions and modifications. Segmentation and functios of legs .Abdomen. Its segmentation appendages and processes Structure of typical male and female external genitalia .Soft parts Morphology and physiology of various system including embryology (upto dorsal closure) and metamorphosis (excluding organogenesis) Ecology Trophic relationship Competition Social systems and behavior populations under insecticidal stress Biological control strategies in Reproduction

Laboratory Work Outline

1. Dissection Cockroaclh grasshopper, red cotton bug, Gryllus butterfly honey-bee yellow wasp house fly and mosquito drosophila.
2. Microscopic preparations:Mouth-parts, wings,legs,genitalia of the above insects.
3. WholeMounts: Collembola, silver fish, thrips, birds-louse antlion aphids, whiteflies, fig insects, Head Louse, fleas.

Books Recommended

1. Richards, O.W. and Davies, R.J., (1977). Imm's General Textbook of Entomology.
2. Ross, H.H., (1965). A Textbook of Entomology, John Wiley, N.Y.

3. Patton, R.L., (1963). Introductory Insect Physiology, W.B. Saunders, London.
4. Candy, D.J. and Kilby, B.A., (1975). Insect Biochemistry and Function, Chapman and Hall, London.
5. Price, P.W., (1984). Insect Ecology, John Wiley, N.Y.
6. Snodgrass, R.F. (1935). Principles of Insect Morphology, McGraw Hill, N.Y.
7. Chapman, R.G., (1985). The Insects: Structure and Function, Hodder and Stoughton, London.

Wigglesworth, V.B., (1974). The Principles of Insect Physiology, Chapman and Hall, London.

Course Name: Functional Morphology of Invertebrates	**Course Code: ZOL-632**
Course Structure: Lectures: 3, Lab: 1	**Credit Hours: 3+1**

COURSE OUTLINE

A comparative approach in the study of structure with emphasis on function. Major groups of invertebrates and relationship. Living systems and organization relative to life. Adaptation for movements: Protozoa to Echinodermata: Pseudopodia, cilia, muscles and appendages. Nutrition in Protozoa, lower metazoan, filter feeding, intra and extra cellular digestion. Respiration and excretion. Nervous system; primitive and advanced. Reproduction and larval forms.

Laboratory Work Outline

1. Museum study of specimens; Protozoa through Echinodermata
2. Identification and classification of major invertebrate groups
3. Identification through microscopic slides of cilia, flagella, insect mouth parts, insect sperm flagella
4. Study of locomotory adaptations; locomotion of annelids, mollusks, arthropods, insect wing structures.

Books Recommended:

1. Brusca, R. C. and Brusca, G. J. (2002). Invertebrates. 2nd Ed. Sinauer Associates. Inc., Publishers.
2. Pechenik, J.A., 2000. Biology of invertebrates, 4th Edition (International). Singapore: McGraw Hill.
3. Hickman, Jr. C. P; Roberts, L. S and Larson, A. (1998). Biology of Animals. McGraw Hill Co, Inc.
4. Hickman, C.P., Roberts, L.S. and Larson, A., 2001. Integrated Principles of Zoology, 11th Edition (International). Singapore: McGraw Hill.
5. Barrington E. J. W. (1977). Invertebrate structure and function.
6. Rupppert, E, D and Barnes, R. D. (1994). Invertebrate zoology. 6th Ed. Saunders College Publishing.
7. Dorit, R. L., Walker, Jr. W. F and Barnes, R. D. (1991). Zoology. Saunders

College Publishing, Inc.
8. Miller, A.S. and Harley, J.B., 1999 & 2002. Zoology, 4th & 5th Edition (International). Singapore: McGraw Hill.
9. Campbell, N.A., 2002. Biology, 6th Edition. Menlo Park, California: The Benjamin/Cummings Publishing Company, Inc.
10. Miller, S.A., 2002. Genral Zoology Laboratory Manual. 5th Edition (International) Singapore: McGraw Hill;
11. Hickman, C.P. and Kats, H.L., 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill.
12. Marshall, A.J. and Williams, W.D., 1972. *A Textbook of Zoology*,Volume I, Invertebrata. McMillan Co., New York.

Course Name: Functional Morphology Of Vertebrates	**Course Code: ZOL-633**
Course Structure: Lectures: 3, Lab: 1	**Credit Hours: 3+1**

COURSE OUTLINE

Origin of vertebrates, Classification (excluding fossil groups) of vertebrates and characteristics of each group. Comparative anatomy of various body systems in vertebrates. A comparative approach in analysis of morphological organization of vertebrates with emphasis on functions. Major groups of vertebrates and their relationships. Nutrition and feeling strategies: morphological adaptations: Respiration and adaptative mechanism in aquatic, terrestrial environments and in the transition stage; blood and its circulation; morphological changes in the organization of heart andvessels at fish, amphibian and mammalian levels: excretion and osmoregulation: morphological correlates of osmoconformity, osmoregulation, ammonia, urea, uric acid excretion, water conservation and counter current mechanism; sensory and nervous system: morphological correlates of information processing (neuro-reflex arcs), chemoreception, adaptation at various levels; endocrine glands, hormones and change during evolution; reproductive strategies and morphological changes from fish to mammals, oviparity and viviparity.

Laboratory Work Outline

1. Study of Skeleton of Labeo, frog, Varanus, fowl and rabbit.
2. Dissection and study of various systems in Rita rita, frog, Uromastix, pigeon and rabbit.
3. General survey of vertebrates
4. Adaptive features.

1. **Books Recommended:**

2. Hildebrand, M and Goslow, G. (2001). Analysis of vertebrate structure. 5th Edition. John Wiley and Sons, Inc.
3. Kardong, K. V. (2002). Vertebrates. 3rd Ed. Comparative anatomy, function and evolution. McGraw Hill Co.
4. Romer, A.S. and Parsons, T.S., (1986). The Vertebrate Body, Holt Saunders,

Philadelphia.

5. Yapp, W.B., (1965). Vertebrates: Their Structure and Life, Oxford University Press, N.Y. Oxford.
6. Young, J.Z., (1962). Life of Vertebrates, Clarendon Press, Oxford.
7. Hickman, Jr. C. P; Roberts, L. S and Larson, A. (1998). Biology of Animals. McGraw Hill Co, Inc.
8. Dorit, R. L., Walker, Jr. W. F and Barnes, R. D. (1991). Zoology. Saunders College Publishing, Inc.
9. Miller, A.S. and Harley, J.B., 1999 & 2002. Zoology, 4th & 5th Edition (International). Singapore: McGraw Hill.
10. Hickman, C.P., Roberts, L.S. and Larson, A., 2001. Integrated Principles of Zoology, 11th Edition (International). Singapore: McGraw Hill.
11. Kent, G.C. and Miller, S., 2001. Comparative Anatomy of Vertebrates. New York: McGraw Hill.
12. Campbell, N.A., 2002. Biology, 6th Edition. Menlo Park, California: The Benjamin/Cummings Publishing Company, Inc.
13. Miller, S.A., 2002. Genral Zoology Laboratory Manual. 5th Edition (International) Singapore: McGraw Hill;
14. Hickman, C.P. and Kats, H.L., 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill.
15. Marshall, A.J. and Williams, W.D., 1972. *A Textbook of Zoology*,Volume II:, Vertebrata. McMillan Co., New York.
16. Linzey, D. (2001). Vertebrate Biology. McGraw Hill Co.

Course Name: General And Comparative Endocrinology	**Course Code: ZOL-634**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**
COURSE OUTLINE	
An overview of general concepts and principles of endocrinology: The endocrine system; Type of hormones; Endocrine and nervous system relationship; General principles in function, interaction, nature, synthesis, transport of hormones; General concept of feed back, biorhythms, pathology and assessment of endocrine function; Evolution of endocrine system. Hypothalamus and pituitary: Hypothalamic hormones: Origin, chemistry and actions; hormones of anterior pituitary: Hypothalamic pituitary regulation, General chemistry, Physiological action and metabolism of prolactin-growth hormone family, glycoprotein hormone family, corticotiophins and other pro-opiomelanocortin	

peptides; posterior pituitary: Release, regulation and actions of vasopressin and oxytocin. Thyroid gland: Anatomy and histology; Formation and secretion of thyroid hormones; Thyroid hormones in peripheral tissues, Regulation and factors affecting thyroid function. Calcitrophic and Mineral Metabolism Hormones: Chemistry, physiological actions and metabolism of parathyroid hormone, metabolism of calcium and phosphate and magnesium; Parathyroid gland, Calcitonin and Cholecalciferol; Pancreatic Hormones and Regulatory Peptides of the Gut: Anatomy and histology for sources of the hormones; Chemistry, physiological roles and mechanism of action of insulin and glucagon; Physiological roles of gut peptides. Adrenal Medulla and Catecholamines: Chromaffin cell and organization; Structure of adrenal medulla; Biosynthesis, storage, release and metabolism; Adrenergic receptors. Adrenal Cortex: Steroid biochemistry; Physiological actions of corticoid hormones; Regulation and metabolism of glucocorticoids, mineralocorticoids and adrenal sex steroids. Hypothalamic-pituitary-adrenocortical axis, adrenal medulla and sympathetic nervous system together integrate responses to stress. Energetics of reproduction; functional anatomy, synthesis and regulation of gonadal steroids, secretory pattern of gonadal steroids at different stages of life; Male reproduction: Roles of androgen, biology and regulation of spermatogenesis, male puberty; Female reproduction: Roles of ovarian steroids, biology and regulation of oogenesis, female puberty, Steroid biochemistry and biosynthesis; Transport, metabolism and mechanism of action. Endocrinology of heart Heart, Kidney, pineal gland. Functional Diversity of Hormones in Vertebrates. Overview of Endocrine Mechanisms in Invertebrates. Neuroendocrinology; structural and functional abnormalities in endocrine glands, pharamacoendocrinology.

Laboratory Work Outline

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

Books Recommended

1. Greenspan, F.S. and Strewler, G.J., 2002. Basic and clinical endocrinology, 5th Edition. Prentice Hall International Inc., London.
2. Wilson, J.D., Foster, D.W., Kronenberg, H.M. and Larsen, P.R., 1998. Williams textbook of endocrinology, 9th Edition. W.D. Saunders Company, Philadelphia.
3. Turner and Bagnara General Endocrinology.
4. Norman, A. W and Litwaik, G. (1997). Hormones. 2nd Ed. Academic Press.

