

CURRICULUM

OF

**ZOOLOGY
BS/MS**

(Revised 2013)



**HIGHER EDUCATION COMMISSION
ISLAMABAD**

CURRICULUM DIVISION, HEC

Prof. Dr. Mukhtar Ahmed

Mr. Fida Hussain

Mr. Rizwan Shoukat

Mr. Abid Wahab

Mr. Riaz-ul-Haque

Executive Director

Director General (Acad)

Deputy Director (Curr)

Assistant Director (Curr)

Assistant Director (Curr)

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PREFACE

The curriculum, with varying definitions, is said to be a plan of the teaching-learning process that students of an academic programme are required to undergo. It includes objectives & learning outcomes, course contents, scheme of studies, teaching methodologies and methods of assessment of learning. Since knowledge in all disciplines and fields is expanding at a fast pace and new disciplines are also emerging; it is imperative that curricula be developed and revised accordingly.

University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII vide Section 3, Sub-Section 2 (ii), Act of Parliament No. X of 1976 titled “**Supervision of Curricula and Textbooks and Maintenance of Standard of Education**”. With the repeal of UGC Act, the same function was assigned to the Higher Education Commission (HEC) under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

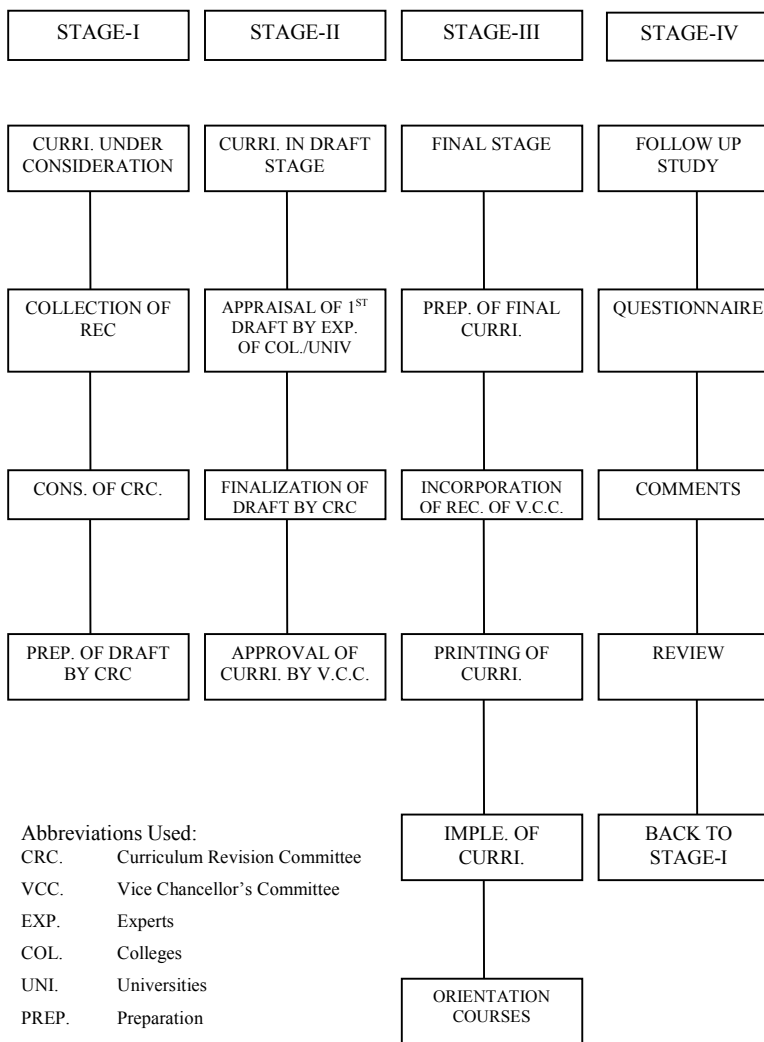
In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities, R&D organizations, councils, industry and civil society by seeking nominations from their organizations.

In order to impart quality education which is at par with international standards, HEC NCRCs have developed unified templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering in 2007 and 2009.

It is hoped that this curriculum document, prepared by the respective NCRC's, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC (www.hec.gov.pk).

(Fida Hussain)
Director General (Academics)

CURRICULUM DEVELOPMENT PROCESS



**MINUTES OF THE FINAL MEETING OF NCRC IN THE
DISCIPLINE OF ZOOLOGY HELD ON APRIL 8-10, 2013 AT
HEC REGIONAL CENTRE, PESHAWAR**

The final meeting of National Curriculum Revision Committee in the discipline of Zoology was held on April 8-10, 2013 at Higher Education Commission, Regional Centre, Peshawar. The purpose of the meeting was to finalize the curriculum of Zoology reviewed by NCRC in its preliminary meeting held on November 14-16, 2012 at the same venue. The following members attended the meeting:

1. **Prof. Dr. Kausar J. Cheema,** **Convener**
Dean, Faculty of Natural Sciences,
Department of Zoology,
Lahore College for Women University,
Lahore.
2. **Prof. Dr. Naureen Aziz Qureshi,** **Member**
Chairperson / Dean,
Department of Wildlife & Fisheries,
Government College University,
Faisalabad.
3. **Prof. Dr. Muhammad Arshad,** **Member**
Professor & Chairperson,
Department of Biological Sciences,
University of Sargodha, Sargodha.
4. **Prof. Dr. Mazhar Qayyum** **Member**
Professor & Chairman,
Department of Zoology,
PMAS-Arid Agriculture University,
Rawalpindi.
5. **Prof. Dr. Nasreen Memon,** **Member**
Professor & Chairman,
Department of Zoology,
University of Sindh, Jamshoro.
6. **Prof. Dr. Javed Iqbal Qazi,** **Member**
Professor,
Department of Zoology,
University of the Punjab, Lahore.
7. **Prof. Dr. Syed Akram Shah,** **Member**
Professor,
Department of Zoology,
University of Peshawar, Peshawar.
8. **Dr. Muhammad Iqbal Yasinzai,** **Member**
Associate Professor,
Department of Zoology,
University of Balochistan, Quetta.

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|-----|--|-------------------------|
| 9. | Dr. Ali Muhammad Yousafzai,
Associate Professor & Chairman,
Department of Zoology,
Islamia College University, Peshawar. | Member |
| 10. | Dr. Saleema Bashir,
Associate Professor
Department of Zoology,
Kinnaird College for Women, Lahore. | Member |
| 11. | Dr. Jabbar Khan,
Assistant Professor,
Department of Biological Sciences,
Gomal University, D.I. Khan. | Member |
| 12. | Dr. Saima Nasir,
Senior Research Officer,
Research and Evaluation Section,
Pakistan Council for Science and
Technology, Islamabad | Member |
| 13. | Dr. Waseem Ahmad Gillani,
Principal Scientific Officer,
Insert Pest Management Programme,
National Agriculture Research Centre,
Islamabad | Member |
| 14. | Dr. Abdul Mateen,
Assistant Professor,
Lecturer
Department of Zoology and Fisheries,
University of Agriculture, Faisalabad. | Member |
| 15. | Mr. Tahir Iqbal,
Lecturer,
Department of Zoology,
University of Gujrat, Gujrat. | Member |
| 16. | Mr. Usman Ali,
Junior Lecturer
Department of Zoology,
Mirpur University of Science &
Technology, Main Campus, AJK | Member |
| 17. | Dr. Irfan Zia Qureshi,
Associate Professor & Chairman,
Department of Zoology,
Quaid-i-Azam University, Islamabad.. | Member/Secretary |
| 2. | The following members could not attend the meeting due to other engagements: | |
| | Prof. Dr. Nusrat jahan,
Professor & Chairperson,
Department of Zoology,
Government College University, Lahore | |

Prof. Dr. Asmatullah Kakar,
Professor & Chairman,
Department of Zoology,
University of Balochistan, Quetta.

Dr. Abdul Manan Shaikh,
Assistant Professor
Department of Zoology
Shah Abdul Latif University, Khairpur

Dr. Saleem M. Rana,
Assistant Professor,
Department of Medical Entomology and Disease
Vector Control, Health Services Academy
Faculty of Medicine, QAU, Islamabad

Dr. Muhammad Irfan Khan
Professor/Chairman/Dean
Department of Environmental Science
International Islamic University, Islamabad

Dr. Nasira Khaton,
Professor
Department of Zoology
University of Karachi, Karachi

Dr. Khalid Z. Rasib,
Associate Professor
Department of Biological Science
Forman Christian College, Ferozpur Road, Lahore

3. The meeting started with the recitation of Holy Verses from the Holy Quran by Mr. Farrukh Raza, Assistant Director (Curriculum), HEC, followed by welcome address by Mr. Farman Ullah Anjum, D.G. (Acad.), HEC. After brief introduction of the participants, the D.G. (Acad.), explained the aims and objectives of the meeting with particular focus on finalizing the curriculum so as to bring it in line with the international standards keeping in view the national needs. The D.G. (Acad.) then requested the Convener and Secretary of NCRC viz. **Prof. Dr. Kausar J. Cheema**, Dean, Faculty of Natural Sciences, Lahore College for Women University, Lahore and **Dr. Irfan zia Qureshi**, Associate Professor & Chairman, Department of Animal Sciences, Quaid-i-Azam University, Islamabad, to conduct the formal proceedings of the meeting for three days.

4. The Convener and Secretary of NCRC thanked the D.G. (Acad.), HEC, and appreciated the endeavors of HEC for providing an opportunity to review / finalize the curriculum of Zoology. The Convener recalled the proceedings of the preliminary meeting and requested the participants to

give their suggestions/inputs for the improvement of the curriculum and opened the house for discussion. After thorough and detailed deliberations during three days, the Committee unanimously approved the curriculum of Zoology for BS, MS/MPhil and made the recommendations **as Annexed**.

5. The Convener of the Committee thanked all the Members for sparing their valuable time and quality contribution towards finalizing the curriculum. The Committee highly admired the efforts made by the officials of HEC for making excellent arrangements to facilitate the smooth work by the Committee and their comfortable accommodation/stay at Peshawar.

6. The meeting ended with the vote of thanks to the Chair as well as participants of the meeting.

BS (4 YEARS) ZOOLOGY PROGRAM

INTRODUCTION

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

Eligibility Criteria: FSc Pre Medical/ A level.

Objectives and Outcomes

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.

Career Opportunities

After obtaining the BS degree in Zoology, the graduates will be able to get jobs in wide range of professions including:

Positions in various government and non-governmental organizations, teaching and research, administration and management, forestry, pharmaceutical, agriculture, biological control program, integrated pest management, poultry, wildlife, aqua culture, fisheries, livestock and other areas.

Pedagogy (Teaching - Learning Methodologies)

1. The courses will be delivered through lectures, seminars, practicals, discussions and field trips.
2. Teaching learning material will include text-books, reference books journals/periodicals, handouts and internet.
3. Using audio/ visual aids i.e., slides/ overhead transparencies / multimedia.

Assessment and Evaluation

Internal evaluation (left to the individual universities)

Midterm test

Seminars and Assignments

Final Examination

LAYOUT FOR BS ZOOLOGY (4 YEAR PROGRAM)

Total number of Credit hours	(Flexible from 133-136)
Duration	4 years
Semester duration	16-18 weeks
Semesters	8
Course Load per Semester	15-18 Cr hr
Number of courses per semester	5-6

Compulsory Requirements (the student has no choice)		General Courses to be chosen from other departments		Discipline Specific Foundation Courses		Major courses including research project/ internship		Elective Courses within the major	
9 courses		7-8 courses		9-10 courses		11-13 courses		4 courses	
Subject	Cr . hr	Subject	Cr. Hr	Subject	Cr . hr	Subject	Cr . hr	Subject	Cr . hr
English-I	3	Bot-I	2+1	Principles of Animal Life-I	3+1	Cell & Molecular Biology	3+1	Elective-I****	2+1
English- II	3	Bot-II	2+1	Principles of Animal Life-II	3+1	Physiology	3+1	Elective-II****	2+1
English-III	3	Bot-III	2+1	Animal Diversity-I	3+1	Animal Behavior	2+1	Elective-III*****	2+1
English-IV* Univ Option	3	Chem-I	2+1	Animal Diversity-II	3+1	Developmental Biology	3+1	Elective-IV****	2+1
Pakistan Studies	2	Chem-II	2+1	Animal Form & Function-I	3+1	Genetics	3+1		
Islamic Studies/ Ethics	2	Chem-III	2+1	Animal Form & Function-II	3+1	Wildlife	2+0		
Mathematics-I	3	Bot-IV/ Chem-IV	2+1	General Biochemistry	3+1	Environmental Biology	3+0		
Biostatistics/ Univ Option	2+1	Geography/ Univ Option	2+0	Biological Techniques	1+2	Zoogeography & Paleontology	2+1		
Introduction to Computer	1+2			Evolution & Principles of Systematics	2+0	Special Paper**	3+1		

					Synopsis/ Research Methodology	2+0		
					Bioinformatics	1+2		
					Thesis/Research Project/Internship***	0+4		
		Note: Botany, Chemistry or any social science subjects Combination of any other related subject that exists in university as department.						
	25		23		34	41		12

* University has the option to recommend any other course in lieu of English IV

** Fisheries / Parasitology / Microbiology / Entomology / Immunology / Environmental Sciences / Marine Zoology / Endocrinology etc. (universities may offer any other special paper depending upon the availability of the expertise)

*** Research Project / Internship will be offered over two semesters and report be submitted at the end of semester VIII for the evaluation

**** All elective subjects should be selected to support the opted special paper

**FORMAT/SCHEME OF STUDIES FOR
4-YEAR INTEGRATED CURRICULA
FOR BS IN ZOOLOGY**

STRUCTURE

Sr. No.	Categories	No. of Courses	Credit Hours
1.	Compulsory Requirement (No Choice)	09	25
2.	General Courses to be chosen from other departments	08	23
3.	Discipline Specific Foundation Courses	09	34
4.	Major Courses including Research Project / Internship	12	41
5.	Electives within the Major	04	12
	Total	42	135

Total number of Credit hours	(Flexible from 133-136)
Duration	4 years
Semester duration	15-18 weeks
Semesters	8
Course Load per Semester	15-18 Cr hr
Number of courses per semester	5-6

**CURRICULUM BS 4 YEARS (8 SEMESTERS) PROGRAM
IN ZOOLOGY**

**YEAR-1
SEMESTER-I**

Course Category	Course Title	Credits
COMPULSORY-I	English-I: Functional English	3(3+0)
COMPULSORY-II	Pakistan Studies	2(2+0)
COMPULSORY-III	Mathematics-I	3(3+0)
GENERAL- I	Botany-I/ Etc.	3(2+1)
GENERAL- II	Chemistry-I/ Etc.	3(2+1)
FOUNDATION-I	Principles of Animal Life-I	4(3+1)
	Total Credits	18

SEMESTER-II

Course Category	Course Title	Credits
COMPULSORY-IV	English-II: Communication Skills	3(3+0)
COMPULSORY-V	Islamic Studies / Ethics	2(2+0)
COMPULSORY-VI	Biostatistics/Univ option	3(2+1)
GENERAL- III	Botany-II/ Etc.	3(2+1)
GENERAL- IV	Chemistry-II/ Etc.	3(2+1)
FOUNDATION-II	Principles of Animal Life-II	4(3+1)
	Total Credits	18

**YEAR-II
SEMESTER-III**

Course Category	Course Title	Credits
COMPULSORY-VII	English-III: Technical writing and presentation skills	3(3+0)
COMPULSORY-VIII	Introduction to Computer	3(1+2)
GENERAL- V	Botany-III/ Etc.	3(2+1)
GENERAL- VI	Chemistry-III/ Etc.	3(2+1)
FOUNDATION-III	Animal Diversity: Invertebrates	4(3+1)
	Total Credits	16

SEMESTER-IV

Course Category	Course Title	Credits
COMPULSORY-IX	English-IV / Univ. Option	3(3+0)
GENERAL- VII	Botany-IV/ Etc.	3(2+1)
FOUNDATION-IV	Animal Diversity: Chordates	4(3+1)
FOUNDATION-V	Animal Form & Function-I	4(3+1)
FOUNDATION-VI	Animal Form & Function-II	4(3+1)
	Total Credits	18

