**DEPARTMENT OF ZOOLOGY**

**UNIVERSITY OF THE POONCH RAWALAKOT**

**CURRICULUM**

**OF**

**ZOOLOGY BS**

****

**DEPARTMENT OF ZOOLOGY**

**UNIVERSITY OF THE POONCH RAWALAKOT**

**AZAD KASHMIR**

**Website:** [**www.upr.edu.pk**](http://www.upr.edu.pk)

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**DEPARTMENT OF ZOOLOGY**

**THE UNIVERSITY OF POONCH RAWALAKOT**

**INTRODUCTION**

The Department of Zoology was established in March, 2013. At present, the department offers BS 4 years, M.Sc. 2 years and M .Phil 2 years programs with different courses ranging from Microbial Biology to advanced disciplines such as Biotechnology, Molecular Biology, and Human Molecular Genetics. The department offers specializations in the field of Fisheries and Aquaculture, Physiology, Endocrinology, Toxicology, Microbiology, Wildlife and Ecology at M.Sc level. The department is committed to ensure the quality teaching and research in the different areas of Zoology which meet all the educational standards of Higher Education Commission. It is the mission of the department to produce professionally skilled and academically sound Zoologists to be helpful to resolve the challenges related to the above mentioned fields of Zoology which are useful directly or indirectly to improve quality of the human life and economy of the country. The department is devoted to enhance student's professional skills and career opportunities. Different study tours and visits are regularly being arranged to expose the students and faculty to various national and international conferences/seminars on current issues relating to the different fields of Zoology. Faculty members also actively participate and present their research works in various national and international conferences/symposia regularly. 2

To ensure the quality of teaching and research, the qualified faculty has been inducted purely on merit basis. Furthermore, the department is fully cooperating with the Quality Enhancement Cell (QEC) of the University to incorporate their recommendations for improving the standard of teaching, quality of learning and achievement of its objectives. This document contains the agenda of the Board of Studies (BOS) meeting with annexed syllabi for BS,M.Sc. and M. Phil degree programs offered in the Department of Zoology. All syllabi fulfil the required standard of Higher Education Commission.

**THE UNIVERSITY OF POONCH RAWALAKOT**

**DEPARTMENT OF ZOOLOGY**

**Proposed agenda and Minutes of 2nd Meeting of Board of Studies**

The final meeting of Board of Studies in the discipline of Zoology was held on October 12, 2018 at Faculty of Basic and Applied Sciences University of the Poonch Rawalakot. The purpose of the meeting was to finalize the curriculum of Zoology. The following members attended the meeting.

|  |  |  |
| --- | --- | --- |
| **Sr. No.** | **Name/ Designation/Address** | **DBOS** |
|  | **Prof. Dr. Muhammad Rafique Khan**  Meritorious Professor  Department of Zoology  University of the Poonch, Rawalakot | **Chairman** |
|  | **Dr. Nausheen Irshad**  Incharge/Assistant Professor  Department of Zoology  University of the Poonch, Rawalakot | **Member** |
|  | **Dr. Majid Mahmood**  Assistant Professor  Department of Zoology  University of the Poonch, Rawalakot | **Member** |
|  | **Dr. Ali Muhammad**  Assistant Professor  Department of Zoology  University of the Poonch, Rawalakot | **Member** |
|  | **Prof. Dr. Muhammad Nasim Khan**  Department of Zoology  University of Azad Jammu and Kashmir, Muzaffarabad | **Member** |
|  | **Dr. Nuzhat Shafi**  Assistant Professor  Department of Zoology  University of Azad Jammu and Kashmir, Muzaffarabad | **Member** |
|  | **Prof. Dr. Mazhar Qayyum**  Professor  Department of Zoology  PMAS-Arid Agriculture University, Rawalpindi | **Member** |
|  | **Dr. Muhammad Tariq**  Associate Professor  Department of Wildlife Management  PMAS-Arid Agriculture University, Rawalpindi | **Member** |
|  | **Dr. Imtiaz Ahmad**  Nominee of Registrar  University of the Poonch Rawalakot | **Observer** |
|  | **Dr. Naveed Iqbal**  Nominee of Controller of Examination  University of the Poonch Rawalakot | **Observer** |

After thorough and detailed deliberations, the members of Board of studies unanimously approved the curriculum of Zoology for BS, M.Sc and M.Phil and made the recommendations as Annexed.

**UNIVERSITY OF THE POONCH RAWALAKOT**

**DEPARTMENT OF ZOOLOGY**

**Proposed Agenda 2nd Meeting of Board of Studies (BOS) 2018**

|  |  |
| --- | --- |
| **Proposed agenda** | **Recommendations** |
| Approval of the scheme of studies BS-4 year Program | Approved |
| Approval of the scheme of studies MSc-2 year Program w.e.f. October, 2018 and onwards | Approved |
| Approval of the scheme of studies M. Phil Program for session 2017-2019 and onwards | Approved as per HEC requirement |
| Approval of the scheme of studies Ph. D. Program from 2018 and onwards | Approved as per HEC requirement |

**Prof. Dr. Muhammad Rafique Khan**

Chairman

Department of Zoology

University of the Poonch Rawalakot

**Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**UNIVERSITY OF THE POONCH RAWALAKOT**

**DEPARTMENT OF ZOOLOGY**

**Proposed Agenda 2nd Meeting of Board of Studies (BOS) 2018**

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**Dr. Majid Mahmood**

Assistant Professor/Member

Department of Zoology

University of the Poonch Rawalakot

**Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**UNIVERSITY OF THE POONCH RAWALAKOT**

**DEPARTMENT OF ZOOLOGY**

**Proposed Agenda 2nd Meeting of Board of Studies (BOS) 2018**

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**Dr. Nausheen Irshad**

Assistant Professor/Member

Department of Zoology

University of the Poonch Rawalakot

**Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**UNIVERSITY OF THE POONCH RAWALAKOT**

**DEPARTMENT OF ZOOLOGY**

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**Dr. Ali Muhammad**

Assistant Professor/Member

Department of Zoology

University of the Poonch Rawalakot

**Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**UNIVERSITY OF THE POONCH RAWALAKOT**

**DEPARTMENT OF ZOOLOGY**

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**Dr. Muhammad Nasim Khan**

Professor and Chairman (Rtd.)

Department of Zoology

University of Azad Jammu and Kashmir, Muzaffarabad

**Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**UNIVERSITY OF THE POONCH RAWALAKOT**

**DEPARTMENT OF ZOOLOGY**

**Proposed Agenda 2nd Meeting of Board of Studies (BOS) 2018**

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**Dr. Nuzhat Shafi**

Assistant Professor and Chairperson

Department of Zoology

University of Azad Jammu and Kashmir, Muzaffarabad

**Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**UNIVERSITY OF THE POONCH RAWALAKOT**

**DEPARTMENT OF ZOOLOGY**

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**Dr. Mazhar Qayyum**

Professor and Director QEC

Department of Zoology

PMAS Arid Agriculture University Rawalpindi

**Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**UNIVERSITY OF THE POONCH RAWALAKOT**

**DEPARTMENT OF ZOOLOGY**

**Proposed Agenda 2nd Meeting of Board of Studies (BOS) 2018**

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**Dr. Tariq Mahmood**

Associate Professor

Department of Wildlife Management

PMAS Arid Agriculture University Rawalpindi

**Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**UNIVERSITY OF THE POONCH RAWALAKOT**

**DEPARTMENT OF ZOOLOGY**

**Proposed Agenda 2nd Meeting of Board of Studies (BOS) 2018**

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**Dr. Imtiaz Ahmad**

Assistant Professor/Nominee of Registrar

Faculty of Veterinary and Animal Sciences

University of the Poonch Rawalakot

**Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**UNIVERSITY OF THE POONCH RAWALAKOT**

**DEPARTMENT OF ZOOLOGY**

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**Dr. Naveed Iqbal**

Assistant Professor/Nominee of Controller of Examination

Department of Chemistry

University of the Poonch Rawalakot

**Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**DEPARTMENT OF ZOOLOGY**

**THE UNIVERSITY OF POONCH RAWALAKOT**

**PROPOSED CURRICULUM**

**FOR**

**BS 4 YEARS PROGRAM**

**IN**

**ZOOLOGY**

****

**DEPARTMENT OF ZOOLOGY**

**THE UNIVERSITY OF POONCH RAWALAKOT**

**AZAD KASHMIR**

**Website:** [**www.upr.edu.pk**](http://www.upr.edu.pk)

**ANNEXURE-I**

**CURRICULUM FOR BS-4 YEARS PROGRAM IN ZOOLOGY**

**DEPARTMENT OF ZOOLOGY**

**THE UNIVERSITY OF POONCH RAWALAKOT**

**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 Molecular Biology, Biochemistry, 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:** F. Sc. Pre medical/ A level.

**Aims and Objectives of Teaching Zoology at Bs-4 Year**

1. To impart knowledge about the major disciplines of Zoology. It will enable the students to understand the principles of organizations and inter-relationships in the biological systems with particular reference to animal diversity.
2. To teach different methods of exploration, investigation, organization of data and its utilization in practical life.
3. To train students for advanced studies and specialization on recently emerging technological and multidisciplinary fields such as Genetic Engineering, Biodiversity, Environmental Science, Wildlife and conservation, Fisheries and aquaculture, Pests and pest management, Biotechnology, etc. After completing the degree / students will be able to apply their knowledge to their respective fields effectively.
4. To equip students with knowledge and skills for better planning and management of animal resources, environment, health, medicine, agriculture and population in the country.
5. To develop the scientific culture and demonstrate professional skills in teaching / research/ managerial positions in wide range of professions in national and international organizations.

**Scheme of Studies for BS-4 Years (8 Semesters) Program in Zoology w.e.f. Fall 2018 and Onward**

Duration 8-12 Semesters

Total credits Hours 136

**YEAR-I**

**SEMESTER-I (Cr. 17)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course Title** | **Credits** | **Status** |
| ENG-3101 | English-I | 3(3-0) | Compulsory |
| COM-3102 | Introduction to Computer | 2(1-1) | Compulsory |
| MAT-3103 | Mathematics-I | 2(2-0) | Compulsory |
| BOT-3101 | Diversity of plants | 3(2-1) | General |
| CHM-3101 | Foundation Chemistry | 3(3-0) | General |
| ZOO-3106 | Principles of Animal Life-I | 4(3-1) | Foundation |
|  | **Total Credits** | **17** |  |

**SEMESTER-II (Cr. 17)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course Title** | **Credits** | **Status** |
| ENG-3201 | English-II | 3(3-0) | Compulsory |
| ISL-3202 | Islamic Studies/Ethics | 2(2-0) | Compulsory |
| STA-3203 | Introduction to Statistics | 2(2-0) | Compulsory |
| BOT-3201 | Plant Systematics, Anatomy and development | 3(2-1) | General |
| CHM-3201 | Organic Chemistry | 3(2-1) | General |
| ZOO-3206 | Principles of Animal Life-II | 4(3-1) | Foundation |
|  | **Total Credits** | **17** |  |

**Year-II**

**SEMESTER-III (Cr. 18)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course title** | **Credits** | **Status** |
| ENG-4302 | Report writing | 3(3-0) | Compulsory |
| PKS-4301 | Pakistan Studies | 2(2-0) | Compulsory |
| BOT-4301 | Cell Biology, Genetics and Evolution | 3(2-1) | General |
| CHM-4301 | Physical Chemistry | 3(2-1) | General |
| ZOO-4305 | Animal Diversity-I | 3(2-1) | Foundation |
| ZOO-4306 | Animal Form and Function-I | 4(3-1) | Foundation |
|  | **Total Credits** | **18** |  |

**SEMESTER-IV (Cr. 17)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Course code** | **Course title** | **Credits** | **Status** |
| ARB-4401 | Arabic | 3(3-0) | Compulsory |
| BOT- 4401 | Plant Physiology and Ecology | 3(2-1) | General |
| CHM-4401 | Inorganic Chemistry | 3(2-1) | General |
| ZOO-4404 | Animal Diversity-II | 4(3-1) | Foundation |
| ZOO-4405 | Animal Form and Function-II | 4(3-1) | Foundation |
|  | **Total Credits** | **17** |  |

**YEAR-III**

**SEMESTER-V (Cr. 18)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Course code** | **Course title** | **Credits** | **Status** |
| ZOO-5501 | Cell Biology | 3(2-1) | Compulsory |
| ZOO-5502 | Animal Physiology | 3(3-1) | Compulsory |
| ZOO-5503 | Basics of Genetics | 3(2-1) | Compulsory |
| ZOO-5504 | Environmental Biology | 3(2-1) | Compulsory |
| ZOO-5505 | Zoogeography | 2(2-0) | Compulsory |
| ZOO-5506 | Chemistry of Bio-Molecules | 3(2-1) | Compulsory |
|  | **Total Credits** | **17** |  |

**SEMESTER VI (Cr. 18)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course title** | **Credits** | **Status** |
| ZOO-5601 | Metabolism of Bio-Molecules | 3(3-0) | Compulsory |
| ZOO-5602 | Developmental Biology | 4(3-1) | Compulsory |
| ZOO-5603 | Principles of Animal Taxonomy | 2(1-1) | Compulsory |
| ZOO-5604 | Research Methods and Reports | 2(1-1) | Compulsory |
| ZOO-5605 | Paleontology and Evolution | 4(3-1) | Compulsory |
| ZOO-5606 | Basics of Molecular Biology | 3(2-1) | Compulsory |
|  | **Total Credits** | **18** |  |

**YEAR-IV**

**SEMESTER–VII (Cr. 17)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Course code** | **Course title** | **Credits** | **Status** |
| ZOO-6701 | Data Analysis | 2(1-1) | Compulsory |
|  | Elective-I | 3(2-1) | Elective |
|  | Elective-II | 3(2-1) | Elective |
|  | Elective-III | 3(2-1) | Elective |
|  | Elective-IV | 3(2-1) | Elective |
|  | Elective-V | 3(2-1) | Elective |
|  | **Total Credits** | **17** |  |

**YEAR-IV**

**SEMESTER-VIII (Cr. 15)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Course code** | **Course title** | **Credits** | **Status** |
|  | Elective-I | 3(2-1) | Elective |
|  | Elective-II | 3(2-1) | Elective |
|  | Elective-III | 3(2-1) | Elective |
|  | Elective-IV | 3(2-1) | Elective |
|  | Elective-V | 3(2-1) | Elective |
| ZOO-6822 | Comprehensive examination | P/F | Compulsory |
| ZOO-6823 | Thesis | 6(0-6) | Elective |
| Note: students who will not opt for thesis, will have to opt 5 elective courses | | | |
|  | **Total Credits** | **15** |  |

**17+ 17+18+17+17+18+17+15=136**

**LIST OF ELECTIVE COURSES FOR BS-4 YEARS PROGRAM IN ZOOLOGY VII SEMESTER**

|  |  |  |
| --- | --- | --- |
| **Course code** | **Course Title** | **Credit Hrs.** |
| ZOO-6702 | Biological techniques | 3(1-2) |
| ZOO-6703 | Immunology | 3(2-1) |
| ZOO-6704 | Biodiversity and Wildlife | 3(2-1) |
| ZOO-6705 | Basic Human Genetics | 3(2-1) |
| ZOO-6706 | Clinical Endocrinology | 3(2-1) |
| ZOO-6707 | Fisheries and Aquaculture | 3(2-1) |
| ZOO-6708 | General Biotechnology | 3(2-1) |
| ZOO-6709 | General Entomology | 3(2-1) |
| ZOO-6710 | General Microbiology | 3(2-1) |
| ZOO-6711 | General Parasitology | 3(2-1) |
| ZOO-6712 | General Toxicology | 3(2-1) |
| ZOO-6713 | Helminthology | 3(2-1) |
| ZOO-6714 | Hematology | 3(2-1) |
| ZOO-6715 | Histology | 3(2-1) |
| ZOO-6716 | Industrial and Microbial Biotechnology | 3(2-1) |
| ZOO-6717 | Invertebrata | 3(2-1) |
| ZOO-6718 | Limnology-A | 3(2-1) |
| ZOO-6719 | Neurophysiology | 3(2-1) |
| ZOO-6720 | Principles of Fish Biology | 3(2-1) |
| ZOO-6721 | Principles of Herpetology | 3(2-1) |
| ZOO-6722 | Principles of Parasitology | 3(2-1) |
| ZOO-6723 | Reproductive Physiology | 3(2-1) |
| ZOO-6724 | Wildlife Parasitology | 3(2-1) |

|  |  |  |
| --- | --- | --- |
| **Course Code** | **Course Title** | **Credit**  **Hrs.** |
| ZOO- 6801 | Animal Behaviour | 3(2-1) |
| ZOO- 6802 | Animal Pests and Disease Producing Organisms | 3(2-1) |
| ZOO- 6803 | Applied Microbiology | 3(2-1) |
| ZOO- 6804 | Biochemistry – II | 3(2-1) |
| ZOO- 6805 | Bioremediation and Environmental Biotechnology | 3(2-1) |
| ZOO- 6806 | Economic Zoology | 3(2-1) |
| ZOO- 6807 | Endocrinology | 3(2-1) |
| ZOO- 6808 | Environmental Issues | 3(2-1) |
| ZOO- 6809 | Fish Physiology | 3(2-1) |
| ZOO- 6810 | Human Genetics | 3(2-1) |
| ZOO- 6811 | Ichthyology (Fish Morphology) | 3(2-1) |
| ZOO- 6812 | Limnology-B | 3(2-1) |
| ZOO- 6813 | Mammalogy | 3(2-1) |
| ZOO- 6814 | Medical Microbiology | 3(2-1) |
| ZOO- 6815 | Medical Parasitology | 3(2-1) |
| ZOO- 6816 | Molecular Physiology | 3(2-1) |
| ZOO- 6817 | Physiological Systems and  Adaptations | 3(2-1) |
| ZOO- 6818 | Ornithology | 3(2-1) |
| ZOO- 6819 | Vector Biology | 3(2-1) |
| ZOO- 6820 | Vertebrata | 3(2-1) |
| ZOO- 6821 | Wildlife | 3(2-1) |

**COURSE CONTENTS OF COMPULSORY/GENERAL FACULTY COURSES FOR BS-4 YEAR PROGRAM IN ZOOLOGY 1st SEMESTER**

**SEMESTER-I (Cr. 17)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course Title** | **Credits** | **Status** |
| ENG-3101 | English-I | 3(3-0) | Compulsory |
| COM-3102 | Introduction to Computer | 2(1-1) | Compulsory |
| MAT-3103 | Mathematics-I | 2(2-0) | Compulsory |
| BOT- 3104 | Diversity of Vascular plants | 3(2-1) | General |
| CHM-3105 | Foundation Chemistry | 3(3-0) | General |
| ZOO-3106 | Principles of Animal Life-I | 4(3-1) | Foundation |
|  | **Total Credits** | **17** |  |

**Note:** The course contents of courses other than zoology will be adopted as prescribed by the relevant departments/University/HEC.

**BOT-3101 Diversity of Plants 4(3-1)**

**Aims and Objectives**

To introduce the students to the diversity of plants and their structures and significance.

**Course Contents**

Comparative study of life form, structure, reproduction and economic significance of:

1. Viruses (RNA and DNA types) with special reference to TMV;
2. Bacteria and Cyanobacteria (Nostoc, Anabaena, Oscillatoria) with specific reference to biofertilizers, pathogenicity and industrial importance;
3. Algae (Chlamydomonas, Spirogyra, Chara, Vaucheria, Pinnularia, Ectocarpus, Polysiphonia)
4. Fungi (Mucor, Penicillium, Phyllactinia, Ustilago, Puccinia, Agaricus), their implication on crop production and industrial applications.
5. Lichens (Physcia)
6. Bryophytes (Riccia, Anthoceros and Funaria)
7. Pteridophytes (Fossils and fossilization, Psilopsida (Psilotum), Lycopsida (Selaginella) Sphenopsida (Equisetum), Pteropsida (Marsilea) and Seed Habit)

h) Gymnosperms (Cycas, Pinus and Ephedra)

**Practical:**

1. Culturing, maintenance, preservation and staining of microorganisms.

2. Study of morphology and reproductive structures of the types mentioned in theory.

3. Identification of various types mentioned from prepared slides and fresh collections.

**Recommended Books:**

1. Lee, R.E. 1999. Phycology. Cambridge University Press, UK
2. Prescott, L.M., Harley, J.P. and Klein, A.D. 2004. Microbiology, 3rd ed. WM. C. Brown Publishers.
3. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 1996. Introductory Mycology. 4th ed. John Wiley and Sons Publishers.
4. Agrios, G.N. 2004. Plant pathology. 8th ed. Academic press London.
5. Vashishta, B.R. 1991. Botany for degree students (all volumes). S. Chand and Company. Ltd. New Delhi.
6. Andrew, H. N. 1961. Studies in Paleobotany. John Willey and Sons.
7. Ingrouille , M. 1992. Diversity and Evolution of Land Plants. Chapman &Hall .
8. Mauseth, J.D. 2003. Botany: An Introduction to Plant Biology 3rd ed., Jones and Bartlett Pub. UK
9. Marti.J.Ingrouille& Plant: Diversity and Evolution. 2006 CUP
10. Taylor, T.N. & Taylor, E.D. 2000. Biology and Evolution of Fossil Plants. Prentice Hall. N.Y.

**ENG-3101 English I 3(3-0)**

**Objectives**

Enhancelanguageskills anddevelopcritical thinking.

**CourseContents**

BasicsofGrammarindetail,Partsofspeechanduseofarticlesindetail,Sentencestructure, activeandpassivevoice,Practiceinunifiedsentence,Analysisofphrase,clauseandsentence structure, Transitive andintransitive verbs, Punctuation and spelling

**Comprehension**

Answers to questions onagiven text

**Discussion**

Generaltopicsandevery-day conversation(topicsfordiscussiontobeatthediscretionofthe teacher keepingin view thelevel of students)

**Listening**

To beimproved byshowingdocumentaries/films carefullyselected bysubject teachers

**Translationskills:**

Urdu to English

**Paragraphwriting**

Topics to be chosen at thediscretion ofthe teacher

**Presentationskills**

Introduction

Note: Extensive readingis required for vocabularybuilding

**Recommended books**

1. Practical English Grammar byA.J. Thomson and A.V. Martinet. Exercises 1. Third edition. Oxford UniversityPress. 1997.ISBN 0194313492

2. Practical English Grammar byA.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford UniversityPress. 1997.ISBN 0194313506.

3. Writing.IntermediatebyMarie-ChristineBoutin,SuzanneBrinandandFrancoise Grellet.OxfordSupplementarySkills.FourthImpression1993.ISBN0194354057, Pages 20-27 and 35-41.

4. Reading.UpperIntermediate. Brain Tomlinson and Rod Ellis. Oxford SupplementarySkills. ThirdImpression 1992.ISBN 0 19 45340.

**COM-3102 Introduction to Computer 2(1-1)**

**Aims and Objectives**

The course is designed to aim at imparting a basic level appreciation program for students. After completing the course, the students must be able to the use the computer for basic purposes of preparing their personnel reports, presentation letters, viewing information on Internet (the web), sending mails, receiving mail, using internet etc.

**Course Outlines**

History,classification,basiccomponents,CPU,memory,peripheraldevices,storagemedia anddevices, machine cycle, Computer Bus, Data Bus, Address Bus, Control Bus,programsand software, systemsoftware,applicationsoftware,operating systems, types of programminglanguages, compilationand interpretation, basic concept of computer networks, LAN, MAN, WAN, client /server network, peer to peer network, network topology and it types.

**LabOutline**

Networking devices,Introductiontoofficetools (Microsoft word, excel and power point) ,Introductiontovariousoperating systems, Use of internet, viewing information on internet, sending and receiving emails, searching topics on internet.

**RecommendedBooks**

1. BrianWilliamsandStaceySawyer,UsingInformationTechnology,LatestEdition, McGraw-Hill,ISBN: 0072260718.

2. Behrouz A. Forouzan, Data Communication and Networking, Latest Edition, Alan R. Apt, ISBN:13 978-0-07-296775-3.

3. William Stallings, Computer Organization and Architecture: Designingfor

Performance, Latest Edition,Prentice Hall, ISBN:0131856448

**MATH-3103 Mathematics I 2(2-0)**

**Specific Objectives of the Course**

To prepare the students, not majoring in mathematics, with the essential tools of algebra to apply the concepts and the techniques in their respective disciplines.

**Course Outline**

**Preliminaries:**Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions. **Matrices:**Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer’s rule. **Quadratic Equations:**Solution of quadratic equations, qualitative analysis of roots of a quadratic equations, equations reducible to quadratic equations, cube roots of unity, relation between roots and coefficients of quadratic equations. **Sequences and Series:**Arithmetic progression, geometric progression, harmonic progression. **Trigonometry:**Fundamentals oftrigonometry, trigonometric identities.

**Recommended Books**

1. Dolciani M. P, Wooton W, Beckenback E F, Sharron S, Algebra 2 and

Trigonometry, 1978, Houghton & Mifflin,

2. Boston (suggested text)

3. Kaufmann J. E, College Algebra and Trigonometry, 1987, PWS-Kent Company,

Boston

4. Swokowski E. W., Fundamentals of Algebra and Trigonometry (6th edition),

1986, PWS-Kent Company, Boston

**CHM-3101 Foundation Chemistry 3(3-0)**

1. **Introduction to Inorganic Chemistry**

History and development of Inorganic chemistry

2**. The Periodic Law and Periodicity**

Modern Periodic Table; Classification of elements based on *s, p, d* and *f* orbitals; group trends, and periodic properties in *s, p, d* and *f* block elements, i.e. atomic radii, ionic radii, ionization potential, electron affinities, electronegativities and redox potential; anomalies in group trends and periodic properties, the uniqueness principle, the diagonal effect and the inert pair effect

3. **Introduction to Classes and Nomenclature of Organic Compounds**

Classification of organic compounds; development of systematic nomenclature; IUPAC nomenclature of hydrocarbons and heteroatom functional groups up to bi functional compounds.

4. **Chemical Bond**

Localized and delocalized chemical bonding; concept of hybridization leading to bond angles, bond lengths, bond energies and shapes of organic molecules.

5. **Introduction to Biochemistry**

Applications of Biochemistry, disciplines related to Biochemistry, biochemistry of the cell. Introduction to biomolecules, classification, composition and biological roles of nucleic acids, proteins, carbohydrates, lipids, vitamins and minerals

6. **Introduction to Physical Chemistry**

Introduction; physical states of matter.

**Recommended Books**

1. Mingos D. M. P. “Essential Trends in Inorganic Chemistry” Oxford University Press, First Indian Edition, 2004.

2. Madan R. D. “Satya Prakash’s Modern Inorganic Chemistry” S. Chand and Company Limited, 2011.

3. Rodgers G. E. “Introduction to Coordination, Solid State and Descriptive Inorganic Chemistry” McGraw-Hill, Inc.

**ZOO-3106 PRINCIPLES OF ANIMAL LIFE – I**

**Aims and Objectives**

The course aims to impart knowledge and understanding of:

1. The concept and status of Zoology in life sciences.
2. The common processes of life through its chemistry, biochemical and molecular processes.
3. The structure and function of cell organelles and how common animal cell diversified in various tissues, organs and organ systems.
4. Biochemical mechanisms eventually generating energy for animal work.
5. Animals and their relationship with their environment.