Bentley, P. J. (2000). Comparative Vertebrate Endocrinology

COURSE NAME: Synopsis and Research Methodology	**COURSE CODE:** ZOL -635
COURSE STRUCTURE: Lectures: 3, Labs: 0	**CREDIT HOURS:** (3+0)

COURSE OUTLINES

Introduction: Research and professions.

- Understanding the research process.
- History and Principles of research ethics.
- Originality of Research
- Conflicts of interest.
- Copyright and Patent Law.
- Aims of research, the research topic.
- Title and research problem.
- Literature review: Search, retrieve and manage information.
- Research design.
- Parametric, non-parametric and semi-parametric methods.
- Qualitative Methodologies and interpretation of results.
- Conclusions and its validity.
- Report writing and the research proposal.
- Community Research.
- Principles of presentation.
- Communication-oral, posters.
- Abstract and manuscript preparation.
- Communicating your own credentials.
- Communicating own work-CV.

Recommended Books

1 Ann Bowling, A. and Ebrahim S., 2005. Handbook of Health Research Methods. Open University Press, Two Penn Plaza, New York, NY.
2. Baumgartner, T. and Hensley, L. 2006. Conducting and Reading Research in Health and Human Performance 4th ed. McGraw-Hill, New York.
3. Kumar, R., 2010.Research Methodology: A Step-by-Step Guide for Beginners. 3rd edition. SAGE Publications, London
4. Flick,U., 2011.Introducing Research Methodology: A Beginner's Guide to Doing a Research Project SAGE Publications London
5. Chilisa, B.,2011.

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

DETAILS OF COURSES

CURRICULUM FOR M.SC (SESSION 2017-2019 AND 2018-2020)

SEMESTER-IV

Course Name: Parasitology	**Course Code: ZOL-641**
Course Structure: Lectures: 3, Lab: 1	**Credit Hours: 3+1**
COURSE OUTLINE	
History and origin of parasitism. Science and terminology. Host-parasite relationships: Phoresis, commensalisms, mutualism, parasitism, theory of parasitism, host specificity. Transmission of parasites. Responses: resistance, tolerance, immunity. Effects of parasites on their hosts and pathology. Evolution of parasites: variations, origin, factors affecting evolution, stability of parasitism. Ecology of parasites: variations, origin, factors affecting evolution, stability of parasitism. Ecology of parasites. Biotic potential among parasites. Various theoretical and experimental aspects of parasite physiology: osmoregulation, excretion, oxygen requirements and growth requirements of Protozoa and Helminthes. Classification of relationships between two individuals: symbiosis, commensalism, parasitisms, myiasis, zoonosis, infection and infestation. Evolutionary aspects related to parasites, geographical distribution factors affecting the geographical distribution, patterns of distribution. Habitat within the host. Epidemiology: incidences of occurrence and prevalence. Classification of parasites: Ectoparasites, endoparasites, temporary parasites, permanent parasites, facultative parasites, occasional or accidental parasites, wandering parasites or aberrant parasites (brief account and examples). Classification of hosts: Definitive hosts, intermediate hosts, paratenic hosts. Host susceptibility and specificity. Various types of susceptibilities. Host-parasite relationships. Morphology and physiology of parasites: Adaptions to parasitic mode of life. Effects of parasitism on parasites. Effects of parasites on hosts: Influence of parasites on host populations. Pathological responses, immuno-parasitology: immunity and immune responses of host. Diagnosis, prevention, control treatment, common drugs and anthelmintics. Vector control methods. Animal Parasitology (Protozoology, Helminthology, Veterinary and Medical Entomology) a. Protozoology: Protozoan parasites of man and other animals, classification, life cycle, habitat, morphology, epedimiology and immunopathology of infections e.g., *Entamoeba* spp. Pathogenic amoeba, *Giardia* spp., Trichomonas, Trypanosoma, Leishmania, Coccdia, Plasmodium and other protozoan parasites of importance. b. Helminthology: Helminth parasites of man and other animals, general account, classification, biology, life cycle, pathology and symptomology and immunology. Platyhelminthes: e.g. Polysystoma, Trematodes: e.g., Fasciola, Schistosoma, Diplastomun. Cestodes: e.g. Taenia, Diphyllobothrium, Acanthocephalas (spiny headed worms). Nematodes: Trichuris, Trichinella, Strongyloides, Ancylostoma, Trichostrongylus, Haemonelm, Toxocara, Filaria worms etc. c. Medical and Veterinary Entomology: Biology and classification of arthropods of veterinary and medical importance. Arthropods as parasites and blood suckers. Biology and life cycle e.g. crustaca, linguatolids, lice, mites, ticks, mosquitoes, fleas, flies, bugs etc. Effects of bites, allergies, pathology and immunology. Arthropods as disease	

transmitters/vectors.

Laboratory Work Outline

1. Study of the prepared slides and preserved specimens of parasites: Protozoan parasites, helminth parasites, Arthropod parasites.
2. Epedimiology of parasitic infections. Survey of incidences of occurrence and prevalence using soil, water (canal drain water samples) and animal population (chicken, goat/sheep, rat, fish etc.), Faecal Egg count Techniques). Survey and study of vectors/intermediate host (population etc.).
3. Preparation of slides for the study of structure of egg larvae of various helminth parasites and staining of cross-section through body regions. Preparation of protozoan parasites slides with various staining techniques. Study and preparation of slides/preservation of arthropod parasites.
4. Study of various host tissues for morphological changes in hosts (prepared slides or diagrams showing comparison) could be used to study the differences.
5. Techniques of collection of parasite samples, preservation and preparation of slides for the study of the morphology.
6. Identification of vector hosts in various habitats and their morphology.
7. Identification of parasites and classification with particular reference to adaptations as parasitic mode of life.
8. Heamatological studies of blood samples of infected/non-infected hosts (sheep/goat, chicken/fish).

Books Recommended

a. Bush, A.O., Fernandez, J.C., Esch, G.W. and Seed, J.R., 2001. Parasitism: The diversity and Ecology of animal parasites. Cambridge University Press, Cambridge, U.K.
b. Matthews, E. E. (1998). An introduction to parasirtology. Cambridge Univ. Press.
c. Smyth, J. D. (1994). Introduction to Parasitology. 3rd Ed. Cambridge Univ. Press.
d. Cox, P. E. G., Krcier, J. P. and Wakelin, D. (1998). Parasitology 9th Ed. Oxford Univ. Press.
e. Smyth, J.D., 1994. Introduction to animal parasitology, 3rd Ed. Cambridge Univ. Press, Cambridge, U.K.
f. Roberts, L.S. and Jonovy, J. Jr., 1996. Foundation of Parasitology, 5th Ed. Wan Brown Publishers, Chicago, U.S.A.
g. Beaver, P.C., Jung, R.C. and Cupp, E.W., 1984. Clinical parasitology, 9th Ed. Lea and Febiger, Philadelphia.
h. Cheesbrough, M., 1981. Medical laboratory manual for tropical countries. Stephen, Austen, Hertford.
i. Noble, E.R. and Noble, G.A., 1989. Parasitology: The Biology of Animal Parasites. Lea and Febiger, Philadelphia.
j. Chappell, L.H., 1980. Physiology of Parasites. Blackie, U.K.
k. Lapage, G., 1962. Monning's Veterinary helminthology and Entomology. Bailiers, Tinndall and Company, London.

l. Beck, J.W. and Davies, J.E., 1981. Medical Parasitology, 3rd Ed. The C.V. Mosby Co., London.
m. Barriga, O.O., 1981. The immunology of parasitic infections. University Park Press, Baltimore.
n. Buckle, A.P. and Smith, R.H., 1994. Rodent Pests and their Control. Cab. International, Oxford, U.K.
o. Wakelin, D., 1984. Immunity to parasites. How animals control parasitic infections? Edward Arnold, London.

Course Name: Fundamental Microbiology	**Course Code: ZOL-642**
Course Structure: Lectures: 3, Lab: 1	**Credit Hours: 3+1**

COURSE OUTLINE

History of Microbiology. Methods of Microbiology, microscopy, Culturing, Identification. Morphology and fine structure of viruses, Bacteria, fungi and Protozoan. Growth of microorganisms: Microbial cultivation (Viruses, Bacteria, Fungi). Microbial nutrition, Microbial reproduction, Growth control. Classification of microorganisms. Bacteria, Fungi, Viruses. Symbiotic relationships of Bacteria and fungi. Microbiology of soil, water and air. Microorganisms and diseases.

Laboratory Work Outline

1. A laboratory studies of the properties of bacteria and relate microorganisms.
2. Techniques of culturing: Media preparation, Sterilization, transfer of culture.
3. Isolation of pure culture: Spread plate method, streak plate method, and pour plate method.
4. Study of Morphology of bacteria, Fungi and Yeast; Staining procedures, Simple staining, Gram,s Staining, Spore staining, Capsule staining, Negative staining, Acid fast staining, Staining of Fungi.
5. Microscopy, light microscopy, Phase contrast microscopy.
6. Estimation of bacterial growth: CFU estimation, Turbidity measurement, Dry cell mass measurement.

Bacterial growth curve.