**YEAR-III
SEMESTER-V**

Course Category	Course Title	Credits
GENERAL-VIII	Psychology/Geography/Etc.	2(2+0)
FOUNDATION-VII	General Biochemistry	4(3+1)
MAJOR-I	Cell & Molecular Biology	4(3+1)
MAJOR-II	Physiology	4(3+1)
MAJOR-III	Animal Behavior	3(2+1)
	Total Credits	17

SEMESTER-VI

Course Category	Course Title	Credits
FOUNDATION-VIII	Biological Techniques	3(1+2)
FOUNDATION-IX	Evolution & Principles of Systematics	3(2+1)
MAJOR-IV	Developmental Biology	4(3+1)
MAJOR-V	Genetics	4(3+1)
MAJOR-VI	Wildlife	2(2+0)
	Total Credits	16

**YEAR-IV
SEMESTER-VII**

Course Category	Course Title	Credits
MAJOR-VII	Environmental Biology	4(3+1)
MAJOR-VIII	Zoogeography & Paleontology	3(2+1)
MAJOR-IX	Special Paper (Univ. Option)	4(3+1)
MAJOR-X	*Synopsis & Research Methodology	2(2+0)

ELECTIVE-I	Univ. Option	3(2+1)
	Total Credits	16

SEMESTER-VIII

Course Category	Course Title	Credits
MAJOR-XI	Bioinformatics	3(1+2)
MAJOR-XII	*Thesis/Research Project/Internship	4(0+4)
ELECTIVE-II	Univ. Option	3(2+1)
ELECTIVE-III	Univ. Option	3(2+1)
ELECTIVE-IV	Univ. Option	3(2+1)
	Total Credits	16

18+ 18+16+18+17+16+16+16=135

YEAR-I
SEMESTER- I

Course Category	Course Title	Credits
COMPULSORY-IV	English-II: Communication Skills	3(3+0)
COMPULSORY-V	Islamic Studies / Ethics	2(2+0)
COMPULSORY-VI	Biostatistics/Univ option	3(2+1)
GENERAL- III	Botany-II/ Etc.	3(2+1)
GENERAL- IV	Chemistry-II/ Etc.	3(2+1)
FOUNDATION-II	Principles of Animal Life-II	4(3+1)
	Total Credits	18

COMPULSORY-I

(ENGLISH-I: FUNCTIONAL ENGLISH)

Cr 3(3+0)

Objectives

The course aims to:

- Enhance language skills through grammar, phrases and sentence making.
- Develop skills for English writing and translation.
- Enhance listening and speaking skills for wider use.

Course Contents

Basics of Grammar: Parts of speech and use of articles, Sentence structure, Active and passive voice, Practice in unified sentence, Analysis of phrase, clause and sentence structure, Transitive and intransitive verb, Punctuation and spelling

Comprehension: Answers to questions on a given text

Discussion: General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

Listening: To be improved by showing documentaries/films carefully selected by subject teachers

Translation skills: Urdu to English

Paragraph writing: Topics to be chosen at the discretion of the teacher

Presentation skills: Introduction to presentations and deliberations

Note: Extensive reading is required for vocabulary building

Books Recommended

1. Thomson, A.J., Martinet, A.V. 1997. Practical English Grammar and Exercises 3rd Ed. Oxford University Press.

2. Boutin, M-C., Brinand, S., Grellet, F. 1993. Writing. Intermediate and Supplementary Skills. Oxford Fourth Impression
3. Tomlinson, B., Ellis, R. 1992. Reading. Upper Intermediate. Oxford Supplementary Skills. Third Impression.

COMPULSORY– II

(PAKISTAN STUDIES)

Cr 2(2+0)

Objectives

The course aims to:

- 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 Contents

Historical Perspective: Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad 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; 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. Zaidi A.S. 2000. Issue in Pakistan's Economy. Karachi: Oxford University Press.
2. Rafique A. M. 1998. Political Parties in Pakistan, Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research.
3. Safdar, M. 1994. Pakistan Political Roots & Development. Lahore.
4. Burke, S.M., Ziring L. 1993. Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press.
5. Noor ul Haq. 1993. Making of Pakistan: The Military Perspective. Islamabad: National Commission on Historical and Cultural Research.
6. Waseem, M. 1987. Pakistan Under Martial Law, Lahore: Vanguard.
7. Javed, B. S. 1980. State and Society in Pakistan. The Macmillan Press Ltd.
8. Lawrence, Z. 1980. Enigma of Political Development. Kent England: WmDawson & sons Ltd.

9. Ansar, Z. 1980. History & Culture of Sindh. Karachi: Royal Book Company.
10. Aziz, K.K. 1976. Party, Politics in Pakistan, Islamabad: National Commission on Historical and Cultural Research.
11. Wayne, W. 1972. The Emergence of Bangladesh., Washington: American Enterprise, Institute of Public Policy Research,.
12. Khalid Bin Sayeed. 1967. The Political System of Pakistan. Boston: Houghton Mifflin.
13. Safdar, M. Pakistan Kayyun Toota, Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
14. Tahir, A. Ethno - National Movement in Pakistan, Islamabad: Institute of Policy Studies, Islamabad.

COMPULSORY– III

(MATHEMATICS-I)

Cr 3(3+0)

Objectives

The course aims to:

- Prepare the students with the essential tools of algebra
- Develop skills to apply the concepts and the techniques

Course Contents

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.

Binomial Theorem: Introduction to mathematical induction, binomial theorem with rational and irrational indices. Trigonometry: Fundamentals of trigonometry, trigonometric identities.

Books Recommended

1. Swokowski, E.W.1986. Fundamentals of Algebra and Trigonometry. 6th Ed., PWS-Kent Company.

2. Kaufmann, J.E., 1987. College Algebra and Trigonometry. PWS-Kent Company, Boston.
3. Dolciani, M.P., Wooton, W., Beckenback, E.F., Sharron, S.1978. Algebra 2 and Trigonometry, Houghton & Mifflin.

GENERAL-I

(BOTANY- I /ETC.)

Cr 3(2+1)

- As per prescribed curriculum of Botany/other

GENERAL- II

(CHEMISTRY- I /ETC.)

Cr: 3(2+1)

- As per prescribed curriculum of Chemistry/other

FOUNDATION – I

PRINCIPLES OF ANIMAL LIFE – I

Cr: 4(3+1)

Objectives

The course aims to impart knowledge and understanding of:

- The concept and status of Zoology in life sciences and the common processes of life through its biochemical and molecular processes.
- The structure and function of cell organelles and how common animal cell diversified in various tissues, organs and organ systems.
- Biochemical mechanisms eventually generating energy for animal work.
- 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, vacuoles;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: Ecosystem, types, homeostasis, biomes, food chain, food web, energy flow and thermodynamics; biogeochemical cycles, and limiting factors, populations and communities, human population growth, pollution, resource depletion and biodiversity.

Practicals

1. Tests for different carbohydrates, proteins and lipids.
Note: Emphasis on the concept that tests materials have been ultimately obtained from living organisms and constituted their body.
2. Study of the prepared slides of epithelial tissue (squamous, cuboidal, columnar), connective tissue (adipose, cartilage, bone, blood), nervous tissue and muscle tissue (skeletal, smooth and cardiac).
Note: Prepared microscopic and/or projection slides and/or CD ROM computer projections must be used.
3. Plasmolysis and deplasmolysis in blood. Preparation of blood smears.
4. Protein digestion by pepsin.
5. Ecological notes on animals of a few model habitats.
6. Field observation and report writing on animals in their ecosystem (a terrestrial and an aquatic ecosystem study).

Books Recommended

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

SEMESTER–II

Course Category	Course Title	Credits
COMPULSORY-IV	English-II: Communication Skills	3(3+0)
COMPULSORY-V	Islamic Studies / Ethics	2(2+0)
COMPULSORY-VI	Biostatistics/Univ option	3(2+1)
GENERAL- III	Botany-II/ Etc.	3(2+1)
GENERAL- IV	Chemistry-II/ Etc.	3(2+1)
FOUNDATION-II	Principles of Animal Life-II	4(3+1)
	Total Credits	18

COMPULSORY–IV

Cr 3(3+0)

ENGLISH - II (COMMUNICATION SKILLS)

Objectives

The course aims to:

- 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

Books Recommended

1. Boutin, Marie-Christine, Brinandm, S.,Grellet, F. 1993. Writing: Intermediate. Oxford Supplementary Skills. Fourth Impression.
2. Nolasco, R. 1992. Writing: Upper-Intermediate. Oxford Supplementary Skills. Fourth Impression. (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).
3. Tomlinson, B., Ellis, R. 1991. Reading. Advanced. Oxford Supplementary Skills. Third Impression.
4. Thomson, A.J., Martinet, A.V. 1986. Practical English Grammar Exercises 2. 3rd Ed. Oxford University Press.
5. Langan, J. Reading and Study Skills by Richard York.

COMPULSORY–V
(Islamic Studies/ Ethics)

Cr 2(2+0)

ISLAMIC STUDIES

Objectives

This course aims to:

- Provide Basic information about Islamic Studies
- Enhance understanding of the students regarding Islamic Civilization
- Improve Students skill to perform prayers and other worships
- Enhance the skill of the students for understanding of issues related to faith and religious life.

Course Contents

Introduction to Quranic Studies: Basic Concepts of Quran: History of Quran; Uloom-ul -Quran

Study of Selected Text of Holy 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)

Study of Selected Text of Holy Quran: 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) Related to thinking, Day of Judgment, Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)

Seerat of Holy Prophet (S.A.W) I: 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

Seerat of Holy Prophet (S.A.W) II: 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

Introduction to Sunnah: Basic Concepts of Hadith; History of Hadith; Kinds of Hadith; Uloom –ul-Hadith; Sunnah & Hadith; Legal Position of Sunnah

Selected Study from Text of Hadith

Introduction to Islamic Law & Jurisprudence: 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

Islamic Culture & Civilization: Basic Concepts of Islamic Culture & Civilization; Historical Development of Islamic Culture & Civilization; Characteristics of Islamic Culture & Civilization; Islamic Culture & Civilization and Contemporary Issues

Islam & Science: Basic Concepts of Islam & Science; Contributions of Muslims in the Development of Science; Quran & Science

Islamic Economic System: Basic Concepts of Islamic Economic System; Means of Distribution of wealth in Islamic Economics; Islamic Concept of Riba; Islamic Ways of Trade & Commerce

Political System of Islam; Basic Concepts of Islamic Political System; Islamic Concept of Sovereignty; Basic Institutions of Govt. in Islam

Islamic History: Period of Khlaft-E-Rashida; Period of Ummayyads; Period of Abbasids

Social System of Islam; Basic Concepts of Social System of Islam; Elements of Family; Ethical Values of Islam.

Books Recommended

1. Hameedullah M, "Emergence of Islam" , IRI, Islamabad
2. Hameedullah M, "Muslim Conduct of State"
3. Hameedullah M. 'Introduction to Islam
4. Mulana Muhammad Yousaf Islahi,"
5. Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" leaf Publication Islamabad, Pakistan.
6. Hasan A.1993. Principles of Islamic Jurisprudence. Islamic Research Institute, International Islamic University, Islamabad.
7. Waliullah, M.1982. Muslim Jurisprudence and the Quranic Law of Crimes. Islamic Book Service.
8. Bhatia, H.S.1989. Studies in Islamic Law, Religion and Society. Deep & Deep Publications New Delhi
9. Zia-ul-Haq M.2001. Introduction to Al Sharia Al Islamia" Allama Iqbal Open University, Islamabad.

COMPULSORY–VI

BIOSTATISTICS

Cr 3(2+1)

Objectives

- The course will provide knowledge about the importance and use of statistics in life sciences. It will help the students to understand the methods to analyze data pertaining to their research work and to assess the significance of their experimental designs.

- 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, Poisson's 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.

Books Recommended

1. Zar, J. H. 2013. Biostatistical analysis 4th Ed. **Dorling Kindersley Publ. Inc**
2. *Forthofer, R. N., Lee E. S., Hernandez, M.* 2011. Biostatistics: A Guide to Design, Analysis and Discovery 2nd Ed. **Elsevier Inc.**
3. Rao, K. V. 2009. Biostatistics: A Manual of Statistical Methods for Use in Health, Nutrition and Anthropology. Jaypee Brothers Publishers.
4. Quinn, G., P., Keough M. J. 2002. Experimental Design and Data Analysis for Biologists. Cambridge University Press.
5. Norman G. R., Streiner, D. L. 2000. Biostatistics: The Bare Essentials. B.C. Decker Inc.
6. Campbell, R. C. 1989. Statistics for Biologists. Cambridge University Press.

GENERAL-III

(BOTANY-II/ETC.)

Cr 3(2+1)

- As per prescribed curriculum of Botany/other

GENERAL-IV

(CHEMISTRY- II/ETC.)

Cr 3(2+1)

- As per prescribed curriculum of Chemistry/other

FOUNDATION–II

PRINCIPLES OF ANIMAL LIFE–II

Cr 4(3+1)

Objectives

The course will impart knowledge and understanding of:

- Cell division and its significance in cell cycle.
- Concepts and mechanisms of inheritance pattern, chromosome and gene linkage and molecular basics of genetics.
- Animal behaviour and communication.
- Theories of evolution, gene flow and mechanism of evolution with reference to animal 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.

Cellular Control: DNA: the genetic material; DNA replication in prokaryotes and eukaryotes; control of gene expression in eukaryotes; gene mutation; recombinant DNA technologies and their applications.

Animal Behavior: Behaviour and its types, proximate and ultimate causes; anthropomorphism; development of behavior; learning; factors controlling animal behavior; communication; behavioral ecology; social behavior.

Evolution: A Historical Perspective: Theories of evolution: Natural selection Lamarckism and 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.

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 for 1-2: Prepared microscopic and/or projection slides and/or CD ROM computer projections must be used).

Books Recommended

1. Pechenik, J.A. 2012. Biology of Invertebrates, 4th Edition (International), Singapore: McGraw Hill.
2. Hickman, C.P., Roberts, L.S., Larson, A. 2004. Integrated Principles of Zoology, 11th Edition (International). Singapore: McGraw Hill.
3. Miller, S.A., Harley, J.B. 2002. Zoology, 5th Edition (International), Singapore: McGraw Hill.
4. Miller, S.A. 2002. General Zoology Laboratory Manual. 5th Ed. (International). Singapore: McGraw Hill.
5. Campbell, N.A. 2002. Biology. 6th Edition. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
6. Kent, G.C., Miller, S. 2000. Comparative Anatomy of Vertebrates. New York: McGraw Hill.
7. Hickman, C.P., Kats, H.L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill.

YEAR–II
SEMESTER– III

Course Category	Course Title	Credits
COMPULSORY-VII	English-III: Technical writing and presentation skills	3(3+0)
COMPULSORY-VIII	Introduction to Computer	3(1+2)
GENERAL- V	Botany-III/ Etc.	3(2+1)
GENERAL- VI	Chemistry-III/ Etc.	3(2+1)
FOUNDATION-III	Animal Diversity: Invertebrates	4(3+1)
	Total Credits	16

COMPULSORY–VII

ENGLISH III (TECHNICAL WRITING AND PRESENTATION SKILLS)
Cr 3(3+0)

Objectives

The course aims to:

- Enhance language skills
- 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

Note: Extensive reading is required for vocabulary building

Books Recommended

1. Langan, J. 2004. College Writing Skills McGraw-Hill Higher Education.
2. Kirszner. L.G., Mandell, S. R. Patterns of College Writing. 4th Ed. by St. Martin's Press.
3. White, R. 1992. Writing. Advanced. Oxford Supplementary Skills. Third Impression (particularly suitable for discursive, descriptive, argumentative and report writing).
4. Neulib, J., Cain, K. S., Ruffus, S., Scharton, M. (Editors). Reading. The Mercury Reader. A Custom Publication. Compiled by northern

Illinois University. (A reader that will give students exposure to the best of twentieth century literature).

COMPULSORY–VIII

(INTRODUCTION TO COMPUTER) Cr 3(1+2)

- As per prescribed curriculum of Computer Science

GENERAL–V

(BOTANY- III/ ETC.) Cr 3(2+1)

- As per prescribed curriculum of Botany/other

GENERAL–VI

(CHEMISTRY- III/ ETC.) Cr 3(2+1)

- As per prescribed curriculum of Botany/other

FOUNDATION– III

ANIMAL DIVERSITY: INVERTEBRATES Cr 4(3+1)

(CLASSIFICATION, PHYLOGENY AND ORGANIZATION)

Objectives

The course is designed to provide students with:

- Taxonomic characteristics and classification of each phylum
- Concepts of evolutionary relationship of animal kingdom
- 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 with evolutionary perspective.