**Course Contents**

**Scope of Zoology:** Introduction; significance and applications of zoology; animal diversity; the scientific method; environment and world resources. **The Chemical Basis of Animal Life:**Brief introduction to biomolecules; carbohydrates, lipids, proteins, and nucleic acids. **Cellular Organization:** Structure of animal cells, cell membrane, cytoplasm and its organelles: ribosomes, endoplasmic reticulum, Golgi apparatus, lysosomes, mitochondria, cytoskeleton, cilia and flagella, centrioles and microtubules, and vacuoles; ribosomes, endoplasmic reticulum, the nucleus: nuclear envelope, chromosomes and nucleolus. **Animal tissues:** Types: epithelial, connective, muscle and nervous tissue; organs and organ systems. **Enzymes:**Structure, types; function and factors affecting their activity; cofactors and coenzymes. **Energy Harvesting:**Aerobic and anaerobic respiration: glycolysis, citric acid cycle and electron transport chain; fermentation, the major source of ATP. **Reproduction and Development:** Types; asexual and sexual, gametogenesis, fertilization, metamorphosis, zygote and early development. **Ecological Concepts:** Individuals and Populations: Animals and their abiotic environment; populations and limiting factors; Communities and Ecosystems: Community structure and diversity; interspecific interactions. Ecosystem, types, homeostasis, biomes, food chain, food web, energy flow and thermodynamics; biogeochemical cycles; Ecological problems; human population growth, pollution, resource depletion and biodiversity.

**Practicals**

1. Tests for different carbohydrates, proteins and lipids.

*Note*: Emphasis on the concept that tests materials have been ultimately obtained from living organisms and constituted their body.

1. Study of the prepared slides of epithelial tissue (squamous, cuboidal, columnar), connective tissue (adipose, cartilage, bone, blood), nervous tissue and muscle tissue (skeletal, smooth and cardiac).

*Note*: *Prepared microscopic and/or projection slides and/or CD ROM computer projections must be used.*

1. Preparation of blood smears.
2. Plasmolysis and deplasmolysis in blood.
3. Protein digestion by pepsin.
4. Ecological notes on animals of a few model habitats.
5. Field observation and report writing on animals in their ecosystem (a terrestrial and an aquatic ecosystem study).

**Recommended Books**

1. Hickman, C.P., Roberts, L.S. and Larson, A. Integrated Principles of Zoology, 12th Edition (International), 2004. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. Zoology, 6th Edition (International), 2005. Singapore: McGraw Hill.
3. Campbell, N.A. Biology, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
4. Miller, S.A. General Zoology Laboratory Manual. 5th Edition (International), 2002. Singapore: McGraw Hill.
5. Hickman, C.P. and Kats, H.L., Laboratory Studies In Integrated Principles Of Zoology. 2000. Singapore: McGraw Hill.
6. Molles, M.C. Ecology: Concepts and Applications. 6th Edition. 2005. McGraw Hill, New York, USA.
7. Odum, E. P. Fundamentals of Ecology. 3rd Edition. 1994. W.B. Saunders.Philadelphia.

**COURSE CONTENTS OF COMPULSORY/GENERAL FACULTY COURSES FOR BS-4 YEAR PROGRAM IN ZOOLOGY 2ND SEMESTER**

**SEMESTER-II (Cr. 18)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course Title** | **Credits** | **Status** |
| ENG-3201 | English-II | 3(3-0) | Compulsory |
| ISL-3202 | Islamic Studies / Ethics | 2(2-0) | Compulsory |
| STA-3203 | Statistics | 3(2-1) | Compulsory |
| BOT- 3204 | Botany-II | 3(2-1) | General |
| CHM-3205 | Organic Chemistry | 3(2-1) | General |
| ZOO-3206 | Principles of Animal Life-II | 4(3-1) | Foundation |
|  | **Total Credits** | **18** |  |

**Note:** The course contents of courses other than zoology will be adopted as prescribed by the relevant departments/University/HEC.

**BOT-3201 Plant Systematics, Anatomy and development 4(3-1)**

**Aims and Objectives**

To understand:

1. Various systems of classification, identification and nomenclature of higher plants.

2. Structures and functions of tissues and organs at embryonic level.

**Course Contents:**

1. **Plant systematics**
2. Introduction to Plant Systematics: aims, objectives and importance.
3. Classification: brief history of various systems of classification with emphasis on Takhtajan.
4. Brief introduction to nomenclature, importance of Latin names and binomial system with an introduction to International Code of Botanical Nomenclature (ICBN).Vienna code.
5. Morphology: a detailed account of various, orphological characters root, stem, leaf, inflorescence, flower, placentation and fruit types.
6. Diagnostic characters, economic importance and distribution pattern of the following families:

Ranunculaceae, Brassicaceae (Cruciferae), Fabaceae (Leguminosae), Rosaceae, Euphorbiaceae, Cucurbitaceae, Solanaceae, Lamiaceae (Labiatae), Apiaceae (Umbelliferae), Asteraceae (Compositae), Liliaceae (Sen. Lato) and Poaceae (Gramineae)

1. **Anatomy**

Cell wall: structure and chemical composition, Concept, structure and function of various tissues like: Parenchyma, Collenchyma, Sclerenchyma, Epidermis (including stomata and trichomes), Xylem, Phloem, Meristem: types, stem and root apices, Vascular cambium, Structure and development of root, stem and leaf. Primary and secondary growth of dicot stem, periderm, Characteristics of wood: diffuse porous and ring –porous, sap and heart wood, soft and hard wood, annual rings.

1. **Development / Embryology**

Early development of plant body: Capsella bursa-pastoris, Structure and development of Anther MicrosporogenesisMicrogametophyte, Structure of Ovule MegasporogenesisMegagametophyte, Endosperm formation, Parthenocarpy, Polyembryony

**Practical**

**Anatomy**

1. Study of stomata, epidermis,
2. Tissues of primary body of plant
3. Study of xylem 3-dimensional plane of wood.
4. T.S of angiosperm stem and leaf.

**Taxonomy**

1. Identification of families given in syllabus with the help of keys.
2. Technical description of common flowering plants belonging to
3. families mentioned in theory syllabus.
4. Field trips shall be undertaken to study and collect local plants.
5. Students shall submit 40 fully identified herbarium specimens.

**Recommended Books:**

1. Mauseth, J.D. 1998. An Introduction to Plant Biology: Multimedia Enhanced. Jones and Bartlett Pub. UK
2. Moore, R.C., W.D. Clarke and Vodopich, D.S. 1998. Botany. McGraw Hill Company, U.S.A.
3. Raven, P.H., Evert, R.E. and Eichhorn, S.E. 1999. Biology of Plants. W.H. Freeman and Company Worth Publishers.
4. Stuessy, T.F. 1990. Plant Taxonomy. Columbia University Press, USA.
5. Lawrence, G.H.M. 1951 Taxonomy of Vascular Plants. MacMillan & Co. New York.
6. Panday, B.P. 2004. A textbook of Botany (Angiosperms). S. Chand and Co. New Delhi.
7. Raymond E, S. E. Eichhorn. 2005. Esau’s Plant Anatomy. Meristems cells and tissues of the plant body, 3rded. John Wiley & Sons. Inc.
8. Fahn, A. 1990. Plant Anatomy. Pergamon Press, Oxford.
9. Esau, K. 1960. Anatomy of Seed Plants. John Wiley, New York.
10. Maheshwari, P.1971. Embryology of Angiosperms, McGraw Hill.New York.
11. Eames A.J. and L.H Mac Daniels. 2002. An Introduction to Plant Anatomy. Tata-Mac Graw-Hill Publishing Company, Limited New Delhi.
12. Pullaiah, T. 2007. Taxonomy of Angiosperms. 3rdEdition Regency Publications, New Delhi.
13. Naik, V.N. 2005 Taxonomy of Angiosperms. 20thReprint. Tata-Mac Graw-Hill Publishing Company, Limited New Delhi.

**ENG-3201 English II 3(3-0)**

**Objectives:**

Enable the students to meet their real life communication needs.

**Course Contents**

**Paragraph writing:**

Practice in writing a good, unified and coherent paragraph**,**

**Essay writing:**

Introduction,

**CV and job application**:

Translation skills, Urdu to English,

**Study skills:**

Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension,

**Academic skills:**

Letter/memo writing, minutes of meetings, use of library and internet,

**Presentation skills**:

Personality development (emphasis on content, style and pronunciation)

**Note:** Documentaries to be shown for discussion and review

**Communication Skills**

1. **Grammar**
2. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. 3rd Edition. Oxford University Press 1986. ISBN 0 19 431350 6.
3. **Writing**
4. Writing. Intermediate by Marie-ChrisitineBoutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
5. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).
6. **Reading**
7. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 4534030.
8. Reading and Study Skills by John Langan
9. Study Skills by Riachard York.

**ISL-3202 Islamic Studies / Ethics 2(2-0)**

**Objectives**

This course is aimed at:

1. To provide Basic information about Islamic Studies
2. To enhance understanding of the students regarding Islamic Civilization
3. To improve Students skill to perform prayers and other worships
4. To enhance the skill of the students for understanding of issues related to faith and religious life.

**Course contents**

Basic Concepts of Quran, History of Quran, Uloom-ul –Quran, Verses of Surah Al-Baqra Related to Faith(Verse No-284-286), Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11), Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77), Verses of Surah Al-Inam Related to Ihkam (Verse No-152-154),Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56, 57,58.), Verses of Surah Al-Hashar (18,19,20),Verses of Surah Al-Saf Related to Tafakar, Tadabar (Verse No-1,14), Life of Muhammad Bin Abdullah ( Before Prophet Hood), Life of Holy Prophet (S.A.W) in Makkah, Important Lessons Derived from the life of Holy Prophet in Makkah,Life of Holy Prophet (S.A.W) in Madina, Important Events of Life Holy Prophet in Madina, Important Lessons Derived from the life of Holy Prophet in Madina ,Basic Concepts of Hadith, History of Hadith, Kinds of Hadith, Uloom-ul-Hadith, Sunnah & Hadith, Legal Position of Sunnah, Basic Concepts of Islamic Law & Jurisprudence, History &Importance of Islamic Law & Jurisprudence, Sources of Islamic Law & Jurisprudence, Nature of Differences in Islamic Law, Islam and Sectarianism, Basic Concepts of Islamic Culture & Civilization, Historical Development of Islamic Culture & Civilization, Characteristics of Islamic Culture & Civilization, Islamic Culture & Civilization and Contemporary Issues, Basic Concepts of Islam & Science, Contributions of Muslims in the Development of Science, Quranic & Science, Basic Concepts of Islamic Economic System, Means of Distribution of wealth in Islamic Economics, Islamic Concept of Riba, Islamic Ways of Trade & Commerce, Basic Concepts of Islamic Political System, Islamic Concept of Sovereignty, Basic Institutions of Govt. in Islam, Period of Khlaft-E-Rashida, Period of Ummayyads, Period of Abbasids, Basic Concepts of Social System of Islam, Elements of Family, Ethical Values of Islam.

**Reference Books:**

1. Hameed ullah Muhammad, “Emergence of Islam” , IRI, Islamabad
2. Hameed ullah Muhammad, “Muslim Conduct of State”
3. Hameed ullah Muhammad, ‘Introduction to Islam

1) Mulana Muhammad YousafIslahi,”

1. Hussain Hamid Hassan, “An Introduction to the Study of Islamic Law” leaf Publication Islamabad, Pakistan.
2. Ahmad Hasan, “Principles of Islamic Jurisprudence” Islamic Research Institute, International Islamic University, Islamabad (1993)
3. Mir Waliullah, “Muslim Jurisprudence and the Quranic Law of Crimes” Islamic Book Service (1982)
4. H.S. Bhatia, “Studies in Islamic Law, Religion and Society” Deep & Deep Publications New Delhi (1989)
5. Dr. Muhammad Zia-ul-Haq, “Introduction to Al Sharia Al Islamia” Allama Iqbal Open University, Islamabad (2001).

**CHM-3201 Organic Chemistry 3(2-1)**

**Properties of Organic Molecules**

Dipole moment; inductive and field effects; resonance; aromaticity; tautomerism; hyperconjugation; hydrogen bonding; acids and bases; factors affecting the strengths of acids and bases.

**Hydrocarbons**

Discussion on the preparation, properties and reactions of alkanes, alkenes, alkynes and aromatics.

**Oxygenated Hydrocarbons**

Discussion on the preparation, properties and reactions of alcohols (phenols), ethers, aldehydes, ketones, carboxylic acids and derivatives.

**Introductory Organic Spectroscopy**

Introduction to IR, UV, 1H-NMR and Mass spectrometric methods, and their usage for structure elucidation of some simple organic compounds.

**Practicals:**

Laboratory work illustrating topics covered in the lecture of CHM-3212

**ZOO-3206 PRINCIPLES OF ANIMAL LIFE-II**

**Aims and Objectives**

The course will imparts knowledge and understanding of:

1. Cell division and its significance in cell cycle.
2. Concepts and mechanisms of inheritance pattern, chromosome and gene linkage and molecular basics of genetics.
3. Animal behaviour and communication.
4. Theories of evolution, gene flow and mechanism of evolution with reference to animals and diversity.

**Course Contents**

**Cell Division:** Cell cycles: Mitosis and meiosis; control of the cell cycle. **Inheritance Patterns:**Mendelian genetics; inheritance patterns; gene, structure, chemical composition and types. **Chromosomes and Gene Linkage:**Eukaryotic chromosomes; linkage and crossing over; chromosomal aberrations. **Molecular Genetics: Cellular Control: DNA:** the genetic material; DNA replication in prokaryotes and eukaryotes; control of gene expression in eukaryotes; gene mutation; recombinant DNA and applications of genetic technologies. **Animal Behaviour:**Behaviour and its types, proximate and ultimate causes; anthropomorphism; development of behavior; learning; factors controlling animal behavior; communication; behavioral ecology; social behavior. **Evolution:** AHistorical Perspective: Theories of evolution: Lamarckism and natural selection, neo larmarckism, Darwinism, and neo Darwinian. **Evolution and Gene Frequencies:**Hardy-Weinberg principle; evolutionary mechanisms: population size, genetic drift, gene flow, de Vries mutation theory and rates of evolution, polymorphism; species and speciation; molecular evolution; mosaic evolution.

**Recommended Books**

1. Hickman, C.P., Roberts, L.S. and Larson, A. Integrated Principles Of Zoology, 11th Edition (International), 2004. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. Zoology, 5th Edition (International), 2002. Singapore: McGraw Hill.
3. Pechenik, J.A. Biology Of Invertebrates, 4th Edition (International), 2000. Singapore: McGraw Hill.
4. Kent, G.C. and Miller, S. Comparative Anatomy Of Vertebrates. 2000. New York: McGraw Hill.
5. Campbell, N.A. Biology, 6th Edition. Menlo Park, California: 2002. Benjamin/Cummings Publishing Company, Inc.

**Practicals**

1. Study of mitosis in onion root tip.
2. Study of meiosis in grasshopper testis (students should prepare the slide).
3. Problem based study of Mendelian ratio in animals.
4. Multiple alleles study in blood groups.
5. Survey study of a genetic factor in population and its frequency.
6. Study of karyotypes of *Drosophila*, mosquito.
7. Study of cytochemical detection of DNA in protozoa and avian blood cell.
8. Study to demonstrate nervous or endocrine basis of behaviour (conditioned reflex or aggression or parental behavior).
9. Study to demonstrate social behaviour (documentary film be shown, honey bee, monkey group in a zoo).

*Note for1-2: Prepared microscopic and/or projection slides and/or CD ROM computer projections must be used).*

**Recommended Books**

1. Miller, S.A. General Zoology Laboratory Manual. 5th Edition (International), 2002. Singapore: McGraw Hill.
2. Hickman, C.P. and Kats, H.L. Laboratory Studies In Integrated Principles Of Zoology. 2000. Singapore: McGraw Hill.

**STA-3203 Introduction to Statistics 2 (1-1)**

**What is Statistics?**

Definition of Statistics, Population, Observations, Data, Discrete and continuous variables, Errors of measurement, Significant digits, Rounding of a Number, Collection of primary and secondary data, Sources, Editing of Data.

**Presentation of Data**

Introduction, basic principles of classification and Tabulation, Graphs and their Construction, Bar charts, Pie chart, Histogram, Frequency polygon and Frequency curve, Cumulative Frequency Polygon or Ogive, Historigram, Ogive for Discrete Variable. Types of frequency curves.

**Measures of Central Tendency**

Introduction, Different types of Averages, Quantiles, The Mode, Empirical Relation between Mean, Median and mode, Relative Merits and Demerits of various Averages. properties of Good Average, Box and Whisker Plot, Stem and Leaf Display, definition of outliers and their detection. Exercises.

**Sampling and Sampling Distributions**

Introduction, sample design and sampling frame, bias, sampling and non sampling errors, sampling with and without replacement, probability and non-probability sampling, Sampling distributions for single mean and proportion, Difference of means and proportions.

**Hypothesis Testing**

Introduction, Statistical problem, null and alternative hypothesis, Type-I and Type-II errors, level of significance, Test statistics, general procedure for testing of hypothesis.

**Recommended Books:**

1. Walpole, R. E. 1982. “Introduction to Statistics”, 3rd Ed., Macmillan Publishing Co., Inc. New York.
2. Muhammad, F. 2005. “Statistical Methods and Data Analysis”, KitabMarkaz, Bhawana Bazar Faisalabad.

**COURSE CONTENTS OF COMPULSORY/GENERAL FACULTY COURSES FOR BS-4 YEAR PROGRAM IN ZOOLOGY 3RD SEMESTER**

**Year-II**

**SEMESTER-III (Cr. 18)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course title** | **Credits** | **Status** |
| ENG-4301 | English-III (Report writing) | 3(3-0) | Compulsory |
| PKS-4302 | Pakistan Studies | 2(2-0) | Compulsory |
| BOT-4303 | Botany-III | 3(2-1) | General |
| CHM-4304 | Analytical Chemistry | 3(3-1) | General |
| ZOO-4305 | Animal Diversity-I | 3(2-1) | Foundation |
| ZOO-4306 | Animal Form and Function-I | 4(3-1) | Foundation |
|  | **Total Credits** | **18** |  |

**Note:** The course contents of courses other than zoology will be adopted as prescribed by the relevent departments/University/HEC.

**BOT-4301 Cell Biology, Genetics and Evolution 4(3-1)**

**Aims and Objectives**

To understand

1. Structure and functions of cell.

2. Nature of genetic material and hereditary process.

3. Familiarization with evolutionary processes.

**Course Contents**

**a) Cell biology**

1. Structures and Functions of Bio-molecules

Carbohydrates, Lipids, Proteins, Nucleic Acids

2. Cell: Physico-chemical nature of plasma membrane and cytoplasm.

3. Ultrastructure of plant cell with a brief description and functions of the following organelles

Cell wall, Endoplasmic reticulum, Plastids, Mitochondria, Ribosomes, Dictyosomes, Vacuole, Microbodies (Glyoxysomes and Peroxisomes)

1. Nucleus: Nuclear membrane, nucleolus, ultrastructure and morphology of chromosomes, karyotype analysis
2. Reproduction in somatic and embryogenic cell, mitosis and meiosis, cell cycle
3. Chromosomal aberrations; Changes in the number of chromosomes. Aneuploidy and euploidy. Changes in the structure of chromosomes, deficiency, duplication, inversion and translocation.

**b) Genetics**

**1.** Introduction, scope and brief history of genetics. Mendelian inheritance; Laws of segregation and independent assortment, back cross, test cross, dominance and incomplete dominance.

**2.** Sex linked inheritance, sex linkage in Drosophila and man (colour blindness), XO, XY, WZ mechanisms, sex limited and sex linked characters, sex determination.

**3.** Linkage and crossing over: definition, linkage groups, construction of linkage maps, detection of linkage.

**4.** Molecular genetics; DNA replication. Nature of gene, genetic code, transcription, translation, protein synthesis, regulation of gene expression (e.g. *lac* operon).

**5.** Transmission of genetic material in Bacteria: Conjugation and gene recombination in *E.coli,* transduction and transformation.

**6.** Principles of genetic engineering / biotechnology; Basic genetic engineering techniques.

**7.** Application of genetics in plant improvement: Induction of genetic variability (gene mutation, recombination), physical and chemical mutagens, selection, hybridization and plant breeding techniques. Development and release of new varieties.

**8.** Introduction to germplasm conservation

**c) Evolution**

The nature of evolutionary forces, adaptive radiations, differential reproductive potential, first plant cell, origin of organized structures, early aquatic and terrestrial ecosystem, first vascular plant.

**Practical**

Study of cell structure using compound microscope and elucidation of ultrastructure from electron microphotographs

1. Measurement of cell size.
2. Study of mitosis and meiosis by smear/squash method and from prepared slides.
3. Study of chromosome morphology and variation in chromosome number.
4. Extraction and estimation of carbohydrate, protein, RNA and DNA from plant sources

**Genetics**

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.

**Recommended Books:**

1. Hoelzel, A. R. 2001. Conservation Genetics. Kluwer Academic Publishers.
2. Dyonsager, V.R. (1986). Cytology and Genetics. Tata and McGraw Hill Publication Co. Ltd,, New Delhi.
3. Lodish. H. 2001. Molecular Cell Biology. W. H. Freeman and Co.
4. Sinha, U. and Sinha, S. (1988). Cytogenesis Plant Breeding and Evolution, Vini Educational Books, New Delhi.
5. Strickberger, M.V. (1988), Genetics, MacMillan Press Ltd., London.
6. Carroll, S.B., Grenier,J.K. and Welnerbee, S.d. 2001. From DNA to Diversity - Molecular Genetics and the Evolution of Animal Design. Blackwell Science.
7. Lewin, R, 1997. Principles of Human Evolution. Blackwell Science.
8. Strickberger, M. W. 2000 Evolution. Jones &Bartlet Publishers Canada
9. Ingrouille M. J. & B. Eddie. 2006. Plant Diversity and Evolution. Cambridge University Press.

**PKS-4301 Pakistan Studies 2(2-0)**

**Introduction/Objectives:**

Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

**Course Outlines:**

1. **Historical Perspective**

Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-i-Azam M. Ali Jinnah. Factors leading to Muslim separatism. PEOPLE AND LAND: Indus Civilization, Muslim advent, Location and geo-physical features. GOVERNMENT AND POLITICS IN PAKISTAN: Political and constitutional phases, 1947-58, 1958-71, 1971-77, 1977-88, 1988-99 and 1999 onward, CONTEMPORARY PAKISTAN: Economic institutions and issues, Society and social structure, Ethnicity, Foreign policy of Pakistan and challenges, Futuristic outlook of Pakistan

**Books Recommended:**

1. Burki, ShahidJaved. State & Society in Pakistan, The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. Issue in Pakistan’s Economy. Karachi: Oxford University Press, 2000.

1. S.M. Burke and Lawrence Ziring. Pakistan’s Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993.
2. Mehmood, Safdar. Pakistan Political Roots & Development. Lahore, 1994.
3. Wilcox, Wayne. The Emergence of Bangladesh., Washington: American Enterprise, Institute of Public Policy Research, 1972.
4. Mehmood, Safdar. Pakistan KayyunToota, Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
5. Amin, Tahir. Ethno - National Movement in Pakistan, Islamabad: Institute of Policy Studies, Islamabad.
6. Ziring, Lawrence. Enigma of Political Development. Kent England: WmDawson& sons Ltd, 1980.
7. Zahid, Ansar. History & Culture of Sindh. Karachi: Royal Book Company, 1980.
8. Afzal, M. Rafique. Political Parties in Pakistan, Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
9. Sayeed, Khalid Bin. The Political System of Pakistan. Boston: Houghton Mifflin, 1967.
10. Aziz, K.K. Party, Politics in Pakistan, Islamabad: National Commission on Historical and Cultural Research, 1976.
11. Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987.
12. Haq, Noor ul. Making of Pakistan: The Military Perspective. Islamabad: National Commission on Historical and Cultural Research, 1993.
13. Amin, Tahir. *Ethno - National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.

**ENG-4302 Report writing 3(3-0)**

**Objectives:**

Enhance language skills and develop critical thinking

COURSE CONTENTS: PRESENTATION SKILLS: ESSAY WRITING: Descriptive, narrative, discursive, argumentative, ACADEMIC WRITING: How to write a proposal for research paper/term paper. How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency), TECHNICAL REPORT WRITING: PROGRESS REPORT WRITING. Extensive reading is required for vocabulary building.

**Recommended Books:**

Technical Writing and Presentation Skills

1. Essay Writing and Academic Writing
   1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).
   2. CollegeWriting Skills by John Langan. McGraw-Hill Higher Education. 2004.
   3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin’s Press.
2. Mercury Reader. A Custom Publication. Compiled by norther Illinois University. General Editiors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharton. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

**CHM-4301 Physical Chemistry 3(2-1)**

**Quantum theory and structure of atom**

Bohr’s atomic model, defects of Bohr’s atomic model, classical mechanics, failure of classical mechanics, quantum mechanics, dual nature of matter, de-Broglie’s equation, Heisenberg’s uncertainty principle, limitation of Heisenberg’s uncertainty principle, concept of atomic orbitals, quantum numbers, Pauli exclusion principle, electronic distribution of elements.

**Physical states of matter**

**1. Gases**

General characteristics of gases, Gay Lussac’s law, ideal gas equation, kinetic molecular theory of gases, molecular velocities (average velocity, mean square velocity, root mean square velocity, most probable velocity), ideal and real gases, deviation of gas from ideality, derivation of kinetic gas equation, molecular collisions, collision diameter, critical phenomenon of gases, liquefaction of gases, mean free path, Vander Waal’s equation for real gases.

**2. Liquid**

General characteristics of liquids, physical properties like surface tension, viscosity, parachor value, rheochor value and their applications, refractive index, specific and molar refraction and their applications, optical activity, specific rotation, dipole moment and molecular structure.

**3. Solids**

General characteristics of solids, types of solids, isotropy and anisotropy, habit of a crystal, crystal lattice and unit cell, crystal systems and Bravis lattices.

**Chemical Thermodynamics**

Introduction, thermodynamic terms like system, surrounding, boundary of system, states and state function, internal energy, extensive and intensive properties, first law of thermodynamics, enthalpy of a system, relationship between free energy change and enthalpy change, heat capacity of gases at constant volume and at constant pressure, , heat capacities relationship, 2nd law of thermodynamics, change in free energy and equilibrium constant.

**Chemical Kinetics**

Introduction, concept of rate of chemical reaction, rate law, velocity constant, elementary and complex reaction, order and molecularity of reaction, zero, fist and second order reactions, derivation of kinetic equation for first order and 2nd order reaction when initial concentration of both reactants is same, various methods for determining the rate of chemical reaction, Arrhenius equation, Lindemmann’ s theory for unimolecular reaction, introduction to transition state theory, transition state theory for bimolecular reaction.

**Basic Electrochemistry**

Introduction, conductors and insulators, electrolytic and electronic conduction, specific conductance, measurement of specific conductance, cell constant and its determination, Ostwald’s dilution law (dependence of degree of dissociation constant on dilution), electrochemical cells, types of cells, EMF and its measurement.

**Solutions**

Introduction, types of solution, concentration units, ideal and non-ideal solutions, Raoult’s law, molecular interactions in solution, colligative properties (lowering of vapour pressure, elevation of 11 boiling point, depression of freezing point, osmotic pressure and their determination),concept of zeotropic and azeotropic mixture.

**Surface Chemistry**

Absoption and adsorption, types of adsorption, characteristics and factors which affect adsorption, applications of adsorption, catalysis, types of catalysis, enzyme catalysis, characteristics of catalysis.

**Practicals:**

• Determination of viscosity and parachor values of liquids.

• Determination of percent composition of liquid solutions viscometrically.

• Determination of refractive index and molar refractivity.

• Determination of percent composition of liquid solutions by refractive index measurements.

• Determination of molecular weight of a compound by elevation of boiling point (ebullioscopic method).