1. **Books Recommended:**

a. Kathleen, PT, Arthur, T (2010). Foundations in Microbilology, Basic Principles. McGraw Hill Companies.
b. Gerard, JJ, Tortora, Funke, Berbell, R, Funke, Christine, L Case (2006). Microbiology and introduction study guide. Benjamin Cummings Publishing Company.
c. Pelezar Jr. MJ Cham, E.C.S. Krieg, NR (1993). Microbiology, concepts and applications. McGraw hill, Inc. N.Y.
d. Wistrich, GA and Lechtman, MD (1990). Microbiology 5th Ed. McMillan Publishing Company. N.Y.

e. Peltier, G. L. (1998). A Laboratory Manual of Microbiology

Course Name: Animal Behavior	**Course Code: ZOL-643**
Course Structure: Lectures: 3, Lab: 0	**Credit Hours: 3+0**

COURSE OUTLINE

Introduction to animal behavior; foundations of ethology, natural selection, conceptual, theoretical and empirical approaches, learning, imprinting, conditioned behavior; ultimate and proximate causation, control of behavior by nervous system and biochemical factors, biological rhythms, clock genes and zeitgebers; sex determination and sex ratios; description and measurement of behavior; Causes of behavioral change; development of behavior; adaptive significance of behavior; phylogeny of behavior; behavioral genetics; applied ethology; habitat selection, niches, migration, hormones and animal behavior, steroid synthesis ad metabolism; mating, fighting, parenting, signaling, social relationship and organization; dominance, territoriality, development of sexes and types, theories of sexual selection and mate choice, mating systems, monogamy, polygamy and polygyny; parental care, social organization and kinship; cooperation; altruism; coalition; optimal foraging theory, foraging alone and in groups, honeybee foraging; predation; communication and honesty; aggression, agonistic behavior and competition; conflict, migration, orientation navigation; animal play behavior; boldness, shyness; evolutionary change and species differences; life strategies and life histories; examples to explain behaviors should be taken from variety of invertebrates vertebrates and humans, human social behavior and human psychology; facial features, gestures, societies, races, impact of religion on human behavior, social relationships, marriage systems from around the world.

Laboratory Work Outline

1. Study of aquarium fishes and frogs for courtship, nesting, foraging, egg laying
2. Field study of bird and mammalian behavior through visits to aviaries and zoos, nesting behavior of birds, through binoculars
3. Study of altruistic behavior in rats and related species
4. Small experiments to show kinship and cannibalistic behavior
5. Study of parental care in different vertebrate classes
6. Study of mouse or rat behavior regarding mating, selection and parental care
7. Study of monkey behavior regarding aggression, dominance, grooming
8. Preparation of ethograms and presentation of data
9. Recording bird songs and animal vocalizations
10. Behaviors of large predators, to understand survival strategies
11. Study of human facial expressions and postures

Books Recommended

1. Adkins-Regan, E. 2005. Hormones and animal social behavior. Princeton University Press.
2. John Alcock. 2010. Animal behavior, an evolutionary approach. 9th Edition. Sinauer Publishers.
3. Scott, G. 2009. Essential Animal Behavior. Wiley publishers.
4. Drickamer, L. C; Vessey, S. H; Jakob, E. M. 2002. Animal behavior: mechanisms, ecology, evolution. 5th ed. McGraw Hill Higher Education.
5. Dugatkin, L. A. 2004. Principles of animal behavior. 1st ed. W. W. Norton & Co. Inc.
6. Sherman, P. W; Alcock, J. (Editors). 2001. Exploring animal behavior. 3rd ed. Sinauer Associates, Inc.
7. Huntingford, F. 1984. The study of animal behavior. Chapman and Hall.

DETAIL OF COURSE CONTENTS OF OPTIONAL COURSES

Course Name: Ichthyology	**Course Code: ZOL-651**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**

COURSE OUTLINE

Biology of commercial food fishes of Pakistan, their morphology, anatomy, systematic, ecology and distribution. Physiology of digestion (food, feeding habits, factor affecting food consumption, digestion, absorption, conservation) body composition (water, protein, fats, carbohydrates and minerals in freshwater and marine fishes), nutrition and growth (dietary requirement, measurement of growth, factors affecting growth rates) reproductive physiology & endocrinology (types, reproductive system, development of ovary and testes, sex differences, sexual maturity, fecundity, fish migration.

Laboratory Work Outline

1. Dissection of a common fish to study systems physiology; blood circulation excretion etc.
2. Measurement of oxygen consumption by fishes.
3. Study of fish respiratory system, gill breathing and swim bladder
4. Determination of length- weight relationship.
5. Condition factor and proximate analysis of a fish.
6. Fish movements and study of movement mechanics.

Books Recommended:

1. Lagler, K.F. *et al*. 1977. Icthyology (Second Edition).
2. Norman, J.R. & Greenwood, P.H. 1975. A history of fishes (Third Ed).
3. Hoar, W.S. *et al*. 1979. Fish Physiology. Vol-VIII.
4. Mirza, M.R. 1975. Freshwater fishes and Zoogeography of Pakistan. Bijdr. Dierk. (Amsterdam), 45: 143-180.
5. Weatherly, A.H. 1972. Growth and Ecology of Fish Populations.
6. Nikolsky, G.V. 1978. The Ecology of Fishes.
7. Wootton, R.J. 1990. Ecology of Teleost Fishes. Chapman & Hall, London.
8. Jobling, M. 1995. Environmental Biology of Fishes. Chapman & Hall, U.K.
9. Weatherly, A.H. and Gill, H.S. 1987. The Biology of Fish growth. Chapman & Hall, U.K.
10. Talwar, P.K. and Jhingran, A.G. 1991. Inland Fishes of India & Adjacent Countries. Vol. I & 11. Oxford & IBH Publishing Co., Pvt. Ltd., New Delhi.
11. Mirza, M.R. and Bhatti, M.N. 1993. Pakistan Ki Machlian aur Mahi Parwari Part-I. Ferozesons (Pvt.) Ltd., Lahore, Pakistan
12. Evans, D.H. 1998. The physiology of fishes, 2nd ed. CRC Press, Boca Raton, New York.

Course Name: Reproductive Physiology	**Course Code: ZOL-652**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**

COURSE OUTLINE

Introduction: Overview of Mode of Reproduction in living organisms; general structure of male & female reproductive system. Sex determination and Differentiation of testis, ovary and accessory reproductive organs. Testicular function: formation of the adult testis, compartment of testis and blood testes barriers, testicular hormones, androgens,

organization of spermatogenesis. Ovarian function: growth of follicular development, ovulation corpus luteum. Reproductive cycles: estrus cycle, menstrual cycle. Hypothelamic-Hypophysical-Gonadal axis in Reproduction: Hormonal and neuronal factors and their interactions in ovarian, testicular andother reproductive targets functions, cytokines in follicalogenesis and spermatogenesis; The interactions in developments in estrous and menstrual cycles; The interactions in transitions from childhood to reproductive and post reproductive states. Rhythms in Reproduction. Peripheral Actions of Steroids in the Adult male and female. Pregnancy: Hormonal mechanism in fertilization, zygote transport and type of implantation, growth factors in implantation. Placentalsteroid and polypeptide hormones; Recognition and maintenance of pregnancy; Maternal metabolism in gestation, Hormonal mechanism I parturition. Lacatation: Hormonal mechanism in lactation; Lactogenesis, Galactopoeisis, Milk ejection. Reproductive Senescence: Hormonal and Metabolic aspects in menopause; Mechanisms in males. Fertility Control Mechanisms.

Laboratory Work Outline

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

1. **Books Recommended:**
2. Knobil, E. and Neill, J.D., *et al*., 1994. The Physiology of Reproduction, Vol.1&2; 2nd Edition, Raven Press, New York.
3. Wilson, J.D., Foster, D.W., Kronenberg, H.M. and Larsen, P.R., 1998. William's Textbook of Endocrinology, 9th Edition. W.B. Saunders Company, Philadelphia.
4. Evert, B.J. and Johnson, M.H., 2000. Essential Reproduction, 5th Edition. Blackwell Science Inc., Oxford

Course Title: Fish Nutrition and Health	**Course code: ZOL-653**
Course structure: lectures:2,Lab:1	**Credit hrs. 2+1**
COURSE OUTLINE	

Digestive physiology and anatomy of fish. Nutritional biochemistry and metabolism and amino acids, proteins. Fatty acids and lipids, carbohydrates, vitamins and minerals. Nutritional bioenergetics; feed stuff, feed ingredients, unconventional feed ingredients. Storages problems of feed and feed stuff, stability of ingredients in fish feeds, fish feed formulation. Fish feed manufacturing in developing countries with special emphasis on Pakistan.

Epizootiology of fish disease, bacterial, viral and fungal diseases of fish and their control; treatments; therapeutics and disease preventive measures for maintaining healthy fish in aquaculture.

Laboratory Work Outline

Identification and study of phytoplankton's, zooplanktons and algae, identification of fish food and fish feed ingredients. Proximate analysis of fish feed ingredients. Isolation, identification and characterization of fish pathogens (parasites, bacteria & fungi).

Books Recommended

1. Najaa, LR, Lie, O and Jauncey, K. 1997. Aquaculture Nutrition. Blackwell Sciences Ltd., Oxney Mead Oxford UK.
2. Noga, EJ, 1996. Fish disease: Diagnosis and treatments. Osney Mead Oxford UK.
3. Halver, JE. 1995. Fish Nutrition. John Wiley, UK.
4. Woo, PTK. 1995. Fish disease and disorders: protozoan and metazoan infections. Voi. 1. Mc Millan & Co. USA.
5. Hirshchhorn, H. 1989. Hand book of fish diseases. Osney Mead Oxford UK.

Course Name: Molecular Biology	**Course Code: ZOL-654**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**

COURSE OUTLINE

Introduction: gene theory, structure of DNA, concept of gene, mutation gene structure and function. DNA replication: prokaryotic and eukaryotic, viral, DNA repair, recombination, transonses their insertion sequence, gene expression: and translation: transcription, pro and eukarotic biosynthesis of RNA ad its regulation, initiation, elongation, and termination, RNA polymerase function and modulation of its activity: promoters, operators repressor, terminator, regulation, post transcriptional processing of rtRNA, mRNA, rRNA, Bacterial protein synthesis and regulation; Eukaryotic protein synthesis and regulation, post translational modification, organelles genome.

Laboratory Work Outline

1. Preparation of plasmid DNA
2. Restriction enzymes digestion of DNA
3. Separation of DNA fragments by gel electrophoresis
4. Determination of melting temperature of DNA

Books Recommended

1. Darnell Jr. J., Lodisch, H. and Balimore, D., (2004). Molecular Cell Biology, Scientific American Inc. N.Y.
2. Zubay, G.L., (1995). Biochemistry, W.H. Freeman & Co., New York.
3. Griffiths, Anthony J. f., Et. Al. (2002). Modern genetic analysis: Integrating genes and genomes Edition 2nd W.H. Freeman, New York.
4. Lehninger, A.L., Nelson, D.L. and Co. N.M., (2000). Principles of Biochemistry. Worth Publishers, N.Y.
5. Lehninger, A.L., Nelson, D.L. and Co. N.M., (2000). Principles of Biochemsitry. Worth Publishers, N.Y.
6. Karp, G., (2002). Cell and Molecular Biology: Concepts & Experiments. 3rd Edition. John Wiley Sons, Inc., N.Y.
7. Weaver, Robert F. (1999). Molecular Biology McGraw-Hill, Boston.