Animal-Like Protists: The Protozoa; 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: 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: Phylum Platyhelminthes: classification up to class; the free-living flatworms and the tapeworms; Phylum Nemertea; Phylum Gastrotricha; further phylogenetic considerations.

Pseudocoelomate Body Plan: Aschelminths: 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: 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: relationship to other animals, metamerism and tagmatization; External structure and locomotion, feeding and the digestive system, gas exchange and circulation, nervous and sensory functions, excretion, regeneration, reproduction and development in different classes; further phylogenetic considerations.

Arthropods: Blueprint for Success: classification and relationships to other animals; metamerism and tagmatization; the exoskeleton; metamorphosis; classification up to class; further phylogenetic considerations; phylogeny and adaptive diversification.

Echinoderms: relationships to other animals; echinoderm characteristics; classification up to class. Maintenance functions, regeneration, reproduction, and development; further phylogenetic considerations.

Lesser Invertebrates: The lophophorates, entoprocts, cyclophores, and chaetognaths.

Practicals

Museum study of representative Phyla, Permanent slide preparations

1. Study of *Euglena*, *Amoeba*, *Entamoeba*, *Plasmodium*, *Trypanosoma*,
2. *Paramecium* as representative of animal like protists. (Prepared slides).
3. Study of sponges and their various body forms.
4. Study of principal representative classes of Phylum Cnidaria.
5. Study of principal representative classes of Phylum Platyhelminthes.

6. Study of representative of Phylum Rotifera, Phylum Nematoda.
7. Study of principal representative classes of Phylum Mollusca.
8. Study of principal representative classes of Phylum Annelida.
9. Study of principal representative classes of groups of Phylum Arthropoda.
10. Brief notes on medical/economic importance of the following:
11. *Plasmodium*, *Entamoeba histolitica*, *Leishmania*, Liverfluke, Tapeworm, Earthworm,
12. Silkworm, Citrus butterfly.

Books Recommended

1. Hickman, C.P., Roberts, L.S., Larson, A. 2011. Integrated Principles of Zoology, 15th Ed. (International). Singapore: McGraw Hill.
2. Miller, S.A., Harley, J.B. 2011. Zoology, 8th Ed. (International), Singapore: McGraw Hill.
3. Pechenik, J.A. 2010. Biology of Invertebrates, 4th Ed. (International), Singapore: McGraw Hill.
4. Campbell, N.A. 2002. Biology, 6th Ed. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
5. Miller, S.A., 2002. General Zoology Laboratory Manual. 5th Ed. (International). Singapore: McGraw Hill.
6. Hickman, C.P., Kats, H.L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill.

SEMESTER-IV

Course Category	Course Title	Credits
COMPULSORY-IX	English-IV / Univ. Option	3(3+0)
GENERAL- VII	Botany-IV/ Etc.	3(2+1)
FOUNDATION-IV	Animal Diversity: Chordates	4(3+1)
FOUNDATION-V	Animal Form & Function-I	4(3+1)
FOUNDATION-VI	Animal Form & Function-II	4(3+1)
	Total Credits	18

COMPULSORY-IX

(ENGLISH- IV/ UNIV. OPTION)

Cr 3(3+0)

- As per university decision

GENERAL-VII

(BOTANY- IV/ ETC.)

Cr 3(2+1)

- As per prescribed curriculum of Botany/other

FOUNDATION-IV

ANIMAL DIVERSITY: CHORDATES

Cr 4(3+1)

Objectives

The course aims to:

- Provide understanding about taxonomic characteristics and classification of each phylum
- Develop concepts of evolutionary relationship of animal kingdom
- Provide knowledge and understanding about the different animal groups with special emphasis on their phylogenetic relationships

Course Contents

Protochordates: Structure, anatomy and organ systems; reproduction; life histories and metamorphosis; phylogenetic relationships; further phylogenetic considerations.

Fishes: Vertebrate Success in Water: phylogenetic relationships; Agnatha and Gnathostomata: locomotory adaptations, 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: phylogenetic relationships; Caudata, Gymnophiona, and Anura; Structure and locomotory adaptations, 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: cladistic interpretation of the amniotic lineage; Testudines or Chelonia, Rhynchocephalia, Squamata, and Crocodilia; 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: phylogenetic relationships; ancient birds and the evolution of flight; diversity of modern birds; 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; diversity of mammals; 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.

Practicals

Museum study of:

1. Protochordates
2. Pisces
3. Amphibia
4. Reptilia
5. Aves
6. Mammalia
7. Field trips to study animal diversity in an ecosystem.

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

Books Recommended

1. Hickman, C.P., Roberts, L.S., Larson, A. 2011. Integrated Principles of Zoology, 15th Ed. (International). Singapore: McGraw Hill.

2. Campbell, N.A. Biology, 9th Ed. 2011. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc. Miller, S.A. and Harley, J.B. 2010. Zoology, 8th Edition (International) Singapore: McGraw Hill.
3. Miller, S.A. 2002. General Zoology Laboratory Manual. 5th Ed. (International), Singapore: McGraw Hill.
4. Kent, G.C., Miller, S. 2001. Comparative Anatomy of Vertebrates. Latest edition New York: McGraw Hill.
5. Hickman, C.P., Kats, H.L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill.

FOUNDATION–V

ANIMAL FORM AND FUNCTION–I (A COMPARATIVE PERSPECTIVE)

Cr 4(3+1)

Objectives

The course aims to teach the students about:

- Animals diversity adapted in different ways for their functions through modifications in body parts.
- 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.
- Organ systems, their specialization and coordination with each other and constantly changing internal and external environment, inside and outside the animal's body.
- 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-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 ventral nerve cord

and ganglia, the vertebrate brain, the spinal cord, cranial and spinal nerves; 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 and water, skin sensors of mechanical stimuli, sonar, smell, taste and vision in vertebrates.

Communication III: The Endocrine System and Chemical Messengers: Chemical messengers: hormones chemistry; and their feedback systems; mechanisms of hormone action; some hormones of porifera, cnidarians, platyhelminthes, nemertean, nematodes, molluscs, annelids, arthropods, and echinoderms invertebrates; an overview of the vertebrate endocrine system; endocrine systems of vertebrates, endocrine systems of birds and mammals.

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.

Practicals

1. Study of insect chitin, fish scale, amphibian skin, reptilian scales, feathers and mammalian skin.
2. Study and notes of skeleton of *Labeo*, *Rana tigrina*, *Varanus*, fowl and rabbit.
Note: Exercises of notes on the adaptations of skeletons to their function must be done.
3. Earthworm or leech; cockroach, freshwater mussel, *Channa* or *Catla catla* or *Labeo* or any other local fish, frog, pigeon and rat or mouse and rabbits are representative animals for study in dissections.
4. Study of models or preserved brains of representative animals and notes on adaptations.
5. Study of nervous system of earthworm and a fish.
6. Study of endocrine system in an insect and a rabbit.

7. Study of different types of blood cells in blood smear of rabbit.
8. Study of heart, principal arteries and veins in a representative vertebrate (dissection of representative fish/mammals).
9. Study of respiratory system in cockroach or locust and a vertebrate representative (Model).

Books recommended

1. Pechenik, J.A. 2013. Biology of Invertebrates, 4th Ed. (International), Singapore: McGraw Hill.
2. Hickman, C.P., Roberts, L.S., Larson, A. 2004. Integrated Principles of Zoology, 11th Ed. (International), Singapore: McGraw Hill.
3. Miller, S.A. and Harley, J.B. 2002. Zoology, 5th Ed. (International), Singapore: McGraw Hill.
4. Campbell, N.A. 2002. Biology, 6th Ed. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
5. Miller, S.A. 2002. General Zoology Laboratory Manual. 5th Ed. (International), Singapore: McGraw Hill.
6. Kent, G.C., Miller, S. 2001. Comparative Anatomy of Vertebrates. New York: McGraw Hill.
7. Hickman, C.P., Kats, H.L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill.

FOUNDATION–VI

ANIMAL FORM AND FUNCTION–II

Cr 4(3+1)

(A COMPARATIVE PERSPECTIVE)

Objectives

The course

- provides understanding of the basis of structure and functions of animal nutrition, digestion, homeostasis and temperature regulation.
- introduce the basic concepts in reproduction and development in animal kingdom.
- impart 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 fate of mesoderm.

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.

- Study of early stages in the development of a frog, chick and a mammal.

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

Books Recommended

- Pechenik, J.A. 2013. Biology of Invertebrates, 4th Ed. (International), Singapore: McGraw Hill.
- Hickman, C.P., Roberts, L.S., Larson, A. 2004. Integrated Principles of Zoology, 11th Ed. (International), Singapore: McGraw Hill.
- Miller, S.A., Harley, J.B. 2002. Zoology, 5th Ed. (International), Singapore: McGraw Hill.
- Campbell, N.A. 2002. Biology, 6th Ed. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
- Miller, S.A. 2002. General Zoology Laboratory Manual. 5th Ed. (International), Singapore: McGraw Hill.
- Kent, G.C., Miller, S. 2001. Comparative Anatomy of Vertebrates. New York: McGraw Hill.
- Hickman, C.P., Kats, H.L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill.

YEAR-III SEMESTER-V

Course Category	Course Title	Credits
GENERAL-VIII	Psychology/Geography/Etc.	2(2+0)
FOUNDATION-VII	General Biochemistry	4(3+1)
MAJOR-I	Cell & Molecular Biology	4(3+1)
MAJOR-II	Physiology	4(3+1)
MAJOR-III	Animal Behavior	3(2+1)
	Total Credits	17

GENERAL-VIII

(PSYCHOLOGY/ GEOGRAPHY/ ETC.)

Cr 2(2+0)

- As per prescribed curriculum of the subject

FOUNDATION-VII

GENERAL BIOCHEMISTRY

Cr 4(3+1)

Objectives

The course aims to

- Provide in-depth knowledge about the polymerized organic compounds of life.
- Develop an understanding about the dynamism life as it proceeds with inter-conversion of the chemicals from feeding to the liberation of energy for work.
- Understand that inter-conversion is performed by various tools called as enzymes.
- Enable students to know how organisms harvest of energy for growth, duplication etc.,

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; Proteins: level of structural organization, example of structural and functional proteins.

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 on enzyme activity.

Carbohydrates: Classification, types, important characteristics and structure of carbohydrates; cyclic structure of 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 B complex group.

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 and starch; regulation of glycogen metabolism.

Citric acid (TCA) cycle: 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; Electron transport and its components, oxidative phosphorylation, chemiosmotic theory, ATP synthesis, uncouple electron transport and heat generation.

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; Ketone bodies their biosynthesis, utilization and role in the tissues; cholesterol metabolism: Steroid hormones.

Nitrogen metabolism: metabolic fate of amino acids; catabolism of amino acids; deamination and transamination; nitrogen excretion and urea cycle; regulation of urea cycle.

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

Books Recommended

1. Nelson, D. L., Cox, M. M. 2012. Lehninger Principles of Biochemistry. McMillan worth Publishers, New York.
2. Berg, J. M., Tymoczko, J. L., Lubert Stryer. 2010. Biochemistry. 7TH Ed.

3. Lodish, H., Berk, A., Zipursky, S. L., Paul. M., Baltimore D., Darnell, J. 2012. Molecular Cell Biology.
4. McKee, T., McKee, J.R. 2003. Biochemistry: The Molecular Basis of Life. 3rd Edition, McGraw Hill.
5. Wilson, K., Walker, J. 1994. Practical Biochemistry: Principles and Techniques, 4th Ed., Cambridge University Press.

MAJOR– I

CELL & MOLECULAR BIOLOGY

Cr 4(3+1)

Objectives

The course aims to:

- Impart knowledge about the animal cell and its complex organization of architecture
- Provide understanding about the unified role of a cell for the ultimate sustainability of the organisms.
- Enable students to understand 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 and their role in protein synthesis and drug metabolism, Golgi apparatus its role in synthesis of glycoprotein, Mitochondrial respiration and its significance as semi-autonomous organelle; Lysosome, its diverse roles due to hydrolytic activity of enzymes, Peroxisome, its role in metabolism of hydrogen peroxide, Glyoxysome with reference to glyoxylic acid cycle.

Nucleus: chromatin, heterochromatin, euchromatin, chromosome structure, coiling and nucleosome during different phases of cell cycle.

Replication: mechanism, DNA replication in prokaryotes specially with reference to variety of DNA polymerases and other proteins involved, DNA replication in Eukaryotes with emphasis on DNA polymerases, concept of replicons etc., **Transcription:** variety of RNA and their characteristics, synthesis of mRNA, rRNA and tRNA with special reference to enzymes involved, RNA splicing, split genes, concept of ribozymes and

posttranscriptional processing, RNA transduction, Genetic code, point mutations.

Translation: Specific role of Ribosomes, various factors, and posttranslational processing, control of gene expression in Prokaryotes.

Practicals

1. Identification of cell organelles
2. Preparation of temporary whole mount.
3. Preparation of permanent whole mount (demonstration)
4. Preparation of human blood smear and identification of Leucocytes.
5. Tissues (permanent slides of epithelial tissues, striated muscle, smooth muscle, cartilage, bone).
6. Squash preparation of onion root tip for mitotic stages.
7. Mounting of polytene chromosome (Drosophila/Chironomous.) Demonstration.
8. Detection and quantitative determination of chromosomal DNA and RNA.
9. Cultural and staining of bacteria and yeast.
10. Separation of different sized DNA fragments on agarose gel.
11. Isolation and characterization of proteins on polyacrylamide gel electrophoresis (native and sub-unit molecular weights).

Books Recommended

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D. 2013. Molecular Biology of the Cell. Garland Publishing Inc., New York.
2. Damell Jr. J., Lodisch, H., Balimore, D. 2013. Molecular Cell Biology, Scientific American Inc. N.Y.
3. Friefelder, D. 2010. Molecular Biology.
4. Geoffrey M.C., Robert E.H. 2007. The cell: A Molecular Approach,. Sinauer Associates, INC.
5. Karp, J. 2005. Cell and Molecular Biology, Concepts and Experiments, Jhon Wiley and Sons, INC.
6. De Robertis, E. D. P., De Robertis Jr. E. N. F. 1987. Cell and Molecular Biology, Lea & Febiger, New York.

MAJOR – II

PHYSIOLOGY

Cr 4(3+1)

Objectives

The course aims to

- Provide information about the physiological mechanisms underlying animal functions.
- Enable students to understand neuro-endocrine coordination, physiology of heart, hemodynamics and kidney function.
- Impart information on respiratory function and gut physiology
- Give understanding about the mechanism of homeostasis, physiological regulation of temperature and its maintenance

Course Contents

Central themes in Physiology: Homeostasis, Concepts of conformity and regulation; physiological adaptations.

Membrane Physiology: Ionic distribution across membrane, Resting membrane potentials: Electrogenic ion pump, Donnan equilibrium, Ion channels

Nerve and Muscle Physiology: Action potentials in neurons; Electrical and chemical synaptic transmission; Neurotransmitters; Excitatory and inhibitory postsynaptic potentials; tetany; 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.

Receptors Physiology: Receptor types: Mechanoreceptors, Olfactory and taste receptors, Photoreceptors, Photochemistry and Phototransduction; acoustico-lateralis system, Cutaneous receptors, electro-receptors. Sensory transduction, coding and adaptations. Range fractionation.

Endocrine Physiology: Gland types; Hypothalamus, Pituitary, Thyroid, Parathyroid, Pineal, Pancreatic Islets, Gastric glands, Adrenal, Ovary, Testis and Placenta; Overview of hormones; types, peptide and steroid hormones, chemistry, synthesis and roles. Hormone receptors and signal transduction. Feedback mechanisms.

Cardiovascular Physiology: Electrical activity of heart: Autorythmicity, Electrocardiography, Kymography; Hemodynamics, Relationship between blood flow, pressure and resistance. Control of cardiac activity, cardiac output and peripheral circulation.