• Determination of molecular weight of a compound by lowering of freezing point (cryoscopic method).

• Determination of heat of solution by solubility method.

• Determination of heat of neutralization of an acid with a base.

**ZOO-4305 ANIMAL DIVERSITY-I (NVERTEBRATES)**

(Classification, Phylogeny and Organization)

**Aims and Objectives**

The course is designed to provide students with:

1. Concepts of evolutionary relationship of animal kingdom.
2. Knowledge about animal kingdom, emphasizing their phylogenetic relationships and simple to complex mode of animal life.

**Course Contents**

**Introduction**: Architectural pattern of an animal, taxonomy and phylogeny, major subdivisions of animal kingdom. **Animal-Like Protists**: The Protozoa Evolutionary perspective; life within a single plasma membrane; symbiotic life-styles. Protozoan taxonomy: (up to phyla, subphyla and super classes, wherever applicable). Pseudopodia and amoeboid locomotion; cilia and other pellicular structures; nutrition; genetic control and reproduction; symbiotic ciliates; further phylogenetic considerations. **Multicellular and Tissue Levels of Organization**Evolutionary perspective: origins of multicellularity; animal origins. Phylum porifera: cell types, body wall, and skeletons; water currents and body forms; maintenance functions; reproduction. Phylum cnidaria (coelenterata) the body wall and nematocysts; alternation of generations; maintenance functions; reproduction and classification up to class. Phylum ctenophora; further phylogenetic considerations. **Triploblastics and Acoelomate Body Plan:**Evolutionary perspective; phylum platyhelminthes: classification up to class; the free-living flatworms and the tapeworms; phylum nemertea; phylum gastrotricha; further phylogenetic considerations. **Pseudocoelomate Body Plan**: Aschelminths Evolutionary perspective; general characteristics; classification up to phyla with external features; feeding and the digestive system; other organ systems; reproduction and development of phylum rotifera and phylum nematoda; phylum kinorhyncha. Some important nematode parasites of humans; further phylogenetic considerations. **Molluscan Success:**Evolutionary perspective: relationships to other animals; origin of the coelom; molluscan characteristics; classification up to class. The characteristics of shell and associated structures, feeding, digestion, gas exchange, locomotion, reproduction and development, other maintenance functions and diversity in gastropods, bivalves and cephalopods; further phylogenetic considerations. **Annelida:** The Metameric Body Form Evolutionary perspective: relationship to other animals, metamerism and tagmatization; classification up to class. External structure and locomotion, feeding and the digestive system, gas exchange and circulation, nervous and sensory functions, excretion, regeneration, reproduction and development, in polychaeta, oligochaeta and hirudinea; further phylogenetic considerations. **Arthropods**: Blueprint for Success Evolutionary perspective: classification and relationships to other animals; metamerism and tagmatization; the exoskeleton; metamorphosis; classification up to class; further phylogenetic considerations. Crustaceans, Hexapods and Myriapods, general nature, classification, phylogeny and adaptive diversification.**Echinoderms**: Evolutionary perspective: relationships to other animals; echinoderm characteristics; classification up to class. Maintenance functions, regeneration, reproduction, and development in asteroidea, ophiuroidea, echinoidea, holothuroidea and crinoidea; further phylogenetic considerations; some lesser-known invertebrates: the lophophorates, entoprocts, cycliophores, and chaetognaths.

**Recommended Books**

1. Hickman, C.P., Roberts, L.S. and Larson, A. Integrated Principles Of Zoology, 15th Edition (International), 2011. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. Zoology, 8th Edition (International), 2011. Singapore: McGraw Hill.
3. Pechenik, J.A. Biology Of Invertebrates, 4th Edition (International), 2000. Singapore: McGraw Hill.
4. Campbell, N.A. Biology, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.

**Practicals**

1. Museum study of representative phyla, permanent slide preparations
2. Study of *Euglena, Amoeba, Entamoeba, Plasmodium, Trypanosoma,*
3. *Paramecium* as representative of animal like protists. (Prepared slides).
4. Study of sponges and their various body forms.
5. Study of principal representative classes of phylum Coelenterata.
6. Study of principal representative classes of phylum Platyhelminthes.
7. Study of representative of phylum Rotifera, phylum Nematoda.
8. Study of principal representative classes of phylum Mollusca.
9. Study of principal representative classes of phylum Annelida.
10. Study of principal representative classes of groups of phylum Arthropoda.
11. Brief notes on medical/economic importance of the following:
12. *Plasmodium, Entamoeba histolitica, Leishmania*, Liverfluke, Tapeworm, Earthworm,
13. Silkworm, Citrus butterfly.

**Recommended Books**

1. Hickman, C.P. and Kats, H.L. Laboratory Studies In Integrated Principles Of Zoology. 2000. Singapore: McGraw Hill.
2. Miller, S.A., General Zoology Laboratory Manual. 5th Edition (International), 2002. Singapore: McGraw Hill.

**ZOO-4306 ANIMAL FORM AND FUNCTION-I (INVERTEBRATES)**

(A Comparative Perspective)

**Aims and Objectives**

The course aims to teach the students about:

1. Animals diversity adapted in different ways for their functions through modifications in body parts.
2. The diversity in integumentary, skeletal, muscular, nervous and sensory, endocrine, circulatory, respiratory, nutritive, excretory, osmoregulatory and reproductive systems according to strategies to survive in their specific conditions.
3. Organ systems, their specialization and coordination with each other and constantly changing internal and external environment, inside and outside the animal’s body.
4. The basic structure of each system that determines its particular function.

**Course Contents**

**Protection, Support, and Movement:** Protection: the integumentary system of invertebrates and vertebrates; movement and support: the skeletal system of invertebrates and vertebrates; movement: non-muscular movement; an introduction to animal muscles; the muscular system of invertebrates and vertebrates. **Communication I: Nerves:** Neurons: structure and function; neuron communication: introductory accounts of resting membrane potential, action potential (nerve impulse) and transmission of the action potential between cells; invertebrate and vertebrate nervous systems: the spinal cord, spinal nerves, the brain, cranial nerves and the autonomic nervous system. **Communication II: Senses:** Sensory reception: baroreceptors, chemoreceptors, georeceptors, hygroreceptors, phonoreceptors, photoreceptors, proprioceptors, tactile receptors, and thermoreceptors of invertebrates; lateral-line system and electrical sensing, lateral-line system and mechanoreception, hearing and equilibrium in air, hearing and equilibrium in water, skin sensors of damaging stimuli, skin sensors of heat and cold, skin sensors of mechanical stimuli, sonar, smell, taste and vision in vertebrates. **Communication III:** The Endocrine System and Chemical Messengers: hormones chemistry; and their feedback systems; mechanisms of hormone action; some hormones of porifera, cnidarians, platyhelminthes, nemerteans, nematodes, molluscs, annelids, arthropods, and echinoderms invertebrates; an overview of the vertebrate endocrine system; endocrine systems of vertebrates, endocrine systems of birds and mammals. **Circulation, Immunity, and Gas Exchange:** Internal transport and circulatory systems in invertebrates: characteristics of invertebrate coelomic fluid, hemolymph, and blood cells; transport systems in vertebrates; characteristics of vertebrate blood, blood cells and vessels; the hearts and circulatory systems of bony fishes, amphibians, reptiles, birds and mammals; the human heart: blood pressure and the lymphatic system; immunity: nonspecific defenses, the immune response; gas exchange: respiratory surfaces; invertebrate and vertebrate respiratory systems: cutaneous exchange, gills, lungs, and lung ventilation; human respiratory system: gas transport.

**Recommended Books**

1. Hickman, C.P., Roberts, L.S. and Larson, A. Integrated Principles Of Zoology, 11th Edition (International), 2004. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. Zoology, 5th Edition (International), 2002. Singapore: McGraw Hill.
3. Pechenik, J.A. Biology Of Invertebrates, 4th Edition (International), 2000. Singapore: McGraw Hill.
4. Kent, G.C. and Miller, S. Comparative Anatomy Of Vertebrates. 2001. New York: McGraw Hill.
5. Campbell, N.A. Biology, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.

**Practicals**

1. Study of insect chitin, fish scale, amphibian skin, reptilian scales, feathers and mammalian skin.
2. Study and notes of skeleton of *Labeo, Rana tigrina, Varanus,* fowl and rabbit.

*Note*: *Exercises of notes on the adaptations of skeletons to their function must be done.*

1. Earthworm or leech; cockroach, freshwater mussel, *Channa* or *Catla catla* or *Labeo* or any other local fish, frog, pigeon and rat or mouse and rabbits are representative animals for study in dissections.
2. Study of models or preserved brains of representative animals and notes on adaptations.
3. Study of nervous system of earthworm and a fish.
4. Study of endocrine system in an insect and a rabbit.
5. Study of different types of blood cells in blood smear of rabbit.
6. Study of heart, principal arteries and veins in a representative vertebrate (dissection of representative fish/mammals).
7. Study of respiratory system in cockroach or locust and a vertebrate representative (Model).

**Recommended Books**

1. Hickman, C.P. and Kats, H.L. Laboratory Studies In Integrated Principles Of Zoology. 2000. Singapore: McGraw Hill.
2. Miller, S.A. General Zoology Laboratory Manual. 5thEdition (International), 2002. Singapore: McGraw Hill.

**COURSE CONTENTS OF COMPULSORY/GENERAL FACULTY COURSES FOR BS-4 YEAR PROGRAM IN ZOOLOGY 4TH SEMESTER**

**SEMESTER-IV (Cr. 17)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Course code** | **Course title** | **Credits** | **Status** |
| ARB-4401 | Arabic | 3(3-0) | Compulsory |
| BOT- 4402 | Botany-IV | 3(2-1) | General |
| CHM-4403 | Inorganic Chemistry | 3(2-1) | General |
| ZOO-4404 | Animal Diversity-II | 4(3-1) | Foundation |
| ZOO-4405 | Animal Form and Function-II | 4(3-1) | Foundation |
|  |  |  |  |
|  | **Total Credits** | **17** |  |

**Note:** The course contents of courses other than zoology will be adopted as prescribed by the relevent departments/University/HEC.

**BOT-4402 Environmental Biology 3(2-1)**

**Aims and Objectives**

To provide updated knowledge of environmental problems and sustainable environmental management.

**Course Contents**

1. Environment: Introduction, scope, pressure

2. Pollution: definition, classification and impact on habitats

i. Air pollution: Sources and effect of various pollutants (inorganic, organic) on plants, prevention, control, remediation. Photochemical smog. Smog. Acid rain: 1. Theory of acid rain, 2. Adverse effects of acid rains. Chlorofluorocarbons and its effects.

ii. Water pollution: Major sources of water pollution and its impact on vegetation. Prevention, control remediation, eutrophication, thermal pollution.

iii. Sediments pollution: fungicide, pesticides, herbicide, major sources of soil pollution and its impact. Prevention, control remediation. Heavy metal pollution. Tanneries. Hospital waste. Treatments of sewage, sludge, and polluted waters.

iv. Noise pollution.

v. Radiation pollution (including nuclear): Measurement, classification and effects, Principle of radiation protection, waste disposal

3. Environmental Buffers. Forest: importance, deforestation, desertification and

conservation

4. Ozone layer:

i. Formation

ii. Mechanism of depletion

iii.Effects of ozone depletion

5. Greenhouse effect: causes, impacts.

6. Range management: Types of rangelands, potential threats, sustainable management.

**Practical**

1. Examination of industrial waste water and Municipal sewage and sludge for

i. Total dissolved solids.

ii. pH and EC.

iii. BOD/COD.

iv. Chlorides, carbonate, and Nitrates.

3. Examination of water samples forms different sites for the presence and diversity of organisms.

4. Effect of air pollutants on plants.

5. Visits to environmentally compromised sites and evolution of remediation methods.

**Books Recommended:**

1. Newman, E.I. 2001. Applied Ecology. Blackwell Science. UK

2. Mooney, H.A. and Saugier, B. 2000. Terrestrial Global Productivity. Academic Press, UK.

3. Eugene, E.D. and Smith, B.F. 2000. Environmental Science: A study of interrelationships. McGraw Hill. USA.

4. French, H. 2000. Vanishing Borders: Protecting the Planet in the Age of Globalization. W.W. Norton and Company, NY.

5. Hall, C.A.S. and Perez, C.L. 2000. Quantifying Sustainable Development. Academic Press, UK.

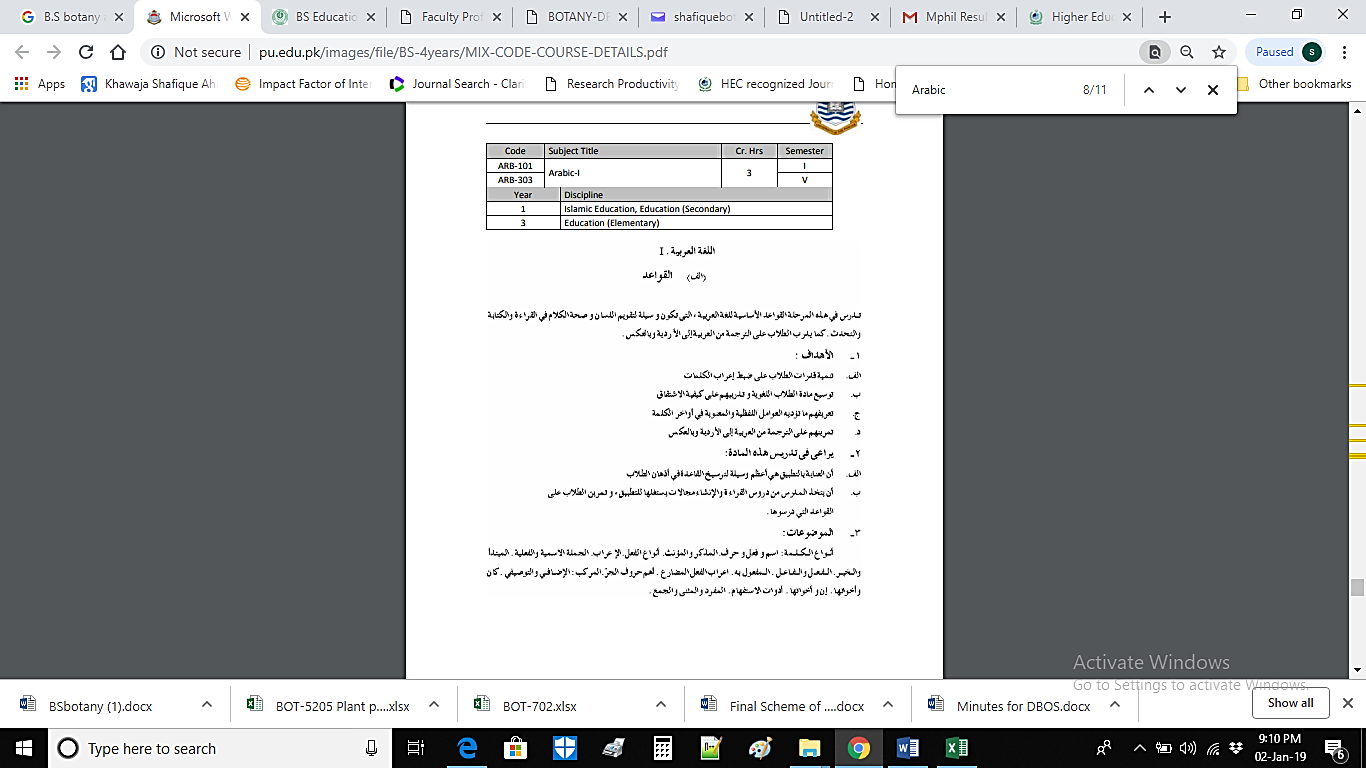
6. Bazzaz, F.A. 2004. Plants in changing environments: Linking physiological, population, and community ecology. Cambridge Univ. Press.

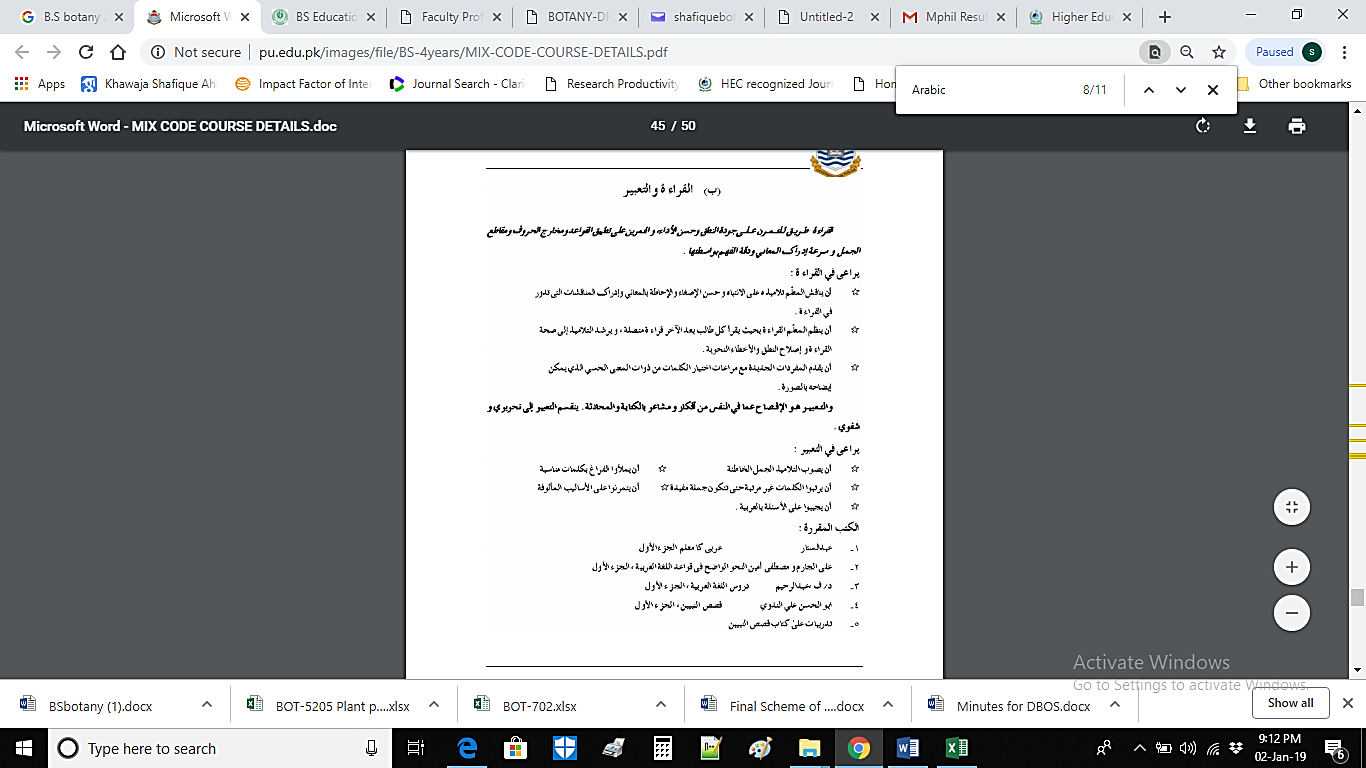
7. Bush, M.B. 1997. Ecology of a changing planet. Prentice Hall, UK.

8. Marsh, M.W. and Grossa Jr., J.M. 1996 Environmental geography: Science, land use, and earth systems. John Wiley and Sons.

9. Lambers, H., T. L. Pons and F. Stuart. 2008. Plant Phyiological Ecology.

**ARB-4401 Arabic 3(3-0)**

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**ZOO-4404 ANIMAL DIVERSITY-II (CHORDATA)**

**Aims and Objectives**

The course provides knowledge and understanding about the different animal groups, emphasizing their phylogenetic relationships.

**Course Contents**

**Hemichordates and Invertebrate Chordates**: Evolutionary Perspective: Phylogenetic Relationships; Classification up to subphylum or class where applicable; Further Phylogenetic Considerations. **Fishes**: Vertebrate Success in Water: Evolutionary perspective: phylogenetic relationships; survey of super class agnatha and gnathostomata; evolutionary pressures: adaptations in locomotion, nutrition and the digestive system, circulation, gas exchange, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations. **Amphibians**: The First Terrestrial Vertebrates Evolutionary perspective: phylogenetic relationships; survey of order caudata, gymnophiona, and anura. Evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction, development, and metamorphosis; further phylogenetic considerations. **Reptiles**: The First Amniotes Evolutionary perspective: cladistic interpretation of the amniotic lineage; survey of order testudines or chelonia, rhynchocephalia, squamata, and crocodilia; evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations. **Birds**: Feathers, Flight, and Endothermy Evolutionary perspective: phylogenetic relationships; ancient birds and the evolution of flight; diversity of modern birds; evolutionary pressures: adaptation in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and regulation, nervous and sensory systems, excretion and osmoregulation, reproduction and development; migration and navigation. **Mammals**: Specialized Teeth, Endothermy, Hair, and Viviparity: Evolutionary perspective: diversity of mammals; evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, behavior, reproduction and development.

**Recommended Books**

1. Hickman, C.P., Roberts, L.S. and Larson, A. Integrated Principles Of Zoology, 15th Edition (International), 2011. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. Zoology, 8th Edition (International) 2010. Singapore: McGraw Hill.
3. Kent, G.C. and Miller, S. Comparative Anatomy Of Vertebrates. Latest Edition 200?. New York: McGraw Hill.
4. Campbell, N.A. BIOLOGY, 9th Edition. 2011. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.

**Practicals**

1. Museum study of representative phyla
2. Study of a representative of Hemichordate and Chordate.
3. Study of representative groups of class Fishes.
4. Study of representative groups of class Amphibia.
5. Study of representative groups of class Reptilia.
6. Study of representative groups of class Aves.
7. Study of representative groups of class Mammalia.
8. Field trips to study animal diversity in an ecosystem.

*Note*: *Preserved specimen and/or colored projection slide and/or CD ROM projection of computer must be used.*

**Recommended Bookso**

1. Hickman, C.P. and Kats, H.L. Laboratory Studies In Integrated Principles Of Zoology. 2000. Singapore: McGraw Hill.
2. Miller, S.A. General Zoology Laboratory Manual. 5th Edition (International), 2002. Singapore: McGraw Hill.

**ZOO-4405 ANIMAL FORM AND FUNCTION-II (CHORDATES)**

(A Comparative Perspective)

**Aims and Objectives**

The course deals with the:

1. Basis of structure and functions of animal nutrition, digestion, homeostasis and temperature regulation.
2. It introduces the basic concepts in reproduction and development in animal kingdom.
3. Provides knowledge about the development of chordate body plan and fate of germinal layers.

**Course Contents**

**Nutrition and Digestion:** Evolution of nutrition; the metabolic fates of nutrients in heterotrophs; digestion; animal strategies for getting and using food, diversity in digestive structures of invertebrates and vertebrates; the mammalian digestive system: gastrointestinal motility and its control, oral cavity, pharynx and esophagus, stomach, small intestine: main site of digestion; large intestine; role of the pancreas in digestion; and role of the liver and gallbladder in digestion. **Temperature and Body Fluid Regulation:** Homeostasis and Temperature Regulation; The Impact of Temperature on Animal Life; Heat Gains and Losses; Some Solutions to Temperature Fluctuations; Temperature Regulation in Invertebrates, Fishes, Amphibians, Reptiles, Birds and Mammals; Heat Production in Birds and Mammals; Control of Water and Solutes (Osmoregulation and Excretion); Invertebrate and Vertebrate Excretory Systems; How Vertebrates Achieve Osmoregulation; Vertebrate Kidney Variations; Mechanism in Metanephric Kidney Functions. **Reproduction and Development:** Asexual reproduction in invertebrates; advantages and disadvantages of asexual reproduction; sexual reproduction in invertebrates; advantages and disadvantages of sexual reproduction; sexual reproduction in vertebrates; reproductive strategies; examples of reproduction among various vertebrate classes; the human male reproductive system: spermatogenesis, transport and hormonal control, reproductive function; the human female reproductive system: folliculogenesis, transport and hormonal control, reproductive function; hormonal regulation in gestation; prenatal development and birth: the placenta; milk production and lactation. **Descriptive Embryology:** Fertilization; embryonic development: cleavage, and egg types; the primary germ layers and their derivatives; echinoderm embryology; vertebrate embryology: the chordate body plan, amphibian embryology, development in terrestrial environments, avian embryology, and the fate of mesoderm.

**Recommended Books**

1. Hickman, C.P., Roberts, L.S. and Larson, A. Integrated Principles of Zoology, 11th Edition (International), 2004. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. Zoology, 5th Edition (International), 2002. Singapore: McGraw Hill.
3. Pechenik, J.A. Biology of Invertebrates, 4th Edition (International), 2000. Singapore: McGraw Hill.
4. Kent, G.C. and Miller, S. Comparative Anatomy of Vertebrates. 2001. New York: McGraw Hill.
5. Campbell, N.A. Biology, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.

**Practicals**

1. Study of excretory system in an invertebrate and a vertebrate representative (Model).
2. Study of nutritive canal in an invertebrate and a vertebrate representative (Dissection).
3. Study of male reproductive system in an invertebrate and a vertebrate representative (Dissection).
4. Study of female reproductive system in an invertebrate and a vertebrate representative (Dissection).
5. Study of hormonal influence of a reproductive function (Model).
6. Study of preserved advanced stages of avian and mammalian development for amniotic membranes and placenta (Model).
7. Study of stages in the development of an Echinoderm.
8. Study of early stages in the development of a frog, chick and a mammal.

*Note for9-10: Prepared slides and preserved specimen and/or projection slides and/or CD ROM computer projections may be used.*

**Recommended Books**

1. Hickman, C.P. and Kats, H.L. Laboratory Studies in Integrated Principles of Zoology. 2000. Singapore: McGraw Hill.
2. Miller, S.A. General Zoology Laboratory Manual. 5thEdition (International), 2002. Singapore: McGraw Hill.

**CHM-4401 Inorganic Chemistry 3(2-1)**

**1. Introduction to Chemical Bonding**

Attainment of a stable configuration, types of bonds (ionic bonds, covalent bonds, coordinate bonds), oxidation number and formal oxidation number. The localized bonding approach (Introduction to valence bond theory and hybridization. The delocalized bonding approach (MOT applied to homonuclear diatomic molecules).

**2. Acids and Bases**

Concepts of acids and bases (Arrhenius, Lowry-Bronsted, Lewis and SHAB concept), relative strength of acids and bases. pH, pKa, pKb and buffer solutions and their significance. Theory of Indicators, solubility, solubility product, common ion effect and their applications.

**3. Chemistry of p-block Elements**

General characteristics of the following group of p-block elements with reference to the aspects given against each:

Boron and Aluminum

Gradation of the characteristic properties within the group. Structures, properties and applications of electron deficient molecules such as boron hydrides and aluminium hydrides.

Carbon and Silicon

Gradation of the characteristic properties within the group). Production of pure silicon for solar energy and silicon chips. Structural aspects of ortho and metasilicates and their industrial applications.

Nitrogen and Phosphorus

Gradation of the characteristic properties within the group. Oxides of nitrogen (NO and NO2) and their role in air pollution, oxyacids (HNO2 and HNO3) of nitrogen. Industrial preparation of urea and superphosphate fertilizers.

Oxygen and Sulfur 26 Gradation of the characteristic properties within the group. Role of sulphur dioxide in air pollution. Thionic acids (H2SO3 and H2SO4) and uses of hypo in photography.

The Halogens

Gradation of the characteristic properties within the group, anomalous behaviour of fluorine. Preparation of oxyacids of halogens (HClO3 and HClO4) and their uses. Interhalogens, pseudohalogens.