Course Title: Epidemiology of Animal Parasites	**Course code: ZOL-655**
Course structure: lectures: 2, lab:1	**Credit hrs.2+1**
COURSE OUTLINE	
Animal association, adaptation to parasitism, protazoa, mollusca, arthropoda, acarina, insecta, nematode, acathocephala, trematoda, cestoda, stress. Effect of micro-environment on the parasite distribution in bost. Population an communities; ecological niche, ecological factors in parasite. Host complex, size relationships. Host age and parasite number, seasonal variations. Movements and hypobiosis: density of population; density dependence; parasite mix; food changes; microenvironments of host. Symobiotic cleaning. Host specificity, action of parasite upon their host.	
Laboratory Work Outline Culture, isolation and separation of parasitic larvae from soil and herbage material. Baerrmann technique for nematode larvae separation, McMaster technique for egg per gram counting, field herbage collection for carpological examination.	
Books Recommended 1. Anderson, R.C. 1992. Nematode Parasites of Vertebrate: Their Development and Transmission. CAB 2. International, USA. 3. Noble, E.R. and Noble G.A. 1982. Parasitology. Lea and Febiger, UK. 4. Bear, J.G. 1980. Ecology of Animal Parasites. Univ. of Illinois Press, Urbana, USA.	

Course Name: Introduction to Environmental Biology	**Course Code: ZOL-656**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**
COURSE OUTLINE	
Environment: Introduction, scope, pressure. Pollution: definition, classification and impact	

on habitats. Air pollution: sources, prevention, control, remediation. Photochemical smog. Acid rain, theory and its effects. Chlorofluorocarbons and their effects; Water pollution: sources, impact, prevention, remediation. Eutrophication, thermal pollution. Sediments pollution: fungicides, pesticides, herbicides, prevention, control remediation. Heavy metal pollution. Noise pollution, radiation protection. Forests: importance, deforestation, desertification and conservation. Ozone layer, effects of ozone depletion. Greenhouse effect. Human population explosion. Brief review of major environmental problems of Pakistan and their solutions. Wetland and sanctuaries protection. Range management.

Laboratory Work Outline

1. Measurement of environmental factors on land, water and air.
2. Study of different ecosystems: pond, agricultural or grassland, forest.
3. Community analysis through different sampling techniques (quadrat, transect).
4. Population dynamic of grasshoppers.
5. Adaptive features of animals in relation to food and environment.
6. Food chain studies through analysis of the gut contents.
7. Analysis of polluted and fresh water for biotic and abiotic variations.
8. Field visits for study of selected terrestrial habitat and writing notes.
9. Development of an ecological management plan of some selected area.

Books Recommended

1. Chiras DD. 2010. Environmental Science. 8th Ed. Jones and Bartlett Publishers, LLC.
2. Wright, R. T., Nebel, B. J. 2002. Environmental Science: Toward a Sustainable Future, 8th Ed. Prentice Hall.
3. Odum, E., Brewer, R., Barrett, G. W. 2004. Fundamentals of Ecology. 5th ed. Brooks Cole.
4. Additional Reading:
5. Newman, E.I. 2001. Applied Ecology, Blackwell publishers.
6. Moony, H. G. A., Saugier, B. 2000. Terrestrial Global Productivity. Academic Press, UK.
7. Eugene, E.D., Smith, B.F. Environmental Science: A study of interrelationships, McGraw, USA
8. Marsh,M.W., Grosa, Jr., J.M.,1996. Environmental geography: Science, land use and earth system. John Wiley and Sons.
9. Robert L. McConnell, Daniel C. Abel 2002. Environmental Issues Measuring, Analyzing, Evaluating (2nd Edition) Prentice Hall.
10. France, H. 2000. Vanishing Borders: Protecting the planet in the age of globalization. W.W.Norton and Company, NY.
11. Hall, C.C.S., Perez, C.L. 2000. Quantifying Sustainable Development. Academic Press, UK.
12. Bazzaz, F.A. 1996. Plants in changing environment: Linking physiological, population, and community ecology. Cambridge Univ. Press.

11. Bush, M.B. 1997. Ecology of a changing planet. Prentice Hall, UK.

12. Singby, D. and Cork, D., 1986. Practical Ecology. McMillan Education Ltd., London.

13. Chapman, J.L. and Reiss, M.J., 1997. Ecology. Principles and Application. Cambridge Univ. Press, Cambridge.

14. Smith, R.L. 1996. *Ecology and Field Biology*, Harper and Row.

15. Southwick, C.H., 1976. *Ecology and Quality of our Environment*. D. Van Norstrand Co, New York.

16. Boyd, C.E. 1981. *Water quality in warm water fish ponds*. Craft Master Printers Incorporation, Alabama.

Course Title: Advances in Aquaculture	**Course code: ZOL-657**
Course structure: Lectures:2, Lab:1	**Credit hrs.2+1**

COURSE OUTLINE

Introduction to advanced aquaculture. hydrometrology in pond fish culture, application of lime and fertilizers in fish farm, new trends in fish farm management, enhancing production of carp fingerlings by the use of growth promoting substances, intensive and semi-intensive culture of major carps, culture of freshwater prawns and freshwater shrimps, oyster culture, aquaculture in raceways, cages, enclosures and ponds with particulars references to the site and design of cages, use of agricultural and urban wastes in aquaculture, paddy culture.

Laboratory Work Outline

1. Dissection of a common fish to study systems physiology; blood circulation excretion etc.
2. Measurement of oxygen consumption by fishes.
3. Study of fish respiratory system, gill breathing and swim bladder
4. Determination of length- weight relationship.
5. Condition factor and proximate analysis of a fish.
6. Fish movements and study of movement mechanics

Books Recommended

1. Pillay, T. V. R., 1999. Aquaculture: Principles and Practices. Fishing News Books, London.
2. Stickney, R.R. 1992. Principles of Warmwater Aquaculture. John Wiley & Sons, N. York.
3. Agrawal, V. P. 1999. Recent Trends in Aquaculture. Society of Biosciences. India.
4. Meade, J. W. 1998. Aquaculture Management. Chapman & Hall Inc. N. York.
5. Deborah, A. T. 1989. Aquaculture, Mansell, N. York.
6. Karunasagar, I, I. Karunasagar and A. Reilly. 1999. Aquaculture and Biotechnology. Oxford & IBH Publishing Co., N. Delhi.

1. Jobling, M. 1995. Environmental Biology of Fishes. Chapman & Hall, U.K.
2. Weatherly, A.H. and Gill, H.S. 1987. The Biology of Fish growth. Chapman & Hall, U.K.
3. Talwar, P.K. and Jhingran, A.G. 1991. Inland Fishes of India & Adjacent Countries. Vol. I & 11. Oxford & IBH Publishing Co., Pvt. Ltd., New Delhi.
4. Mirza, M.R. and Bhatti, M.N. 1993. Pakistan Ki Machlian aur Mahi Parwari Part-I. Ferozesons (Pvt.) Ltd., Lahore, Pakistan

Evans, D.H. 1998. The physiology of fishes, 2nd ed. CRC Press, Boca Raton, New York.

Course Name: Biomembranes and Signal Transduction	**Course Code: ZOL-658**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**

COURSE OUTLINE

Introduction, surfaces and interfaces, chemical compositions; lipid, protein, carbohydrate. Structure of membranes; physiochemical techniques. Isolation of membranes, morphology and function of different biological membranes (plasma membrane, mitochondrion, chloroplast, mesosome, endoplasmic reticulum, Golgi apparatus, lysosomes, tonoplast, nucleus, other membranes). Membrane transport, transport of non-electrolycetes, transport of ions, transport of water. Transport by special mechanism, receptor-ligand interaction.

Signalling through biomembrane, molecular mechanism of signal transduction, signaling receptors,signaling ligands and signaling complexes, signaling cascades, signal transduction in immune system, TCR and BCR signaling, ROS effect on signaling, signal transduction in cancer, signaling through growth factor receptors, thera[eutic intervention involving signaling mechanism.

Books Recommended

1. Karp, G., (2009). Cell and Molecular Biology: Concepts & Experiments. 3rd Edition.
2. John Wiley Sons, Inc., N.Y. Darnell Jr. J., Lodisch, H. and Balimore, D., (2010). Molecular Cell Biology, Scientific American Inc. N.Y.Bruce Alberts, Alexander Johnson, (2002) Molecular Biology of the Cell, 4th Edition, Garland Sciences.
3. Berg, Jeremy M., Tymoczko, John L., (2002) Biochemistry, W. H. Freeman, New York.
4. Albert B, Johnson A. 2007. Molecular biology of the cell. 5th edition. Gerald Sciences UK.
5. Nelson N. 2008. Structure and function in cell signaling. John Wiley sons Inc., USA.
6. Mary Lucky. 2008. Membrane structural biology: Biochemical and

biophysical foundations. Cambridge University Press, N.Y.

7. David Sheehan. 2009. Physical biochemistry: Principles and Applications. 2nd edition. John Wiley sons Inc., USA.
8. Peter Jomo Walla. 2009. Modern biophysical chemistry: Detection nad analysis of Biomolecules. John Wiley sons Inc., USA.

Course Name: Radiobiology	**Course Code: ZOL-659**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**
COURSE OUTLINE	
Introduction, ionizing radiations, characteristic types and nature of radioactive emission. The law of radioactive decay, carbon and uranium dating, effects of radiation on biological systems at molecular, subcellular, cellular and tissue levels. The genetic effects of ionizing radiation. Radiation hazards and principles of protection. Radio-tracers as a useful instrument for biological research.	
Laboratory Work Outline 1. Demonstration of techniques of scintillation spectrometry for assay of radioactivity. 2. Technique for radio immuno-assay. **3.** Methods of application of radio-labeled compounds, methods for uptake, transport and metabolism of radiotracers.	