Respiratory Physiology: Respiratory epithelia, gas exchange in gills and lungs; Transport of O₂ and CO₂, Structure of alveoli, lung volumes and capacities, surfactants, control of breathing; hypoxia; Hypercapnia etc., air breathing in divers.

Renal Physiology: Osmoregulation: Osmoregulation in aquatic and terrestrial animals; Kidney and Vertebrate nephron as osmoregulatory and

excretory organ: Glomerular filtration, Tubular absorption and secretion; Nitrogenous waste products; Patterns of nitrogenous excretion and their phylogenetic significance.

Physiology of Digestion: Physiologic anatomy of digestive tract (mammalian model), Regulation of digestive secretions; Absorption of water, ions and nutrients; Potential and Movements in gastrointestinal tract; Control of motility. Deglutition, Peristalsis, Absorption, Assimilation and defecation.

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. Determination of haemoglobin content, haematocrit and cell counting.
2. Preparation of blood smears.
3. 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.
4. 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.
5. Normal cardiac activity, effect of temperature, effect of drug, heart block, tetanization of heart. Measurement of blood pressure.
6. 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.
7. Effect of insulin on glycemia, study of stages in estrous cycle.

Books Recommended

1. Guyton, A.C., Hall, J.E. 2013. Textbook of Medical Physiology, 10th Ed. W.B. Saunders Company, Philadelphia. Sherwood 2013
2. Tharp, G., Woodman, D. 2010. Experiments in Physiology, 10th Ed. Benjamin Cummings.
3. Fox, S. 2010. Laboratory manual of human physiology. McGraw-Hill Sciences.

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

MAJOR-III

ANIMAL BEHAVIOR

Cr 3(2+1)

Objectives

The course aims to

- Impart knowledge about animal responses to external stimuli
- Emphasize different kinds of behaviors classical and modern concepts
- Explain through examples development, evolution and occurrence of behavior
- understand the genetic and neurophysiological basis of behavior

Course Contents

Foundations of animal behavior: ethology, classical ethology

Development of behavior: innate mechanisms, imprinting

Kinds of behavior: innate, conditioned, complex behaviour patterns, habituation.

Mechanisms of behavior: Nervous system and behavior, hormones and behavior,

Social behavior: agonistic, altruistic, kinship, mating, ritualization, dominance, territoriality

Biological rhythms: circadian clocks, clock genes etc.

Social organization: conflict, sexual behaviour, reproduction and fitness, parental care, social system.

Animal Communication: chemical attraction, in moths, honey bees, communication displays, pheromones etc.

Practicals

1. Locomotory behavior of small animals, earthworm, garden snails etc.
2. Ear pinna reflex responses in domestic cats
3. Preparation of skinner box or maze for study of mouse or rat behavior
4. Mother-pup bond in mice and rats
5. Infant killing behavior
6. Pecking behavior of chickens
7. Hiding behavior of chicks
8. Observation of birds nests and study of parental behavior
9. Altruistic behavior in monkeys

Books Recommended

1. Dugatkin, L. A. 2012. Principles of Animal Behavior. W.W. Norton and Co. New York.
2. Scott, G. 2005. Essential Animal Behavior. Blackwell Pub. New York.
3. Goodenough, J., McGuire, B., Wallace, R.A. 2001. Perspective on Animal Behavior. John Wiley & Sons, New York.

SEMESTER– VI

Course Category	Course Title	Credits
FOUNDATION-VIII	Biological Techniques	3(1+2)
FOUNDATION-IX	Evolution & Principles of Systematics	3(2+1)
MAJOR-IV	Developmental Biology	4(3+1)
MAJOR-V	Genetics	4(3+1)
MAJOR-VI	Wildlife	2(2+0)
	Total Credits	16

FOUNDATION–VIII

BIOLOGICAL TECHNIQUES

Cr 3(1+2)

Objectives

The course aims to:

- Develop scientific technical expertise, culture and work habits.
- Familiarize with the basic tools and techniques of scientific study with emphasis on biological sciences
- Develop basic understanding of the equipments usage

Course Contents

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.

Micrometry 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, Ultracentrifugation, cell fractionation, filtration, Distillation, Use of Soxhlet and Rotary evaporator for extraction.

Separation Techniques: Chromatography: Principle, applications, types, thin layer, column, gas, ion exchange chromatography. Electrophoresis: Principle, applications, types.

Spectrophotometry: 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.

Practicals

1. Observation of wet mounts of human cheek cells employing bright and dark field microscopy
2. Measurement of cell size: bacterial and eukaryotic
3. Recording of microscopic observations with the help of camera lucida
4. Liquid handling: proper use of pipettes and micropipettes
5. Histological preparations: skeletal muscle, intestine liver and testes
6. Handling of centrifuge machines
7. Thin layer chromatography of amino acids
8. Spectrophotometric estimation of glucose

9. Spectrophotometric estimation of total proteins
10. Preservation of representative animals of various phyla
11. Electrophoretic separation of proteins
12. Electrophoretic separation of DNA

Books Recommended

1. Dean, J. R. 1999. Extraction Methods for Environmental Analysis. John Wiley and Sons Ltd. UK.
2. Cheesbrough, M. 1998. District Laboratory Practice in Tropical Countries. Part I. Cambridge University Press, UK.
3. Cheesbrough, M. 1998. District Laboratory Practice in Tropical Countries. Part II. Cambridge University Press, UK.
4. Curos, M. 1997. Environmental Sampling and Analysis: Lab Manual. CRC Press LLC. USA.
5. Curos, M. 1997. Environmental Sampling and Analysis: For Technician. CRC Press LLC. USA.
6. Slings by, D., Cock, C. 1986. Practical Ecology. McMillan Education Ltd. London.

FOUNDATION–IX

EVOLUTION & PRINCIPLES OF SYSTEMATICS Cr 3(2+1)

Objectives

The course aims to:

- Provide in-depth knowledge of origin of life
- Develop concepts about forces responsible for evolutionary changes
- Study the importance and history of systematics with basic rules and regulations about the identification and naming of organisms

(Note: Evolution and Principles of Systematic Zoology 60% and 40% weightage, respectively. Three questions from Evolution and two questions from Systematic will be attempted by the students).

Course Contents

(i). Evolution

The nature and origin to life: Evidences of evolution (molecular, embryological & paleontological).

Theories of Evolution: Theories to explain the diversity of life - Modern synthetic theory, 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/mega evolution) - allometry, orthogenesis, adaptive radiation.

Modern concept of Natural Selection: Levels of selection, selection patterns, laboratory and field example regarding action of Natural Selection. Action of Natural Selection leading to convergence, radiation, regression and extinction, Batesian mimicry, Mullerian mimicry, Sexual selection: Darwin's concept, Fisher's view, Zahavi's handicap theory, Recapitulation theory, Trend and rates in evolution.

(ii). Systematic Zoology

Importance and applications of systematics: Taxonomy in Animal science, systematics as a profession and its future perspectives.

History of taxonomy: systematics, basic terminology of systematics, theories of biological classifications.

Taxonomic characters: Kinds and weightage, microtaxonomy, taxonomic categories: specific category, infraspecific category, higher categories; Species concept.

Typological species concept: Nominalistic species concept, biological species concept, Evolutionary species concept. Kinds of different species, Speciation,

Taxonomic procedures, taxonomic collection; their preservation and duration, Taxonomic keys, different kinds of keys and their merits and demerits.

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

Evolution

1. Strickberger. M.W. 2012. *Evolution*. Jones & Barrett Publishers.

2. Ridley, M. 1993. *Evolution*. Blackwell Scientific Publications.
3. Moody, P.A. 1989. *Introduction to Evolution*, Harper and Row Publishers, New York.
4. Dobzhansky, T., Ayala, F.J., Stebbins, G.L., Valentine, J.W. 1973. *Evolution*. W.H. Freeman and Company.
5. Mayr, E. 1965. *Populations, Species and Evolution*, Harvard University Press.
6. Dobzhansky, T. 1951. *Genetics and the origin of species*. Columbia University Press, New York.

Systematic Zoology

1. Wiley, E. O. and Lieberman, B. S. 2011. *Phylogenetics: Theory and practice of phylogenetic systematics*. 2nd Ed. Wiley-Blackwell.
2. Mayer, E. *Principles of Systematic Zoology*. 1994. McGraw 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.
6. Whili, M.J.D. *Modes of Speciation*, 1978. W.H. Freeman and Co., San Francisco.

MAJOR–IV

DEVELOPMENTAL BIOLOGY

Cr 4(3+1)

Objectives

The course aims to:

- Provide information on transmission of traits from the parents in their gametes, the formation of zygote and its development
- Impart detailed knowledge about cellular basis of morphogenesis, mechanisms of cellular differentiation and induction.
- Provide understanding of the mechanisms of organogenesis, factors controlling growth and oncogenesis.

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 and 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.

Post embryonic Development and metamorphosis

Hormones as mediators of development; Regeneration in vertebrates.

Practicals

1. Study of the structure of gametes in some representative cases, i.e. frog, fish, fowl and a mammal.
2. 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/fish through induced spawning under laboratory conditions.
3. Preparation and study of serial sections of frog or chick embryos.
4. Application of microsurgical techniques on chick embryos *In vitro*. Preparation and staining of histological slides.

Books Recommended

1. Gilbert, S. F. 2012. Developmental Biology, Sinauer Associates, Sunderland, MA.
2. Klaus, K. 2001. Biological Development. 2nd Ed., McGraw Hill.
3. Balinsky, B. I. 1985. An Introduction to Embryology, Saunders.
4. Oppenheimer, S.S. 1984. Introduction to Embryonic Development, Allen and Bacon.
5. Saunders, J. W. 1982. Developmental Biology, McMillan and company.
6. Ham, R. G., Veomett, M. J. 1980. Mechanism of Development. C. V. Mosby Co.

MAJOR–V

GENETICS

Cr 4(3+1)

Objectives

The course aims to: Provide understanding about the continuity of the life from one generation to other generation is based on the mechanisms involving nucleus, chromosomes and genes etc.

- Develop the concept that continuity not only transfers the traits of the parents but also imparts variations that render the generations sustainable in changing environment.

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, changes in chromosomal number, euploidy, aneuploidy, polyploidy; structural changes, insertion, deletion (Cri du chat syndrome), duplication and translocation

Pedigree Analysis: Normal human chromosome complement; Karyotyping.

Sex-determination and Sex-linkage: Sex determination in animals and humans, linkage, recombination and chromosome mapping in eukaryotes.

Molecular Genetics: Elements of genetic engineering; genetic basis of diseases, like cancer, genetic control of animal development.

Human Genetics; Single and Multifactorial Disorders: Autosomal anomalies, Pseudoautosomal genes, (eg. Down syndrome, Edwards syndrome and),

Single gene disorders Gene mutation and disorders; autosomal single gene disorders (Sickle cell anemia, brachydactyly; inborn errors of metabolism such as Phenylketonuria, alkaptonuria). Definition - characteristics criss-cross inheritance. Polygenic traits - Cleft lip and cleft palate,

Sex-linked Chromosomal anomalies: Klinefelters syndrome, and Turners syndrome.

Sex-influenced inheritance: Hemophilia, muscular dystrophy, color blindness.

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. X^2 test
9. Study of transformed bacteria on the basis of antibiotic resistance.

Books Recommended

1. Snustad, D.P., Simmons, M.J. 2003. Principles of Genetics. 3rd Ed., John Wiley and Sons Ins. New York, USA.
2. Tamarin, R.H. 2001. Principles of Genetics. 7th Ed., WCB Publishers USA.
3. Lewin, B. 2000. GENE-VIII. Oxford University Press. UK.
4. Gardener, E.J., Simmons, M.J., Snustad, D.P. 1991. Principles of Genetics. John Wiley and Sons Ins. New York, USA.
5. Strickberger, M.W. 2014. Genetics. McMillan, New York. USA.

MAJOR–VI

WILDLIFE

Cr 2(2+0)

Objectives

The students will learn:

- About wildlife, distribution pattern world over
- Regarding wildlife of Pakistan, threatened, endangered species
- Modern techniques used in animal tracking, data collection
- How to protect, maintain, control and preserve the health and environment of wildlife.

Course Contents

Wildlife: Animal occurrence, protection, needs of animals, maintenance, and the habitat.

Techniques: Ground and aerial tracking, GPS, radiotelemetry, maps etc.

Wildlife Conservation: Philosophy and significance, Biodiversity and sustainability of wildlife.

Wildlife Agencies: National and International agencies involved in conservation and management of wildlife. International conventions, agreements.

Wildlife of Pakistan: identification, distribution, status, conservation and management (population estimate technology) of fishes, reptiles, birds and mammals of major importance in Pakistan.

Wildlife rules and regulations in Pakistan: Sanctuaries, Game Reserves and National Parks in Pakistan. Endangered species of Pakistan.

(Note: The teacher is suggested to provide blank maps of Pakistan in the theory class to the students to indicate the distribution of the animals. Similar blanks maps should be attached with the question paper, if distribution of animals is asked from the student in the theory paper).

Books Recommended

1. Ali, S.S. 1999. Paleontology, Zoogeography & Wildlife Management. Nasim Book Depot. Hyderabad, India.
2. Roberts, T. J. 1998. *The Birds of Pakistan*, (Vol. II), Oxford University Press.
3. Roberts, T. J. 1992. *The Birds of Pakistan*, (Vol.I). Oxford University Press.
4. Magon, C.F. 1988. *Biology of Freshwater Ponds*. Longman and Scientific Publication.
5. Bailey, J.A. 1986. *Principles of Wild life Management*. John Wiley and Sons.
6. Robinson, W.L., Bolen, E.G. 1984. *Wildlife Ecology and Management*. McMillan, Cambridge.
7. Roberts, T.J. 1977. *Mammals of Pakistan*. Ernest Benon Ltd, London.
8. Ali S., Ripley S. D. 1973. *A Handbook of Birds of India & Pakistan*, Oxford University Press, London.
9. Elirza Z.B, the Birds of Pakistan.

YEAR-IV SEMESTER-VII

Course Category	Course Title	Credits
MAJOR-VII	Environmental Biology	4(3+1)
MAJOR-VIII	Zoogeography & Paleontology	3(2+1)
MAJOR-IX	Special Paper (Univ. Option)	4(3+1)
MAJOR-X	*Synopsis & Research Methodology	2(2+0)
ELECTIVE-I	Univ. Option	3(2+1)
	Total Credits	16

MAJOR–VII

ENVIRONMENTAL BIOLOGY

Cr 4(3+1)

Objectives

The main goal of this course is to:

- Enable students to develop strong expertise in contemporaneous themes in ecological research
- Develop critical thinking and to discuss about advanced topics in population, community and ecosystem ecology as well as in biodiversity research.
- Develop expertise to update their knowledge continuously, and to design their own research in ecology.

Course Contents

Energy: laws of thermodynamics, primary and secondary productions, trophic levels and energy variation with increasing trophic levels, energy flow, food chains and food webs. Biogeochemical cycle: nitrogen, phosphorus, sulphur, water, carbon, nutrient. Limiting factors: basic concepts, temperature, soil, water and humidity, light, fire.

Global ecosystems: (atmosphere, hydrosphere, lithosphere, ecosphere). An overview of ecosystem with special reference to ecological niche: basic concepts and types. Major ecosystem of world: Marine, Estuarine, Freshwater, Wetlands, Tundra, Forest, Grassland, Desert and Agricultural ecosystems.

Population ecology: basic population characters, growth and growth curves, population dynamics and regulations. Community ecology: basic concepts, community analysis, ecotones, inter-population interactions.

Applied Ecology: resources and their ecological management (mineral, agricultural desalination and weather modification, forest and range management, landscape and land use);

Pollution: (definition, types, cost, origin and management); water (sources, domestic and industrial pollution, heavy metals); air (sulphur dioxide, nitrogen oxide, carbon monoxide, ozone, smog and PAN, MTBE & CFCs); land pollution (pesticides, bacterial toxins, synthetic hormones); noise pollution.

Radiation ecology: global environmental changes (ozone depletion, acid rain, greenhouse effect and global warming, Koyota protocol, desertification, deforestation, exotic and invasive species, radioactivity leakage, environmental laws).