The Noble Gases

Preparation, properties and uses of xenon fluorides; Commercial uses of noble gases.

4. **Chemistry of d-block Elements**

Electronic configuration and general characteristics of d-block elements. Industrial applications of transition metals. Werner’s concept and nomenclature of coordination compounds.

5. **Introduction to Modern Materials**

Liquid crystals, engineering ceramics, fiber glass and thin films.

**PRACTICAL**

1. Laboratory Ethics and safety measures

Awareness about the toxic nature of chemicals and their handling, cleaning of glassware, safe laboratory operations

2. Qualitative analysis

Analysis of four ions (two anions and two cations) from mixture of salts

3. Quantitative analysis

a. Acid-Base Titrations (minimum 02)

b. Redox Titrations (minimum 02)

c. ComplexometricTirations (minimum 02)

4. Inorganic Preparations

a. Preparation of Ferrous sulphate

b. Preparation of Ferric alum

c. Preparation of Barium silphate

**Recommended Books**

1. Huheey, J. E., Keiter, E. A. and Keiter, R. L., “Inorganic Chemistry: Principles of Structure and Reactivity”, 4th Ed., Harper and Row, New York, 2001

2. Cotton, F. A., Wilkinson, G. and Gaus, P. L., “Basic Inorganic Chemistry”, 3rd Ed., Wiley, New York, 1995.

3. Clyde Day, M. &Selbin, J., “Theoretical Inorganic Chemistry”, 2nd Ed., Van Nustrand Reinhold, 1969.

4. Lee, J.D., “Concise Inorganic Chemistry”, Chapman and Hall, 5th Edition,1996.

5. Shriver, D. F., Atkins, P. W. and Langford, C. H., “Inorganic Chemistry”, Oxford University Press, 2nd Edition, 1994.

6. Cartmell E. and Fowles G. W. A. “Valency and Molecular Structure” Adlard and Sons Limited 3rd Edition (1966)

7. Douglas B., McDaniel D. and Alexander J. “Concepts and Models of Inorganic Chemistry” John Wiley & Sons, Inc. 3rd Edition (1994)

8. Harvey K. B. and Porter G. B. “Introduction to Inorganic Physical Chemistry” Addison-Wesley Publishing Company, Inc. (1963)

9. Hill J. W. and Petrucci R. H. “General Chemistry” Prentice-Hall, Inc. (1996)

10. Marr G. and Rockett B. W. “Practical Inorganic Chemistry” Van Nostrand Reinhold Company. (1972)

11. Miessler G. L. and Tarr Donald A. “Inorganic Chemistry” Prentice-Hall International, Inc. Prentice-Hall International Edition (1991)

12. Moody B. “Comparative Inorganic Chemistry” Routledge, Chapman and Hall, Inc. 3rd Edition (1991)

13. Kennedy, Friedlander, “Nuclear and Radiochemistry” (latest edition).

Bassette, J., Denney, G. H. and Mendham, J., “Vogel’s Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis” English Language Book Society, 4th Edition, 1981.

Vogel, A. I., “A Textbook of Micro and Semi-micro Qualitative Inorganic Analysis” Longman Green & Co. 1995.

**COURSE CONTENTS OF COMPULSORY FACULTY COURSES FOR BS-4 YEAR PROGRAM IN ZOOLOGY 5TH SEMESTER**

**YEAR-III**

**SEMESTER-V (Cr. 17)**

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| --- | --- | --- | --- |
| **Course code** | **Course title** | **Credits** | **Status** |
| ZOO-5501 | Cell Biology | 3(2-1) | Compulsory |
| ZOO-5502 | Animal Physiology | 3(3-1) | Compulsory |
| ZOO-5503 | Basics of Genetics | 3(2-1) | Compulsory |
| ZOO-5504 | Environmental Biology | 3(2-1) | Compulsory |
| ZOO-5505 | Zoogeography | 2(2-0) | Compulsory |
| ZOO-5506 | Chemistry of Bio-Molecules | 3(2-1) | Compulsory |
|  | **Total Credits** | **17** |  |

**Details**

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| **ZOO-5501** | **Cell Biology** | **3(2-1)** |

**Aims and Objectives**

The objectives of the course are to impart knowledge about the animal cell and its complex organization of architecture and the unified role it plays for the ultimate sustainability of the organisms. The various ultra-structural, molecular and functional aspects of the cells will be communicated in this course.

**Course Contents**

**Introduction to prokaryotic and eukaryotic cells:** Plasma membrane, its chemical composition structure and functions: of plasma membranes, cell permeability, active transport, endocytosis, phagocytosis. Cytoskeleton: Microfilaments, Microtubules, Intermediate filaments. **Cytoplasmic Organelles:** Membrane system (structural and functional commonalities). Ultrastructure, chemical composition and functions of Endoplasmic Reticulum with special reference to their role in protein synthesis and drug metabolism), Golgi Apparatus (with reference to its role in synthesis of glycoprotein), Mitochondria (with reference to its role in cellular respiration, and its significance as semi-autonomous organelle), Lysosome (with reference to its diverse roles due to hydrolytic activity of enzymes), peroxisome (with reference to metabolism of hydrogen peroxide), glycoxysome (with reference to glyoxylic acid cycle). **Nucleus,** chromatin, heterochromatin, euchromatin, chromosome structure with reference to coiling and nucleosome during different phases of cell cycle.

**Practicals**

1. Detection and quantitative determination of chromosomal DNA and RNA
2. Preparation and staining of histological slides.
3. Identification of different cell organelles on slide

**Recommended Books**

1. Damnell Jr .J; lodisch, H. and Baltimore, D (1990). Moleculer Biology, Scientific American Inc.N.Y.
2. Alberts B., Brary, D., Lewis, j., Raff, M., Roberts, Kand Watson, J.D. (1989). Moleculer Biology of Cell.Garland Publishing Inc. New York.
3. De Robertes, E.D.P. And De Robertis Jr, E.N.F. (1987). Cell and Moleculer Biology .Laea and febiger New York
4. Karp, J. Cell and Molecular Biology, Concepts and Experiments, 2005. Jhon Wiley and Sons, INC.
5. Geoffrey M.C., Robert E.H. The Cell: A Molecular Approach, 2007. Sinauer Associates, INC.

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| **ZOO-5502** | **Animal Physiology** | **3 (3-1)** |

**Aims and Objectives**

The course aims to:

1. Understand basic physiological mechanisms relating to membrane excitability, nerve and muscle, receptor function.
2. Understand neuro-endocrine coordination and secretions of glands.
3. Know the physiology of heart, hemodynamic system and kidney function.
4. Understand the digestive physiology and nutritive functions of gut.
5. Understand physiological regulation of temperature and its maintenance

**Course Contents**

**Central themes in Physiology:** Homeostasis, Concepts of conformity and regulation; physiological adaptations. **Neuro-muscular physiology:** Cellular homeostasis, resting and action potential, synaptic transmission, muscle contraction, general sensory mechanism, cutaneous sensation, audition, vision, tast, olfaction, the motor control system, sleep and consciousness. Muscles: Structure, types, components, muscle proteins, molecular basis of muscle contraction: sarcoplasmic reticulum and role of calcium, muscle action potentials, isometric and isotonic contraction, leverage factor, muscle fatigue. **Cardiovascular Physiology:** Vessels, heart, electrocardiography, cardiac rate, rhythm, and conduction disturbances, heart as a pump, cardiodynamics, hemodynamics, cardiac output and venous return, control of cardiovascular system, responses to stress. **Respiratory physiology:** Respiratory mechanics, gas exchange between atmosphere and the body, gas transport, pulmonary circulation, respiratory control, hypoxia. **Renal Physiology:** Body fluid compartment, renal tubular function, renal clearance, glomerular filtration and GFR, reabsorption and secretion, composition of urine, formation of dilute and concentrated urine, effect of ADH, Aldosterone and Atrial Natriuretic Factor on renal Physiology. **Gastrointestinal Physiology:** Digestive system, the oral cavity, composition of saliva, pharynx, oesophagus, the stomach, regulation of gastric juice, small intestine, liver, regulation of bile, pancreatic and intestinal enzymes and their regulation, the colon, absorption of nutrients. **Endocrine Physiology:** General features of hormones, types of hormone action, basic concepts of endocrine control, endogenous opioid peptides, pituitary gland, thyroid gland, parathyroid hormones, calcitonine, Vitamin D. Adrenal Medulla, Adrenal cortex, Testis, Ovary, Endocrine placenta, Endocrine Pancreas. **Temperature Regulation:**Temperature classification of animals; Temperature relation of ectotherms in freezing and cold and warm and hot environment; Costs and benefits of ectothermy; Temperature relations of heterotherms and endotherms; Dormancy: Sleep, Torpor, Hibernation and Estivation.

**Practicals**

1. **Muscle and Neuromuscular Activity:** Nerve muscle preparation, Muscle twitch, Comparison of muscle and nerve irritability, effect of stimulus strength, effect of stimulus frequency (tetany), effect of load or stretch, effect of prolonged activity (fatigue), neuromuscular fatigue, stimulation of motor points in human.
2. **Excitability, Sensation and Behaviour:** Recording of action potential by oscilloscope and demonstration of its various features. Experiments to demonstrate characteristic of reflex arc. Experiment in human (students themselves) to demonstrate some aspect of sensory physiology.
3. **Cardiovascular Activity:** Normal cardiac activity, effect of temperature, effect of drug, heart block, tetanization of heart. Measurement of blood pressure.
4. **Respiration and Exercise:** Oxygen consumption in fish and effect of temperature (by dissolved oxygen meter) and terrestrial animal (mouse). Oxygen consumption (by respirometer), heart rate, blood pressure glycemia altered by exercise.
5. **Endocrine and Reproductive Mechanisms:** Effect of insulin on glycemia, study of stages in estrous cycle.

**Recommended Books**

1. Randall, D., Burggren, W., French, K. and Fernald, R. Eckert Animal Physiology: Mechanisms and Adaptations, 5th Edition. 2002. W.H. Freeman and Company, New York
2. Bullock, J., Boyle, J. and Wang, M.B. Physiology, 4th Edition. 2001. Lippincott, Williams and Wilkins, Philadelphia.
3. Berne, R.M. and Levy, M.N. Principles of Physiology, 3rd Edition. 2000. St. Lious, Mosby.
4. Guyton, A.C. and Hall, J.E. Textbook of Medical Physiology, 10th Edition. 2000. W.B. Saunders Company, Philadelphia.
5. Withers, P.C. Comparative Animal Physiology. 1992. Saunders College Publishing, Philadelphia.
6. Schmidt-Nelsen, K. Animal Physiology, Adaptation and Environment, 5th Edition. 1997. Cambridge University Press, Cambridge.
7. Bullock, J., Boyle, J. and Wang, M.B. Physiology, 4th Edition. 2001. Lippincott, Williams and Wilkins, Philadelphia.

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| **ZOO-5503** | **Basics of Genetics** | **3(2-1)** | **Compulsory** |

**Aims and Objectives**

The continuity of the life from one generation to other generation is based on the mechanisms involving nucleus, chromosomes and genes etc. The process of continuity not only transfers the traits of the parents but also imparts variations that render the generations sustainable in changing environment. These concepts will be imparted to the students in this course.

**Course Contents**

**Classical genetics:** Scope and importance of genetics, gene concept (classical and modern), **multiple alleles,** blood groups and coat color in rabbits, **Chromosomal basis of inheritance:** interaction of genes, chromosomal changes (euploidy, aneuploidy, structural changes), Karyotyping-Normal human chromosome complement.  Pedigree Analysis. **Sex-determination and sex-linkage:** Sex determination in animals and humans, linkage, recombination and chromosome mapping in eukaryotes, quantitative inheritance. genetics of viruses, bacteria, transposons. **Molecular genetics** – analysis and techniques of molecular genetics (elements of genetic engineering), genetic basis of cancer, genetic control of animal development, the genetic control of the vertebrate immune system, complex inheritance patterns. **Human Genetics:** Autosomal anomalies, Pseudoautosomal genes, (eg. Down syndrome, Edwards syndrome and Cri du chat syndrome), Single gene disorders Gene mutation and disorders (Brief mention) Autosomal single gene disorders (Sickle cell anemia, brachydactyly;   inborn errors of metabolism such as phenyle ketonuria, alkaptonuria). Definition - characteristics criss-cross inheritance. Multifactorial disorders - Polygenic traits -   Cleft lip and cleft palate, Sex-linked and sex-influenced inheritance: Haemophilia and colour blindness.  Sex chromosomal anomalies (Kline felters syndrome, and Turners syndrome). **Prenatal Diagnosis:** (Amniocentesis) and choriovillus sampling - Ultrasound scanning and Fetoscopy. Genetic counselling, Eugenics and Euthenics.**Population genetics** – Hardy-Wienberg equilibrium, systematic and dispersive pressures, inbreeding and heterosis.

**Practicals**

1. Mitosis (Onion root tips.)
2. Meiosis (Grass hopper testes)
3. Blood groups.
4. Salivary gland Chromosomes of *Drosophila melanogaster*
5. General morphology of *Drosophila melanogaster*
6. Human Pedigree analysis problems
7. Human Genetics problems
8. Probability problems. Tossing of coins. X2 test
9. Study of transformed bacteria on the basis of antibiotic resistance.

**Recommended Books**

1. Snustad, D.P. and Simmons, M.J. Principles of Genetics. 3rd Edition, 2003. Johan Wiley and Sons Ins. New York, USA.
2. Tamarin, R.H. Principles of Genetics. 7th Edition, 2001.WCB publishers USA.
3. Gardener, E.J., Simmons, M.J. and Snustad, D.P. Principles of Genetics. 1991. John Wiley and Sons Ins. New York, USA.
4. Stickberger, M.W, (1985). Genetics, McMillan, N.Y.
5. Herskowitz, I.H. (1985). Genetics, Little Brown, Bostan.
6. White-House, H. L. K. (1965). Towards an understanding of mechanism of hereditary
7. Crow, J.F. (1976). Genetics notes Burgess Publishing Company, Minneapolis.
8. Mays L.L. (1989).Genetics –A Molecular Approach, McMillan and Company N.Y.
9. Lewin, B. (2000). Gene VIII, Oxford University press, UK.

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| **ZOO-5504** | **Environmental Biology** | **3 (2-1)** |

**Aims and Objectives**

The main goal of this course is to enable the students to develop strong expertise in contemporaneous themes in ecological research and to be able to discuss these issues in a broad context. The students will be able to think and discuss about advanced topics in population, community and ecosystem ecology as well as in biodiversity research. They will also have the expertise to update their knowledge continuously, and to design their own research in ecology.

**Course Contents**

An overview of concepts of ecosystem with emphasis on interaction and homeostasis. **Basic global ecosystems**: atmosphere, hydrosphere, lithosphere, ecosphere. An overview of major ecosystem of the world: Marine, Estuarine, Freshwater, Wetlands, Tundra, Forest, Grassland and Desert. **Biogeochemical cycle:** nitrogen, phosphorus, sulpher, water, carbon, nutrient. **Limiting factors:** basic concepts, temperature, soil, water and humidity, light, fire. **Energy:** laws of thermodynamics, primary and secondary productions, trophic levels and energy variation with increasing trophic levels, energy flow, food chains and food webs. **Population ecology:** basic population characters, growth and growth curves, population dynamics and regulations. **Community ecology:** basic concepts, community analysis, ecotones, inter-population interactions. **Ecological niche:** basic concepts and types. **Applied Ecology:** Resources and their ecological management (mineral, agricultural and forest, range management, desalination and weather modification, landscape and land use); **Pollution:** (definition, types, cost, origin and management); water (sources, domestic and industrial pollution, heavy metals, water purification, waste water treatment); air (sulpher dioxide, nitrogen oxide, carbon monoxide, ozone, smog and PAN, MTBE and CFCs); land pollution (pesticides, bacterial toxins, synthetic hormones); noise pollution. **Contemporary environmental themes**: (ozone depletion, acid rain, green house effect and global warming, Koyota protocol, desertification, deforestation, exotic and invasive species, radioactivity leakage, environmental laws).

**Practicals**

Measurement of environmental factors on land, water and air. Study of different ecosystems: pond, agricultural or grassland, forest. Community analysis through different sampling techniques (quadrat, Transect). Population dynamics of grasshoppers. Adaptive features of animals in relation to food and environment. Food chain studies through analysis of gut contents. Analysis of polluted and fresh water for biotic and abiotic variations. Field visits for study of selected protected areas and writing reports. Development of an ecological management plan of some selected area.

**Recommended Books**

1. Odum, E. P. 1994. Fundamentals of Ecology. 3rd Edition W.B. Saunders. Philadelphia.
2. Molles, M.C. 2005 Ecology: Concepts and Applications. 6th Edition, McGraw Hill, New York, USA.
3. Dondson, 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, UK.
4. Slingsby, D. and Cook, C., 1986. Practical Ecology. McMillan Education Ltd. UK.
5. Chapman, J.L. and Reiss, M.J.1997. Ecology: Principles and Applications. Cambridge Univ. Press, UK.
6. Smith, R.L. 1980. Ecology and Field Biology, Harper and Row.
7. Newman, I. 1993. Applied Ecology. Black Well Scientific Publications Oxford. UK.
8. Cox, C.B and Morre, D. 2000. Biogeography: An Ecological and Evolutionary Approach, 6th Edition. Life Sciences King’s College, London, UK.

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| **ZOO-5505** | **Zoogeography** | **2(2-0)** | **Compulsory** |

**Aims and Objectives**

The course imparts knowledge and concepts of evolution based distribution of animals on the globe. This course provides information on the distribution of animals and their associations in the past; thus, to rationalize their relationship in the present time.

**Course Contents**

Branches of zoogeography (descriptive, chorology, faunistics, systematic, biocoenotic, causal, ecological, historical, experimental and applied zoogeography). Animal distribution (cosmopolitan distribution, discontinuous distribution, isolation distribution, bipolar distribution and endemic distribution), Factors affecting animal distribution. Barriers and dispersal. Zoogeographical regions (division, geographic ranges, physical features, climates, faunas and affinities of Holarctic (Palaearctic, Nearctic regions), Oriental, Ethiopian, Australian, and New tropical Regions. Insolar fauna; (Continental, Oceanic and Ancient Islands). Palaeogeography (Theories of Continental drift and Plate tectonics). Zoogeography of Pakistan: Fauna of land and sea; ecoregions.

**Recommended Books**

1. Darlington, P.J. (1963). Zoogeography, the Geographical Distribution of Animals. John Wiley, N. Y.
2. Parker, Hesse, Allee and Schmidt. (1963). Ecological Animal Geography. John Wiley, N.Y.
3. DeBeaufort, L.F. (1951). Zoogeography of the Land and Inland Waters. Sidgwick and Jackson, London.
4. Ekman, S. (1967). Zoogeography of the Sea, Sidgwick and Jackson, London.
5. Jillies, (1974). Introduction to Zoogeography, London.
6. Muller, P. (1974). Aspects of Zoogeography. W. Junk Publishers, Hague.
7. Ali, S.S. Palaeontology, Zoogeography and Wildlife Management. 1999. Nasim Book Depot, Hyderabad, India.

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| **ZOO-5506** | **Chemistry of Bio-Molecules** | **3(2-1)** | **Compulsory** |

**Aims and Objectives**

1. The course will provide in depth knowledge about the polymerized organic compounds of life.
2. The dynamism of the life proceeds with inter-conversion of the chemicals from feeding to the liberation of energy for work. It will deal with the inter-conversion is performed by various tools called as enzymes.
3. Thus, in this course the concepts of the chemical basis of life and all the mechanisms involved in harvesting of energy for growth, duplication etc., are given.

**Course Contents**

**Amino acids, peptides and proteins:** standard amino acids, their structure and classification; acid/base properties of amino acids and their titration curves; peptides, their ionic behavior and amino acid composition, cytochrome c; Macromolecular separation techniques in biochemistry; ion exchange chromatography; isoelectric focusing; density gradient centrifugation. **Enzymes:** introduction; important characteristics of enzymes; immobilized enzymes; how enzymes work; example of enzymatic reaction; enzyme kinetics, enzyme rate of reaction and substrate concentration, how ph and temperature effect enzyme activity. **Carbohydrates:** classification, types, important characteristics and structure of carbohydrates; history of developments in structure of glucose; monosaccharides; cyanohydrin formation; disaccharides their types structure and function; polysaccharides, storage and structural types; structure and major functions of polysaccharides. **Lipids:** fatty acids, their types and major characteristics; storage lipids, acylglycerols; waxes; structural lipids in membranes; major functions of lipids; lipoproteins, their types and major functions. **Vitamins and cofactors:**occurrence, structure and biochemical function of vitamins of b- complex group.

**Recommended Books**

1. Nelson, D. L. and Cox, M.M. Lehninger Principles Of Biochemistry, 3rd Edition, 2000. McMillan Worth Publishers, New York.
2. Murray, R.K., Granner, D.K., Mayer, P.A. and Rodwells, V.W. Harper’s Biochemistry, 25th Edition, 2000. McGraw Hill, New York.
3. Voet. D., Voet, J.G., and Pratt, C.W. Fundamentals Of Biochemistry, 1999. John Wiley and Sons, Inc., New York.
4. Zubay, G. Biochemistry, 4th Edition, 1995. Wm. C. Brown Publishers, Inc., Oxford, England.
5. Lubert, S. Biochemistry, 4th Edition, 1995. W.H. Freeman and Company, New York.
6. McKee, T. and McKee, J.R. Biochemistry, The Molecular Basis Of Life. 3rd Edition, 2003. McGraw Hill.

**Practicals**

1. Preparation of standard curve for glucose by *ortho-*Toluidine method.
2. Tests for detection of carbohydrates in alkaline and acidic medium.
3. Tests for detection of Disaccharides.
4. Detection of Non-Reducing sugars in the presence of Reducing sugars.
5. Demonstration of Acid Hydrolysis of Polysaccharide.
6. Separation and identification of various types of sugars, fatty acid and amino acid Thin Layer Chromatography (TLC).

**Recommended Books**

1. Plummer, David T. An Introduction to Practical Biochemistry, 1990*.* 4th Edition McGraw-Hill Book Company, London*.*
2. Wilson, K and Walker, J. Practical Biochemistry: Principles and Techniques, 4th Edition, 1994. Cambridge University Press.

**COURSE CONTENTS OF COMPULSORY FACULTY COURSES FOR BS-4 YEAR PROGRAM IN ZOOLOGY 6TH SEMESTER**

**SEMESTER VI (Cr. 18)**

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| **Course Code** | **Course title** | **Credits** | **Status** |
| ZOO-5601 | Metabolism of Bio-Molecules | 3(3-0) | Compulsory |
| ZOO-5602 | Developmental Biology | 4(3-1) | Compulsory |
| ZOO-5603 | Principles of Animal Taxonomy | 2(1-1) | Compulsory |
| ZOO-5604 | Research Methods and Reports | 2(1-1) | Compulsory |
| ZOO-5605 | Paleontology and Evolution | 4(3-1) | Compulsory |
| ZOO-5606 | Basics of Molecular Biology | 3(2-1) | Compulsory |
|  | **Total Credits** | **18** |  |

**ZOO-5601 Metabolism of Bio-Molecules**

**Aims and Objectives**

1. The course will provide in depth knowledge about the polymerized organic compounds of life.
2. The dynamism of the life proceeds with inter-conversion of the chemicals from feeding to the liberation of energy for work. It will deal with the inter-conversion is performed by various tools called as enzymes.
3. Thus, in this course the concepts of the chemical basis of life and all the mechanisms involved in harvesting of energy for growth, duplication etc., are given.

**Course Contents**

**Carbohydrate Metabolism:** detailed description of glycolysis and catabolism of other hexoses; regulation and bioenergetics of glycolysis. Anabolic role of glycolysis; fate of pyruvate under aerobic and anaerobic conditions, lactate, acetyl CoA and ethanol formation; alcoholic fermentation; gluconeogenesis, its regulation and significance in the tissues; feeder pathways in glycolysis; utilization of other carbohydrates in glycolysis; phosphorolysis of glycogen and starch; regulation of glycogen metabolism; utilization of dietary polysaccharides (starch) and disaccharides (sucrose and galactose). conversion of pyruvate to acetyl CoA, pyruvate dehydrogenase, a multi-enzyme complex; detailed description of citric acid cycle; bioenergetics and conservation of energy produced in the cycle. Anabolic or biosynthetic role of citric acid cycle intermediates; replenishing or anaplerotic reactions and their role; regulation of citric acid cycle. **Lipid metabolism:** oxidation of fatty acids; digestion, mobilization and transport of fats; biosynthesis of triacylglycerol; utilization of triacylglycerol; activation of fatty acids and their transportation to mitochondria; beta-oxidation; bioenergetics of beta-oxidation; oxidation of unsaturated and odd chain fatty acids; omega oxidation pathway; biosynthesis of saturated fatty acid, supply of raw material for palmitic acid synthesis; fatty acid synthetase (FAS) multienzyme complex; biosynthesis of unsaturated fatty acids. Ketone bodies their biosynthesis, utilization and role in the tissues; cholesterol metabolism: Steroid hormones. **Amino Acid metabolism:** metabolic fate of amino acids; catabolism of amino acids; deamination and transamination; nitrogen excretion and urea cycle; regulation of urea cycle.

**Recommended Books**

1. Nelson, D. L. and Cox, M.M. Lehninger Principles Of Biochemistry, 3rd Edition, 2000. McMillan Worth Publishers, New York.
2. Murray, R.K., Granner, D.K., Mayer, P.A. and Rodwells, V.W. Harper’s Biochemistry, 25th Edition, 2000. McGraw Hill, New York.
3. Voet. D., Voet, J.G., and Pratt, C.W. Fundamentals Of Biochemistry, 1999. John Wiley and Sons, Inc., New York.
4. Zubay, G. Biochemistry, 4th Edition, 1995. Wm. C. Brown Publishers, Inc., Oxford, England.
5. Lubert, S. Biochemistry, 4th Edition, 1995. W.H. Freeman and Company, New York.
6. McKee, T. and McKee, J.R. Biochemistry, The Molecular Basis Of Life. 3rd Edition, 2003. McGraw Hill.

**Practicals**

1. Preparation of standard curve for glucose by *ortho-*Toluidine method.
2. Tests for detection of carbohydrates in alkaline and acidic medium.
3. Tests for detection of Disaccharides.
4. Detection of Non-Reducing sugars in the presence of Reducing sugars.
5. Demonstration of Acid Hydrolysis of Polysaccharide.
6. Separation and identification of various types of sugars, fatty acid and amino acid Thin Layer Chromatography (TLC).
7. Determination of pKa values of an amino acid by preparation of titration curves.
8. Biochemical tests for detection of different amino acids.
9. Separation of various protein fractions by precipitation method.
10. Demonstration of differential solubility of lipids in various solvents.
11. Quantitative analysis of phospholipids by estimation of inorganic phosphorous.
12. Quantitative analysis of Amylase activity from blood serum or liver.
13. Study on the effect of temperature on the enzymatic rate of reaction

**Recommended Books**

1. Plummer, David T. An Introduction to Practical Biochemistry, 1990*.* 4th Edition McGraw-Hill Book Company, London*.*
2. Wilson, K and Walker, J. Practical Biochemistry: Principles and Techniques, 4th Edition, 1994. Cambridge University Press.

**ZOO-5602 DEVELOPMENTAL BIOLOGY**

**Aims and Objectives**

The course will provide detailed knowledge about the principal features of development, cellular basis of morphogenesis, mechanisms of cellular differentiation and concepts of induction in development. It will provide understanding of the mechanisms of organogenesis, factors controlling growth and oncogenesis. The concept related to the theory in Developmental Biology will be practically demonstrated in this course. In the continuity of the animals during reproduction following the union of the traits from the parents in their gametes, the zygote proceeds through enormous phenomena of development up to their emergence resembling to the parents. The concepts of all these developmental mechanisms will be communicated to the students in this course.