Books Recommended

1. Meredith, W.J. and J.B. Massey, 1978, Fundamental Physics of Radiology. Bristol. John Wiley and Sons, Ltd. U.K.
2. Lawrence, C.W. 1975: Cellular Radiobilogy, Edward Arnold (Publishers) Ltd, London.
3. Coggle, J.E. 1973: Biological Effects of Radiation. Wykehem Publications (London) Ltd.
4. Alper, T. 1981: Cellular Radiobiology. Cambridge University Press, London.
5. Margan, K. 1978: Principles of Radiations Protection, John Wiley & Sons, N.Y.
6. Granier, R. and Devis, J. (1999). Applied radiation biology and protection. Ellis Hawood Ltd. England.
7. Farshier, S. (2001). Essentials of radiation biology and protection. Blackwell publisher UK.
8. Bodri, W. (2000). How to neutralize the harmful effects of radiation or radioactive exposure. Blackwell publishers, UK.
9. Davidovits, P. (2001). Physics in biology and medicine, Edition 2nd Harcourt Science and Technology Company, San Diego.

Course Name: Enzymology	**Course Code: ZOL-670**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**

COURSE OUTLINE

Introduction and basic concepts of Enzymology nomenclature and classification of enzymes the structure of enzyme monomeric and oligomeric enzme kinetics kinetic of single substrate and multi substrate catalyzed reaction and sigmoidal kinetics Mechanism of enzyme activity, enzyme inhibition coenzymes classification and mechanism in enzyme catalysis Enzyme application in medicine and industry Biotechnological application of enzymes immobilization of enzyme immobilization practical application subunit study of enzymes .Isoenzymes structure of isoenzymes formation of isoenzymes identification of isoenzymes functional significance of isoenzymes.

Laboratory Work Outline

1. Estimation of acid protease
2. Estimation of acid phosphatase
3. Estimation of lactate dehydrogenase
4. Etimation of LDH isozymes
5. Effect of pH temperature metal ions and time on enzyme stability and activity
6. Kinetic studies of enzymes

Books Recommended

1. Fersht, Alan (1999). Structure and mechanism in protein science: a guide to enzyme catalysis and protein folding W.H. Freeman, New York.
2. Wiseman, A. (1995). Handbook of enzyme biotechnology. Edition 3rd Ellis Horwook, London.
3. Zubay, G.L., (1995). Principles of Biochemistry McMillan Publishing Co.
4. Stryer, L. (1995). Biochemistry, W.H. Freeman & Co., New York.
5. Davlin, J. (1992). Textbook of Biochemistry with Clinical Correlations, John Wiley & Sons.

Course Name: Toxicology	**Course Code: ZOL-671**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**
COURSE OUTLINE	
Basic principles of toxicology. Absorption, distribution, storage, and elimination of toxins. Biotransformation of toxins. Toxicokinetics. Mechanisms of toxicity. Chemical, biochemical and Genetic Toxins. Organ system toxicology, eco toxicology, regulatory toxicology. Toxicity assays. Risk assessment and Bioremediation.	

Books Recommended

1. Principles of Toxicology by Williams and Roberts
2. Toxicology by Marquardt and Schafer
3. Industrial Toxicology by Williams and Burson
4. Environmental Toxicology, Sethi, Iqbal, Satake and Mido
5. Medical Microbiology by Samuel Baren

Course Name: Principles Of Gene Manipulation	**Course Code: ZOL-672**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**

COURSE OUTLINE

Introduction: Methods of creating recombinant DNA molecules (restriction enzymes). Cloning in *E.coli* plasmid as cloning vehicles, bacteriophage and cosmid vectors, cloning strategies and gene libraries, isolation of clone genes, recombinant selection and screening, expression in *E.coli* , of cloned DNA molecules.

Cloning in organisms of other then E. colo: cloning in bacteria other then E. coli, cloning in yeast and other eukaryotes, cloning in plant cells, cloning in mammalian cells in cultures, cDNa, Chromosome walking for isolating long stretches of eukaryotic DNA, split genes. Micro infecting genes into animal oocytes, eggs and embryos. Application of recombinant DNA technology in biology and medicine.

Laboratory Work Outline

1. Construction of Restriction Enzyme +Map
2. Amplification of DNA by PCR
3. Preparation of probe for DNA analysis
4. Southern blotting and hybridization
5. Northern blotting and hybridization
6. Heat shock transformation of bacterial cell
7. Agrobacterium medicated transformation of plant cell.

Books Recommended

1. Bernard R. Glick & Jack J. Pasternak. (2003). Molecular Biotechnology: Principles and Applications of Recombinant DNA, Third Edition, ASM Press Washington.
2. H. Kreuzer & A. Massey. (2001). Recombinant DNA and Biotechnology, 2nd Edition., ASM Press.
3. Old, R.W. and Primrose S.C. (1995). Principles of gene manipulations. Blackwell Science.
4. Sambrook, Joseph; Russell, David W., (2001). Molecular cloning: a laboratory Edition 3rd Cold Spring Harbor Laboratory Press, new York.
5. Jain, S.K. (2000). Textbook of biotechnology: fundamentals of molecular CBS Publishers, New Delhi.
6. Thiel, Teresa; Bissen, Shirley (2002). Biotechnology DNA to protein: a laboratory project in molecular biology, McGraw-Hill, Boston;
7. Brown, T.A. (2001) Gene Clonning and DNA analysis: an introduction. Blackwell Science Ltd. Oxford.

Course Name: Clinical Biochemistry	**Course Code: ZOL-673**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**
COURSE OUTLINE	
Biochemistry of blood biochemical aspects of cardiovascular , neurological and endocrine inborn errors of metabolism ,immunology of human diseases immunodiagnostics, biochemical aspects of cancer etiology ,clinical diagnosis and treatment interferon discovery and implication and antibacterial agent, disease due to infection and infestation , diseases due to chemical and physical agents ,genetic and constitutional factors in disease diseases of organs.	
Laboratory Work Outline 1. Analysis of Urine, blood 2. Determination of glycerol and cholesterol/sterols and unsaturated fatty acids. 3. Estimation of Urea, Protein, Cholesterol bilirubin, calcium, phosphorus, uric acid, creatininine and analysis in serum/Urine. 4. Determination of vitamins in serum. **5.** Separation of steroids by TLC.	
Books Recommended 1. Cumings, J. N and Kremer, M. (1973). Biochemical aspects of Neurological disorders. **2.** Hoffman, W. S. (1977).Biochemistry of Clinical Medicine, 4th Ed	

Course Name: **Research Techniques &Instrumentation**	**Course Code: ZOL-674**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**
COURSE OUTLINE **(Theory and Practical)**	
Estimation methods for biopolymers. Chromatographies: gel filtration, ion exchange, affinity, chromatofoussing. Isoelectric focussing, HPLC, GLC, electron microscopy, Electrophoresis: polyacrylamide, SDS-polyacrylamide. Immuno-electrophoresis. Double diffusion. Spectrometers; visible, UV, IR, mass, X-ray diffraction and Atomic absorption. Beta and gamma counters.	

Books Recommended

1. Williams, B.L. and Wilson, K.A. 1983. Biologist's guide to principles and techniques of practical biochemistry. Edward ARnold.
2. Oser, B.L. 1965. Haw's physiological chemistry. McGraw Hill Book Co.
3. Work, T.S. and Work, E. 1975. Laboratory techniques in biochemistry and molecular biology. Vols. 1-3 North Holland America

Course Name: Nucleic Acids	**Course Code: ZOL-675**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**

COURSE OUTLINE

Chromosomes and DNA, Flow of Genetic Information, Organization of Nuclear and Mitochondrial Genomes, Gene Structure, RNA Splicing, Pseudogenes, Classes of Mutations, Repetitive DNA Sequences, Gene Expression, Cloning of Genes, Mapping Genes on Chromosomes. Transcript Mapping, Mutation Identification, Gene Structrue and Functions.

Laboratory Work Outline

1. Extraction of nucleic acids
2. Electrophoresis of RNA and genomic DNA
3. Purification of DNA fragment from gels
4. Transformation
5. Transfection
6. Preparation of Single and Double Stranded DNA
7. Sequencing of DNA

Books Recommended

1. Garrett, Reginald H.; Grisham, Charles M (1995). Molecualr aspects of cell biology. Saunders College Publishing, Fort Worth.
2. Strachen, T., Read, A.P. (2000). Human Molecualr Genetics. 2nd Ed. BIOS Scientific Publications Ltd.
3. Karp, G., (2002). Cell and Molecular Biology: Concepts & Experiments. 3rd Edition. John Wiley Sons, Inc., N.Y.
4. Darnell Jr. J., Lodisch, H. and Balimore, D., (2004). Molecuarl Cells Biology, Scientific American Inc. N.Y.
5. Malacinski, George M. (2003). Essentials of Molecular biology Edition 4th Jones and Bartlett Publishers, Boston.

Course Name: Vitamins And Hormones	**Course Code: ZOL-676**

Course Structure: Lectures: 2, Lab: 1	Credit Hours: 2+1
COURSE OUTLINE	
Vitamins classification, chemical structure and properties: metabolism, function, effect of deficiency and excess. Hormones; structure, structure activity relationship, biosynthesis, regulation, mechanism of action and immunology of: protein and polypeptide hormones, hormones steroids, neurotransmitters, and phytohormone. Hormonal analysis (bioassays, immunoassay). Methods of isolation, purification and physicochemical characterization. Biotechnology (monoclonal antibodies, gene cloning).	
Laboratory Work Outline 1. Determination of vitamins in seum 2. Separation of steroids by TLC 3. Studies on recognition and response of receptors. 4. Studies of disorders of pituitary by observing anatomical and histological features. 5. Studes of thyroid status in deficient and excess hormone functions.	
Books Recommended: 1. Darnell Jr. J., Lodisch, H. and Balimore, D., (2004). Molecular Cell Biology, Scientific American Inc. N.Y. 2. Zubay, g.L., (1995). Principles of Biochemistry McMillan Publishing Co. 3. Stryer, L. (1995). Biochemistry, W.H. Freeman 7 Co., New York. 4. Davlin, J. (1992). Textbook of Biochemistry with Clinical Correlations, John Wiley & Sons. 5. Lehninger, A.L., Nelson, D.L. and Co. N.M., (2000). Principles of Biochemistry. Worth Publishers, N.Y. 6. Karp, G., (2002). Cell and Molecular Biology: Concepts & Experiments.3rd Edition. John Wiley Sons, Inc., N.Y.	