Practicals

1. Measurement of environmental factors on land, water and air.
2. Study of different ecosystems: pond, agricultural or grassland, forest.
3. Community analysis through different sampling techniques (quadrat, Transect),
4. Population studies mark and recapture method, statistical analysis of field data.
5. Adaptive features of animals in relation to food and environment.
6. Food chain studies through analysis of gut contents.
7. Analysis of polluted and fresh water for biotic and abiotic variations.
8. Field visits for study of selected terrestrial habitat and writing notes.
9. Experimental design and approaches in ecological research; writing a research project
10. Development of an ecological management plan of some selected area.

Books Recommended

1. Molles, M.C. 2005. Ecology: Concepts and Applications. 6th Ed., McGraw Hill, New York, USA.
2. Cox, C.B., Morre, D. 2000. Biogeography: An Ecological and Evolutionary Approach, 6th Ed., Life Sciences King's College, London, UK.
3. Dondson, S.I., Allen, T.F.N., Carpenter, S.R., Ives, A., Jeanne, R.L., Kitchell, J.F., Langston, N.E., Turner, M.G. 1998. Ecology. Oxford Univ. Press, UK.
4. Chapman, J.L., Reiss, M.J.1997. Ecology: Principles and Applications. Cambridge Univ. Press, UK.
5. Odum, E. P. 1994. Fundamentals of Ecology. 3rd Ed. W.B. Saunders.Philadelphia.
6. Newman, I. 1993. Applied Ecology. Black Well Scientific Publications Oxford. UK.
7. Slingsby, D., Cook, C., 1986. Practical Ecology. McMillan Education Ltd. UK.

MAJOR–VIII

ZOOGEOGRAPHY & PALEONTOLOGY

Cr 3(2+1)

Objectives

The course aims to:

- Provide information on the distribution of animals and their associations in the past and to rationalize their relationship in the present time.
- Impart knowledge and concepts of evolution mainly on the basis of fossil record.
- Give understanding that fossil record also provide information about the distribution of animals in the past eras.

Course Contents

(i) Zoogeography 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, barriers and dispersal.

Zoogeographical regions: zoogeographic division and boundaries, geographic ranges, physical features, climates, faunas and affinities of Palaearctic, Nearctic regions, Oriental, Ethiopian, Australian, and Neotropical Regions, insular fauna

Palaeogeography: Theories of continental drift and plate tectonics; Pangea.

Zoogeography of Pakistan:

(ii). Paleontology

The Planet Earth: History, age, shells of earth; atmosphere, hydrosphere, biosphere and lithosphere.

Rocks: types; Igneous rocks, sedimentary rocks and metamorphic rocks.

Fossil types and uses of fossils, nature of fossils.

Fossilization: Geological time scale. Pre-Cambrian life. Post Cambrian life, Palaeozoic life, Mesozoic life, Cenozoic life.

Geochronometry: Uranium/Lead dating, radiocarbon dating, methods, index fossils; evolutionary history of man, elephant, horse and camel, Paleoecology, Paleomagnetism.

Practicals

1. Study of fauna of various zoogeographical regions.
2. Study of mould, cast, pseudomorph, coprolite, petrified fossils of plants and animals.
3. Study of invertebrate fossils of coelenterates, trilobites, ammonite, brachiopods, molluscs and echinoderms.
4. Study of vertebrate fossils e.g. horse/elephant/camel/bovids.

5. Study and identification of Igneous, Sedimentary and Metamorphic rocks
6. Map work for identification of various zoogeographical regions of the World.

Books Recommended

Zoogeography

1. Beddard, F. E. 2008. A text book of zoogeography. Bibliobazar, LLC.
2. Tiwari, S.K. 2006. Fundamentals of world zoogeography. Wedams eBooks Ltd (India) Sarup & Sons. Delhi.
3. Ali, S.S. 1999. Palaeontology, Zoogeography and Wildlife Management. Nasim Book Depot, Hyderabad, India.
4. Darlington, P. J. Jr. 1963. Zoogeography, John Wiley and Sons.

Paleontology

1. Michael, J. B. David, A and Haper, T. 2009. Paleobiology and the fossil record. 3rd Ed. Wiley Black, UK.
2. Foote, M and Millar, A. I. 2007. Principles of paleontology. 3rd Ed. W. H. Freeman & Co. USA.
3. Ali, S.S. 1999. Palaeontology, Zoogeography and Wildlife Management. Nasim Book Depot, Hyderabad, India.
4. Brouwer, A. 1977. General Palaeontology, Oliver and Boyed, London.

MAJOR–IX

SPECIAL PAPER

Cr 4(3+1)

*Note: **University Option:** To be selected from the list provided (Annexure-I) as special paper (Major-X). For example, Fisheries/ Parasitology/ Microbiology/ Entomology /Immunology/ Environmental Sciences/ Marine Zoology/ Endocrinology etc (Annexure-II). The individual university can add more courses to this list according to the requirement and expertise available.*

MAJOR–X

SYNOPSIS & RESEARCH METHODOLOGY

Cr 2(2+0)

Objectives

The course is aims to:

- Develop research skills

- Provide understanding how to design scientific research, to collect data and its interpretation
- Emphasize the importance of ethics in scientific research
- Enable students to write a research proposal

Course Contents

Significance: objectives of research, Types of research, Research approaches, **Research process:** steps involved in research process, (Survey, Observation, case study, experimental, historical and comparative methods)

Data: Types of Data, Data collection, processing, analysis, Review of literature, Research problem, Hypothesis.

Bioethics: Ethical, legal, social and scientific issues in Biological Research. Plagiarism:

Funding Sources: A brief idea about the funding agencies such as HEC, PSF, USAID etc.

Writing of Research Proposal: Thesis/Report and Research Paper: Footnotes and Bibliography.

Books Recommended

1. Robert, A. Day. 1989. How to write and publish a scientific research paper. 3rd Edition.
2. Holmann, H.H. 1962. Biological research method. Olvyer and Boyd Ltd.

ELECTIVE–I

Cr 3(2+1)

*Note: **University Option:** To be selected from the list provided (Annexure-I) to support special paper (Major-X). The individual university can add more electives to this list according to the requirements and expertise available.*

SEMESTER–VIII

Course Category	Course Title	Credits
MAJOR-XI	Bioinformatics	3(1+2)
MAJOR-XII	*Thesis/Research Project/Internship	4(0+4)
ELECTIVE-II	Univ. Option	3(2+1)
ELECTIVE-III	Univ. Option	3(2+1)
ELECTIVE-IV	Univ. Option	3(2+1)
	Total Credits	16

MAJOR–XI

BIOINFORMATICS

Cr 3(1+2)

Objectives

The course will provide:

- An introduction to bioinformatics with a focus on fundamental bioinformatics problems,
- Information on the tools used to compute solutions to those problems, and the theory upon which those tools are based.

Course Contents

Introduction to BI: What is BI; history of BI; Uses of BI (Protein, Gene); comparison of BI with experimental tools.

Basic principles of computing in bioinformatics: Basic acquisition and database: DDBJ, NCBI and EMBL

Short introduction to DNA, RNA and protein: amino acids, sequence; analyzing Protein sequence by the use of BI tools; sequence-structure-function.

Retrieving protein sequences from database (FASTA): Alignment of protein\ nucleotide sequences (BLAST, CLUSTALW); Computing physico-chemical parameters of proteins (eg. PROTPARAM); Predicting elements of secondary structure of proteins (eg. PSSP); Retrieval, understanding and predicting 3D structure of protein from sequence; PTMs (eg NETPHOS etc.)

Enzyme classification: retrieval databases

Short introduction to DNA/RNA: structure, genetic code; analyzing the DNA/RNA sequence by the use of BI tools

Retrieving the DNA sequence from database; Computing the sequence Identifying restriction sites; Predicting elements of DNA/RNA secondary structure; Computing the optimal alignment between two or more DNA sequences

PRIMER designing for PCR (PRIMER3+, PRIMER-BLAST, OLIGO-CALC etc.)

Short introduction to proteomics and genomics, and the role of bioinformatics in the pharmaceutical industry.

Practicals

1. Retrieval of FASTA sequence
2. Determination of proteins physical and chemical parameters
3. Finding similar sequences for protein and DNA
4. Multiple alignment
5. Predicting proteins secondary structure
6. Predicting RNA secondary structure
7. Predicting protein PTM
8. Finding protein families
9. Determination of gene location on chromosome

10. SNPs
11. Primer design

Books Recommended

1. Baxevanis, A.D., Ouellette, B.F.F, 2011. Bioinformatics: A Practical Guide to The Analysis of Genes and Proteins. John Wiley & sons, Inc.
2. Rastogi, S.C., Mendiratta, N., Rastogi, P. 2011. Bioinformatics Methods and Applications: Genomics, Proteomics and Drug Discovery. PHI publishing.
3. Selzer, P., Marhofer, R. and Rohwer, A. 2008. Applied Bioinformatics: An Introduction. Springer publishing, Germany.
4. Baxevanic, A.D., Ouellette, B.F.F. 2004. Bioinformatics: A Practical Guide to The Analysis of Genes and Proteins, 3rd Ed. O'Reilly publishers.
5. Moody, G. 2004. Digital Code of Life: How Bioinformatics is Revolutionizing Science, Medicine and Business. John Wiley and Sons.
6. Westhead, D.R., Parish, J.H., Twyman, R.M. 2003. Instant Notes on Bioinformatics. Viva Books Private Limited.
7. Orengo, C. A., Jones, D.T., Thornton, J.M. 2003. Bioinformatics: Genes, Proteins and Computers (Advanced Text). Roulledge.
8. Krane, D.E. and Raymer, M.L. 2002. FUNDAMENTAL CONCEPTS OF BIOINFORMATICS. Benjamin Cummings.
9. Gibas, C. and Jambeck, P. 2001. Developing Bioinformatics Computer SKILLS. O'Reilly publishers.

Websites

1. <http://www.ncbi.nlm.nih.gov>
2. <http://www.ebi.ac.uk>
3. <http://foldoc.doc.ic.ac.uk/foldoc/index.html>
4. <http://wit.integratedgenomics.com/GOLD/>

MAJOR–XII

THESIS/RESEARCH PROJECT/INTERNSHIP Cr 4(0+4)

ELECTIVE–II Cr 3(2+1)

*Note: **UNIVERSITY OPTION:** To be selected from the list provided (Annexure-I) to support special paper (Major-X). The individual university can add more electives to this list according to the requirements and expertise available.*

ELECTIVE–III**Cr 3(2+1)**

*Note: **UNIVERSITY OPTION:** To be selected from the list provided (Annexure-I) to support special paper (Major-X). The individual university can add more electives to this list according to the requirements and expertise available.*

ELECTIVE–IV**Cr 3(2+1)**

*Note: **UNIVERSITY OPTION:** To be selected from the list provided (Annexure-I) to support special paper (Major-X). The individual university can add more electives to this list according to the requirements and expertise available.*

ANNEXURE-I

LIST OF ELECTIVE AND SPECIAL COURSES

The courses listed below can be taught as elective subjects. They can also be taught as special subjects provided there is no overlap of the course contents studied earlier.

The individual university can add more Electives & Special courses to this list according to the requirements and expertise available.

1. Agricultural Biotechnology
2. Mechanisms of Development
3. Animal Adaptations
4. Animal Behavior*
5. Animal Communication
6. Animal Pests and Disease Producing Organisms
7. Aquaculture*
8. Arachnology
9. Fundamentals of Human Genetics*
10. Behavioral Ecology
11. Biochemistry of Drug Action
12. Biodiversity and Wildlife*
13. Biodiversity of Inland and Terrestrial Molluscs*
14. Biology and Control of Vertebrate Pests*
15. Biomedical Technology
16. Biotechnology
17. Biotechnology in Aquaculture
18. Cancer Biology
19. Clinical Biochemistry
20. Comparative Developmental Biology*
21. Conservation Biology*
22. Ecological Genetics
23. Economic Zoology
24. Elements of Stratigraphy and Structural Geology
25. Endocrinology
26. Entomology (Classification of Insects and Pest Management)*
27. Entomology (Morphology, Physiology and Ecology)*
28. Environmental Issues*
29. Environmental Physiology
30. Environmental Pollution
31. Environmental Toxicology*
32. Fish Bioenergetics

33. Fish Culture*
34. Fish Ecology*
35. Fish Endocrinology
36. Fish Health Management
37. Fish Feeding Management*
38. Fish Physiology and Breeding*
39. Fundamentals of Microbiology*
40. General and Comparative Endocrinology*
41. General Microbiology*
42. Helminthology and Host-Parasite Relationship*
43. Hematology*
44. Herpetology
45. Histology
46. Ichthyology*
47. Immunology*
48. Insect Bioacoustics
49. Insect Biochemistry and Physiology
50. Insect Pathology
51. Insects of Veterinary and Medical Importance*
52. Invertebrate Paleontology
53. Limnology*
54. Mammalogy*
55. Microbiology and Biotechnology*
56. Microbiology of Extreme Environment
57. Molecular Biology*
58. Molecular Genetics*
59. Neurobiology
60. Ornithology*
61. Parasitology
62. Pharmacological and Pathological Endocrinology
63. Physiology of Coordination*
64. Physiological Systems and Adaptations*
65. Physiology of Functional Systems
66. Population Biology
67. Principles and Kinetics of Toxicology*
68. Fundamentals of Fish Biology*
69. Principles of Parasitology*
70. Quantitative Zoology
71. Radiation Biology
72. Reproductive Biology

73. Restoration Ecology and Sustainable Development*
74. Teratology
75. Techniques in Fisheries Research
76. Vector Biology
77. Vertebrate Paleontology
78. Veterinary and Wildlife Parasitology
79. Wild life Parasitology*
80. Zoological Techniques

ANNEXURE-II

The individual university can add more Elective/Special Courses to this list according to the requirements and expertise available.

COURSE CONTENTS OF SOME ELECTIVE AND SPECIAL COURSES*

Elective/Special

ENTOMOLOGY (MORPHOLOGY, PHYSIOLOGY AND ECOLOGY)

Objectives

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

Course Contents

General characteristics of insects. Relationship with other Arthropods, splitting up into different evolutionary lines, Reasons for success of the insects in diverse environments.

Hard Parts: General segmentation, tagmatosis and organization.

Cuticle: Detailed structure along with its biochemistry. Epidermal layer; its structure and function. Basement membrane. Colors of insects. cuticular outgrowths and appendages sclerotization.

Head: cephalization, sclerites, modifications.

Antennae: Different modes of ingestion and types of mouth parts.

Neck: Sclerites.

Thorax: Sclerites: legs, their different modifications and functions.

Wings: Origin; Different regions. Development and basal attachments, main veins and their branches (generalized insects), wing coupling.

Abdomen: Secondary appendages and external genitalia, Flight; types of flight. Aerodynamics, fuels, endoskeleton; head, thorax and abdomen.

Soft Parts: Muscular system; basic structure, types of muscles; muscle contraction and its energetics, comparative structure of all the systems, e.g., digestive, excretory, respiratory, incubatory, and nervous system and their physiology.

Sense organs: sound and light producing organs.

Nutritive requirements: Fat body, exocrine and endocrine glands including pheromones and their functions.

Reproduction: Reproductive organs and different types of reproduction in insects, egg fertilization and maturation.

Development: Embryology up to dorsal closure, different types of metamorphosis, apolysis and ecdysis and the role of endocrine secretions.

Ecology: Carrying capacity 'r' and k selection, Food chains, predation and competition, insect defenses and adaptations, diapause insect population and community studies, insect communication.

Practicals

1. Preparation of permanent slides. All the hard parts (antennae, mouth parts, wings, legs, terminal segments and genitalia).
2. Different systems, especially digestive, reproductive of the following insects. American cockroach, Gryllus, grasshopper, housefly, butterfly, mosquito, any common beetle. Red cotton bug. Wasp and honey bee.
3. Sympathetic nervous system of cockroach and gryllus. Salivary glands of cockroach, red cotton bug and honey bee.