**Course Contents**

**Introduction:** Principal features of development, origin of sexual reproduction, developmental patterns; Spermatogenesis; Oogenesis. **Fertilization:** Recognition of sperm and egg, fusion of gametes, activation of egg metabolism, rearrangement of egg cytoplasm. **Cleavage:** Patterns of embryonic cleavage, mechanism of cleavage. **Gastrulation:** Fate maps, gastrulation in sea urchin, amphibians, birds nd mammals. **Early Vertebrate Development:**Neurulation, ectoderm, mesoderm and endoderm. **Cellular Basis of Morphogenesis:** Differential cell affinity, cell adhesion molecules. **Mechanism of Cellular Differentiation:** RNA processing, translational regulation of developmental process, cell-fate by progressive determinants, autonomous cell specification by cytoplasmic determinants, establishment of body axes and mechanism of teratogenesis; Secondary Induction. **Organogenesis:**A brief account; Origin and migration of germ cells in vertebrates. Factors controlling growth and oncogenesis. Hormones as mediators of development; Regeneration in vertebrates.

**Practicals**

Study of structure of gametes in some representative cases, i.e., frog, fish, fowl and mammal. Study of cleavage and subsequent development from prepared slides and/or whole mounts in various animals i.e., frog, chick etc. Study of fertilization, early development of frog through induced spawning under laboratory conditions. Preparation and study of serial sections of frog or chick embryos. Application of microsurgical techniques on chick embryos *in vitro*. Preparation and staining of histological slides.

**Recommended Books**

1. Gilbert, S. F. Developmental Biology, 2010.Sinauer Associates, Sunderland, MA.
2. Balinsky, B. I. An Introduction to Embryology, 1985. Saunders.
3. Saunders, J. W. Developmental Biology, 1982. McMillan and company.
4. Oppenheimer, S.S. Introduction to Embryonic Development, 1984. Allen and Bacon.
5. Ham, R. G. and Veomett, M. J. Mechanism of Development. 1980. C. V. Mosby Co.
6. Klaus, K. Biological Development. 2nd Edition, 2001.McGraw Hill.

### **PRINCIPLES OF ANIMAL TAXONOMY**

**Course code: ZOO-5603 Credit Hours**:2(1-1)

**Course Objectives:**

The course aims to:

1. Provide in-depth knowledge of taxonomy in animal sciences
2. Develop concepts about importance of the systematics.
3. Study the history of systematics with basic rules
4. Demonstrate about identifications and naming of the organisms according to international code of zoological nomenclature.

**Course Contents:**

1. **Importance and application**s **of systematics:** Taxonomy in Animal science, systematics as a profession and its future perspectives.
2. **History of taxonomy**: systematics, basic terminology of systematics, theories of biological classifications.
3. **Taxonomic characters**: Kinds and weightage, micro taxonomy, taxonomic categories: specific category, intraspecific category, higher categories; Species concept.
4. **Typological species concept**: Nominalist species concept, biological species concept, Evolutionary species concept. Kinds of different species, Speciation,
5. **Taxonomic procedures**, taxonomic collection; their preservation and duration, Taxonomic keys, different kinds of keys and their merits and demerits.
6. **Formation of specific names,** brief concept of cladistics, phylogenetics. Theory and practice of cladistics and phylogenetic systematics.
7. **Systematics publications**: International code of zoological nomenclature; its objective, principles, interpretation, application of important rules, with reference to: Zoological nomenclature, law of priority and validity of names.

**Practicals:**

1. Study of preserved invertebrate species and their classification upto class level.
2. Collection, preservation and identification of common species with the help of keys.
3. Preparation of keys for the identification of specimens.
4. Methods of statistical analysis of samples from populations T-test, Analysis of variance etc.

**Books Recommended:**

1. Wiley, E. O. and Lieberman, B. S. 2011. Phylogenetics: Theory and practice of phylogenetic systematics. 2nd Ed. Wiley-Blackwell.
2. Hill, New York.
3. Mayer, E. and Asblock, P.D. Principles of Systematic Zoology. 1991. McGraw-Hill, New York
4. Mayr, E. *Animal Species and Evolution,* 1985.Harvard University Press.
5. Heywood, V.H. *Taxonomy and Ecology.* 1975. Academic Press, London.

Whili, M.J.D. *Modes of Speciation,* 1978. W.H. Freeman and Co., San Francisco

**ZOO-5604 Research Methods and Reports**

**Aims and Objectives**

The main objectives of this paper are to introduce student to the basics of research and research design in biology and to prepare them to develop and design their own research works, formulate their research manuscripts etc.

**Course Contents**

**Introduction:**Meaning of research, objectives and significance of research, research processes, criteria for good research, problems encountered by researchers in Pakistan. **Defining research problem:**Selecting research problem, techniques involved in defining a problem. Developing hypothesis. **Review of literature:** Different forms and sources of acceptable data and techniques of acquiring required literature. **Research and sampling design:**Need for research design, characteristics of a good research design, basic principles of experimental designs, Steps in sampling designs, different types of sampling designs, developing a research proposal/ plan. **Data collection:** types of data, methods of data collection, processing and analysis of data,**Writing of Research Thesis/Report and Research Paper:** (composition, arrangement and formatting); Publication of research work, finding of suitable journal, formatting and submitting of manuscript, Ethical, legal, social and scientific issues in Biological Research. Plagiarism. **Introduction to scientific research projects/funding:** Finding financial support and industry partnership. A brief idea about the funding agencies such as HEC, PSF, EU, USAID. etc.

**Practical**

Designing and developing case studies. Practice of Review of literature from different sources. Practice of writing scientific papers/ projects.

**Recommended Books**

1. Michael P. Marder, 2011. Research Methods for Science. Cambridge University Press
2. [Thomas E. Ogden](http://www.amazon.com/s/ref=rdr_ext_aut?_encoding=UTF8&index=books&field-author=Thomas%20E.%20Ogden), [Israel A. Goldberg](http://www.amazon.com/s/ref=rdr_ext_aut?_encoding=UTF8&index=books&field-author=Israel%20A.%20Goldberg), 2002. Academic Press USA
3. C.R.Kottari. 1990. Research Methodology: Methods and Techniques (2nd ed.) Ram Printograph. Delhi
4. Robert, A. Day. 1989. How to write and publish a scientific research paper. 3rd Edition.
5. Holmann, H.H. 1962. Biological research method. Olvyer and Boyd Ltd.

**ZOO-5605 PALAEONTOLOGY AND EVOLUTION**

**Aims and Objectives**

The course imparts knowledge and concepts of evolution mainly based on the past fossil records. The fossil records also provide the information regarding the presence and distribution of animals in the past eras. The course is designed to provide in depth knowledge of origin of life, and forces responsible for evolutionary changes.

**Course Contents**

Paleoecology, Paleomagnetism. Fossilization; Nature of fossils. Geological time scale, Pre-Cambrian life, Post-Cambrian life. Index fossils and their use in biostratigraphy with special reference to Pakistan. Earth, Shells of earth; (atmosphere, hydrosphere, biosphere and lithosphere). Rock, types of rocks (lgneous rocks, sedimentary rocks and metamorphic rocks) Fossil, types and uses of fossils. Geochronometry (Uranium/Lead dating, radiocarbon dating, methods), evolutionary history of man, elephant, horse and camel, Application of geochronometry in paleontology: Uranium/lead dating, the use of zircon, carbon dating, Micropaleontology, evolutionary history of man, elephant, horse and camel, Paleoecology, Paleomagnetism. The nature and origin of life. Theories to explain the diversity of life: Lamarckism, Darwinism, theory of special creation and the present status of these theories. The species as a key stone of evolution. Species Concepts. Kinds of Species. Factors initiating elementary evolutionary changes (micro-evolution) by changing gene frequencies, mutation pressure, selection pressure, immigration and crossbreeding, genetic drift. Role of isolation in evolution. Factors of large evolutionary changes (macro-evolution)-allometry, orthogenesis and adaptive radiation. Modern concept of Natural Selection: Levels of action, direction, intensity, laboratory and field experiments to demonstrate the action of Natural Selection. Action of Natural Selection leading to convergence, radiation, regression and extinction.

**Practicals**

1. Study of mold, casts, pseudomorphs, petrified fossils, imprints, foot prints.
2. Study of fossils, coelenterates, crustaceans, brachiopods; trilobites molluscs and echinoderms.
3. Study of vertebrates fossils of evolutionary importance e.g. horse, elephant, camels and primates.

**Recommended Books**

1. Michael Foote and Arnold I. Miller, 2007. Principles of Palaeontology (3rd Ed.) Freeman and Company.
2. Michael, J.B. and David, A.T. Harper, 2009. Palaeobiology and the fossil record (3rd Ed.). Wiley Blackwell.
3. Dunbar, C.O. (1969). Historical Geology. JohnWiley and Sons, N.Y.
4. Brouwer, A. (1977). General Paleontology .Oliver and Boyd, London.
5. Gilbert, E.H. (1980). Evolution of Vertebrates, JohnWiely, New York.
6. Moore, R.C., Lallcker, G.C. and Fisher, A.G. Invertebrates Fossils. McGraw Hill, N.Y.
7. Romer, A. S. (1958). Vertebrates Paleontology, The University of Chicago Press.
8. Shrock, R.A. and Twenhoefel, W.W. (1953). Principles of invertebrate Paleontology McGraw, Hill, New York.
9. Dobzhansky, T., Ayala, F.J., Stebbins, G.L. and Valentine, J.W. EVOLUTION. 1973. W.H. Freeman and Company.
10. Sheppard, P.M. (1958). Natural Selection and Heredity, Hutchison University Library, London.
11. Dobzhansky, T. Genetics and the Origin of Species, Columbia University Press, New York.
12. Mayr, E. Populations, Species and Evolution, Harvard University Press.
13. Moody, P. A., (1989). Introduction to Evolution, Harper and Row Publishers, New York.
14. Caln, A. J. (1963). Animal Species and their Evolution, Hutchinsons University Library, London.
15. Strickberger. M.W. Evolution. 2000. Jones and Barrett Publishers.

**ZOO-5606 Basics of Molecular Biology**

**Aims and objectives**

Objectives of the course are to impart knowledge about the macromolecules in animal cell and their complex organization of architecture and the unified role it plays for the ultimate sustainability of the organisms.

**Course Contents**

Molecular Biology of DNA, RNA, Protein, DNA replication and DNA repair. Transcription. Translation, Gene expression in prokaryotes and eukaryotes. Control of gene expression in prokaryotes. Control of gene expression in eukaryotes. Molecular biology of DNA and RNA viruses and yeast. Molecular immunology, Oncogenes and cancer.

**Practicals**

DNA Extraction and Quantification by PCR, Gel Electrophoresis, Restriction Fragment Length Polymorphism techniques, Protein Isolation techniques.

**Recommended Books**

1. Kornberg, A. (1980). DNA Replication, W.H. Freeman, San Francisco.
2. Kornberg, A. (1982). Supplement to DNA Replication, W.H. Freeman, San Francisco.
3. Old, R.W. and Primrose, S.B. (1981). Principles of Gene Manipulation, Blackwell, Oxford.
4. Watson, J.D., Hpkins, N.H., Roberts, J.W., Steitz, J.A. and Weiner, A.M. (1990). Molecular Biology of the Gene, Benjamin, California.
5. DuPraw, Advances in Cell and Molecular Biology, Academic Press.
6. Bukhari, A.I., Shapiro, J.A., and Adhya, S.L. (1977). DNA Insertion Elements, Plasmids and Episomes, Cold Spring Harbour Laboratories.
7. Stent, G.S., (1971). Molecular Genetics, Freeman, San Francisco.
8. Glass R.E., (1982). Gene Function: E. coli and its Heritable Elements, Croom Helm, London.
9. Adams, R.L.P., Knowler, J.T. and Leaer, D.P. (1986). The Biochemistry of the Nucleic Acids, Chapman and Hall.
10. Davis, R.W., Botstein, D. and Roth, J.R. (1980). Advanced Bacterial Genetics, Cold Spring Harbor Lab., N.Y.
11. Freifelder, D. (1983). Molecular Biology, A Comprehensive Introduction to Prokaryotes and Eukaryotes. Science Books International, Boston.

**COURSE CONTENTS OF COMPULSORY/ELECTIVE COURSES FOR BS-4 YEAR PROGRAM IN ZOOLOGY 7TH SEMESTER**

**YEAR-IV**

**SEMESTER–VII (Cr. 17)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Course code** | **Course title** | **Credits** | **Status** |
| ZOO-6701 | Data Analysis | 2(1-1) | Compulsory |
|  | Elective-I | 3(2-1) | Elective |
|  | Elective-II | 3(2-1) | Elective |
|  | Elective-III | 3(2-1) | Elective |
|  | Elective-IV | 3(2-1) | Elective |
|  | Elective-V | 3(2-1) | Elective |
|  | **Total Credits** | **17** |  |

**ZOO-6701 Data Analysis**

**Aims and Objectives**

1. The course will provide knowledge about the importance and use of statistics in life sciences. It will help the students to understand the methods to analyze data pertaining to their research work and to assess the significance of their experimental designs.
2. After this course students will be able to apply basic statistical procedures for analysis of data for practical and research.

**Course Contents**

**Introduction and scope**, use of statistics in biology. Population and sample, Stages of research, **Types of data**: methods of data collection. Data arrangement and presentation, formation of tables and charts. **Measures of central tendency**: computation of mean, median and mode from grouped and ungrouped data. **Measures of dispersion**: computation of variance, standard deviation, standard error and their coefficients. **Probability rules**. Binomial, poissons and normal distributions. Hypothesis testing, Student ‘t’ test, Chi square test. **Handling of multiple samples**: Analysis of variance and LSD. **Correlation and regression**. Experimental designing, planning of an experiment, replication and randomization.

**Recommended Books**

1. Geoffery, R. Norman, David L. Streiner, Biostatistics: The Bare Essentials. 2000. B.C. Decke Inc.
2. Gerry, P. Quinn, Michael J. Keough, Experimental Design And Data Analysis For Biologists. 2002. Cambridge University Press.
3. Campbell, R. C. Statistics For Biologists. 1989. Cambridge University Press.
4. Simpson, G.G., Roe, A. and Lewonhtin, R.C. (1960). Quantitative Zoology, Harcourt Bruce and Company.
5. Sokal, R.R. and Rohlf, F.J. (1973). An Introduction to Bio-statistics, Toppan.
6. Mather, K. (1960). Statistical Analysis in Biology. Methuen.
7. Bailey, N.T.J. (1981). Statistical Methods in Biology, English University Press.

Mishra, B.N. (1982). Introduction to Practical Biostatics.

**LIST OF ELECTIVE COURSES FOR BS-4 YEARS PROGRAM IN ZOOLOGY VII SEMESTER**

|  |  |  |
| --- | --- | --- |
| **Course code** | **Course Title** | **Credit Hrs.** |
| ZOO-6702 | Biological techniques | 3(1-2) |
| ZOO-6703 | Immunology | 3(2-1) |
| ZOO-6704 | Biodiversity and Wildlife | 3(2-1) |
| ZOO-6705 | Basic Human Genetics | 3(2-1) |
| ZOO-6706 | Clinical Endocrinology | 3(2-1) |
| ZOO-6707 | Fisheries and Aquaculture | 3(2-1) |
| ZOO-6708 | General Biotechnology | 3(2-1) |
| ZOO-6709 | General Entomology | 3(2-1) |
| ZOO-6710 | General Microbiology | 3(2-1) |
| ZOO-6711 | General Parasitology | 3(2-1) |
| ZOO-6712 | General Toxicology | 3(2-1) |
| ZOO-6713 | Helminthology | 3(2-1) |
| ZOO-6714 | Hematology | 3(2-1) |
| ZOO-6715 | Histology | 3(2-1) |
| ZOO-6716 | Industrial and Microbial Biotechnology | 3(2-1) |
| ZOO-6717 | Invertebrata | 3(2-1) |
| ZOO-6718 | Limnology-A | 3(2-1) |
| ZOO-6719 | Neurophysiology | 3(2-1) |
| ZOO-6720 | Principles of Fish Biology | 3(2-1) |
| ZOO-6721 | Principles of Herpetology | 3(2-1) |
| ZOO-6722 | Principles of Parasitology | 3(2-1) |
| ZOO-6723 | Reproductive Physiology | 3(2-1) |
| ZOO-6724 | Wildlife Parasitology | 3(2-1) |

**ZOO-6702**

**BIOLOGICAL TECHNIQUES**

**Aims and Objectives**

1. To make aware of the basic philosophy of science, its history, concepts and scope
2. To develop proper scientific mind, culture and work habits
3. To familiarize with the basic tools and techniques of scientific study with emphasis on biological sciences
4. Scientific drawing -Purpose and principle, Basic understanding on principle and uses of the following:

**Course Contents (theory and practicals)**

**Microscopy:** Principles of light microscopy. Magnification, Resolution, Contrast. Types of microscopy, Bright field (Compound Microscope), Scanning microscopy, Eyepiece micrometers, Camera Lucida Phase Contrast Dark field Interference microscope, Electron microscope. **Micrometery and Morphometry**: Use of stage and ocular micrometer. Calibration of ocular micrometer. Size measurement (length, width, diameter). **Standard system for weight, length, volume :** Calculations and related conversions of each:- Metric system- length; surface; weight - Square measures- Cubic measures (volumetric)- Circular or angular measure- Concentrations- percent volume; ppt; ppm - Chemical molarity, normality - Temperature- Celsius, centigrade, Fahrenheit. Preparation of stock solutions of various strengths. **Specimen preparation for optical microscopy**: **Microtomy:** Fixation, embedding, Section cutting (transverse, longitudinal section, mounting and staining. Sections in paraffin and cryosections. **Extraction techniques:** Centrifugation, Ultra centrifugation, cell fractionation, filtration, Distillation, Use of Soxhalet and Rotary evaporator for extraction. **Separation Techniques:** Chromatography: Principle, applications, types, thin layer, paper, column, gas, ion exchange chromatography. Electrophoresis: Principle, applications, types. **Spectrophotometery:** Principle, applications, types, visible spectrum, UV spectrum, atomic absorption. **Basic principles of Sampling and Preservation:** Sampling soil organisms, Invertebrates, Aquatic animals, Mammals, Estimation of population size, Preservation of dry and wet specimens. Preservation techniques – Taxidermy - Rearing techniques, Laboratory and field.

**Recommended Books**

1. Dean, J. R. Extraction methods for environmental analysis. 1999. John Wiley and Sons Ltd. UK.
2. Curos, M. Environmental sampling and analysis: Lab Manual. 1997. Crc Press Llc. USA. 38
3. Curos, M. Environmental sampling and analysis: For Technician. 1997. CRC Press LLC. USA.
4. Cheesbrough, M. District laboratory practice in tropical countries. Part i. 1998. University Press Cambridge, UK.
5. Cheesbrough, M. District laboratory practice in tropical countries. Part ii. 1998. University Press Cambridge, UK.
6. Slingsby, D. and Cock, C. Practical ecology. 1986. Mcmillan Education Ltd. London.

**ZOO-6703 Immunology**

**Aims and Objective**

The aim of the course is to provide a greater understanding of the role of the immune system in preventing human disease and to focus on how deficiencies in immunity can result in disease susceptibility; in addition, students study the main subject areas in biosciences and medically related research; these subject areas include biochemistry, genetics, cell and molecular biology, anatomy and physiology as related to human health disease and treatment.

**Course Contents**

Cell mediated and humoral immunity, immunoglobulins, and the synthesis of antibody. Theories of antibodies synthesis. Antigenicity interaction of antigen and antibody. Hypersensitivity and its types with mechanism, classical and alternate compliment sequence, immunology in transplantation, autoimmunity to infections, immune deficiency diseases. Application of immunological phenomena in experimental biology.

**Practicals**

Antigens and elicitation of immune response. Experiments on methodology that employs immunological procedure such as radioimmuno assay.

**Recommended Books**

* 1. Roitt, M., (1979). Essential of Immunology, BlackWell, Oxford.
  2. Benecerra, B. and Unanue, F.R. (1979). Text book of Immunology.
  3. Bellanti, J.A. (1978). Immunology II, W. B. Saunders Company.
  4. Fundehberg. H. Hstites, D.P., Classwel, J. B, and Wells J. O.V. (1980). Basic and Clinical Immunology, Lang Medical Los Angelos, California.
  5. Hyde R., Hand Pathod, R.A., (1980). Immunology. Prentice Hall. Reston, Virginia.

**ZOO-6704 BIODIVERSITY and WILDLIFE**

**Aims and Objectives**

The aim of this course is to provide basic knowledge to students about the basic concepts of biological diversity, threats to biodiversity and management. It also provides the knowledge about the threatened and endangered species of wild animals and their management principles and efforts being made at global and regional level.

**Course Contents**

Definition, Types; Levels; Status of Biodiversity; Importance of Biodiversity. Causes of loss of biodiversity, Conservation of biodiversity-in-situ and ex-situ conservation, Introduction to wildlife, Wildlife importance, IUCN Species status category. Endangered and Endemic wildlife species of Pakistan. Protected areas concept and categories, Ramsar sites, captive breeding, biotechnological intervention in biodiversity conservation, International laws/conventions (CBD, CMS, CITES etc.) regarding biodiversity conservation and Pakistan.

**Practicals**

1. Procedures for studying biodiversity, species richness, Simpson Index, Shannon and Weiner Function.
2. Bird’s population Census Techniques.
3. Mammal’s population Census Techniques.

**Recommended Books**

1. Gaston, G. and J. Spicer. 2007. Biodiversity. Blackwell Publishing and Co. London, UK.
2. [K. V. Krishnamurthy](http://www.google.com.pk/search?tbo=p&tbm=bks&q=inauthor:%22K.+V.+Krishnamurthy%22), 2003. Text Book of Biodiversity, Science Publisher USA
3. B.N. Pandey, A.P. Sharma, P.N. Pandey, P.K. Katiha and K. Jaiswal (editors), 2012. Biodiversity: Issues Threats and Conservation :   Narendra Publishing House.
4. Kumar and Asija, 2000. Biodiversity, Principles and Conservation.
5. Mary Jenking and Ann Boyce, 1987. The Diversity of Life.
6. R. Rehmani and Salim Ali: Birds Censing Techniques.
7. Roberts, T. J. The Birds of Pakistan, (Vol. II), 1992. Oxford University Press.
8. Roberts, T. J. The Mammals of Pakistan, 1997. Oxford University Press.
9. Mirza, Z. B. 1998. Illustrated handbook of Animal Biodiversity of Pakistan. Printopak.
10. Mitsch, W. J. and Gosselink, J. G. 2007. Wetlands 4th ed. John Wiley and Sons, Inc.
11. Grimmett, R. Roberts, T. J and Inskipp, T. 2008. Birds of Pakistan. Helm Field Guide.
12. Hickman, Roberts, and Larsen, 2003. Animal Diversity (3rd Edition).McGraw Hill, New York.
13. Boyd, C.E. and Tucker, C. S. Pond Aquaculture and Water Quality Management. 1998. Boston, Kluwer Publishers Alabama.
14. Ali, S.S. Paleontology, Zoogeography and Wild-Life Management. 1999. Nasim Book Depot. Hyderabad, India.

**ZOO-6705 BASIC HUMAN GENETICS**

**Aims and Objectives**

The course aims to help students learn to define basic genetics mechanisms in human inheritance to analyze inherited characteristics and diseases of human to understand genes, genomes, chromosomes and gene expression profiles with relations to phenotypic appearances, to use this knowledge for genetic research and counseling.

**Course Contents**

Nucleic acids, Genetic linkage: family method, somatic cell hybridization, deletion mapping and duplication mapping. Introduction to human genome. Karyotyping. Patterns of transmission of single gene traits: Pedigree analysis with criteria for identification of various modes of inheritance. Genetic defects in prenatal development; oncogenes and cancer, normal chromosomes, congenital malformations. Introduction to Human genome project.

**Practicals:**

1. Pedigree analysis.
2. Karyotyping of normal and abnormal human chromosomes.
3. Screening of metabolic and other disorders.
4. Problems solving on genetic counseling.
5. Orientation with different molecular techniques including PCR, RFLP

**Recommended Books**

1. Strachan, T., A. P. Read, Human Molecular Genetics, 3rd edition, Garland Science/Taylor and Francis. 2003.
2. Ehrlich P.R., Human Natures: Genes, Cultures, and the Human Prospect, 1st edition, Penguin USA Paper, 2002.
3. Relethford J. H., Genetics and the Search for Modern Human Origins, Wiley-Liss 2001.
4. Molecular Biology of the Cell, 4th Ed. Garland Publishing Inc. New York. 2002.

**ZOO-6706 CLINICAL ENDOCRINOLOGY**

**Aims and Objectives**

To study that degeneration disease are the results of alterations in biochemical homeostasis regulated by endocrine system.

**Course Contents**

Functional pathology of Endocrine Glands: Neuroendocrine disorders of gonadotropin, prolactin, growth hormone, corticotrophin regulation; Pituitary disorders: Prolactinomas, Acromegaly, Cushing’s syndrome. Diabetes insipidus, hypo- and hyper-tonic syndromes; Thyroid diseases of excess and deficient hormones and autoimmunity; Adrenal cortex: Disorders of cortical hypo and hyper-function; Disorders of Adrenal medullary function; Disorders of Ovarian function and hormonal therapy; Abnormalities of Testicular functions and hormonal therapy. Fuel homeostasis: Glucose homeostasis and Hypoglycemia; Diabetes mellitus; Disorders of lipoprotein metabolism; Eating disorders: Obesity, Anorexia nervosa and Bulimia nervosa. Development and Growth: Disorders of growth and puberty. Endocrine Hypertension. Poly-endocrine Syndromes. Hormones and Cancer: Hormonal effect on Tumors, Breast and Prostate Cancer; Endocrine Therapy; Humoral Manifestation of Malignancy. Geriatric Endocrinology: Endocrine and associated metabolism in aging: specifically thyroid, glucose and calcium homeostasis.

**Practicals**

Studies of disorders of pituitary by observing anatomical and histological features. Studies of thyroid status in deficient and excess hormone functions; Studies of type 1 and type 2 diabetes mellitus: epidemiology of the types in population, studies of management of the type 2 diabetes mellitus. Model studies of disorders of Ovarian and Testicular disorders; Model studies of obesity and anorexia; Studies of status in puberty and aging.

**Recommended Books**

1. Greenspan, F.S. and Strewaler, G.J. 2002 Basic and Clinical endocrinology, 5th Edition. Prentice Hall International lnc. London.
2. Wilson, J.D., D.W., Kronenberg, H.M. and Larsen, P.R., 2008. Wlliams Textbook of endocrinology, 9th Edition. W.D. Saunders Company, Philadelphia.
3. DeGroot, L.J., Jameson, J.L. 2001. Endocrinology, Vol. I, II and III, 4th edition. W.B. Saunders, Philadelphia.
4. Giffin, J.E. and Ojeda, S.R., 2000. 4th Edition. Textbook of Endocrine Physiology. Oxford University Press, Oxford.
5. Neal, J.M., 2000. Basic Endocrinology: An Interactive Approach. Blackwell Science Inc. London.

**ZOO-6707 FISHRIES AND AQUACULTURE**

**Aims and Objectives**

The aim of this course is to provide knowledge about differnt requirments for the culture of different cultivable aquatic species. The subject provides practicals information to obtain better growth by following physiological aspects during extensive or semi-intensive culture. It also emphasizes thoroughly in breeding and diseases of most culturable freshwater fishes and prawns.