Course Name: Medical Microbiology	Course Code: ZOL-677
Course Structure: Lectures: 2, Lab: 1	Credit Hours: 2+1
COURSE OUTLINE	
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.Bacterial pathogens and associated diseases. Staphylococcus, skin and wound infections. Streptococcus, sore throat, scarlet fever, glomerulo nephritis. Pneeumococcus, respiratory infections. Cornyebacterium. Erysipelothrix: Listerial, Diphtheria. Mycobacterium tuberculosis: pulmonary and other tuberculosis infections. Actinomyces. Neisseria: Meningitis, Gonorrhoea. Salmonella, Shigella. Escherichia coli, Klesbsiella, Proteus, Providencia. Anthrax bacillus. Clostridum tetani. Poxiviruses. Herpes viruses. Herpes simplex. Cytomega-lovirus infections.	

Adenoviruses. Influenza viruses. Miscellaneous viruses: Rubella Corona, Areana viruses. Hepatisis viruses. Arboviruses. Rickettsia. Pathogenetic Fungi. Protozoa. Infective Syndromes and diagnostic procedures. Stratagy of antimicrobial therapy. Prophylactic immunization.

Laboratory Work Outline

1. Basic techniques. Widal test
2. Laboratory diagnosis and control of infections: Streptpococcus. Corynebacterium, Erysispelothrix Listeria Mycobacterium. The Entero bacteriaceae: Salmonella. Shigella Escherichia, Klebsiella. Proteus and other Enter bacteria. Clostridium I Clostridium II
3. Protozoa. Blood tests: TLC, DLC, RBC.

Books Recommended

1. Boyd. R. F. (1995). Basic Medical Microbiology. 5th Ed. Little Brown and Co.
2. Ingles, T. S. S. (2003). Microbiology and Infection. 2nd Ed. Churchill livingstone.
3. Wester, E. W., Anderson, D. G., Pearsall, N. (2004). Microbiology: A human perspective. McGraw Hill.
4. Cruickshank, R, Duguid, J.P., Hermion, B.P. and Swain, R.H.A., (1975). *Medical Microbiology*, (Vol. 1 & Vol. 2), Churchill Livingstone, N.Y.
5. Turk, D.C. and Poster, I.A., (1978). *A Short Textbook of Medical Microbiology*, Hodder and Stoughton.
6. Vollum, R.L., Jamison, and Cummins C.S. (1970). *Fairbrother's Textbook of Bacteriology*, William Heinemann, London.
7. Collins, C.H. and Lyne P.M. *Microbiological Methods*.

Course Name: Immunology	**Course Code: ZOL-678**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**
COURSE OUTLINE (3+1)	

The immune system: organs constituting the immune system, their location in the human body and basic architecture, principles and techniques of seriology. The immunnocompetent cells; their origin, surface makers, populations and subpopulations, immuniological characterization and function. Anibody induction and production: antigen and antibody metabolism, cells involved in cellular sequence of events, kinetics of antibody synthesis, Antibody diversity. The role of T-cells and immunoglobulins in the immune response. Immunologic memory: positive and negative phenomena of natural tolerance.Manifestations of antigens antibody reactions including precipitation, agglutination, omplement fixation and neutralization. Basic and applications of ELISA, RIA, Immunoflorescence and Immunoblotting. Role of

MHC in antigen presentation. Immunological disorders: Autoimmunity, Immunnodeficiency, Tissue rejection. Nature of tumor transplantation and immunology and immunogenetics. Resistance and immunonization to infectious diseases.

Laboratory Work Outline

1. Techniques used in serological studies, RBC and WBC count.
2. Differential leukocyte count
3. Blood grouping
4. Agglutination tests and precipitation tests
5. Complement fixation tests
6. ELISA tests
7. Allergy reaction tests
8. Hypersensitivity

Books Recommended:

1. Abbas, K. Lichtman and Jordan, S. Pober (Latest Edition) Cellular and Molecular Immunology". W.B. Saunders.
2. Janeway-Travers. (Latest Edition) Immunobiology. Current Biology Ltd. UK.
3. Riott, IM, Delves, PJ (2001). Roitt's Essential Immunology. Blackwell Scientific Pub, London.
4. Geo f. brooks, Stephen A. Morse, Janet Butel, Janet S. Butel (2001). Jawetz, Melnick and Adelberg's Medical Microbiology McGraw-Hill Companies.
5. Kuby, J. (1996). Immunology Immunology 2nd Ed. W.H. Freeman & Co. USA.
6. Benjamini, E. Immunology. (2001).

Course Title: Aquaculture Systems Management	**Course Code: ZOL-679**
Course Structure: Lectures: 2, Lab: 1	**Credit hrs. 2+1**

COURSE OUTLINE

Basis of aquatic Productivity; ecological principles underlying Aquaculture. Desirable characters for aquaculture organisms. Ranges of aquaculture practice, aquaculture systems and level of management. Economic, social and geographic factors and market attributes governing aquacultural; decision making. Major culturable fish groups of Pakistan and other aqua cultural organisms. Status of aquaculture in Pakistan and comparison with other developed and developing nations. Fisheries sector (levels of fisheries sector and factors influencing fish sector). Fisheries planning and management. Economics of fisheries and fish marketing and business marketing.

Laboratory Work Outline

Sampling techniques for fish and other pond organisms, identification of culturable species of fish and shellfish; study of nutrient cycle, physical and chemical parameters of fish pond. Identification and study of phytoplankton's, zooplanktons and algae, identification of fish food and fish feed ingredients. Study the difference in reservoir and various pond culture systems, feed stuff management system and artificial diet preparation.

Books Recommended

1. Nash CE. 1997. Aquaculture sectors Planning and Management. Blackwell science Ltd., Oxford UK.
2. Pillay, TVR. 1997. Aquaculture Development progress and prospects. Blackwell Sciences Ltd., Oxford. UK
3. Chasaton, I. 1997. Marketing in Fisheries and Aquaculture, Blackwell Science Ltd., Oxford UK.
4. Bromage, N and Roberts, RJ. 1997. Broodstock Management and egg and larval quality. Blackwell Science Ltd., Oxford UK.

Course Name: Herpetology	**Course Code: ZOL-680**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**

COURSE OUTLINE

Classification and variety of forms of amphibians and reptiles. Their structure, habits, habitats, origin, evolution, reproduction, homeostatic, relation to biotic environment, behavior, mechanisms of speciation and geographic distribution, Their food and growth and role of reptiles in keeping insects and rodent populations under control.

Laboratory Work Outline

1. Classification and museum study
2. Animal collection, handling preservation and identification
3. Dissection of major reptiles; lizard, turtle, snake
4. Study of Skelton and adaptations
5. Behavior of reptiles

Books Recommended

1. Pough, G. 1982. Biology of Reptilia. Academic Press, London.
2. Coleman, J. and G. Olive. 1971. Introduction to Herpetology (2nd Ed.). W.H., freeman.
3. Richard, C. 1969. The World of Reptiles. Chatto and Windus, London.
4. Linsey, D. 2001. Vertebrate Biology. McGrawHill
5. Hildebrand, M and Goslow, G. (2001). Analysis of vertebrate structure. 5th Edition. John Wiley and Sons, Inc.
6. Kardong, K. V. (2002). Vertebrates. 3rd Ed. Comparative anatomy, function and evolution. McGraw Hill Co.
7. Romer, A.S. and Parsons, T.S., (1986). The Vertebrate Body, Holt Saunders, Philadelphia.
8. Yapp, W.B., (1965). Vertebrates: Their Structure and Life, Oxford University Press, N.Y. Oxford.
9. Young, J.Z., (1962). Life of Vertebrates, Clarendon Press, Oxford.

Course Name: Mammology	**Course Code: ZOL-681**

Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**

COURSE OUTLINE

Introduction to mammals; primitive mammals; origin from reptiles; central heating system of mammals; Mammals' perfumes; milk and reproduction; parental care; evolution; society and sexual dimorphism; sons; daughters and favoritism; size and the energy crisis; cost of living and diet; quantity versus quality; population explosion. The monotremes; the marsupials; the edentates; the ungulates; the insectivores; the carnivores; the rodents; the primates.

Laboratory Work Outline

a. Study of common laboratory and zoo mammals
b. Study of anatomy through dissections of rabbit, rat and mouse
c. Skeleton: axial and appendicular
d. Study of Skulls and brain structures and capacities
e. Study of locomotory adaptations
f. Flying mammals and study of bats
g. Classification and identification
h. Collection and preservation of small mammals
i. Identification of mammals through paw patterns

Books Recommended:

1. Macdonald, D. (1995). The encyclopedia of mammals. Andromeda Oxford Ltd.
2. Roberts, T. J. 1991-1992. The mammals of Pakistan. Oxford University Press, Karachi.
3. Hildebrand, M and Goslow, G. (2001). Analysis of vertebrate structure. 5th Edition. John Wiley and Sons, Inc.
4. Kardong, K. V. (2002). Vertebrates. 3rd Ed. Comparative anatomy, function and evolution. McGraw Hill Co.
5. Romer, A.S. and Parsons, T.S., (1986). The Vertebrate Body, Holt Saunders, Philadelphia.
6. Yapp, W.B., (1965). Vertebrates: Their Structure and Life, Oxford University Press, N.Y. Oxford.
7. Young, J.Z., (1962). Life of Vertebrates, Clarendon Press, Oxford.
8. Hickman, C.P., Roberts, L.S. and Larson, A., 2001. Integrated Principles of Zoology, 11th Edition (International). Singapore: McGraw Hill.
9. Kent, G.C. and Miller, S., 2001. Comparative Anatomy of Vertebrates. New York: McGraw Hill.
10. Miller, S.A., 2002. Genral Zoology Laboratory Manual. 5th Edition (International) Singapore: McGraw Hill;
11. Hickman, C.P. and Kats, H.L., 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill.
12. Marshall, A.J. and Williams, W.D., 1972. A Textbook of Zoology,Volume II:, Vertebrata. McMillan Co., New York.
13. Linzey, D. (2001). Vertebrate Biology. McGraw Hill Co.