Books Recommended

1. Tembhare, Db. Modern Entomology. 2002. Himalaya Publishing House. India.
2. Krebs, C. J. Ecology: the experimental analysis abundance. 5th Edition. 2000. Benjamin-Cummings Publishing Company.
3. Chapman, R.F. The insects: structure and function. 2000. Blackwell Science Inc., London.
4. Price, W. Insect ecology. 1997. John Wiley & Sons.
5. Yazdani, S.S., and Agarwal, M.L. 1997. Elements of insect ecology. Narosa Publishing House. India.
6. Wigglesworth, V. B. Insect Physiology 8th Edition. 1984. Springer Publisher.
7. RICHARDS, O. W. and DAVIES, R. G. IMM'S General Textbook of Entomology. Vol.1, 10th Edition. 1977. Chapman & Hall, London,
8. Southood, T.R.E. Ecological Methods. 1978. Chapman and Hall, London.
9. Robert L. Patton. W. B. Insect Physiology. 1963. Saunders Co., Philadelphia.

ENVIRONMENTAL TOXICOLOGY

Cr: 3(2+1)

Objectives

This course will

- provide scientific basis to toxicology as it applies to the workplace and the environment. cover the diverse chemical hazards encountered in the modern workplace and natural environment
- provide a practical understanding of these hazards for those concerned with protecting the health of humans and ecosystems

Course Contents

Toxicology: History, Terms and Definitions; Principles of Toxicology; Development and present Scope of Environmental Toxicology; Frame Work of Environmental Toxicology; Toxicological Evaluations. Sources of Environmental Toxicants / Pollutants: Gaseous Chemicals and Heavy Metals. Toxicity Testing. Characteristics of Exposure: Spectrum of Toxic Effects, Indices of Toxicity. Toxicodynamics. Toxicokinetics (Absorption, Distribution, and Elimination of Toxic Agents). Biotransformation, Detoxification & Biodegradation. Pollution and Remediation. Ecological Risk Assessment.

Practicals

1. Measurement of Environmental Toxicants
2. Sampling of toxicants for Chemical Analysis
3. Risk Assessment

Books Recommended

1. Whitacre, D. M. (Editor) 2012. Reviews of Environmental Contamination and Toxicology. Vol. 223. Springer, Switzerland.
2. Swarties, F. A. (Editor) 2011. Dealing with Contaminated Sites. From Theory towards Practical Application. 1st Edition. 1104 p.
3. Landus, W. G. and Yu, M.H. 2005. Introduction to Environmental Toxicology: Impact of Chemicals upon Ecological Systems. 3rd Edition. Lewis Publishers.
4. James, R. C. and Roberts, S. M. 2000. Principles of Toxicology: Environmental and Industrial Applications, 2nd Edition, Phillip L. Williams (Editor), John Wiley & Sons, Inc.
5. Hughes, W.W. (Editor) 1996. Essentials of Environmental Toxicology. The effects of environmentally hazardous substances on human health. 176 p. Taylor & Francis Ltd.

WILDLIFE PARASITOLOGY

Aims and Objectives

- To give knowledge to the students about parasites of wild animals and birds fauna as previously this field of study was ignored.
- 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 outline 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, feces / droppings from wild animals and birds.
3. Processing of parasitic material for examination.
4. Preparation of permanent mounts.
5. Identification of parasites

Books Recommended

1. Bush, A. O., Fernandez J. C., Esch, G. W. and Seed, J. R. 2001. Parasitism: The diversity and Ecology of animal Parasites. Cambridge University Press, Cambridge, UK.
2. Fowler, M. E. 1999. Zoo and wild animal medicine: Current Therapy- 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 Iowa State University Press, Ames, Iowa, 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 Iowa State University Press. Ames, Iowa, USA.

BIODIVERSITY OF INLAND AND TERRESTRIAL MOLLUSCS

Objectives

The course is designated to provide with:

- Principles of evolutionary relationship to other animals
- Concept of phylogenetic relationship emphasizing on knowledge about animal kingdom
- Knowledge and focuses on strategies regarding the conservation of Gastropods and Bivalves and to develop pearl industry

Course Contents

Evolutionary perspective; Phylogenetic relationship with other animals; Origin of Coelom; Molluscan characteristics; Diagnostic features of shell and associated structures; Mechanism of feeding, digestion, gas-exchange, locomotion, reproduction and development in Gastropods and Bivalves; Slugs Characteristics and classification; Structure and function of Radula; Torsion and Detorsion in Gastropods. Pearl culturing; Threats; Conservative strategies and Economic importance of Molluscs.

Books Recommended

1. Miller, A. S. and Harty, I. B. 2002. Zoology. 4th Edition (International) Singapore McGraw Hill.
2. Baker, G. 2001. The Biology of Terrestrial Molluscs. 3rd Edition.
3. Rober, T. and Dilton, Jr. 2000. The Ecology of Freshwater Molluscas. Cambridge University Press 1-499.
4. Preston, S. B. 1915. Mollusca (Freshwater Gastropods and Decapods). Fauna of British India including Ceylon and Burma. 244 p. Taylor and Francis Red Lion Court, London.

Practicals

1. Study of Museum Molluscan Specimens
2. Study of Gastropods and Bivalves shell
3. Classification of Gastropods and Bivalves representatives
4. Study of different parts and dissection of the representatives of Gastropods and Bivalves
5. Field study trips on diversity with emphasis on their adaptation.

ENTOMOLOGY (CLASSIFICATION OF INSECTS AND PEST MANAGEMENT) Cr: 3(2+1)

Aims and Objectives:

The students will

- learn to identify the pests damaging to the crops
- understand methods of population estimation of the pest
- become aware of the applications of different control strategies

Course Contents

A general account including classification of insect orders: Collembola, Orthoptera, Dictyoptera, Isoptera, Hemiptera, Lepidoptera, Diptera, Hymenoptera, Coleoptera. Only diagnostic characters of the remaining insect orders: Thysanura, Diplura, Protura, Ephemeroptera, Odonata, Plecoptera, Grylloblattoidea, Phasmida, Dermaptera, Embioptera, Zoraptera, Psocoptera, Mallophaga, Siphunculata, Thysanoptera, Neuroptera, Mecoptera, Tricoptera, Siphonaptera, Strepsiptera, Insects of economic importance.

Brief account of biological control, chemical control and integrated pest management: common sampling techniques in insect pest management, concept of economic levels, economic damage and economic boundary, economic injury level and economic threshold. Household pests and their management. Knowledge of Pests of cotton, rice, sugarcane.

Practicals

1. Collection, preservation and identification of insects upto families (except for the identification upto species of a few pests of great economic importance), with the help of keys/literature.

Books Recommended

1. Pedigo, L.P. Entomology and Pest Management. 1991. Maxwell Macmillan.
2. Richards, O.W. and Davies, R.J. *Imm's General Textbook of Entomology*. 1977. Vol-2. Chapman & Hall, London.
3. Metcalf, C.L. and Flint, W.P. *Destructive and Useful Insects*. 1962. McGraw Hill.

GENERAL AND COMPARATIVE ENDOCRINOLOGY

Cr:3(2+1)

Objectives

- General concepts and principles of chemical coordination.
- The details of the endocrine mechanisms in relation to various functions such as reproduction and lactation.
- Recent trends of endocrinology in relation to diversified function.
- Comparative studies of endocrine mechanisms in various invertebrates and vertebrates.

Course Contents

An overview of general concepts and principles of endocrinology: The endocrine system; Type of hormones; Endocrine and nervous system relationship; General principles in function, interaction, nature, synthesis, transport of hormones; General concept of feedback, biorhythms, pathology and assessment of endocrine function; Evolution of endocrine system.

Hypothalamus and pituitary: Hypothalamic hormones: Origin, chemistry and actions; Anterior pituitary & hormones: Hypothalamic pituitary regulation, General chemistry, Physiological action and metabolism of prolactin-growth hormone family, glycoprotein hormone family, corticotrophins and other pro-opiomelanocortin peptides; posterior pituitary: Release, regulation and actions of vasopressin and oxytocin.

Thyroid gland: Anatomy and histology of gland; Formation and secretion of thyroid hormones; Thyroid hormones in peripheral tissues, Regulation and factors affecting thyroid function.

Calcitropic and Mineral Metabolism Hormones: Chemistry, physiological actions and metabolism of parathyroid hormone, calcitonin and calciferols; Homeostasis of calcium, phosphate and magnesium.

Pancreatic Hormones and Regulatory Peptides of the Gut: Anatomy and histology for sources of the hormones; Chemistry, physiological roles and mechanism of action of insulin and glucagon; Physiological roles of gut peptides.

Adrenal Medulla and Catecholamines: Chromaffin cell and organization; Structure of adrenal medulla; Biosynthesis, storage, release and metabolism; Adrenergic receptors.

Adrenal Cortex: Steroid biochemistry; Physiological actions of corticoid hormones; Regulation and metabolism of glucocorticoids, mineralocorticoids and adrenal sex steroids.

Testes: Androgenic tissue: Structure and chemistry; Transport, metabolism and mechanism of action.

Ovaries: Ovarian hormones: Steroid biochemistry and biosynthesis; Transport, metabolism and mechanism of action.

Endocrinology of Pregnancy: Hormones in conception and implantation; Hormonal actions and adaptation in pregnancy and parturition.

Endocrinology of Lactation: Hormones in lactation.

Endocrinology of Heart, Kidney, Immune system: Growth and pineal gland. Functional diversity of hormones in vertebrates; Overview of endocrine mechanisms in invertebrates.

Practicals

- Demonstration of endocrine glands and associated structures in dissections, transparencies, computer projections etc;
- Histological and ultra-structure features of endocrine glands;
- Experiments to demonstrate physiological roles of hormones of different endocrine glands;
- Experiments to demonstrate regulation of hormones' releases.
- Experiments to demonstrate functional diversity of hormones in different vertebrates.
- Experiments on endocrine mechanism in vertebrates.

Books Recommended

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

MOLECULAR BIOLOGY- *ELECTIVE/OPTIONAL SUBJECT* **Cr: 3(2+1)**

Objectives

The course will provide

- An understanding of how molecular mechanisms are constructed and regulated
- Knowledge about different molecular biological techniques

Course Contents

Chemical, Physical and Biological Properties of DNA. Structure and chemical composition of a gene, Types of gene. DNA polymerases, their types in eukaryotes and functions. RNA, its types and structures, Types of RNA polymerases in prokaryotes and in eukaryotes. Gene expression and regulation in both prokaryotes and eukaryotes. Mutation, mutagenes, Chemical, physical and Biological mutagenes, DNA repair. Transposons, its types, mechanism of transposition. Recombinant DNA Technology, its

necessary elements, Restriction enzymes, types of restriction enzymes and their mode of action. Cloning vectors, Plasmids as cloning vectors, bacteriophage lambda as cloning vector, Cosmids as cloning vectors and shuttle vectors. Synthesis of cDNA, Cloning in Ecoli, Yeast and in Higher eukaryotes. Anti-sense RNA, Tripple helix DNA and chromosomal walking. Applications of recombinant DNA technology.

Prcacticals

1. Separation of different sized DNA fragments on agarose gel.
2. Isolation and characterization of proteins on polyacrylamide gel electrophoresis (native and sub-unit molecular weights).

Books Recommended

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D.2013. Molecular Biology of the Cell. Garland Publishing Inc., New York.
2. Damell Jr. J., Lodisch, H., Balimore, D. 2013. Molecular Cell Biology, Scientific American Inc. N.Y.
3. Friefelder, D. 2010. Molecular Biology.
4. Geoffrey M.C., Robert E.H. 2007. The cell: A Molecular Approach,. Sinauer Associates, INC.
5. Karp, J. 2005. Cell and Molecular Biology, Concepts and Experiments, Jhon Wiley and Sons, INC.
6. De Robertis, E. D. P., De Robertis Jr. E. N. F. 1987. Cell and Molecular Biology, Lea & Febiger, New York.

MOLECULAR AND CLINICAL ENDOCRINOLOGY Cr: 3(2+1)

Objectives

- To study that degeneration disease are the results of alterations in biochemical homeostasis regulated by endocrine system.
- To provide understanding about the manifestation of degeneration diseases at molecular level.

Course Contents

General Mechanisms in Molecular Endocrinology: Subcellular structure of cells secreting protein hormones; Process of hormone secretion; Transcription factors in developmental organisms in endocrine systems. Recombinant DNA technology and molecular genetics in diagnosis and treatment of endocrine diseases. Measurements of hormones: Radioimmunoassay, immunoradiometric, immunochemiluminometric and radioreceptor assays and their statistical procedures.

Mechanisms of Action of Hormones: Hormone systems and intracellular communication; Hormones acting at cell surface: Properties of hormone

receptor interaction, structure, biosynthesis and turnover of membrane receptors; Hormones acting in transcription regulation: Biochemistry and molecular interaction of steroid receptor, gene expression, messenger RNA stability and metabolism in hormone action.

Functional Pathology in Endocrine Glands: Neuroendocrine disorder of gonadotrophin, 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. Polyendocrine Syndromes. Hormones and Cancers: Hormones 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

1. Studies on recognition and response of receptors;
2. Studies of disorders of pituitary by observing anatomical and histological features;
3. Studies of thyroid status in deficient and excess hormone functions;
4. Studies of type 1 and type 2 diabetes mellitus;
5. Epidemiology of the types in population, studies of management of the type 2;
6. Model studies of disorders of Ovarian and Testicular disorders;
7. Model studies of obesity and anorexia;
8. Studies of hormonal status in puberty and aging.

Books Recommended

1. Greenspan, F.S. and Strewler, G.J. Basic And Clinical Endocrinology, 5th Edition. 2002. Prentice Hall International Inc., London.
2. Wilson, J.D., Foster, D.W., Kronenberg, H.M. and Larsen, P.R. Williams Textbook Of Endocrinology, 9th Edition. 1998. W.D. Saunders Company, Philadelphia.

3. DeGroot, L.J., Jameson, J.L. Endocrinology, 4th Edition. 2001. W.B. Saunders, Philadelphia.
4. Giffin, J.E. and Ojeda, S.R. Textbook of Endocrine Physiology. 4th Edition. 2000. Oxford University Press, Oxford.
5. Neal, J.M. Basic Endocrinology: An Interactive Approach. 2000. Blackwell Science Inc., London.

PHYSIOLOGY OF COORDINATION

Cr: 3(2+1)

Objectives

- To study the details of nervous and hormonal coordination at molecular and cellular level in animals.
- Biosynthetics, secretory and regulatory aspects of coordination.

Course Contents:

Physiological Mechanisms at Cell: Cellular membrane and transmembrane transport; resting membrane potentials; Generation and conduction of action potentials; synaptic transmission; Membrane receptors, Second messenger and signal-transduction pathways.

Nervous System: Organization of nervous system; General sensory system; Visual, Auditory, Vestibular and Chemical sensory system; Motor system with brainstem, Cortical, Cerebellar and basal ganglia control of posture and movements; Autonomic system and its control; Higher functions of nervous system including state of consciousness, learning, memory.

Muscle and Movements: Molecular basis of contraction; Muscles activity on skeleton; Adaptation of muscles for various activities; Muscles in the walls of hollow organs.

Endocrine System: General principles of endocrine physiology; Hormones in homeostasis of metabolism; Endocrine regulation of metabolism of calcium and phosphate; Parathyroid gland, Calcitonin and Cholecalciferol; Hypothalamus and Pituitary: Hypothalamic regulation of pituitary, pituitary gland hormone in physiological coordination; Thyroid gland: Functional anatomy, biosynthesis, regulation and roles in physiological functions, mechanism of thyroid hormones action; Adrenal cortex: Hormones biosynthesis, physiological roles and control; Adrenal medulla: Hormones biosynthesis, physiological roles, and hypothalamic-pituitary-adrenocortical axis, adrenal medulla and sympathetic nervous system together integrate responses to stress; Endocrine function of kidney, heart and pineal gland; General reproductive mechanisms: Energetics of reproduction; Functional anatomy, synthesis and regulation of gonadal steroids, secretory pattern of gonadal steroid at different stage of life; Male reproduction: Roles of

androgen, biology and regulation of spermatogenesis, male puberty; Female reproduction: Roles of ovarian steroids, biology and regulation of oogenesis, female puberty, cyclic changes and adaptations in gestation, parturition, lactation and menopause.

Practicals

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

Books Recommended

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. Louis, 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. Tharp, G. and Woodman, D. Experiments in Physiology, 8th Edition. 2002. Prentice Hall, London.

PHYSIOLOGICAL SYSTEMS AND ADAPTATIONS

Cr:3(2+1)

Objectives:

- To study the details of physiological systems maintaining the homeostasis of animals.
- Interrelations of the systems
- Regulatory features of the each system's function.