**Course Contents**

Basic principles of Aquaculture (fish and prawn). Natural food and feeding. Growth and breeding of the important culturable prawns and fishes. Diseases and their control.

**Practicals**

Study of the gut contents of important fishes. Study of the major parasites of fish. Study of early developmental stages of fishes. Methods of induced spawning.

**Recommended Books**

1. Auet, M. (1972). Textbook of Fish Culture, Breeding and Cultivation of Fish.
2. Various publications of the Directorate of Fisheries on fish-farming etc.
3. Brenabe, G. Aquaculture, Vol. I. 1992 Blackwell Publishing, Oxford. UK.
4. Maseke C. Fish Aquaculture. 1987. Pergamon Press, Oxford. UK.

**ZOO-6708 GENERAL BIOTECHNOLOGY**

**Aims and Objectives**

Biotechnology is a science that uses the method and process for transformation of natural raw materials into useful product by the application of living organism in the industrial process. Thus, it is the biology in service to mankind. Main aims of biotechnology are: 1) To develop industrial processes for production of antibiotics, enzymes etc, 2) To develop gene surgery and gene therapy to cure genetic disease. 3) To create immproved varieties of plants and animals through genetic engineering and plant breeding. 4) To develop techniques for tissue culture, cell culture and organ transplantation. 5) To develop bioenergy. 6) To develop biological processes of waste treatment to reduce the impact of pollution. 7) To develop biological process of plant disease control.

**Course Contents**

Restriction and modification system: Types, Enzyme, classification, Nomenclature, Genetics and applications. Cloning Vectors: Plasmids (Bacterial and yeast), Viruses (Ca, MV, SV40, BPV) phages (Lambda, Mu, M13). Cosmids and phagmids. Cutting and joining of DNA: Isolation and purification of DNA, Ligation of DNA molecules, blunt ends and cohesive termini. Cloning Strategies; selection and characterization molecules, verification and amplification of desired genes, Gene Banks, PCR, RFLP, DNA sequencing techniques, DNA cloning, Southern blotting, Northern blotting, western blotting, site specific mutagenesis. Protein engineering. Applications of recombinant DNA technology with comprehensive theoretical know-how macromolecules of desired characters for transgenic.

**Practicals**

1. Isolation of plasmids and chromosomal DNA from bacteria and yeast.
2. Screening of bacteria for plasmids by electrophoresis of total cell lysate.
3. Gel electrophoresis of plasmids DNA chromosomal DNA and RNA.
4. Comparing plasmids of different molecular weights using Molecular Weights markers.

**Recommended Books**

1. Rehm, J.J. 1998. Fundamentals of Biotechnology, VCH Publishers, N.Y.
2. Lee, B.H. 1996. Fundamentals of Food Biotechnology, VCH Publishers, N.Y.
3. Pirt, J.B. 1975. Microbes and Cell Cultivation, Blackwell Scientific Publishers, London.
4. Bailey, J.E. and Ollis, D. F., 1986. Biochemical Engineering Fundamentals, McGraw Hills.
5. Watson, J.D., Tooze, J. and Kurta, D.T. 1983. Recombinant DNA-A short Course, Scientific American Books, New York.
6. Old, R.W. and Primrose, S.B. 1989. Principles of gene manipulation. 4th edition, Blackwell Scientific Publishers, London.
7. Molecular cloning, 1989. A Laboratory manual, 2nd edition, Cold spring Harbor Laboratory.
8. Higgins, I.J., Best, D.J. and Jones, J. 1988. Biotechnology Principles and Applications. Blackwell Scientific Publishers, London.
9. Rehm, J.J. 1988. Biotechnology: Special Microbial Process, Vol. 6 (b), VCH Publishers, N.Y.
10. Demain, A.L. and Solomon, N.A. 1986. Manual of Industrial Microbiology.
11. Old R.W. and S. B. Primrose. Principles of Gene Manipulation, An introduction to Genetic Engineering (4th Edition). Blackwell Scientific Publications. 1994.
12. Setlow J. K., Genetic engineering; Principles and methods. Kluwer Academic Publishers 2000.
13. Nicholl. D. S.T., An introduction to Genetic Engineering, Cambridge University Press, 2000.
14. Yount L., Genetic Engineering, Gale group, 2002.
15. Sambrook J., D. W. Russell, J. Sambrook, Molecular Cloning: A laboratory Manual 93-Volume Set), Cold Spring Harbor Laboratory press, 2002
16. Brown T.A., An introduction to Gene Cloning and DNA analysis: 4th Edition Blackwell Science Inc. 2001

**ZOO-6709 GENERAL ENTOMOLOGY**

**Aims and Objectives**

The students will learn to identify the pest during damaging to the crop; Students will understand methods of population estimation of the pest and application of different control strategies.

**Course Contents**

Introduction, Phylum Arthropoda and its classification; external and internal morphology and physiology with particular reference to a typical insect; metamorphosis and its types; insect classification, salient characters of insect orders and families of economic importance with examples of each family.

**Practicals**

Characters of classes of Arthropoda; collection, identification and preservation of insects; external and internal morphology of typical insects; temporary mounts of different types of appendages of insects; types of metamorphosis

**Recommended Books**

1. Elzinga, R. T. 2003. Fundamentals of Entomology. Prentice Hall.
2. Gullan, P.I. and P. S. Crauston, 1994. The insects (*an outline of Entomology*) Chapman and Hall New York.
3. Jhonson, N.F., Triplehorn, C.A. Borror and Delong’s, 2004. Introduction to the study of Insects. Brooks Cole. 7th Edition.
4. Lohar, M.K. 1998. Introductory Entomology, Kashif Publications, Hyderabad, Pakistan.
5. Main, M.S., 1990. General Entomology (4th Ed). Oxford and IBH publishing Co. Pvt. Ld. New Delhi.
6. Richards, O.W. and R. G. Davies, 1984. Imm’s General Text-book of Entomology, Vol. I. and II, 10th ed. Chapman and Hall, London, N.Y.
7. Shahid, M. 1984. Lab Mannual of General Entomology. National Book Foundation, Paksitan.
8. Tonap, G. T., 1994. Experimental Entomology, An Aid to Laboratory and Field Studies. C.B.S. Publishers and Distributors Delhi.
9. Chapman, R.F. The Insects: Structure and Function, 2000. Blackwell Science Inc., London.
10. Krebs, C. J. Ecology: The Experimental Analysist Abundance. 5th Edition. 2000. Benjamin-Cummings Publishing Company.
11. Tembhare, DB. Modern Entomology. 2002. Himalaya Publishing House, India.

**ZOO-6710 GENERAL MICROBIOLOGY**

**Aims and Objectives**

The course is designed to enable the students to work with microorganisms. The basic techniques of sterilization, culturing, isolation and determining different characteristics of the microorganisms are included.

**Course Contents**

**The beginnings of Microbiology:** Discovery of the microbial world; Discovery of the role of microorganisms in transformation of organic matter, in the causation of diseases, development of pure culture methods. The scope of microbiology. Microbial evolution, systematics and taxonomy; Characterization and identification of microorganisms. Nomenclature and Bergey’s manual. **Viruses:** Bacteriophages and phages of other protests. Replication of bacteriophages. Viruses of animals and plants; History, structure and composition; classification and cultivation of animal viruses. Effects of virus infection on cells. Cancer and viruses. **Morphology and fine structure of bacteria:** Size, shape and arrangement of bacterial cells, Flagella and motility, Pili, Capsules, sheaths, Prosthecae and stalks, structure and chemical composition of cell wall, cytoplasmic membrane, protoplasts, spheroplasts, the cytoplasm, nuclear material. **The Cultivation of Bacteria:** Nutritional requirements, nutritional types of bacteria, bacteriological media, physical conditions required for growth, choice of media, conditions of incubation. **Reproduction and growthof bacteria:** Modes of cell division, New cell formation, Normal growth cycle of bacteria, synchronous growth, continuous culture, quantitative measurement of bacterial growth; Direct microscopic count, Electronic enumeration of cell numbers, the plate count method, Membrane-filter count, Turbidimetric method, Determination of nitrogen content, Determination of the dry weight of cells, The selection of a procedure to measure growth, Importance of measurement of growth. **Pure cultures and cultural characteristics:** Natural microbial populations, selective methods; Chemical methods, Physical methods, Biological methods, Selection in nature, Pure cultures; Methods of isolating pure cultures, Maintenance and preservation of pure cultures, Culture collections, Cultural characteristics; Colony characteristics, Characteristics of broth cultures. **Eukaryotic Microorganisms:** Algae: Biological and economic importance of algae; Characteristics of algae; Lichens. Fungi: Importance of fungi; Morphology; Physiology and reproduction, Cultivation of fungi. Protozoa: Ecology and importance of protozoa. Classification of protozoa.

**Prokaryotic diversity Bacteria:** Purple and green bacteria; cyanobacteria, prochlorophytes, chemolithotrophs, methanotrophs and methylotrophs, sulfate and sulfur-reducing bacteria, homoacetogenic bacteria, Budding and appendaged bacteria, spirilla, spirochetes, Gliding bacteria, Sheathed bacteria, Pseudomonads, Free living aerobic nitrogen fixing bacteria, Acetic acid bacteria, Zymomonous and chromobacterium, Vibrio, Facultatively aerobic Gram-negative rods, Neisseria and other Gram-negative cocci, Rickettsias, Chlamydias, Gram-positive cocci, Lactic acid bacteria, Endospore forming Gram-positive rods and cocci, Mycoplasmas, High GC Gram-positive bacteria; Actinomycetes, Coryneform bacteria, propionic acid bacteria, Mycobacterium, Filamentous Actinomycetes. **Prokaryotic Diversity:** Archaea: Extremely Halophilic archaea, Methane producing archaea: Methanogens, Hyperthermophilic archaea, Thermoplasma. **Microbial Ecology:** Microorganisms in nature, Microbial activity measurements, Aquatic habitats, Deep-sea microbiology, Terrestrial environments, Hydrothermal vents, Rumen microbial ecosystem, Microbial leaching, Biogeochemical cycles; Trace metals and mercury, Biodegradation of Xenobiotics.

**Practicals**

The culture of microorganisms: preparation and sterilization of culture media, broth culture, agar slope, agar slab, streak plates, pour plates. Isolation of a bacterial culture, Quantitative plating methods. The turbidimetric estimation of microbial growth.

**Recommended Books**

1. Pelczar, Jr., Chan, E.C.S. and kreig, M.R. (1986). Microbiology, McGraw Hill, London.
2. Peltler, G.L.A Laboratory Manual of Microbiology.
3. Benson, H.J. Microbial Applications: Laboratory Manual in General Microbiology, 1994. WMC Brown Publishers, England.
4. Madigan, M.T., Martinko, J.M. and Parker, J. Brock Biology of Microorganisms, 1997. Prentice-Hall, London.

**ZOO-6711 GENERAL PARASITOLOGY**

**Aims and Objectives**

This course aims to provide knowledge regarding different modes of transmission of parasites of medical and veterinary importance along with their pathology, host parasite relationship and control measure. The goals of the course are to equip students with a fundamental understanding of parasitology science and competence in relevant recent parasitological techniques.

**Course Contents**

Principles of Parasitology. Various concepts of Parasitism. Systematics, biology, pathology and control of protozoan and helminthes parasites of medical and veterinary importance. Ecology of parasites. Host-parasite relationship. Parasitic zoonoses. Immunity and resistance.

**Practicals**

Preparation of temporary and permanent slides and identification of parasitic protozoan and local helminthes of medical and veterinary importance. Section cutting of the infected tissues and the study of their pathology.

**Recommended Books**

1. Robberts, L. Sand Janovy John Jr. (2009). Foundation of Parasitology. 8th edition. McGraw Hill, Boston
2. Chandrasoma , P. and Taylor, C.R.(1997). Concise Pathology. Prentice Hali International Inc. New Jercy USA.
3. Facust, E. C. and Russell, P. F. (2001). Craig and Faust’s clinical Parasitology. Lea and Febiger, 8th edition London
4. Markell, E.K. Mo. Vogo. (1999). Medical Parasitology. W. B. Sundress Co: Philadelphia.
5. Olsen, O. W. (1986). Animal Parasites: their life cycle and ecology. University Park Press Baltimore
6. Peters, W and Gills, H.M. (1989). A color atlas of Tropical medicine and Parasitology. Wolfe Medical Publications Ltd., Netherlands.
7. Robbins, S. L. Basic Pathology. W. B. Saunders Co: London, Toronto.
8. Soulsby: E. J. L. (1981). Textbook of veterinary clinical Parasitology Vol: 1 Blackwell Scientific Publication, London.
9. Smyth, J. D. (1994). Introduction to Animal Parasitology, 3rd edition. Cambridge University Press, Cambridge.
10. Walter, J.B. and Israel, M.S. (1979). General Pathology, Charchill Living Stone Edinburgh, London and New York.

**ZOO-6712 GENERAL TOXICOLOGY**

**Aims and Objectives**

The course provides knowledge and understanding about the nature and mode of action of different categories of toxicants. The will be enabled to understand the differential effects of variety of toxicants on different cellular sites. They will also learn about the procedural protocols used in toxicological studies.

**Course Contents**

History and general introduction to Toxicology; Types of Toxicology; Specialized areas in Toxicology; Classification of Toxic chemicals; Types of Exposure and Exposure response including exposure characteristics; Spectrum of undesirable effects; Variation in toxic responses; Dose Response relationship; Acute lethality; Descriptive animal Toxicity Testing; Sub-acute, sub-chronic and chronic toxicity; Developmental/Reproductive toxicity; Mutagenicity; Absorption, Distribution and Excretion of toxicants; Biotransformation/Disposition of toxicants; Phase-I and Phase II Biotransformation Reactions; Mechanism of Toxicity; Delivery, form the site of exposure to the target; Absorption versus pre-systemic elimination; Distribution to and away form the target; Excretion versus re-absorption; Toxication versus Detoxication; Toxicity resulting from Delivery; Reaction of the Ultimate Toxicant with the Target molecule; Attribution of Target Molecules; Effects of Toxicant on Target Molecules; Cellular dysfunction and resultant toxicities; Toxicant-induced cellular dysregulation; Toxic alterations of Cellular Maintenance; Repair and Dysrepair.

**Practicals**

1. Determination of LD50 values of some pesticide against any insect pest.
2. Determination of LD50 of any toxic compound in mammalian system.
3. Effect of any toxicant on body weight in mice.
4. Toxicity of some toxic compound on relative organ weight in mice.
5. Effect of toxicant on food consumption in mice.
6. Study of toxicity of any chemical on total leukocytes count.
7. Effect of toxicant on total erythrocyte count in blood of mice.
8. Effect of any toxicant on hemoglobin level in mice.
9. Study of inhibition of cholinesterase enzyme activity by organophosphate insecticides in mice.
10. Study of liver function enzyme (Alanine Aminotransferase) activity following administration of toxic compound to experimental animals.
11. Determination of blood glucose level following toxic exposure.

**Recommended Books**

1. Klaassen, Curtis D., (1996). Casarett and Doull’s Toxicology; The Basic Science of Poisons; 5th Edition (International). McGraw-Hill, Health Professions Division, New York.
2. Timbrel, J. A. 1995. Introduction to Toxicology, 2nd Edition. Taylor and Francis Ltd. London.

**ZOO-6713 HELMINTHOLOGY**

**Aims and Objectives**

This course aims at introducing the common parasites of man and livestock to students with a view to understanding their lifecycles, morphology, pathology, diagnosis, epidemiology and control.

**Course Contents**

Introduction to the phylum: Platyhelminthes, Trematoda, Aspidohothria, Trematoda, Form function, Life cycle and classification of digeneans, Digenians, Strigeiformes, *Schistosoma haematobium, S. japonicum, S. mansoni* (schistosomiasis); Digenians echinostomiformes; *Fasciola hepatica, F gigantica, Paramphistomum cervi.*

**Recommended Books**

1. Chandler, C. and Read, C.P. 1961. Wiley Toppan. Introduction to Parasitology.
2. Crewe, W.H.K. 1977. A Guide to Human Parasitology, Lowis and Company Ltd.
3. Noble and Noble, 1982. Parasitology, The Biology of Animal Parasites, Lea and Febiger.
4. Beck, J. W. and Davies, J.E. 1981. Medical Parasitology Mosby Company, Toronto, London.
5. Cheesbrough, M. Medical 1987. Laboratory Manual For Tropical Medicine, Vol. I. University Press Cambridge.
6. Sood, R. 1998. Parasitology: Protozoology And Helminthology,
7. Smith, J.D. 1998. Introduction to Animal Parasitology, University Cambridge Press.
8. Roberts, L.S. and Janovy, J. Jr. 2000. Foundations of Parasitology, Brown Publishers, Chicago, London.

**ZOO-6714 HAEMATOLOGY**

**Aims and objectives**

Hematology is the study of blood, blood forming tissues and organs, and blood disorders. The aims of the course are to import the knowledge and practice to the students to specialize them in the diagnosis, treatment, and prevention of blood disorders including anemia, blood clots, bleeding disorders, and blood cancers. Because blood runs through every organ and tissue in the body, hematology has an enormous ripple effect extending to all fields of medicine.

**Course Contents**

Introduction of blood, Constituents of blood, Function of the cellular elements of blood, Types of blood ( Jaundic, Lipemic, Hemolytic, Anemic, Normal), Erythocytes, Erythopoiesis, Effect of erythropoietin, Erythroblastosis fetalis, Anemia (Nutritional anemia, Prernicious anemia, Aplastic anemia, Renal anemia, Hemorrhagic anemia, Hemolytic anemia, Sickle cell anemia, Hypochromic anemia). Types of Polycythemia (Primary polycythemia / polycythemia vera and Secondary/ Physiological polycythemia) Types of leucocytes, Types of lymphocytes, Typical human cell count, Blood cell production (Hemopoiesis), Plasma, Composition of plasma, Importance of blood group matching before blood transfusion, Factors involved in blood coagulation and clot lysis., Platelets, Formation of a platelet plug, Role of thrombin in hemostasis, Clot pathways, Anticoagulants, Types of hemophilia, Blood doping.

**Practicals**

Study of erythrocytes. Differential leukocytic counts in normal and immunized animals.

**Recommended Books**

1. Hoft Brand, A.V. And petit, Je. (1981). Essential of Hematology, Blackwell, Oxford.
2. Essential Haematology. Hoffbrand, A.V. and Hoffbrand, I.E. 2002. Peltit and PAH Moss
3. Haematology. Dacie and Lewis. 2002.

**ZOO-6715 HISTOLOGY**

**Aims and Objectives**

The fundamental aim of histology is to determine how tissues are organized at all structural levels, from cells and intercellular substances to organs.

**Course Contents**

Brief introduction to cells and tissues, study of epithelial tissues, connective tissues, blood cells, lymphatic tissues and the immune system, bone and cartilage, joints, muscles. Anatomy of heart, lungs, liver, kidney, spleen, digestive tract, brain, skin and endocrine glands.

**Practicals**

Preparation and study of stained slides of different tissues of animals

**Recommended Books**

1. Eroschenko, Victor, P. (2008). Difioe’s Atlas of Histology with Functional Correlations 11th Edition. Wolters Kluwer health (India) Pvt. Ltd. New Delhi.
2. Luiz Carlos Junqueira and Jose Carneiro (2005). Basic Histology Text and Atlas 11th Edition. McGraw Hill Medical Publishing Division New York.
3. Mills, Stacey, E. (2007). Histology for Pathologists 3rd Edition. Lippincott Williams and Wilkins a Wolters Kluwe Business Philadelphia.
4. Ham, Arthur W., Cormack, David, H (1987). Ham’s Histology 9th Edition. J.B. Lippincott Company, Phlladelphla. London.
5. Arthur Smith and John Bruton (1977). A Colour atlas of Histlogical Staining Techniques. Wolfe Medical Publication Ltd. London WC2.
6. Copenhaver, Wilred M., and Kelly, Douglas E., and Wood, Richard, L (1978). The Williams and Wilkins Company/Baltimore Tokyo.
7. M. Ahsan Karim, and Khalid M. Khan, (1986). A Guide Histology Practical. Feroz Sons Lahore Pakistan.
8. Ham, Arthur W., (1969). Histology 6th Edition. J.B. Lippincott Company Philadelphia Toronto

**ZOO-6716 INDUSTRIAL AND MICROBIAL BIOTECHNOLOGY**

**Aims and Objectives**

Industrial biotechnology (IB) is the use of biological resources (including plant, algae, marine life, fungi and micro-organisms) for producing and processing of materials, chemicals and energy. Microbes are also used to produce high level of inductrial products through fermentation processes (e.g. brewing, bakery, industry) and enzyme engineering (as per securing vitamins, antibiotics and various biochemicals); cell and tissue technology (e.g. for increasing an organism’s Physiological efficiency).

**Course Contents**

Application of biotechnology in industry; biotechnology of raw ore processing (bioleaching of sulphides, carbonates, silicates etc.) accumulation of metals by microbial cells, biopulping, biofuels, microbial enhanced oil recovery; application in agriculture, food and livestock products; biofertilization; production of cheese, probiotics, bread, single cell protein, citric acid, amino acid, acetic acid, production in drinks; microbial enzymes in industry, enzyme immobilization. Significance of Industrial Microbiology, Classification of microorganisms, fermentation principles, Culture techniques, Measurement and control of microbial processes, Introduction of probiotics. Introduction to industrial biotechnology, Biotechnology in textile, Chemical, Food, Pharmaceuticals, Agricultural industries, Industrial biocatalysts, Industrial waste, Industrial strain improvement, Screening for new metabolites, Recombinant DNA technology, Substrates for industrial fermentation, Regulation of primary and secondary metabolism, Design and development of industrial bioreactors, Problems and possibilities in fermentation scale up procedure, Bioreactors,  Fermentors and controls, Bioenergy and Biofuels,  Product recovery and refinement.

**Practicals**

Screening of enzymes of industrial significance, enzyme immobilization; Production of cheese, yogurt, citric acid, amino acid and acetic acid.

**Recommended Books**

1. Old R.W. and S. B. Primrose. Principles of Gene Manipulation, An introduction to Genetic Engineering (4th Edition). Blackwell Scientific Publications. 1994.
2. Setlow J. K., Genetic engineering; Principles and methods. Kluwer Academic Publishers 2000.
3. Nicholl. D. S.T., An introduction to Genetic Engineering, Cambridge University Press, 2000.
4. Yount L., Genetic Engineering, Gale group, 2002.
5. Sambrook J., D. W. Russell, J. Sambrook, Molecular Cloning: A laboratory Manual 93-Volume Set), Cold Spring Harbor Laboratory press, 2002.
6. Brown T.A., An introduction to Gene Cloning and DNA analysis: 4th Edition Blackwell Science Inc. 2001.

**ZOO-6717 INVERTEBRATA**

**Aims and Objectives**

The course is designed to provide students with the concepts of structure, classification biology and evolutionary relationship of invertebrate phyla.

**Course Contents**

Structure, classification and biology of Protozoa, Mesozoa, Coelenterata, Centiphora, Platyhelminthes, Nematoda, Rotifera, Annelida, Echiurida, Sipunculida, Bryozoa, Branchiopoda, Mollusca and Echinodermata.

**Practicals**

Preparations of slides, Daphnia, Cyclops, Housefly, Mosquito, Mouth parts of cockroach and butterfly, Honey bee, Museum study of prepared slides.

**Recommended Books**

1. Parker and Haswell. A Text Book of Zoology (Vol .1) McMillan. London
2. Barrington, E.J.W., (1969) Invertebrates structure and function, the English Language book society, London.
3. Henger and Engelmann. Invertebrate Zoology.
4. Borradial, L.D., (1963). The Invertebrata Cambridge university press
5. Hyman, L.H. (1940). Invertebrates (Vol 1.VI). McGraw-Hill, New York.

**ZOO-6718 Limnology-A**

**Aims and Objectives**

To provide information about inland waters, biological productivity and to minimize the pollution of inland water for better aquaculture production. The student will be able to learn about physical and chemical properties of water in order to increase biological production.

**Course Contents**

Definition, Importance, Inland waters, Sources of bottom materials, Physical features of water, temperature, light, currents, density and water turbidity. Chemical features of water dissolved gasses, dissolved solids, pH, Electrolytes alkalinity, hardness, salinity, brief description of nitrogen and phosphorous cycles.

**Practicals**

Survey of major water bodies in Azad Kashmir and Pakistan (lotic and lentic waters). Morphometric analysis of rain water, stream water, lake water, pond water and ground water. Preliminary general tests, odour, colour, dissolved gases, dissolved solids, suspended solids, pH, alkalinity, salinity, hardness, micronutrients.

**Recommended Books**

1. Goldman, C.R. and Horne, A.J. 1983. Limnology. McGraw Hill, International Book Company, Japan.
2. Welch, P.S. 1968. Limnology, 4th Edition, McGraw Hill book. Inc. New York.
3. Allen S. E. 1990. Chemical Analysis of Ecological Materials, Scientific Publishers, London.
4. Robert G. Wetzel. 1983. 2nd Edition. Limnology. Saunder Publishers, New York.
5. Gerald A. Cole. 1983. 3rd Edition. A Text Book of Limnology. Waveland Press Inc. USA.

**ZOO-6719 NEUROPHYSIOLOGY**

**Aims and Objectives**

The course aims to understand the basic physiological mechanisms relating to the body coordination through cell membran, nerve, muscle excitation and receptor function.

**Course Contents**

Foundation of excitability at cell membrane level: Membranes, channels and transport. The physical basis of neuronal function: Membrane excitation, resting and action potentials. Communication along and between neurons: Propagation of action potential, synaptic transmission, pre and postsynaptic mechanisms. Neurotransmitters: synthesis, release and their fate. Learning related changes at synapse. Neurochemical basis of behaviour. Organization of sensory receptors. Physiological basis of receptors functions: Mechanoreceptors, photoreceptors, chemoreceptors, Thermoreceptors, Electroreceptors and Nocireceptors.

**Practicals**

Experiments demonstrating: Nervous organizations in vertebrates (mammals), Potentials particularly the nerve impulse. Nervous regulation of functional system.

**Recommended Books**

1. Aidley, J. David, 1998. The Physiology of excitable cells. Cambridge University Press, Cambridge, U.K.
2. Ganong, W.F., 2000. Review of Medical Physiology. Prentice-Hall International Inc., London.
3. Randall, D., Burggren, W. And French, Kathleen, 1998. W.F. Freeman and Company, New York.

**ZOO-6720 Principles of Fish Biology**

**Aims and Objectives**

The aim of this course is to enable students in obtaining complete understanding about freshwater as well as marine fishes in general and freshwater culturable fishes in particular. It comprises morphology, anatomy, classification and some understanding about various feeding groups found in different water bodies. After having complete knowledge of above, students will be able to practice independently.

**Course Contents**

Fish Morphology: Head (Size, shape, and orientation), Scales (types, arrangements, coloration, scaleless fishes), Operculum, fins, fin rays and fin spine (Dorsal, pectoral, caudal, anal), Barbel (upper lip barbels, lower barbels). Anatomy: Skeleton (skull, backbone, spines), Brain and spinal cord, Gills (No, size, arrangements), Vital organs (heart, liver, kidney), Viscera and mesenteries. Swim bladder, stomach, spleen, pancreas, intestine, glands. Systematic: Identification of fishes up to; families, Order, Genus and Species, Feeding groups of fishes, herbivore, Plankton eater, Larvivore, Carnivore, Voracious. Ecology of fishes: Freshwater, Brackish water, Marine.