Course Name: Neurobiology	Course Code: ZOL-682
Course Structure: Lectures: 2, Lab: 1	Credit Hours: 2+1

COURSE OUTLINE

The organization of the nervous system; Electrical signals of nerve cells; Membrane permeability; Channels and transporters; Synaptic Transmission; Neurotransmitters; their receptors and effects; Intracellular signal transduction; The somatic sensory system; Pain; Vision; central visual pathways; the auditory system; the vestibular system; the chemical senses; lower motor neuron circuits and motor control; upper motor neuron control of the brainstem and spinal cord; modulation of movement by the basal ganglia and the cerebellum; eye movements and sensory motor integration; the visceral motor system; brain development; construction of neural circuits; modification of brain circuits as result of experience; plasticity of mature synapses and circuits; The association cortices; Language and lateralization; sleep and wakefulness; emotions; sex, sexuality and brain; human memory.

Laboratory Work Outline

1. Culture of embryonic neurons
2. Immunohistochemistry
3. Histology of neuronal tissue
4. Ionic basis of resting potential.
5. Sciatic nerve compound action potential.
6. Introduction to intracellular recording.
7. Recording of action potentials on oscilloscope
8. Study of Synaptic physiology and Synaptic activity with neuromuscular preparations.
9. Demonstration of nervous system organization
10. Sensory organs study.
11. Experiments on characteristics of skeletal muscle contractions.
12. Responses of intestinal muscles.

Books Recommended

1. Haines, D, E. (1997). Fundamental Neuroscience. Churchill Livingstone. Inc.
2. Purves, D., Augstine, G. J., Fitzpatrick, D., Katz, L. C., LaManta, A-S., McNamara, J. O., Williams, S. M. (2001). Neuroscience. Sinauer Associates, Inc.
3. Shepherd, G. M. (1994). Neurobiology. Oxford University Press, Inc.
4. Levitan, I. B. and Kaczmarek, L. K. (1997). The neuron: cell and molecular biology. Oxford University Press. Inc.
5. Matthews, G. G. (1998). Neurobiology. Blackwell Science.
6. Conn, P. M. (1995). Neuroscience in medicine. J. B. Lippincott Co.
7. Beatty, J. (2001). The human brain. Sage Publications, Inc.
8. Revest, P. and Longstaff. (1998). Molecular neurosciences. BIOS Scientific

Publishers. Ltd.
9. FitzGerald,M.J.T and Jean Folan- Curran (2002).Clinical neuroanatomy and related neuroscience.Harcourt Publishers Limited.
10. Rafael Yuste and Arthur Konnerth (2005). Imaging in neuroscience and development a laboratory manual. Cold spring Laboratory press.

Course Name: Protozoology	**Course Code: ZOL-683**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**
COURSE OUTLINE	
Structure, including ultra-structure, taxonomic significance, biology, life cycle and host parasite relationships of parasitic protozoa which will include Mastigophora: *Trypanosoma gambiense; Schizotrypanum cruzi; Leishmania donovani; L. tropica; Giardia intestinalis* and *Trichomonas vaginalis.* Sarcodina: *Entamoeba histolytica; E. coli; E. gingivalis; Endolimax nana* and *Acanathamoeba castellanii.* Sporozoa: Malarial parasites of man, and Coocidia of poultry. Ciliata: *Balantidium coli.*	
Laboratory Work Outline 1. Study of protozoa through prepared microscopic slides 2. Protozoa culturing 3. Isolation of parasitic protozoa from the guts of higher animals, slide preparation and identification 4. Soil protozoa 5. Marine and freshwater protozoa **6.** Study of physiological properties of various protozoa	

Books Recommended

1. Brusca, R. C. and Brusca, G. J. (2002). Invertebrates. 2nd Ed. Sinauer Associates. Inc., Publishers.
2. Pechenik, J.A., 2000. Biology of Invertebrates, 4th Edition (International). Singapore: McGraw Hill.
3. Hickman, Jr. C. P; Roberts, L. S and Larson, A. (1998). Biology of Animals. McGraw Hill Co, Inc.
4. Hickman, C.P., Roberts, L.S. and Larson, A., 2001. Integrated Principles of Zoology, 11th Edition (International). Singapore: McGraw Hill.
5. Barrington E. J. W. (1977). Invertebrate structure and function.
6. Rupppert, E, D and Barnes, R. D. (1994). Invertebrate zoology. 6th Ed. Saunders College Publishing.
7. Dorit, R. L., Walker, Jr. W. F and Barnes, R. D. (1991). Zoology. Saunders College Publishing, Inc.
8. Miller, A.S. and Harley, J.B., 1999 & 2002. Zoology, 4th & 5th Edition (International). Singapore: McGraw Hill.
9. Campbell, N.A., 2002. Biology, 6th Edition. Menlo Park, California: The Benjamin/Cummings Publishing Company, Inc.
10. Miller, S.A., 2002. Genral Zoology Laboratory Manual. 5th Edition (International) Singapore: McGraw Hill;
11. Hickman, C.P. and Kats, H.L., 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill.
12. Marshall, A.J. and Williams, W.D., 1972. *A Textbook of Zoology*,Volume I, Invertebrata. McMillan Co., New York.

Course Name: Ornithology	**Course Code: ZOL-684**
Course Structure: Lectures: 2, Lab: 1	**Credit Hours: 2+1**
COURSE OUTLINE	
Introduction to ornithology, class Aves, taxonomy of birds up to orders, families and major species; evolution of birds; biology of fossil birds; archaeopteryx, archaeornithes, neoornithes; morphology and surface anatomy of bird, and development structure of feathers, plumage; structure of bones; basic embryology of birds; internal anatomy of birds; systems physiology; blood circulatory, cardiovascular physiology, heart, blood cells and hemodynamics; respiratory system, air sacs, ventilation of lungs, metabolic rates, oxygen consumption; urinary system, kidney physiology and production of solid or semisolid excreta, brain physiology and anatomy, special senses, olfaction, vision, taste; digestive system, anatomy, guts and feeding strategies; morphological and physiological adaptations of birds to flying, kinds of flight, mechanisms of aerodynamics; reproductive organs anatomy and physiology, egg laying and breeding seasons; bird migration, song production, bird behavior, courtship, mating, egg incubation strategies, brood parasitisim; predator-prey relationship; homing behavior; learning, imprinting; nest building; bird parasite; endangered species of birds; bird conservation and sanctuaries.	

Laboratory Work Outline

1. Identification characteristics and taxonomy of birds to orders and families
2. Dissection of sparrow, pigeon, myna, other available birds
3. Anatomy of bones, skull, girdles, spine, vertebrae, feathers, plumage
4. Study of gut contents of birds to understand feeding habits
5. Incubation of chicken eggs to learn avian embryogenesis
6. Bird stuffing and preservation of eggs
7. Identification of bird species through feathers and egg shells
8. Beak and claw structures
9. Study of bird songs, recording bird songs, fundamental
10. experimentation to understand bird songs in sensitive and sensorimotor phases
11. Bird watching and preparation of ethograms
12. Study of Predator-prey relationship among birds
13. Study of Brood parasitism
14. Study of flying mechanics through models

Books Recommended

1. Kaiser, G. W. (2008). The Inner Bird: Anatomy and Evolution. Amazon Co.
2. Howell, S. N. G. (2010). Peterson Reference Guide to Molt in North American Birds (Peterson Reference Guides. Amazon Co.
3. Richard Grimmett, Carol Inskipp and Tim Inskipp (2008). Birds of India: Pakistan, Nepal, Bangladesh, Bhutan, Sri Lanka, and the Maldives. Princeton Book Co.
4. A J Urfi (2009). Birds of India: A Literary Companion, OUP.
5. Frank B. Gill. (2004). Ornithology. 2nd Ed. W. H. Freeman & Co.
5. Handbook of Bird Biology by Cornell Lab of Ornithology. Princeton University Press. New Jersey. 2004
7. Rank B. Gill. (2004). Ornithology: Ecology and Evolution of Darwin's Finches 99 ed. (rev). Princeton. W. H. Freeman.
8. David Allen Sibley and Alfred A. Knopf (2003). The Sibley Field Guide to Birds of Eastern North America. New York Press
9. David Allen Sibley and Alfred A. Knopf (2002). Sibley's Birding Basics New York Press.
10. Salim Ali and S. Dillon Ripley (2001). Handbook of the Birds of India and Pakistan : Together with Those of Bangladesh, Nepal, Bhutan and Sri Lanka/. Reprint. New Delhi, Oxford University Press, 10 Vols.
11. Noble S. Proctor, Patrick Lynch, Patrick J. Lynch, Patrick J. Lynch (1998). Manual of Ornithology: Avian Structure and Function. Yale University Press.
12. Audubon Handbook: How to Identify Birds? 88th ed. Mcgraw-Hill Publishing Company.

Course Name: Freshwater Fish Culture	Course Code: ZOL-685
Course Structure: Lectures: 2, Lab: 1	Credit Hours: 2+1

COURSE OUTLINE

Laboratory Work Outline

1. Selection of site, collection of soil and its analysis for fish farm
2. Water analysis for fish culture
3. To calculate the lime requirement for fish pond.
4. Checking fish pond fertility by sacchi disc method.
5. Collection and identification of Common freshwater commercial fishes of Pakistan
6. Assessment of age and growth with the help of scale.
7. To determine the feeding habit of fish by observing their gut contents.
8. Proximate composition of fish feed ingredients and diets.
9. Sampling and identification of zooplankton and phytoplankton from various water bodies.
10. Analyses of water samples from polluted areas for water quality.
11. To determine Food conversion ratio, specific growth rate of commercial fishes of Pakistan
12. Visit of fish farm and submission of report

Books Recommended

Text Books

1. Sarkar, S.K. (2002). Freshwater fish culture. Vol. 1. Daya publishing House, Tri Nagar, Delhi.
2. Stickney, R.R. (2005). Aquaculture: An introductory Text. CABI publishing.