Course Contents

Cardiovascular System: Blood and homeostasis; Physiology of cardiac muscles; Automaticity and rhythmicity in heart activity and cycle; Electrocardiography; Regulation of heart activity; Hemodynamics; Arterial system; Microcirculation and lymphatics; Control of cardiac output; Special circulations: Cutaneous, skeletal, coronary, cerebral, fetal.

Respiratory System: Overview of respiratory system; Pulmonary and bronchial circulations; Mechanical aspects of breathing; Transport of oxygen and carbon dioxide; Regulation of ventilation; Respiratory responses in extreme conditions.

Renal System: Elements of renal function; Tubular function in nephron; Control of body fluid volume and osmolality; Potassium, Calcium and Phosphate homeostasis; Role of kidney in acid-base balance.

Gastrointestinal System: Gastrointestinal secretions and their control: Salivary, gastric, pancreatic and liver; Digestion and Absorption of carbohydrates, proteins, lipids, vitamins, ions and water; Motility of gastrointestinal tract: Functional anatomy, regulation and motility in various segments.

Osmoregulation: Problems of osmoregulation; Obligatory exchange of ions and water; Osmoregulators and osmoconformers; Osmoregulation in aqueous and terrestrial environments.

Environmental Challenges: Temperature and animal energetics; Temperature relation of Ectotherms, Heterotherms and Endotherms; Dormancy: Special metabolic state; Body rhythms and energetic; Energy, environment and evolution.

Practicals

1. Experiments on the study of heart in prepared frogs;
2. Study of blood pressure in various physiological states;
3. Study of electrocardiograms;

4. Blood coagulation study. Determination of oxygen consumption in fish and mouse and effects of factors;
5. Demonstration of respiratory volume and pulmonary function tests.
6. Experiments on digestion on nutrients by enzymes and effects of factors; Study of exocrine secretion in stomach or pancreas and effects of factors. Experiments on kidney regulation of osmolality;
7. Urine analysis;
8. Study of osmoregulatory adaptations in animals inhabiting various environments; Demonstration of effect of temperature on several physiological responses; Study of animals in various types of dormancy.

Books Recommended

1. Randall, D., Burggren, W., French, K. and Fernald, R. 2002. Eckert Animal Physiology: Mechanisms and Adaptations, 5th Edition. W.H. Freeman and Company, New York
2. Tharp, G. and Woodman, D. 2002. Experiments in Physiology, 8th Edition. Prentice Hall, London.
3. Bullock, J., Boyle, J. and Wang, M.B. 2001. Physiology, 4th Edition. Lippincott, Williams and Wilkins, Philadelphia.
4. Berne, R.M. and Levy, M.N. 2000. Principles of Physiology, 3rd Edition. St. Louis, Mosby.
5. Guyton, A.C. and Hall, J.E. 2000. Text Book of Medical Physiology, 10th Edition. W.B. Saunders Company, Philadelphia.
6. Withers, P.C. 1992. Comparative Animal Physiology. Saunders College Publishing, Philadelphia.
7. Schmidt-Nelsen, K. 1997. Animal Physiology, Adaptations and Environment, 5th Edition. Cambridge University Press, Cambridge.

COMPARATIVE DEVELOPMENTAL BIOLOGY Cr 3(2+1)

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 organogenesis.
- Concept related to the theory in developmental biology will be practically demonstrated in this course.

Course Contents

Historical review of embryology. Uses of modern molecular techniques in developmental biology. Origin of germ cells (gametogenesis).

Spermatogenesis & Oogenesis, Structure and organization of male and female gametes.

Fertilization: Chemistry of fertilization, Molecular biology of fertilization, surface changes in the egg and sperm surface, *In vitro* Fertilization (test tube technology). Mono- & Di-zygotic Twinning ,

Parthenogenesis, Uses of Transgenic animals in Developmental biology, Cleavage, Blastulation, Fate maps and their preparation,

Morphogenetic movements and Gastrulation in Amphioxus, mammals, chick and frog. Stem cells technology and its uses in developmental biology.

Embryonic adaptations (fetal extra-embryonic membranes) and Placentation, Umbilical cord, Parturition (birth) and its stages.

Regeneration and regenerative powers of vertebrates. Aging

Practicals

1. Study of model eggs of different invertebrates and vertebrates.
2. Dactylography, and its uses in embryology.
3. Isolation, identification and culture of various developmental stages of *Ascaris lumbricoides* eggs from human/ *Neoascaris vituolarum* eggs from cattle dung (kept for 3 weeks at 24°C in desiccator) by using Telman's centrifugation technique.
4. Study of prepared slides for the development of Amphioxus, mammals, frog and chick.
5. Semen analysis by using improved Neubauer Hemocytometer, Use of dactylography in developmental biology,
6. Peripheral blood smear (abnormal erythrocyte morphology eg., target cells, microcyte, macrocytes, slit cell, acanthocytes & tear drop cells as screening procedure for thalassemia diagnosis.

Books Recommended

1. Scott, F. Gilbert (2010). Developmental Biology, 9th Edition. Sinauer Publishing Co., New York.
2. Patten, B.N. (2004). Foundation of Embryology. McGraw Hill Books Company, Inc, New York, London.
3. Rao, K.V. (2003). Developmental biology: A modern synthesis. Oxford is publishing Co. Ltd., Delhi.
4. Oppenheimer, S.B & Lefevre, G. (1984). Introduction to Embryonic Development.. Allen and Bacon Publishers, New York.
5. Sandler, T. W. (1995). Langmans Medical embryology. Library of congress Cataloguing-in-Publication Data. Williams & Wilkins Publishers, USA.

6. Carlson, B.M. (2001). Patten's Foundations of Embryology (6th Edition). McGraw-Hill, Inc. New York, London, Tokyo, Sydney.

PROTOZOLOGY

Cr: 3(2+1)

Objectives

This course aims to

- Provide knowledge regarding different modes of transmission of parasites of medical and veterinary importance along with their pathology, life cycles and host parasite relationship
- Impart advance knowledge on various important protozoan parasites
- Give understanding about host parasite relationship and control measure

Course Contents

Part I: Protozoology: Systematic, geographical distribution, habitats, biology, pathogenesis, important symptoms, mode of transmission laboratory methods of diagnosis, and control of protozoa of medical and veterinary importance.

Part II: Pathology and Immunity: The cell and cell injury and its relationship to disease. Acute and chronic inflammations, wound healing, disorders of growth, benign and malignant tumors in case of infections immunity, and hypersensitivity in case of parasitic diseases.

Practicals

1. A study of parasitic Protozoa of medical veterinary importance with special reference to differential morphological features.
2. Preparation of permanent mounts of parasitic Protozoa.
3. Examination of human feces and from domesticated animals by using standard laboratory techniques.
4. Techniques and study of blood parasite study of different types of pathological tissues from prepared slides.

Books Recommended:

1. Robberts, L. Sand Janovy John Jr. 2009. Foundation of Parasitology. 8th edition. McGraw Hill, Boston
2. Facust, E. C. and Russell, P. F. 2001. Craig and Faust's clinical Parasitology. Lea and Febiger, 8th edition London
3. Markell, E.K. Mo. Vogo. 1999. Medical Parasitology. W. B. Sundress Co: Philadelphia.

4. Chandrasoma, P. and Taylor, C.R. 1997. Concise Pathology. Prentice Hali International Inc. New Jersey USA.
5. Peters, W and Gills, H.M. 1989. A color atlas of Tropical medicine and Parasitology. Wolfe Medical Publications Ltd., Netherlands.
6. Olsen, O. W. 1986. Animal Parasites: their life cycle and ecology. University Park Press Baltimore
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.

HELMINTHOLOGY AND HOST-PARASITE RELATIONSHIP

Cr: 3(2+1)

Objectives

The course will

- provide knowledge regarding basic principles of host parasite interactions
- impart knowledge on helminth parasites of medical, veterinary and agricultural importance

Course Contents

Part I: Helminthology Theory: Classification, Basic principles and concepts in Parasitology, Taxonomy, etiology, biology, epidemiology, pathology and pathogenesis, diagnosis, control and treatment of

Digenetic Trematodes: *Schistosoma mansoni*, *S. japonicum*, *S. haematobium*, *Fasciola hepatica*, *Fasciolopsis buski*, *Dicrocoelium dendriticum*, *Paragonimus westermani*, *Colonoorchis sinensis*, *Heterophyes heterophyes*,

Monogenetic trematodes: *Dactylogyrus vastator*, *Gyrodactylus*, *Diplozoon paradoxum* and *Polystoma integrimum*.,

Cestodes: *Diphyllobothrium latum*, *Sparganosis*, *Taenia saginata*, *T. solium*, *Echinococcus granulosus*, *E. multilocularis*, *Hymenolepis nana*, *Dipylidium caninum*, *Moniezia expansa*.,

Nematodes: *Trichuris trichiura*, *Capillaria hepatica*, *Trichenella spiralis*, *Strongyloides stercoralis*, *Ancylostoma duodenale*, *Necator americanus*.,
Creeping eruption: *Haemonchus contortus*, *Ascaris lumbricoides*, *Toxocara canis*, *Anisakis* spp., *Heterakis gallinarum*, *Enterobius vermicularis*,

Wuchereria bancrofti, Brugia malayi, Onchocerca volvulus, Loa loa and Dracunculus medinensis.

Part II: Host Parasite Relationship

Host parasite relationship: as associative organization between two organisms. Structural aspects of the association interface.

Nutrient exchanges in associations.

Physiological and regulatory interactions: between associates.

Behavioral Aspects of organism associations.

Ecology and evolution of intimate associations;

Anthelmintic resistance detection methods.

Detection and characterisation of parasites causing emerging zoonoses

Practicals

1. Stage and ocular micrometry for measurement of helminths. Preparation of temporary and permanent mounts of parasites from the following animals:
2. a. Fish b. Frog/toad c. Fowl/Pigeon d. Rat/Mouse.
3. Study of helminths from prepared slides. Study of eggs/larvae from feces and prepared slides. Diagnosis of medically important parasites in fecal specimen by using: Tillman's centrifugation technique, by Lugol's iodine staining technique, Baermanns procedure for nematode culture.

Books Recommended

1. Robberts, L. Sand Janovy John Jr. 2009. Foundation of Parasitology. 8th edition. McGraw Hill, Boston
2. Facust, E. C. and Russell, P. F. 2001. Craig and Faust's clinical Parasitology. Lea and Febiger, 8th edition London
3. Markell, E.K. Mo. Vogo. 1999. Medical Parasitology. W. B. Sundress Co: Philadelphia.
4. Chandrasoma, P. and Taylor, C.R.1997. Concise Pathology. Prentice Hali International Inc. New Jercy USA.
5. Peters, W and Gills, H.M. 1989. A color atlas of Tropical medicine and Parasitology. Wolfe Medical Publications Ltd., Netherlands.
6. Smyth, J. D. 1994. Introduction to Animal Parasitology, 3rd edition. Cambridge University Press, Cambridge.
7. Taylor, A.E.R & Muller, R. (1987). Genetic aspects of host parasite relationships. Symposium of the British Society for Parasitology. . Blackwell Scientific Publications Oxford

8. Whitfield, P. J. (Recent edition). The biology of parasitism; an introduction to the study of association organisms. Edward Arnold. Publishers, UK

PRINCIPLES OF PARASITOLOGY

Cr 3(2+1)

Objectives

This course will

- Introduction to general parasitology
- provide knowledge regarding different modes of transmission of parasites of medical and veterinary importance
- knowledge about their pathology, host parasite relationship and control measures

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.

Books Recommended

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

ORNITHOLOGY

Cr: 3(2+1)

Objectives

The course will

- Provide knowledge about bird diversity
- Avian anatomy, physiology and adaptations
- Bird behavior and socioeconomic and ecological importance

Course Contents:

Introduction to ornithology, class Aves, taxonomy of birds up to orders, families and major species; evolution of birds; biology of fossil birds; archaeopteryx, archaeornithes, neoornithes; morphology and surface anatomy of bird, and development structure of feathers, plumage; structure of bones; basic embryology of birds; internal anatomy of birds; systems physiology; blood circulatory, cardiovascular physiology, heart, blood cells and hemodynamics; respiratory system, air sacs, ventilation of lungs, metabolic rates, oxygen consumption; urinary system, kidney physiology and production of solid or semisolid excreta, brain physiology and anatomy, special senses, olfaction, vision, taste; digestive system, anatomy, guts and feeding strategies; morphological and physiological adaptations of birds to flying, kinds of flight, mechanisms of aerodynamics; reproductive organs anatomy and physiology, egg laying and breeding seasons; bird migration, song production, bird behavior, courtship, mating, egg incubation strategies, brood parasitism; predator-prey relationship; homing behavior; learning, imprinting; nest building; bird parasite; endangered species of birds; bird conservation and sanctuaries. Introduction, evolution, geographical distribution. 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, behavioral). Anatomy & physiology of game and predatory species. Birds of Pakistan: Aquatic, Forest and Game birds and birds of prey. Birds as pests.

Practicals

- Identification characteristics and taxonomy of birds to orders and families
- Dissection of sparrow, pigeon, myna, other available birds
- Anatomy of bones, skull, girdles, spine, vertebrae, feathers, plumage
- Study of gut contents of birds to understand feeding habits
- Incubation of chicken eggs to learn avian embryogenesis
- Bird stuffing and preservation of eggs
- Identification of bird species through feathers and egg shells
- Beak and claw structures
- Study of bird songs, recording bird songs, fundamental experimentation to understand bird songs in sensitive and sensorimotor phases

- Bird watching and preparation of ethograms
- Study of Predator-prey relationship among birds
- Study of Brood parasitism
- Study of flying mechanics through models

Books Recommended

1. Howell, S. N. G. 2010. Peterson Reference Guide to Molt in North American Birds (Peterson Reference Guides. Amazon Co.
2. Kaiser, G. W. 2008. The Inner Bird: Anatomy and Evolution. Amazon Co.
3. Richard Grimmett, Carol Inskipp and Tim Inskipp 2008. Birds of India: Pakistan, Nepal, Bangladesh, Bhutan, Sri Lanka, and the Maldives. Princeton Book Co.
4. A J Urfi 2009. Birds of India: A Literary Companion, OUP.
5. Frank B. Gill. 2004. Ornithology. 2nd Ed. **W. H. Freeman & Co.**
6. Handbook of Bird Biology by Cornell Lab of Ornithology. Princeton University Press. New Jersey. 2004
7. Rank B. Gill. 2004. Ornithology: Ecology and Evolution of Darwin's Finches. 99 ed. (rev). Princeton. W. H. Freeman.
8. David Allen Sibley and Alfred A. Knopf 2003. *The Sibley Field Guide to Birds of Eastern North America*. New York Press
9. David Allen Sibley and Alfred A. Knopf 2002. *Sibley's Birding Basics* New York Press.
10. Salim Ali and S. Dillon Ripley 2001. Handbook of the Birds of India and Pakistan: Together with Those of Bangladesh, Nepal, Bhutan and Sri Lanka/. Reprint. New Delhi, Oxford University Press, 10 Vols.
11. Noble S. Proctor, Patrick Lynch, Patrick J. Lynch, Patrick J. Lynch 1998. Manual of Ornithology: Avian Structure and Function. Yale University Press.
12. Audubon Handbook: How to identify birds? 88th ed. McGraw-Hill Publishing Company.
13. Ali, S. 1979. The book of Indian Birds. Bombay Natural History Society, Bombay, India,
14. Bibby, C. J., Burgess, N.D. and Hill, D.A. 1992. Bird Census Techniques. Academic Press London.
15. Del Hayo, J.D., Elliot, A. and Saegatal, J. 1997. Handbook of the birds of the world. Hoatzin to Auks. Birdlife International, Lynx, editions, Barcelona.
16. Ridgway, R. 1974. Ornithology. Ayer Publishing.
17. Rand, A.L. 1974. Ornithology: an introduction. Penguin Books.
18. Roberts, T.J. 1992. Birds of Pakistan. Vol 1 & 2. Oxford University Press.