**Practicals**

1. Collection, Preservation and identification of freshwater fish species.
2. Study of different organs of various fish species
3. Study and survey of various fish collection present in museum like Natural History Museum at Islamabad, G.C. Lahore and at P.U. Lahore.

**Recommended Books**

* 1. Kestin Farmed Fish Quality (2001).
  2. Woo. Fish diseases and Disorder: *Protozoan and Metazoan infections* (1995)
  3. Brenabe Aquaculture Vol. IandII (1992) Fishing News Books Ltd. England
  4. Maseke C. Aquaculture, IandII (1992) Pergamon Press, Oxford.
  5. Huet M. Text Book of Fish Culture: *Breeding and cultivation* Fishing News Book Ltd. England.
  6. Kestin, S. C. and Warris, P.D. (Edition). Kestin Farmed Fish Quality, 2002, Blackwell Science, Oxford, UK.

**ZOO-6721 PRINCIPLES of Herpetology**

**Aims and Objectives**

The aim of this course is to provide knowledge about the classification, population and distribution of amphibia and reptiles with refernece to their ecological adoptations and interactions.

**Course Contents**

Classification of amphibians and reptiles. Evolution, geographical distribution, population biology of reptiles and amphibians. Biology, including anatomical, physiological adaptations to their environment, reproduction, foods/feeds, communication (vocal, chemical, behavioural). Mechanism of hibernation in herpeto-fauna (effect of climatic factors). Poisonous species. Sensory mechanisms, predator-prey relationships, chemistry and physiological actions of venoms and patho-physiology and treatment of snake bite.

**Practicals**

1. Visit of PMNH for study of preserved specimens of herpeto-fauna in relation to their taxonomy and ecosystem.
2. Field visits of different habitats for direct/indirect observations of amphibians and reptiles with respect to their ecologies and weather conditions.
3. Visit to Zoos and wildlife parks.

**Recommended Books**

1. Daniel, J.C. 1992. The Book of Indian Reptiles. Bombay Natural History Society, India.
2. Girard, C. 1978. Herpetology. Arno Press.
3. Pough, F. H. 2001. Herpetology. Prentice Hall.
4. Zug, G. R. 1993. Herpetology: An introductory biology of Amphibian and Reptiles. Academic Press.
5. Sharif, M. Herpato-Fauna of Pakistan.

**ZOO-6722 PRINCIPLES OF PARASITOLOGY**

**Aims and Objectives**

This course aims to provide knowledge regarding different modes of transmission of parasites of medical and veterinary importance along with their pathology, host parasite relationship and control measure.

**Course Contents**

Introduction to parasitology. Relationship to other sciences, parasitology and human welfare. Parasites of domestic and wild animals. Camers in parasitology. Some basic definitions. Basic principles and concepts. Parasite ecology and evolution. Basic principles and concepts. Immunology and pathology. Susceptibility and resistance, innate defence mechanisms. Acquired immune response in vertebrates. Immunity in invertebrates. Immunodiagnosis, pathogenesis of parasitic infections. Accommodation and tolerance in the host-parasite relationship. Parasitic protozoa, form, function and classification: Kinetoplasta, trypanosomes and their kin, forms of trypanosomatidae. Other flagellated protozoa, order Retortamonadita, order Diplomonadida, order Trichomonadida, order Opalinida. The Amoebas. Order Amoebida, order Schizopyrenida. Phylum Apicomplexa, Gregarines, Coccidia and related organisms. The apical complex, class Gregarinea, class Coccidea. Phylum Apicomplexa, Malana, organisms, and pyroplasms, order Haemospondea, order Pyroplasmida. Phylum ciliophora, ciliated protistan parasites, class Spirotoichea, class Litostomitea, class Oligohymenophorea. Phyla Microspora and Myxozoa. Parasites with polar filaments. Phylum Microspora, Phylum Myxozoa. The Mesozoa, pioneers or Degenerates. Class Rhombozoa, class orthonectida, Phylogenetic position, physiology and Host parasite relationship. Classification of Phylum Mesozoa. Systematics, morphology and biology of Arthropods (Causing or responsible for transmission of disease). Chemical and non-chemical control of Arthropods of Medical and Veterinary importance. Pathology of Helminths: Host parasite relationships and control of parasitic Helminths with particular reference to Helminths of Medical and Veterinary importance.

**Practicals**

1. Preparation of temporary and permanent slides and identification of parasitic protozoan and local helminthes of medical and veterinary importance.
2. Section cutting of the infected tissues and the study of their pathology.
3. Methods of collection, preservation and transportation of parasitic material.
4. Qualitative and quantitative faecal examination for helminth ova.
5. Collection, preservation and preparation of slides of local helminthes and their identification.
6. Identification of insects of medical and veterinary importance.

**Recommended Books**

1. Roberts, L.S. and Janovy, J. Foundation of Parasitology, 6th Edition. 2000. McGraw Hill Book Co.
2. Hausman, K. and Hulsmann, N. T. Protozoology, 2nd Edition. 1996. Medical Publishers, Inc. New York.
3. Noble, E.R. and Noble, G.A. Parasitology. The Biology of Animal Parasites. 5th Edition. 1982. Lea and Febiger Publisher.
4. Beck, J.W. and Davies, J.E. Medical Parasitology. 3rd Edition. 1981. C.V. Mosby Company, Toronto, London.
5. Cheesbrough, M. Medical Laboratory Manual for Tropical Medicine. Vol.I. 1987. University Press Cambridge.
6. Smyth, J.D. Introduction to Animal Parasitology. 1994. Cambridge University Press.
7. Roberts, L.S. and Janovy, J. Jr. Foundations of Parasitology. 7th Edition. 2005. Wm Brown Publishers, USA.
8. Urquhart, G.M., Hucan, J.L., Dunn, A.M. and Jennings, F.W. Veterinary Parasitology. 2000. Longman Scientific and Technical publications, Longman Group, UK.

**ZOO-6723 REPRODUCTIVE PHYSIOLOGY**

**Aims and Objectives**

The aim of the subject is to learn about the essential reproductive, histology and physiology of reproductory organs and other relevant organs to integrate this knowledge to study processes that regulate metabolic processes in the body. In addition it includes the study processes of reproduction and examples of bodily dysfunction and disease that illustrate the basic principles of normal physiology through the absence of normal function.

**Course Contents**

**Note**: Theemphasis shall be mainly on human being and poultry.

Cytological and genetic basis of sex. Female and male reproductive tracts, morphology and histology. Differentiation of sex and role of hormones. Gonadotropins, their chemistry and physiological characteristics. Mammalian ovary. Mammalian female reproductive cycles and its controlling mechanisms. Oogensis and Folliculogenesis. Brief study of avian ovary and its functional mechanisms. Mammalian testis. Spermatogenesis in man and domestic animals. Accessory sex organs in male mammals. Fertilization, early development, embryo transfer and implantation. Hormonal mechanisms in pregnancy, parturition. Mammary Gland development, milk synthesis and lactation. Nutrition and reproductive efficiency. Anti-fertillity mechanisms in human. Sterility causes in domestic animals.

**Practicals**

Study of male and female reproductive tracts in a mammal and a bird. Histology of different parts of the tract. Study of Spermatogenesis and folliculogenesis. Study of reproductive cycles in a mammal. Experiments on nutrition and reproductive efficiency in mammals and birds.

**Recommended Books**

1. Parkes, D.A. Marshalls, Physiology of Reproduction (Vol. I, II and III).
2. Young, W. C. Sex and Internal Secretion (Vol. I and II), Williams and Wilkins Co. London
3. Cole, H.H. and Cupps, P. T. (1977). Reproduction in Domestic Animals, Academic Press, New York.
4. Bearden H.J. and Fuquay, (1980). Applied Animal Reproduction, Reston Publishing Co. Inc. Reston.
5. Finn, C.A. (1979-81). Oxford. Review of Reproductive Biology (Vol. I, II and III), Clarendon Press, Oxford.
6. Hafez, E.S.E. (1982). Reproduction in Farm Animals, Lea and Febiger.

**ZOO-6724 WILDLIFE PARASITOLOGY**

**Aims and Objectives**

1. To give knowledge to the students about parasites of wild animals and birds fauna as previously this field of study was ignored.
2. To impart tools of parasites survey of wild fauna and methods of parasites collection to students in field study.

**Course Contents**

Overview of wildlife: A brief out line of wild-life in Pakistan; introduction and classification. Introduction to wildlife parasitology: Host parasite relationship; Occurrence and prevalence of parasites in Wild animals such as Mammals with exception to Carnivora; Birds; and Reptiles excluding Crocodilla; Pathogenesis of parasitic infection; Diagnosis, Prevention and Treatments. Diseases dissemination: Role of wild animals in spreading of parasitic diseases to Domestic Animals and Man; Control of Ecto and Endo-parasites of wild animals and birds; Zoonotic and Epizootic of wild-wide importance.

**Practicals**

1. Collection of literature on parasites of wild animals and birds.
2. Collection of parasites, faces / droppings from wild animals and birds.
3. Processing of parasitic material for examination.
4. Preparation of permanent mounts.
5. Identification of parasites

**Recommended Books**

1. Bush, A. O., Femandez J. C., Esch, G. W. and Seed, J. R. 2001. Parasitism: The diversity and Ecology of animal Parasites. Cambridge University Press, Cambridge, UK.
2. Fowler, M. E. 1999. Zoo and wild animal medicine: Current Theraphy-4 w. b. Saunders Company Philadelphia, USA.
3. Smyth, J. D. 1994. Introduction to animal Parasitology. 3rd Edition Cambridge University Press, Cambridge, UK.
4. Davis, J.W. and Anderson, R. C. 1971. Parasitic diseases of Wild Mammals. The Lowa State University Press, Ames, Lowa, USA.
5. Soluby, E. J. L. 1986. Helminths, Arthropods and Protozoa of Domesticated Animals. 7th Edition Bailliere and Tindal, London.
6. Lavin. N. D. 990. Veterinary Parasitology. The Lowa State University Press. Ames, Lowa,

**LIST AND COURSE CONTENTS OF ELECTIVE/OPTIONAL/SPECIAL COURSES FOR BS-4 YEAR PROGRAM IN ZOOLOGY 8TH SEMESTER**

**YEAR-IV**

**SEMESTER-VIII (Cr. 15)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Course code** | **Course title** | **Credits** | **Status** |
|  | Elective-I | 3(2-1) | Elective |
|  | Elective-II | 3(2-1) | Elective |
|  | Elective-III | 3(2-1) | Elective |
|  | Elective-IV | 3(2-1) | Elective |
|  | Elective-V | 3(2-1) | Elective |
| ZOO-6822 | Comprehensive examination | P/F | Compulsory |
| ZOO-6823 | Thesis | 6(0-6) | Elective |
| Note: students who will not opt for thesis, will have to opt 5 elective courses | | | |
|  | **Total Credits** | **15** |  |

**CONTENTS OF ELECTIVE COURSES FOR BS-4 YEAR IN ZOOLOGY 8TH**

**SEMESTER**

**ZOO-6801 ANIMAL BEHAVIOUR**

**Aims and Objectives**

To teach students:

1. The concept of physiological mechanism.
2. Functional aspects in animal life
3. The designs of mechanisms in nervous and hormonal coordination, muscle and movements, respiratory gas exchange, excretion and osmoregulation, nutrition and thermal regulation.
4. To correlate these mechanisms at biochemical, molecular and cellular levels to the functions at organ system and organism level.
5. Physiological mechanisms in manifestation of behaviour.

**Course Contents**

The Study of Animal Behaviour: Introduction. History of animal behaviour. Approaches and methods. Mechanisms of behaviour: The nervous system and behaviour. Hormones and behaviour Immunology and behaviour. Biological rhythms. Development of behaviour. Learning behaviour. Communication. Finding Food and shelter: Migration, Orientation and navigation. Habitat selection. Foraging behaviour. Social Organization and Mating systems:Conflict. Sexual reproduction and parental care. Mating systems and parental Care. Social systems.

**Practicals**

Experiments on reflexes, latency, after-discharge, summation, warm up, fatigue, inhibition and feedback. Experiments on habituation, conditioned reflex type I and trial and error learning. Experiments showing hormonal involvement in behavioural responses. Study of social integration in social insects. Study of hibernation and biological rhythms.

**Recommended Books**

1. Drickamer, L. C., Vessey, S. H. and Jacob, E. 2002. Animal behaviour: Mechanism, Ecology Evolution. 5th Edition.
2. Manning, A. and Dawkins, M. S. 1997. An Introduction to Animal Behaviour, 8th edition. Cambridge University Press, Cambridge.
3. Tonap, G. T. 1998. Experimental Entomology an Aid to Laboratory and FieldStudies. C. B. S. Publishers Delhi.

**ZOO-6802 ANIMAL PESTS AND DISEASE PRODUCING ORGANISMS**

**Aims and Objectives**

The course aims to provide knowled and awareness to students about the different invertebrates and invertebrates animal pests and to aquip the student with suficient knowlege to generate technologies and strategies being used for pest and disease management include testing new pesticides (Chemical and biological) for inclusion in integrated pest management (IPM), to counter this challenge.

**Course Contents**

Nature and mechanism of damages caused by animals pest injuries to cash crops, vegetables and fruit plants, stored grains and forest plants with brief description of their biology, ecology and control. Role of insects, helminthes, nematodes, protozoans and other pathogens in disease transmission and myiasis. Insects and mites of medical and veterinary importance in Pakistan. Study of mammalian pests of Pakistan.

**Practicals**

Collection, mounting studying and identification of important animal pests. Endo and ecto-parasite of various animals. Mounting of slides after processing the parasites.

**Recommended Books**

1. Ahmad, M., 1990. Agricultural Entomology of Pakistan. Nalt. Long Auth, Islamabad.
2. Choudhry, G.U. 1970. Survey of insect fauna of forests of Pakistan.
3. Ghani, M.A. and Cheema, M.A. 1973. Biology, ecology and behaviour of principal natural enemies of major insects pests of forests of Pakistan.
4. USDA, 1956. Year Book of Agriculture, Insects.

**ZOO-6803 APPLIED MICROBIOLOGY**

**Aims and Objectives**

Aims of this course to let the students know about the applications of the science of microbiology in the different fields of life. The course may initiate their interest in agricultural, industrial and/or environmental microbiology.

**Course Contents**

Control of microorganisms: Fundamentals of control, control by physical and chemical agents, antibiotics and other chemotherapeutic agents. Microorganisms and diseases: Host-microbe interactions. Resistance and immunity. Air, food and water-borne human infections. Human contact diseases. Infectious diseases of animals. Environmental microbiology: Fundamentals of microbial ecology. Microbiology of air. Aquatic microbiology. Soil microbiology. Microbiology of domestic water and sewage. Microbiology of food, milk and milk products. Industrial Microbiology: Scope of industrial microbiology in food production, control of insects, human therapy, petroleum, mining and bioremediation. Biotechnology and its role in modern human comforts.

**Practicals**

1. Bacteriological examination of water. Isolation and Identification of enteric pathogen. Selective medium for the isolation of pathogenic Staphylococci. The coagulase test for pathogenic *Staphylococcus*, Sucrose plates*. Streptococcus silvarius*. Normal throat flora and reactions on Blood Agar. Slide Agglutination test.

2. Inhibition and destruction of microorganisms by physical agents (temperature, desiccation, light). Action of disinfectants on bacteria. Bacteriostatic action of certain dyes and drugs. Blood groups. Determination of human blood groups.

**Recommended Books**

1. Eugene W. N., Denise, G., Anderson, M. T., Nester, C., Roberts, E. Nancy, N. Microbiology: A Human Perspective, 2001. McGraw Hill Higher Education.
2. Jacquelyn, G.G. Microbiology Principles and Explorations, 2001. John Wiley and Sone Inc.
3. Pelczar Jr., Chan, E.C.S. and Krieg, M.R., Microbiology, 1986. McGraw Hill, London.
4. Benson, H.J. Microbial Applications: Lab Manual in General Microbiology, 1998. WMC Brown Publishers, UK.

**ZOO-6804 BIOCHEMISTRY-II**

**Aims and Objectives**

The course will provide in depth knowledge about the biochemical processes and organic compounds of life including macromolecules. The dynamism of the life proceeds with inter-conversion of the chemicals from feeding to the liberation of energy for work. It will deal with the inter-conversion is performed by various tools called as enzymes. Thus, in this course the concepts of the chemical basis of life and all the mechanisms involved in harvesting of energy for growth, duplication etc., are given.

**Course Contents**

Constituents of living organisms, Prebiotic molecular evolution, Origin of biomolecules and living cells. Properties of aqueous solutions, Acid, Base, buffers and pH. Thermodynamics principles, Laws of thermodynamics, Free energy chemical equilibria. Characteristics and biological functions of amino acids, proteins, carbohydrates and lipids. DNA (double helix, DNA melting eukaryotic chromosomes), Synthesis of oligonucleotides RNA (messenger, transfer and ribosomal). Characteristics of enzymes activity. Metabolic pathways: Glycolysis; Citric acid cycle; Electron transport chain and Oxidative phosphorylation; Other pathways of carbohydrate metabolism. Photosynthesis. Lipid digestion, absorption and transport, Fatty acid oxidation and synthesis of ketone bodies and cholesterol metabolism. Biosynthesis of amino acids, amino acid deamination, decarboxylation, transamination, Urea Cycle. Nitrogen fixation. Nucleotide synthesis and degradation. Interrelation and regulation of metabolic pathways and energy metabolism.

**Practicals**

1. Qualitative tests of amino acids.
2. Qualitative estimation of proteins by UV and Lowry’s method. Extraction and slating out of proteins. Gel filtration, Ion exchange chromatography and polyacrylamide gel electrophoresis of proteins. Determination of molecular size of proteins by SDS –PAGE.
3. Qualitative test of different lipids. Fractionation of brain lipids and their analysis by thin layer chromatography.
4. Qualitative test for carbohydrates. Glycogen isolation and hydrolysis. Determination of reducing sugars. Enzymatic determination of glucose. Paper chromatography of sugars.
5. Isolation of lactate dehydrogenase from heart muscles of rabbit and analysis of isoenzymes of PAGE. Isolation of peroxide from turnip and study of its kinetics.

**Recommended Books**

1. Voet, D and Voet, J.G. (1990). Biochemistry, John Wiley and Sons
2. Zubay, G.l. (1983). Biochemistry, McMillan Publishing Co.
3. Rawn, J.D (1989). Biochemistry, Neil Patterson Publishers, North Carolina.
4. Conn and Stumpf, (1989). Out lines of Biochemistry, John Wiley and Sons.
5. Stryer, L. (1988). Biochemistry, W. H. Freeman and Co., New York.
6. Davlin, J. (1992). Textbook of Biochemistry with Clinical Correlation, John Wiley and Sons.

**ZOO-6805 Bioremediation and Environmental Biotechnology**

**Aims and Objectives**

Biodegradation of various pollutants and also acts as the microbial metabolism to remove pollutants. The purpose of environmental and bioremediation is used to study harmul substances which are contaminating the environment and discovering and inventing such processes which can be beneficial for the environment.

**Course Contents**

Concept of bioremediation; Bioremediation of heavy metals, xenobiotic compounds and hazardous wastes; techniques used in bioremediation, bioremediation through consortia of microbes and invertebrates; renewable and non-renewable resources; bioleaching and biomining (low grade and sulfide containing ores processing); domestic solid waste and management. Waste water, sludge and sewage management; biological methods of wastes treatment; sample collection and preservation; bioremediation of crude and petroleum oils. Role of yeast in bioremediation. Biological fuel generation; Bioremediations of industrial effluents.

**Practicals**

Bioremediation of heavy metals through invertebrates, consortia of microorganism, mycoremediation.

**Recommended Books**

1. Environmental Science (Earth as a living planet). 2000. 1st ed. Botkin, D. and Keller, E. John Wiley and Sons Inc. New York, USA.
2. Practical Environmental bioremediation the field guide, 1977. R. Barry. King, Gilbert M. Long John K. Sheldon, Lewis Publishers.
3. General Microbiology, 1995. Schlegel, H.G., Cambridge University Press.
4. Biotechnology, 1996. Smith, J.F., Cambridge University Press.
5. Environmental Biotechnology Principles and Applications, 2000.Pruce, R. Hmana, Parry McCarty, McGraw Hill.
6. Biodegradation and Remediation, 1999. Martin Alexander Academic Press Inc.

**ZOO-6806 ECONOMIC ZOOLOGY**

**Aims and Objectives**

The course provides the basic knowledge about the economic importance of various species of animal kingdom. It provides knowled about the delitarious effects of different species (e.g., parasites) on human society and also provides the basic knowledge on the posive aspects of different animal species.

**Course Contents**

Parasitic protozoa and diseases. Phytoparasitic, Nematodes and their control. Helminthes Parasites of man and other domestic animals and their control. Mites and ticks and their control. House holds insects. Insects of cash crops. Apiculture, Lac-culture, Sericulture and fisheries in Pakistan. Aquaculture value added by products of fishing industry. Poultry economic importance of mammals. Genetic improvement of animal. Leather industry. Wool industry. Pharmaceuticals from animals. Bioactive substances from animals, Rats and their control. Resource survey and management

**Recommended Books**

1. Shukla, G.S. Economic Zoology.
2. Vishwaprem, K. K. C. Economic Zoology.
3. Jawaid Ahsan, Subhas Prasad Sinha. A Hand Book On Economic Zoology.
4. Shukla and Upadhyaya. 2009. Economic Zoology 4th ed. Rastogi Publications.
5. Mathur S., 2009. Economic Zoology Biostatistics and Animal Behaviour. Rajpal and Sons Publishing.

**ZOO-6807 ENDOCRINOLOGY**

**Aims and Objectives**

1. General concepts and principles of chemical coordination.
2. The details of the endocrine mechanisms in relation to various functions such as reproduction and lactation.
3. Recent trends of endocrinology in relation to diversified function.

**Course Contents**

Introduction Endocrinology, Vertebrate Endocrine System. Mechanism of Hormone Action Endocrine Methodologies, Pituitary Hormones, the Endocrine Hypothalamus, Neurohypophysial Hormones, Opiomelanocortins, Hormonal control of Calcium Homeostasis, GIT hormones, Pancreatic hormones and metabolic regulation, Growth hormones, Thyroid hormones, Catechoalmines and sympathoadrenergic system, Adrenal steroid hormones, Endocrinology of sex differentiation and development, Hormones of male reproductive physiology, Hormones of female reproductive physiology, Endocrinology of Pregnancy, Parturition and Lactation, Endocrinology of Pineal Gland. Pathophsiology of hormones.

**Praticals**

Gross and histological structure of endocrine glands. Techniques of ansthesia and surgery. Studies in physiological effects of hormones.

**Recommended Books**

1. Basic and clinical endocrinology.Greenspan, F.S. and Strewler, G.J., 2002. 5th Edition. Prentice Hall International Inc., London.
2. Williams Textbook of Endocrinology, Wilson, J.D., Foster, D.W., Kronenberg, H.M. and Larsen, P.R., 1998. 9th Edition. W.D. Saunders Company, Philadelphia.
3. Endocrinology.DeGroot, L.J., Jameson, J.L. et al., 2001. Vol.I, II, III, 4th ed. W.B. Saunders, Philadelphia.
4. Textbook of Endocrine Physiology.Giffin, J.E. and Ojeda, S.R., 2000. 4th Edition. Oxford University Press, Oxford.
5. Basic Endocrinology: An interactive approach. Neal, J.M., 2000. Blackwell Science Inc., London.
6. Turner, C.D. and Bagnara, J.T. (1976). General Endocrinology, W.B, Saunder London.
7. Barrington, E.J.W. (1963). An introduction to General and Comperative Endocrinology, Calrendom Press.
8. Bently, P.I. (1982). Comparative Vertebrate Endocrinology, Cambridge University Press Cambridge.
9. Wilson, J.D. and Foster D.W. (1985). Text Book of Endocrinology. W.B Saundres, Philadeliphia.

**ZOO-6808 Environmental Issues**

**Aims and Objectives**

This course is designed to provide students with an appreciation for the complexity of environmental issues and an awareness of the tools that can be applied to understand and solve problems involving the environment.

**Course Contents**

Life a factor of rapid change in the environment, Population increase of diversified life in an ecosystem, Population system in an ecosystem balance; Mechanisms inter-playing in balance, consequences of imbalance, Endangering and extinction of species, decline of biodiversity, consequences of losing biodiversity. Human population: Main actor in an environment, Human population explosion, Technologies in sustaining population and affluence, addressing population problem, population and development. Poverty; integrated approach to alleviate poverty, Life style: Urban sprawl, consequences of ex-urban migration, Health in life style; Environment and health. Food production (Crops and livestock). Land for cultivation and farming. Food production, its distribution, economics and politics, Hunger, malnutrition and famine, Soil, irrigation, Stalinization, Desertification, Losing soil/ground. Pests and pest controls: Need and approach to pest control. Alternate pest control methods. Socio-economic pressure and pest management, Environmental policy in pest management. Water: Water cycle and water management, Human impact on water resources. Pollution. Bi-products of production systems: Sediments, Nutrients and eutrophication, the process and symptoms of eutrophication, combating eutrophication, long term strategies. Sewage pollution: Sewage hazards and potential, sewage management, recycling and impediment to recycling. Hazardous chemical pollution: Nature and chemical risks, pollution sources and control. Major atmospheric changes: Acid deposition, Global warming/cooling, Green house effect, Ozone depletion. Solid wastes (trash): Landfills, combustion, solutions and management. Energy resources (Fuel of production and development): energy sources and uses, fossil fuel, alternate fossil fuel; Nuclear Power, promises and problems, sustainable energy option, solar and other renewable energy sources. Environmental issues of Pakistan: Ecological issues (Soil erosion, deforestation, issues related to irrigated system, natural hazards), issues related to conservation of habitat and biodiversity (major threats to biodiversity in Pakistan, conservation strategy), pollution and industrial resources (water issues, air issues, soil issues, mineral resources issues, energy issues, food, population issues and socio-economic issues.

**Practicals**

Review, reports, field trips, discussions on current local, national, regional and global issues. Approaches and strategies, mitigation measures.

**Recommended Books**

1. Botkin, D.B. and Keller, E.A. 2008. Environmental science (Earth as a living planet). 3rd Ed. John Wiley and Sons Inc. N.Y, USA.
2. Ahmad, R.Z. 2000. Pakistan-A-descriptive Atlas (A comprehensive geopolitics Course). 1st Ed. Ferozsons Pvt. Ltd. Lahore Pakistan.
3. Nebel, B.J. and Wright, R.t. 1998. Environmental Sciences (the way the world works). 1st Ed. Prentice Hall International Inc. London, UK.
4. Gaston, K.J. and Spicer, J.I. 1998. ‘Biodiversity (An Introduction), 1st Ed. Blackwell Science Ltd. UK.
5. Brandbury, I.K. 1998. The Biosphere. 2nd Ed. John Wiley and Sons Inc. UK.
6. Mckinny, M.L. and Schoch, R.M 1998. Environmental Science (systems and solutions). Jones and Artlett Publications Inc. USA.
7. Emiliani, C. 1997. Planet Earth (Cosmology, geology and the evolution of life and environment). 3rd Ed. Cambridge. University Press, UK.
8. Khan, F.K. Geography of Pakistan Environment (Environment, People and economy). 1993. Oxford University Press, NY, USA.
9. Hussain, S.S. 1992. Pakistan Manual of Plant Ecology (A text book of plant ecology for degree students). National Book Foundation, Islamabad, Pakistan.
10. Daily news papers for current issues.