Additional Related Books

1. Nakagawa, H., Sato, M. and Gatlin, D. M. (2010) Dietary Supplements for the Health and Quality of Cultured Fish. CABI publishing.
2. Van der Zijpp, A.J., J., Verreth J.A.J., Tri, L., van Mensvoort, M.E.F,. Bosma R.H. and Beveridge M.C.M. (2008). Fish ponds in farming systems. Wageningen Academic Publishers.
3. Hart, J. B. P. and Reynolds, J. D. (2002). The Handbook of Fish Biology and Fisheries. Vol. 1 & 2. Blackwell publishing
4. Boyd, C.E. and Tucker, C.S. (1998). Pond-Aquaculture Water Quality Management. Boston, Kluwer.
5. Swift, D. (1993).Aquaculture: Training Manual.2nd Ed. Fishing News Books, A division of Blackwell scientific Publishing Ltd.
6. Pillay, T.V.R. (1993). Aquaculture, Principles and Practices, Fishing News Books
7. Ali, S.S. (1993). An introduction to freshwater fishery biology, U.G.C. Islamabad, Pakistan
8. Mirza, M.R. and Bhatti, M.N. (1993). Pakistan Ki Machlian aur Mahi Parwari Part-I. Ferozesons (Pvt.) Ltd., Lahore, Pakistan

Course Title: Introduction to Human Genetics	Course code: ZOL-686
	Credit hrs: 2+1
COURSE OUTLINE	

Introduction, overview and scope of human genetics; Mendelian genetics and transmission rules; pedigree analysis and determining the mode of inheritance; extensions and exceptions to Mendel's laws; multiple allele systems and ABO blood groups; X-linked inheritance; sex-determination; Y-linkage; penetrance, expressivity and pleiotropy; twin studies and heritability; mitochondrial inheritance; monogenic disorders; consanguinity and its calculation; multifactorial traits; cytogenetics and chromosomal disorders.

Laboratory Work Outline

1. Pedigree construction and study of trait transmission in human families
2. Understanding multiple alleles through ABO and Rh blood group systems and determining allele frequencies
3. Study of human physical monogenic traits and determining the allele frequencies of selected polymorphisms
4. Study of gene diversity and differentiation at blood group polymorphisms in model populations
5. Study of human polygenic traits, e.g., height, weight
6. Dermatoglyphics analysis in humans and studying it genetic and medico-legal importance
7. A survey of online databases and catalogues of human genetic diseases (eg., Oxford Medical Database; Online Mendelian Inheritance in Man, OMIM, http://www.ncbi.nlm.nih.gov/sites/OMIM
8. A survey of chromosomal variations in human (http://jws-edck.wiley.com:8096/)

Books recommended

9. Lewis, Ricki. (2007). Human Genetics: concepts and applications. McGraw Hill Boston.
10. Griffiths, Anthony J.F., Gelbart, William M., Lewontin, Richard C., and Miller, Jeffrey H. (2005). Modern Genetic Analysis. 3rd ed. W.H. Freeman and Co.
11. Cummings, Michael R. (2005). Human Heredity, Principles and Issues. 6th ed. Brooks/Cole Publishing.
12. Leviten, Max. (1988). Textbook of Human Genetics. 3rd ed. Oxford University Press. New York.
13. Mertenes, Thomas R, and Hammersmith, Robert L. (2001). Genetics Laboratory Investigations. 12th ed. Prentice Hall, Upper Saddle, New Jersey 07458.

Course title: Vector Biology	Course code:ZOL-687
Course structure: Lectures:2, Lab:1	Credit hrs. 2+1
COURSE OUTLINE	

Biological and mechanical vectors of all medical and veterinary importance: including morphology, biology, pathogenic and control and *Simulium, Phlebotomus, Anopheles, Culex, Musca, Hematobia, Oestruis, Lucilia, Hypoderma, Dermatobia etc.* Biology, morphology, Pathogenesis and life cycle of biting lice of mammals and birds. Biology, morphology, pathogenesis and life cycle of biting fleas of mammals and birds biology, morphology, pathogenesis and life cycle of biting ticks of mammals and birds Ectoparasitides – their mode of action, method of applications, uses in farm and pet animals and their resistance.

Laboratory Work Outline

Collection, preservation/culture and preparation of slides of local biological and mechanical vectors of medical and veterinary importance and their identification.

Books Recommended

1. Robert, LS, and Jonovy, Jr. 1996. Foundations Parasitology 5th edition. Wan Brown Publishers, Chicago. USA.
2. Urquhart, GM, Armour, J, Duncan, JL, Dunn, AN, Jennings, FW. 1995. Veterinary Parasitology. ELBS. USA.
3. Smyth, JD. 1994. Introduction to animal Parasitology. 3rd edition. Cabridge University Press. UK

Course title: Epidemiology of Animal Parasites	**Course Code: ZOL-688**
Course structure:lecture:2, Lab:1	**Credit hrs:2+1**
COURSE OUTLINE	
Animal association, adaptation to parasitism, protazoa, mollusca, arthropoda, acarina, insecta, nematode, acathocephala, trematoda, cestoda, stress. Effect of micro-environment on the parasite distribution in bost. Population an communities; ecological niche, ecological factors in parasite. Host complex, size relationships. Host age and parasite number, seasonal variations. Movements and hypobiosis: density of population; density dependence; parasite mix; food changes; microenvironments of host. Symobiotic cleaning. Host specificity, action of parasite upon their host.	
Laboratory Work Outline Culture, isolation and separation of parasitic larvae from soil and herbage material. Baerrmann technique for nematode larvae separation, McMaster technique for egg per gram counting, field herbage collection for carpological examination.	
Books Recommended 1. Anderson, R.C. 1992. Nematode Parasites of Vertebrate: Their Development and Transmission. CAB 2. International, USA. 3. Noble, E.R. and Noble G.A. 1982. Parasitology. Lea and Febiger, UK. 4. Bear, J.G. 1980. Ecology of Animal Parasites. Univ. of Illinois Press, Urbana, USA. **i.**	

Course Title: Medical Virology	**Course code: ZOL-689**
Course Structure:lectures:2,Lab:1	**Crdit hrs: 2+1**

Introduction: structure & characteristics: pathogenesis; implantation and portal of entry; local replication and spread; dissemination form portal of entry; incubation period (lytic & lysogenic viruses); shedding of viruses; latent, chronic, slow infections and persistent infections; viral epidemiology; zoonosesl; evolution of viruses; nonspecific defenses – anatomical barriers; inhibitors; phagocytosis; viral interference/interferon; immune defenses; immune prophylaxis – active & passive; sanitation and vector control; chemotherapy; mechanisms, targets, limitations and future of antiviral drugs; clinical manifestations, structure, pathogenesis, epidemiology, mode of transmission, diagnosis and control of a few animal/human viruses – polio virus; Rubella virus; Lassa virus; influenza viruses; Dengue, encephalitis and yellow fever viruses; rabies virus; mumps virus; measles virus; HIV; hepatitis viruses; Newcastle virus; Ebola virus; sub-acute spongiform virus encephalopathic viruses (mad cow disease) and its human equivalent.

Laboratory Work Outline

Laboratory techniques, rules and regulations; ELISA, RIA, techniques; HCV. HBsAg testing kits, HIV kits testing of blood sera; visitation to hospitals, pharmaceuticals to further enhance knowledge of virology techniques.

Books Recommended

1. Topley and Wilson's Principles of Bacteriology, Virology, Mycology, Parasitology and Immunity (Vols. 1-6). 9th
2. edition, 1998. Edward Arnold Publishers, UK.
3. Pelczar, Jr., MJ, Chan, ECS. And Kreig, NR. 1997. Microbiology: Concepts and Applications. International
4. Edition. McGraw Hill Publishers, USA.
5. Cappuccino, JG and Sherman, N. 1996. Microbilolgy – a laboratory manual. Benjamin/Cummings Publishers,
6. USA.
7. Joklik, WK., Willert, HP., Amos, DB. And Wilfert, CM, 1992. Zinsser Microbiology. Appleton and Lange, USA.
8. Baron, S. 1993. Medical Microbiology. Churchill Livingston, UK.

Course Title: Clinical Bacteriology	**Course Code: ZOL-690**
Course Structure: Lectures:2, Lab:1	**Credit hrs.2+1**

COURSE OUTLINE

Introduction: Source of infection; types of infection – summer borne and winter borne diseases. Endemic, epidemic, sporadic and pandemic diseases – especially with reference to Pakistan. Transmission of pathogen – animal to man and vice versa. Control of transmission. Diagnostic Microbiology – microbiological techniques involved in diagnosis of various bacterial infections. Opportunistic bacterial pathogens; obligate pathogens and associated diseases; signs and symptoms, pathogenesis, control an treatment of *staphylococcus: streptococcus: pneumococcus; Lactobacillus; bordetella; Corynebacterium; Listeria; Hemphilus; Mycobacterium; Pseudomonas; Aeromonas; Vibrios; Bacillus; Clostridium; Enterobacteriaceae-Escherichia; shigella; Salmonella; Enterobacter; Klebsiella; Proteus; Serratia species* infections.

Laboratory Work Outline

Interaction of microbes and host: epidemiolog, Koch's postulates. Isolation, identification and characterization of bacteria from various clinical samples: urine, skin, stool, blood, sputum etc.

Books Recommended

1. Topley and Wilson's Principles of Bacteriology, Virology, Mycology, Parasitology and Immunity: Vols. 1-6,
2. 1998, 9th edition. Edward Arnold Publishers, UK.
3. Pelczar Jr., M.J., Chan, ECS., Krieg, NR. 1997. International Eition. 1993. McGraw Hill, Inc. N.Y.
4. Cappuccino, J.g. and Sherman, N. 1996. Microbiology. A Laboratory Manual. 4th edition Benjamin / Cummings
5. Publishing Co., Inc. N.Y.
6. Baron, s. (editor) 1995. Medical Microbiology. Churchill Livingston Publication, London.
7. Boys, R.F. 1995. Basic Medical Microbiology. 5th edition. Little, Brown, and Co., Boston, USA.
8. Mahon, C.R. and Mauselis Jr., G.W.B. 1995. Textbook of Diagnostic Microbiology. Saunders Co., Pennsylvania.
9. Schacchter, M., Medoff, G., Einsenstein, BL. Mechansims of Microbial Disease. 1993. 2nd edition Williams & Wilkins, Maryland.