**ZOO-6809 FISH PHYSIOLOGY**

**Aims and Objectives**

The aim of this course is to provide sufficient knowledge about all physiological phenomena in fishes. The subject provides practicals information to obtain better growth by following physiological aspects during extensive or semi-intensive culture.

**Course Contents**

Food digestion and nutrition. blood circulation, respiration, excretion, reproduction, learning and memory. Ethyological analysis of fish behaviour. Biological rhythm and fish migration.

**Practicals**

Study of the different species of fish to acquire knowledge of the major feeding types with special emphasis on feeding adaptations and modification in the shape of the mouth. Study of adaptations for air breathing. Study of adaptation for air breathing among fishes and study of accuracy respiratory structure in fishes. Determination of O2 and NH3 in water.

**Recommended Books**

1. Lagler, K.F., (1977). Ichthyology.
2. Norman, J. R. and greenwood, P.H. (1975). A history of fishes.
3. Kestin, S. c. and Warris, P. D. (Edition). Kestin Farmed Fish Quality, 2002. Blackwell Science, Oxford, UK.
4. Saksena, D. N. Ichthyology: Recent Research Advances. 1999. Oscar Publications. India.

**ZOO-6810 HUMAN GENETICS**

**Aims and Objectives**

1. The concepts and mechanisms of inheritance pattern, chromosome and gene linkage and molecular basics of genetics.
2. Extend provision in knowledge of human genome
3. To study impact of human genes on health

**Course Contents**

Review of basic concepts of genetics. Compound heterozygote, Multiple alleles. Dominance and codominance. Penetrance and expressivity. Allelic heterogeneity. Locus heterogeneity. Human genes nomenclature. Simple Autosomal inheritance. Lethal genes. Chromosomal abnormalities. Linkage and crossing over. Variation in the expression of the genes. The study of twins as a special method of genetic inference.Human genome project; inherited human diseases single gene diseases, Polygenic/multifactorial disease. Organisation of the human genome. Human genetics methodology: Pedigree analysis. Autosomal recessive diseases in population. Hardy-Weinberg equilibrium. Gene frequencies. Heterozygotic advantage and gene frequency in population. Autosomal dominant inheritance. Molecular basis of dominant inheritance. Sex linked inheritance. Hollandric inheritance. Linkage analysis. VNTR sequences and DNA fingerprinting. Structure and function of telomeric DNA. Interspersed repetitive DNA (SINE and LINES). Human genome polymorphism. Structure of human genes. Morphology of human chromosomes. Sex chromosomes organization. Classification of genes present on sex chromosomes. Molecular basis of sex determination. Structure and inheritance of mitochondrial DNA. Mitochondrial diseases. Mitochondrial DNA as a tool to study human origin.

**Practicals**

Pedigree analysis. Ability to test PTC. Human chromosomes (slides). Study of inheritance of some human characteristic- hair color, eye color and tongue rolling. Demonstration of various Cytogenetic techniques, Karyotyping and Banding, DNA extraction and sequencing.

**Recommended Books**

1. Stern C. (1949). The principle of human genetics, Freeman, San Fransisco.
2. Levitan and Montagu. Text book of human genetics, Oxford University Press.
3. Harris. Human’s, Biochemical genetics, Cambridge University Press.
4. Sutton E.H. (1964). Genes enzymes and inherited diseases, Holt Rinehart and Winston.
5. Tom Strachan and Andrew P. Read (2004). Human Molecular Genetics, Garland Science.
6. Willam S. Klug, Michael R. Cummings and Charlotte Spencer (2006). Concepts of genetics. Pearson education, Inc.

**ZOO-6811 ICHTHYOLOGY (FISH MORPHOLOGY)**

**Aims and Objectives**

The purpose ofthis course is to provide students with a thorough introduction to fundamental ichthyology with emphasis on aspects of fish anatomy, biology and form and function.

**Course Contents**

Basic Morphology, Systematic, Zoogeography of fin fishes, shell fishes and crustaceans with special references to Pakistan. Brief survey of world fisheries and non-fish resources. Fishing Technology, fish preservation, Shelf life of fisheries of various types.

**Practicals**

Collection and identification of local fishes (fin fishes and shell fishes) and study of anatomy of selected fishes.

**Recommended Books**

1. Lagler, K.F. (1977). Ichthylogy.
2. Norman, J.R. and Green wood, P.H. (1975). A history of fishes.
3. Kestin, S. C. and Warris, P. D. (Edition). Kestin Farmed Fish Quality, 2002. Blackwell Science, Oxford, UK.
4. Huet M. Text Book of Fish Culture: Breeding And Cultivation. 1973. Blackwell Publishing Company.

**ZOO-6812 LIMNOLOGY-B**

**Aims and Objectives**

Limnology is the study of inland waters – lakes (both freshwater and saline), reservoirs, rivers, streams, wetlands, and groundwater – as ecological systems interacting with their drainage basins and the atmosphere. The limnological discipline integrates the functional relationships of growth, adaptation, nutrient cycles, and biological productivity with species composition, and describes and evaluates how physical, chemical, and biological environments regulate these relationships.

**Course Contents**

Dynamics of lotic and lentic series, Organisms in lotic and lentic environments, Influence of physical and chemical conditions on biota and their adaptations to physical and chemical conditions, Bacteria and other fungi, Nektons, Biological productivity.

**Practicals**

Collection, preservation and study of fauna and flora of various approachable water bodies; preparation of slides of microfauna and flora, identification, study of adaptive characteristics of animals and plants.

**Recommended Books**

1. Agrawal, S.C. 1999. Limnology. A.P.H. Publishing Corporation, N. Dehli.
2. Goldman, C.R. and Home, A.J. 1983. Limnology, McGraw Hill, International Book.
3. Welch, P.S. 1968. Limnology 8th Edition, McGraw Hill Book Co.l Inc., New York.
4. Singh, H.R. Advances in Limnology. Narendra. Publishing House, N. Delhi.
5. Allen S.E. 1990. Chemical Analysis of Ecological Materials. Scientific Publishers, London.

**ZOO-6813 MAMMALOGY**

**Aims and Objectives**

The purpose of this course is to acquaint students with the origin, evolution, identification, characteristics, systematics, life history, and adaptive strategies of the Mammalia and to expose them to field techniques used in their study.

**Course Contents**

Classification of mammals (including Mesozoic mammals: Triconodonts, Symmetrodonts, Multituberculates, Docodonts and pantotheres); Mammalian characteristics; The Monotremes, Marsupials and Placental mammals; Specialization of Mammalian teeth; Mammalian molar and its origin (Trituberular Theory); Distribution, Dispersal; Territory and Territoriality; Classification of mammals according to their diet; Food and food storage in mammals; Hibernation and Aestivation; Defense and Protection; Movement in mammals (running, leaping, fossorial, swimming, arboreal, flying and gliding mammals); Origin and evolution of mammals.

**Practicals**

1. General survey and classification up to species of important mammals
2. Skeleton of Mongoose or Cat, Hedgehog and Rabbit.

**Recommended Books**

1. Terry, A. Vaughan, J.M. Ryan and N.J. Czaplewski, 2009. Mammalogy 5th Ed. Jones and Bartlett Publishers.
2. F. Harvey, Pough, Christine, M. Janis, John, B. Heiser. Vertebrate Life. 2003. Pearson Education.
3. Hickman, Roberts, and Larsen, 2005, Integrated principles of Zoology (13th Edition). McGraw Hill, New York.
4. David, D., 1963. Principles of Mammalogy.
5. Davis. Principles of Mammalogy.
6. Gelder, Biology of Mammals.
7. Miller and Harley, 1999. Zoology (8th Edition).
8. Hickman, Roberts, and Larsen, 2001. Integrated Principles of Zoology (11th Edition).

**ZOO-6814 MEDICAL MICROBIOLOGY**

**Aims and Objectives**

Aims of this course are to let the students know about the science of microbiology, to work with microorganisms, their pathogenecity, and various diseases and problems caused by microorganisms. The course may also initiate their interest in agricultural, industrial and/or environmental microbiology. The course will enable the students to identify specific areas in practical life where the science of microbiology is being applied. Thus they can seek different job in various organizations such as clinical, industrial and environmental microbiology sections.

**Course Contents**

Morphology and fine structure of bacteria: Size, shape and arrangement of bacterial cells, Flagella and motility, Pili, Capsules, sheaths and stalks, structure and chemical composition of cell wall, cytoplasmic membrane, the cytoplasm, nuclear material. Microbiology and Medicine, antimicrobial agents, mode of action. Bacterial pathogenicity, sources and spread of the infections in the community. Immunological principles, antigen, antibodies and antigen-antibody reactions. Bacterial pathogens and associated diseases. *Staphylococcu*s, skin and wound infections. *Streptococcus*, sore throat, scarlet fever, glomeruonephritis. *Pneumococcus*, respiratory infections*. Corynebacterium*. *DiphtheriaeMycobacterium tuberculosis*: Pulmonary and other tuberculosis infections. .*Actinomyces. Neisseria meningitis*, Gonorrhea, *Salmonella, Shigella ,Escherichia coli, Klebsiella proteus, Providenica, Bacillus anthracis. Clostridium tetnai*. Pox viruses, Herpes viruses. Herpes simplex. Cytomegalovirus infections. Adenoviruses. Influenza viruses. Hepatitis viruses. Arbovirsus, Rickettsia, Pahtogenic. Fungi and Protozoa.

**Practicals**

Basic techniques.( Staining of microorganisms: Simple stains, positive staining; negative staining. Demonstration of special structures by stains: Spore stain, Flagella stain. Differential stains: Gram stain, Metachromatic Granule stain, Acid fast stain. Culturing of microorganisms: Preparation and sterilization of culture media, agar slope, agar slab, streak plates, pour plates methods. Isolation of a bacterial culture. Quantitative plating methods) Widal test. Laboratory diagnosis and control of infections: Streptococcus. Corynebacterium, Listeria, Mycobacterium. The Entero bacteriaceae: Salmonella. Escherichia, Klebsiella and Clostridium. Blood tests: TLC, DLC, RBC.

**Recommended Books**

1. [Kenneth Ryan](http://www.mhprofessional.com/contributor.php?id=47543), [C. George Ray](http://www.mhprofessional.com/contributor.php?id=49896), [Nafees Ahmad](http://www.mhprofessional.com/contributor.php?id=37479), [W. Lawrence Drew](http://www.mhprofessional.com/contributor.php?id=42933), [James Plorde](http://www.mhprofessional.com/contributor.php?id=47661). (2010).Sherris Medical Microbiology, Fifth Edition. McGraw Hill Publishers, Washington DC
2. Patrick R. Murry, Ken S. Rosenthal, Michael A. Pfaller: [Medical Microbiology](http://www.intl.elsevierhealth.com/catalogue/title.cfm?ISBN=0323033032)**,** 5th edition, Philadelphia: Elsevier/Mosby, 2005.
3. P.K. Murray, Ph.D., K.S. Rosenthal, Ph.D., G.S. Kobayashi, Ph.D., and M.A. Pfaller, MD, 4th Edition, Mosby, Inc. 2002. ISBN #0323012132
4. Sherris medical microbiology: an introduction to infectious diseases  
   C. George Ray, Editor; McGraw-Hill/Appleton and Lange 5th edition, McGraw-Hill/Appleton and Lange, 2003. ISBN#0838585299
5. Microbial Applications (Complete Version) Laboratory Manual In General Microbiology, 1994. Benson, H.J. WMC Brown Publishers, England.
6. Microbiology, 1986. Pelczar Jr., Chan, E.C.S. and Krieg, M.R. McGraw Hill, London.
7. Brock Biology Of Microorganisms, 1997. Madigan, M.T., Martinko, J.M. and Parker, J. Prentice-Hall, London.
8. Cruickshank, R, Duguid, J.P., Hermion, B.P. and Swain, R.H.A., (2003). Medical Microbiology. Churchill Livingstone, N.Y.
9. The Microbial World, 1986. Stainier, R.Y., Ingraham, J.L., Wheelis, M.L. and Painter, R.R. Prentice Hall, London.
10. Foundations in Microbiology. (1998). Talaro and Talaro. WCB Publishers, New York.
11. Microbiology: A Human Perspective, 2001. Eugene W. Nester, Denise, G., Anderson, Martha, T., Nester, C., Evans Roberts, Nancy, N. McGraw Hill Higher Education.
12. Microbiology Principles and Explorations, 2001. Jacquelyn, G.G. Wiley John and Sons Inc.

**ZOO-6815 MEDICAL PARASITOLOGY**

**Aim and Objectives**

To provide an overview of the major parasitic diseases of man and their vectors prevalent in Pakistan. By the end of these course students should be able to:

1. demonstrate understanding of the biology and the life cycles of the major parasites and of their vectors or intermediate hosts;
2. identify the major parasites, vectors and intermediate hosts;
3. demonstrate understanding of the pathogenesis and pathology of the major parasitic diseases and the immune responses to these parasites;
4. appreciate the epidemiology of the major parasitic infections;
5. appreciate methods available for chemotherapy and control.

**Course Contents**

Systematic, biology, pathology, host parasite relationships. Study of parasites belonging to phyla: Protozoa, Platyhelminthes, Nematoda, Annelida and Arthropoda. Study of parasitic diseases in animals and humans and their control.

**Practicals**

Methods of collection, preservation and transportation of parasitic material. Isolation of these parasites from different sources and their identification. Identification of insects of medical and veterinary importance.

**Recommended Books**

1. Noble and Noble, 1982. Parasitology. The Biology of Animal Parasites. 5th edition. Lea and Febiger.
2. Beck, J.W. and Davies, J.E., 1981. Medical Parasitology. 3rd edition. The C.V. Mosby Company, Toronto, London.
3. Cheesbrough, M. 1987. Medical Laboratory Manual for Tropical Medicine. Vol. I. University Press Cambridge.
4. Smith, J.D., 1998. Introduction to Animal Parsitology. Cambridge University Press.
5. Roberts, L.S. and Janovy, J.Jr., 2001. Foundations of Parasitology. 5th Edition. Wm Brown Publishers, Chicago, London, Tokyo, Toronto.
6. Urquhart, G.M., Hucan, J.L., Dunn, A.M. and Jennings, F.W., 2000. Veterinary Parasitlogy Longman Scientific and Technical publications, Longman Group, U.K.

### **MOLECULAR PHYSIOLOGY**

**Course Code: zoo-6816 Credit Hours: 3(2-1)**

**Course Objectives:**

**Knowledge**

At the end of the course the student will be able to:

1. Understand on the molecular and cellular mechanisms of physiological function as the basis of unity in diverse animals e.g. membrane excitability, exchange of respiratory gases, removal of nitrogenous wastes tissue, osmotic and organ physiological mechanisms underlying animal homeostasis and temperature effects.
2. Grasp the development of performing the function developed at molecular and cellular level in the complexity of the animals such as chemical & nervous integration, respiratory and excretory functions.
3. Know the strategy acquired to perform the functions in diverse environment such as in dry & aquatic and cold and hot at molecular and cellular level and regulations to achieve strategy by chemical and nervous regulation at organ levels.
4. Comprehend the concepts in homeostasis and integration in sustaining the life in constantly changing conditions.

**Skills:**

At the end of the course the student will be able to:

1. Perform experiments designed either primarily for the study of physiological phenomena or for assessment of function.
2. Analyze and interpret experimental/investigative data critically in performance of functions in changed conditions.
3. Distinguish between normal and failure of the function in abnormal conditions even through results of experiments/data collections also by the students in laboratory and fields.

**Course Learning Outcomes:**

Following the completion of this course, each student should have:

1. An understanding of critical concepts, processes, and factual information in the performance of functions and changing conditions.
2. A knowledge of resources for finding the solution for strategies to sustain diverse forms of animal life kept and in wild in normal and abnormal conditions.
3. The ability to utilize knowledge of animal physiology in critical study and for making intelligent decisions in professional life.

***Theory:***

**Concept of Physiology**

1. Principles of Homeostasis and conformity
2. Principles of regulation and adaptation

**Membrane Physiology:**

1. Ionic distribution across membrane
2. Resting membrane potentials: Electrogenic ion pump, Donnan equilibrium, Ion channels.

**Nerve and Muscle Physiology:**

1. Action potentials in neurons
2. Electrical and chemical synaptic transmission
3. Neurotransmitters in communications
4. Receptors of neurotransmitters in diverse physiological responses
5. Excitatory and inhibitory postsynaptic potentials
6. Neuronal networks and their role in nervous integration
7. Muscles: Structure, types, components, muscle proteins
8. Molecular basis of muscle contraction
9. Sarcoplasmic reticulum and role of calcium
10. Neuromuscular interaction at cell and molecular level muscle
11. Types of muscle contractions and muscle fatigue.

**Endocrine Physiology**:

1. Hormones of invertebrates and specifically of arthropods for the functions in their modes of life.
2. Hormones of various vertebrates’ endocrine organs and comparison of their roles in adaptability of mode of life.
3. Mechanisms of hormone actions, hormone receptors, signal transduction and hormonal coordination.

**Respiratory Physiology**:

1. Mechanism of respiratory gases exchange in aquatic and terrestrial respiratory structures.
2. Control of respiration and stimulus factors in various animals.
3. Respiration adaptations in hypoxia and percapnia etc.
4. Air breathing and respiratory adaptations diver animals.

**Excretory Physiology**:

1. Strategy of mammalian large glomerular filtration and reabsorption in nitrogenous excretion.
2. Patterns of nitrogenous excretion in various animals and their phylogenetic significance.

**Physiology of Nutrition**:

1. Adaptation of nutritive canal for digestion and absorption of nutrients in different animals specifically the vertebrates.
2. Regulation of digestive secretions.
3. Mechanisms of of water, ions and nutrients absorptions and their significances in diverse groups.
4. Potential and Movements in gastrointestinal tract and control of motility.

**Practicals:**

**Nerve and Muscle**

1. Study of post synaptic receptor mechanisms in neuromuscular preparation of frogs.
2. Study of excitable and contractile properties of a nerve-muscle preparation.
3. Ultrastructure study of muscle structure for muscle contraction.

**Respiration andcirculation**

1. Respiratory function and oxygen consumption in acidosis and alkalosis in mouse.

**Hormones System:**

1. Video studies on the effects of hormones in breeding season behaviours of various behaviours.
2. Study through clinics data on the insulin and glycemia in type1 and type 2 diabetic subjects.

**Text/Reference Books:**

1. [**PrinciplesofAnimalPhysiologyT**](https://www.abebooks.com/servlet/BookDetailsPL?bi=17255082788)**hird Edition**

Moyes, Christopher D.^Schulte, Patricia M. **Publisher:** Pearson; 3 edition, 2015.

1. **Eckert Animal Physiology Fifth Edition**

David Randall, Warren Burggren, Kathleen French W. H. Freeman; 2001.

1. **Animal Physiology: From Genes to Organisms 2nd Edition**Lauralee Sherwood, HillarKlandorf, Paul Yancey Brooks Cole; 2012.
2. **Animal Physiology 4th Edition**

Richard W. Hill, Gordon A. Wyse, Margaret Anderson Sinauer Associates, Oxford University Press, 2016

**ZOO-6818 Principles of Ornithology**

**Aims and Objectives**

The course provides the knowledge about the general characteristics, classification, behaviour, evolution and geographical distribution. It also provides knowledge to understand the basic physiological adoptations of birds with refernce to differnt environmental condition.

**Course Contents**

Introduction, evolution, geographical distribution and classification. Characteristics of birds, external features, identification of sex and age, reproduction and development, behaviour (migration, territoriality), populations and their regulation. Anatomical, physiological adaptations to their environment, reproductive strategies, food/feed, communication (vocal, behavioural). Anatomy and physiology of game and predatory species. Birds of Pakistan: Aquatic, Forest, Game birds and birds of prey. Birds as pests.

**Practicals**

1. Visit of PMNH for study of preserved specimens of different groups of birds in relation to their taxonomy and ecosystem etc.
2. Field visits for bird watching (population estimation, nesting, vocal calls, feeding and other behaviours etc.) in different ecologies in the vicinity of Muzaffarabad areas.
3. Visit to zoos and wildlife parks.

**Recommended Books**

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 and Co.
6. Handbook of Bird Biology by Cornell Lab of Ornithology. Princeton University Press. New Jersey. 2004.
7. 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.
8. [Noble S. Proctor](http://search.barnesandnoble.com/booksearch/results.asp?ATH=Noble+S%2E+Proctor), [Patrick Lynch](http://search.barnesandnoble.com/booksearch/results.asp?ATH=Patrick+Lynch), [Patrick J. Lynch](http://search.barnesandnoble.com/booksearch/results.asp?ATH=Patrick+J%2E+Lynch), [Patrick J. Lynch](http://search.barnesandnoble.com/booksearch/results.asp?ATH=Patrick+J%2E+Lynch) (1998). Manual of Ornithology: Avian Structure and Function. Yale University Press.
9. Audubon Handbook: How to Identify Birds? 88th ed. Mcgraw-Hill Publishing Company.
10. Roberts, T.J. 1992. Birds of Pakistan. Vol 1and 2. Oxford University Press.

**ZOO-6819 VECTOR BIOLOGY**

**Aims and Objectives**

The course aims to provide students with a broad understanding of the key aspects of insect vector behaviour, vector ecology and vector-parasite interactions relevant to the epidemiology and control of vector-borne diseases.

**Course Contents**

Detailed studies of systematic, Biology and ecology of some vectors of medical importance (order Diptera) Mosquitoes: Anopheles mosquitoes, culicine mosquitoes, Black flies, Sand flies, biting midges, horse flies, deer flies and clegs, tsetse flies, house flies, myiasia producing flies, (blow flies, blue bottles, green bottles, flesh flies, warble flies and bot flies). The study will cover following aspects: Morphology, anatomy, distribution, breeding habits, life-cycle, pathogenesis and seasonal prevalence of the species. Brief account of diseases spread by these vectors, methods of control, modern trends in their biological and chemical control.

**Practicals**

Methods of identification; Dissection of selected vectors i.e. mosquito, house flies, blue bottles, green bottles and bot flies. Study of prepared slides of parasites. Epidemiological studies of Vector born diseases (one e.g. malaria) including field studies of control methods and parasite evaluation.

**Recommended Books**

1. William A. Riley. Medical Entomology. McGraw Hill Book Co. Inc. London.
2. McDonald, G. The Epidemiology and Control of Malaria, London Oxford Press.
3. World Health Organization. Vector Control Series, Training and information guide. The House fly.
4. World Health Importance Geneva, WHO, 1988.
5. Walker, A. 1998. Arthropods of human and domestic animals. A guide to preliminary identification. Chapman and Hall.
6. Service, M.W. 1980. A guide to medical entomology. The McMillan Company, New York.
7. Herms, W.B. and James, M.T. 1960. Medical entomology. The McMillan Company, New York.

**ZOO-6820 VERTEBRATA**

**Aims and Objectives**

The course provides knowledge and understanding about the classification, characteristics and physiological adoptation of different vertebrate animal groups, emphasizing their phylogenetic relationships.

**Course Contents**

Protochordates; Characteristics of vertebrates; Classification of vertebrates up to orders with examples, excluding Fossils except Archaeopteryx. Comparative vertebrates morphogenesis: Egg type, Cleavage, Blastula, Gastrulation, detailed account with support from Spemann’s experiments. Comparative Anatomy and function of integumentary skeletal (General details such as structure of bones, cartilage, limb, evolution of limbs, digestive, circulatory, respiratory, excretory and nervous (including sense organs) system.

**Practicals**

1. Museum study: Identification of common vertebrates and lower chordates.
2. Examination of the following prepared Slides
3. whole mount of Amphioxus sp. T.S. Amphioxus through different regions. Pharynx of an ascidians . Sections of skin of fish, frog and rabbit. Section of mammalian liver, kidney, spleen, thyroid gland, testes, ovary, heart muscle, pancreas, nerve card, lungs and Intestine etc. Whole mounts and histological sections of different developmental stages of chick.

**Recommended Books**

1. Kent, G.C. Comparative Anatomy of the Vertebrates .Mosby Company.
2. Hashmi, T. H. and Bhatti, H.K. Chordate Zoology. Carvan book house Lahore.
3. Romer, A.S. (1962). The Vertebrate Body. W. B. Saunders Company, Philadelipha.

**ZOO-6821 WILDLIFE**

**Aims and Objectives**

The goals of this course are to familiarize students with the field of wildlife ecology and management with special reference to Pakistan and AJK by: (1) exploring the ecological processes affecting wildlife, and (2) discussing various national and international measures and challenges in conserving wildlife.

**Course Contents**

Introduction to wildlife, Wildlife of Pakistan, Identification, classification, distribution, and conservation status of birds and mammals of major importance in Pakistan and AJK. Introduction to major wildlife habitats in Pakistan/AJK. Philosophy and significance of wildlife conservation. Conservation of wildlife- insito and exsito conservation approaches. Wildlife management in Pakistan/AJK. Wildlife rules and regulations in Pakistan/AJK. National and International agencies involved in conservation and management of wildlife. Introduction to some modern techniques (Radio telemetry, remote camera, TIR, GPS, GIS, RS, molecular analysis) used in wildlife conservation. IUCN protected areas categories, Protected areas (Sanctuaries, Game Reserves and National Parks) in Pakistan/ AJK. Human-wildlife conflict and its mitigation.

**Practicals**

1. Study of museum specimens and their classification (Birds and Mammals)
2. Demonstration of distribution of avian and mammalian fauna of Pakistan. (Blank maps may be provided).
3. Study of Birds and mammals censing techniques.
4. Use of GPS in field studies.
5. Visit of Zoos and protected areas

**Recommended Books**

1. Roberts, T.J. (1997). Mammals of Pakistan. Oxford University Press, Karachi.
2. Bailey, J.A., 1986. Principles of Wildlife Management, John Wiley.
3. Gaston, G. and J. Spicer. 2007. Biodiversity. Blackwell Publishing and Co. London, UK.
4. Grimmett, R. Inskipp, C. and Inskipp, T., 2001, Birds of the Indian Sub-Continent. Helm.
5. Grimmett, R. Roberts, T. J and Inskipp, T. 2008. Birds of Pakistan. Helm Field Guide.
6. Hickman, Roberts, and Larsen, 2003. Animal Diversity (3rd Edition).McGraw Hill, New York.
7. Hickman, Roberts, and Larsen, 2008. Integrated principles of Zoology (12th Edition).McGraw Hill, New York.
8. Jordan, E. L. and Verma, P. S. 2011.Invertebrate Zoology, S. Chand and Company.
9. M.S. Khan. 2006. Amphibians and Reptiles of Pakistan. Krieger Publishing Company, Florida USA.
10. M. M. Shafique, 2005. Wildlife Acts and Rules of Pakistan. PFI, Peshawar.
11. Miller and Harly, 2007. Zoology (7th Edition). McGraw Hill, New York.
12. Mirza . Z. B. 1998. Illustrated handbook of Animal Biodiversity of Pakistan. Printopak.
13. Mitsch, W. J. and Gosselink, J. G. 2007. Wetlands 8th ed. John Wiley and Sons, Inc.
14. AJK Wildlife Preservation Act 1975. Government of AJK, 2006.
15. Roberts, T. J. 1991. Birds of Pakistan. Vol. I Oxford University Press
16. Roberts, T. J. 1992. Birds of Pakistan. Vol. II. Oxford University Press
17. Roberts, T. J. 2005. Field Guide to the large and Medium-sized Mammals of Pakistan. Oxford University Press
18. Roberts, T. J. 2005. Field Guide to the small Mammals of Pakistan. Oxford University Press.
19. Robinson, W.L. and Bolen, E.G., 1988. Wildlife Ecology and Management. McMillan, Cambridge.