ANIMAL BEHAVIOR

Cr: 3(2+1)

Objectives

The course will

- provide broader knowledge about behavior of animals, its genetic basis and environmental and experience related shaping
- impart knowledge about different kinds of behavior and social and aggressive interactions
- provide knowledge about reproductive and sexual behaviors

Course Contents

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

Practicals

1. Study of aquarium fishes and frogs for courtship, nesting, foraging, egg laying
2. Field study of bird and mammalian behavior through visits to aviaries and zoos, nesting behavior of birds, through binoculars
3. Study of altruistic behavior in rats and related species

4. Small experiments to show kinship and cannibalistic behavior
5. Study of parental care in different vertebrate classes
6. Study of mouse or rat behavior regarding mating, selection and parental care
7. Study of monkey behavior regarding aggression, dominance, grooming
8. Preparation of ethograms and presentation of data
9. Recording bird songs and animal vocalizations
10. Behaviors of large predators, to understand survival strategies
11. Study of human facial expressions and postures

Books Recommended

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

GENERAL MICROBIOLOGY

Cr: 3(2+1)

Objectives

The course aims to:

- Enable the students to work with microorganisms.
- Understand the basic techniques of sterilization, culturing, isolation
- Determine different characteristics of the microorganisms

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 protists. 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 growth of 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. Economic importance 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, Zymomonas 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.

Practicals

1. Preparation of culture media
2. Pure culturing and cultivation of bacteria
3. Simple, Gram, endospore, capsular, flagellar and acid fast stainings of different genera of bacteria\Vital staining and microscopic observations of protozoa
4. Cultivation methods of fungi
5. Isolation of bacteriophages

Books Recommended

1. Eugene W. N., Denise, G., Anderson, M. T., Nester, C., Roberts, E. Nancy, N. 2001. Microbiology: A Human Perspective, McGraw Hill Higher Education.
2. Jacquelyn, G.G. 2001. Microbiology: Principles and Explorations, John Wiley & Sons Inc.
3. Madigan, M.T., Martinko, J.M. and Parker, J. 1997. Brock Biology of Microorganisms, Prentice-Hall, London.
4. Benson, H.J. 1994. MICROBIAL APPLICATIONS: LABORATORY MANUAL IN GENERAL MICROBIOLOGY, WMC Brown Publishers, England.
5. Pelczar Jr., Chan, E.C.S. and Krieg, M.R. 1986. MICROBIOLOGY, McGraw Hill, London.
6. Stainier, R.Y., Ingraham, J.L., Wheelis, M.L. and Painter, R.R. 1986. THE MICROBIAL WORLD, Prentice Hall, London.

CONSERVATION BIOLOGY

Cr: 3(2+1)

Objectives

- To study historical background of conservation and its comparison with the recent trends
- To study the impact of gene flow and genetic measures for conservation status of animal life
- To ascertain linkages between the conservation crisis and philosophical, economic and social communities in ecosystems

Course Contents

Conservation biology: Historical perspective. Loss of Biodiversity: Rates, causes, consequences, perspectives. Population bottlenecks and genetic diversity: Effective population numbers and fluctuating size. Gene flow and management measures: One migrant per generation rule, selection and migration, inbreeding and outbreeding depression. Molecular versus quantitative-genetic perspectives and conservation: Single species conservation, choosing species. Conservation forensics: Demographic versus genetic consideration in conservation. Habitat fragmentation. Island biogeographic theory and conservation practices. Endangered Species Act. Community level conservation: Ecological and evolutionary perspectives, ecological restoration, ecosystem stress, ecosystem management - politics and economics.

Practicals

1. Modern approaches to conservation of animals
2. Field visits, trapping and marking techniques
3. Generation of census data about animals

Books Recommended

1. Primack, R. B. 2010. Essentials of Conservation Biology, 5th Ed. Sinauer Associates, Inc. USA
2. Groom, M. J., G. K. Meffe and C. R. Carroll. 2006. Principles of Conservation Biology. 3rd Ed. Sinauer Associates Inc., New York, USA.
3. Primack, R. B. 2004. A Primer of Conservation Biology, 3rd Ed. Cambridge University Press, UK.
4. Young, A. G. and G. M. Clarke. 2002. Genetics, Demography and Viability of Fragmented Populations. Cambridge University Press, UK.

FISH CULTURE

Cr 3(2+1)

Objectives

- To disseminate the history, needs and importance of fish culture
- To elaborate the basic components of pond fish culture
- To describe the cultureable fish species and their biology
- To impart knowledge regarding pond fertilization and feeding of fish

Course Contents

Aims and evolution of fish culture. Pond fish culture: Planning and construction of fish pond, water quality criteria, conditions suitable for fish culture, biological production cycle of fish pond. Culturable fishes of

Pakistan. Fertilization of fish pond: Organic and inorganic fertilizers. Artificial feeding in fish culture: Fish feeding methods, different components of fish feed, composition of commonly available feed ingredients, preparation and feed storage methods.

Integrated fish farming: Concepts and practices. Fish enemies. Fish diseases and remedial measures. Fish hatchery management. Fishing gears, pre- and post-harvesting care of fish, maintenance of fish catch quality during transportation, storage and marketing. Fish processing technology.

Practicals

1. Uses of different organic and inorganic fertilizers in fish ponds
2. Identification of various fishes
3. Study of morphological characters and identification of cultureable fish species
4. Practical demonstration of induced fish breeding

Books Recommended

1. Sharma, O. P. 2009. Handbook of Fisheries and Aquaculture. Agrotech Publishing Academy, Udaipur, New Delhi, India.
2. Hart, P. J. B. and J. D. Reynolds. 2008. Handbook of Fish Biology and Fisheries, Volume 2. Blackwell Science Ltd., New York, USA.
3. Horvath, L., G. Tanes and C. Seagrave. 2002. Carp and Pond Fish Culture Fishing News Book, New York, USA
4. Huet, M. 1998. Text Book of Fish Culture - Breeding and Cultivation of Fish. Fishing News, London, UK.

MAMMALOLOGY

Cr 3(2+1)

Objectives

- To teach the students about phylogenetic relationships of the primitive and present mammals, based on taxonomic and modern approaches
- To study the feeding and foraging periodicities of different mammalian groups and impact of environment on feeding behavior
- To ascertain different mammalian population patterns viz. concept of natality, mortality, modeling signaling and effective communication in various mammals

Course Contents

Introduction to mammalogy. History of mammalogy. Mammalian phylogeny. Dental and cranial characteristics. Evolution of viviparity. Biogeography: Mammalian radiation, biogeography of mammals of Pakistan. Food and

feeding: Stenophagy and euryphagy. Population regulation: Natality, mortality, immigration, emigration, population size, mean crowding, population modeling, Signaling: Types and evolution, communication and social organization. Mammalian Adaptations: Molecular basis of torpor, aestivation, hibernation, acoustic orientation (echolocation). Home range and territoriality. Predation: Predator-prey co-evolutionary race.

Practicals

1. General survey of mammalian species (Visits to zoological museums and zoos and field study)
2. Study of techniques for the collection of mammals, their identification and systematic relationships
3. Comparative study of mammalian skeleton
4. Dissection of a rabbit or rat to expose its different systems

Books Recommended

1. Vaghuan, T. A., J. M. Ryan and N. J. Czaplewski. 2010. Mammalogy. 5th Ed. The John Hopkins University Press, New York, USA.
2. Feldhamer, G. A., L. C. Drickamer, S. H. Vessey, J. F. Merritt and C. Krajewski. 2007. Mammalogy: Adaptation, Diversity, Ecology. 3rd Ed. The John Hopkins University Press, New York, USA.
3. Genoways, H.H., 2000. Current Mammalogy. Plennium Press, New York, USA.

FISH ECOLOGY

Cr 3(2+1)

Objectives

- To elaborate the interaction of fish and aquatic environment
- To describe the effects of biotic and abiotic factors on fish
- To impart knowledge regarding fish population dynamics

Course Contents

Introduction to fish ecology. Inter-relationship between fish and their abiotic and biotic environments: adaptations of fish to a biotic environmental factors; density, pressure, salinity, temperature, salt content of water, gases in solution and light. Sound and other vibrations. Bottom deposits and particles suspended in water. Movement of water and modes of fish movements. Biotic inter-relationships among fishes; intra-specific relationships between fishes and bacteria, viruses, plants and other animals. Competition and predation in freshwater communities. Fundamental links in life cycle of fishes: reproduction and development in fishes; population dynamics;

movement, migration and colonization in fishes, spawning, feeding and over-wintering migrations. Over-wintering and hibernation in fishes; feeding and feeding relationships among fishes.

Practicals

1. Study of fishes with special reference to food and feeding habits.
2. Fish population estimation.
3. Study of fish with special reference to changes in ecological conditions.

Books Recommended

1. Harold M. Tyus, 2011. Ecology and Conservation of Fishes. CRC Press, Taylor and Francis Group, USA
2. Pandey B.N. 2004. Fish Research. APH Publishing Corporation.
3. Kauri Bansi Lal. 1999. Advances in Fish and Wildlife Ecology and Biology. Daya Publishing House Delhi.
4. Moss, B. 1998. Ecology of Freshwaters. Blackwell Scientific Series, U.K.
5. Kaul, B.I., 1996. Advances in Fish and Wildlife Ecology and Biology (Vols. I & II). Daya Publishing House, N. Delhi.
6. Jafferries, M. and Mills, D. 1992. Freshwater Ecology: Principles and Applications. CBS Publishers and Distributors Ltd., N. Delhi.
- 7.
- 8.
- 9.
- 10.

BIOLOGY AND CONTROL OF VERTEBRATE PESTS

Cr 3(2+1)

Objectives

- To impart the biology of vertebrate pests,
- To familiarize the students about the modern concepts of pests and their sustainable management
- To impart knowledge about the eco-friendly techniques used in vertebrate pest management

Course Contents

Role of vertebrate pests as vectors of zoonotic diseases. Importance of vertebrate pest management. Biology and control of common vertebrate pests in agro-ecosystems of Pakistan. Types of crops inflicted with damage and economic losses by vertebrate pests. Impact of climatic changes on pest

efficiencies. Strategic pest management measures: Non-chemical and chemical measures. Pest resistance to chemicals. Estimation methods of damage on crops. Recommended and sustainable management measures in economically important crops for vertebrate pests. Induction of communicable and environmentally hazardous diseases by vertebrate pests and their management

Practicals

1. Survey of agro-ecosystems to locate their potential burrow/nest systems of various vertebrate
2. Vertebrate pest damage assessment, collection of samples and preparation of damage reports
3. Use of some mechanical measures for vertebrate pest control in agro-ecosystems and stored grains

Books Recommended

1. Hone, J. 2007. Analysis of Vertebrate Pest Control. 3rd Ed. Cambridge University Press, UK.
2. Koul, O., G. S. Dhaliwal and G. W. Cuperus. 2005. Integrated Pest Management: Potential, Constraints and Challenges. CABI Publishing, London, UK.
3. Singleton, G., W. Jacos and P. Brown. 2005. A Manual of Vertebrate Pest Management in South East Asia. Australian Centre for International Agricultural Research, Canberra, Australia.

ICHTHYOLOGY

Cr: 3(2+1)

Objectives

- To study the evolution and taxonomy of fish,
- To providing the knowledge regarding fish biology,
- To elaborate the anatomy and physiology of fish

Course Contents

Systematic position of fish in animal kingdom, External features of fish, Fish muscular system, locomotion and energetics of swimming. Physiology of respiration and air breathing among fishes. Cardiovascular system, blood and its circulation and hydromineral balance: Osmoregulation, ionic regulation, stress responses, freezing resistance and acid-base balance. Digestion and control of gastro-intestinal motility in fish. Physiology of gas bladder: Use of gas by the fish as a source of static lift. Gas in the gas bladder: Loss, retention and secretion of gas. Process of aestivation in fish.

Control of kidney function in fish. Sensory system and communication in fish: Acoustico-lateralis system, sound reception and production.

Practicals

1. Study of classification of fishes and some selected fish species
2. Study of Fish anatomy, physiology and adaptations, fish dissections
3. Study of fish habitats, fish fauna of Pakistan
4. Study of fish reproduction, oocytes and aquaculture and food requirements
5. Study of environmental, ecological and economic importance of fishes
6. Study of ornamental fishes
7. Field visits to fish hatcheries

Books Recommended

1. Lagler, K.F., J.E. Baradach and R.R. Miller. 2009. Ichthyology. John Wiley and Sons, Inc., New York, USA.
2. Moyle, P.B. and J.J. Cech. 2008. Fishes: An Introduction to Ichthyology. 6th Ed. Prentice Hall, New Jersey, USA.
3. David, H. 2003. The Physiology of Fishes 3rd Ed. CRC Press, UK.
4. Smith, L.S. 2002. Introduction to Fish Physiology. 2nd Ed. Argent Labs. Washington DC, USA.

LIMNOLOGY

Cr 3(2+1)

Objectives

- To impart the knowledge regarding physico-chemical characteristics of water,
- To elaborate the phenomenon of water quality change in natural water bodies,
- To teach about the effects of limnological factors on fish.

Course Contents:

Diversity of aquatic ecosystems. Comparison of fresh, brackish and marine ecosystems. Unusual and extreme habitats, hydrology, physiography and physical properties like temperature, light, turbidity, currents, density, their interactions and relations with aquatic life. Chemical properties like dissolved oxygen, carbon dioxide, pH, alkalinity, hardness, inorganic and organic substances, their distribution, dynamics and influence on aquatic ecosystem. Status and forms of nutrients like nitrogen, sulphur, phosphorus

and carbon in natural waters; nutrients use and remineralization with special reference to processes controlling the levels of nitrogen, phosphorus and sulphur in aquatic ecosystem. Stichiometry of autographs and heterotrophs; concepts of trophic state, aquatic productivity & eutrophication. Managing eutrophication in freshwater habitats. Biodiversity of fresh waters. Ecological classification of aquatic biota. Limnological importance of biota. Adaptations and characteristics of aquatic life. Quantitative and qualitative changes in spatial and temporal distribution of aquatic biota.

Practicals

1. Water sampling and water preservation techniques for physico-chemical and biological analyses
2. Estimation of physical characteristics of water viz. temperature, density, light penetration and turbidity
3. Estimation of chemical characteristics of water viz. dissolved oxygen, carbon dioxide, pH, total alkalinity, total hardness, bicarbonates, chlorides, calcium, magnesium, salinity
4. Collection, preservation and study of fauna and flora of various water bodies

Books Recommended

1. Moss, B. R. 2010. Ecology of Fresh Waters. John Wiley & Sons Inc., New York, USA.
2. Dodds, W. K. 2006. Fresh Water Ecology: Concept and Environmental Applications. Academic Press, New York, USA.
3. Wetzel, R. G. 2001. Limnology: Lake and River Ecosystem. 3rd Ed. Academic Press, New York, USA.
4. Munshi, J. D. and J. S. D. Munshi. 1995. Fundamentals of Freshwater Biology. Narendra Publishing House, New Delhi, India.
5. Ward, H. B. and G.C. Whipple. 1989. Freshwater Biology. John Wiley & Sons Inc., New York, USA.
6. Welch, P. S. 1988. Limnology. 4th Ed. McGraw Hill, New York, USA.

FISH FEEDING MANAGEMENT

Cr 3(2+1)

Objectives

- To elaborate the significance of fish feeding,
- To impart the basic principles of artificial feed preparation,
- To understand the fate of different nutrients in fish

Course Contents

Need of supplementary/ artificial feeding of fish, Scope of artificial feeding in fish, Metabolism of feed nutrients (Protein, Lipid, Carbohydrate) in fish, Feeding practices, Different types of feeders, Diet preparation and processing techniques, Estimation of apparent nutrient digestibility. FCR and FCE indices, Food acquisition and patterns of estimation of food requirements.

Practicals

1. Ration calculation for fish feeding based on body weight, body length etc.
2. Estimation of basic nutrients in feed i.e. moisture, protein, lipid, carbohydrates and ash.
3. Formulation of fish feed.

Books Recommended

1. Lovell, T., 2012. Nutrition and Feeding of Fish. 2nd Ed. Springer Science, USA
2. Pillay T V R, M N Kutty. 2005. Aquaculture: Principles and Practices. Balckwell Publishing. UK.
3. Reddy, M.S. and Sambasiva K.R.S. 1999. A Textbook of Aquaculture. Discovery Publishing House, N. Delhi.
4. Pillay, T.V.R. 1999. Aquaculture: Principals and Practices. Fishing News Books, London.

AQUACULTURE

Cr 3(2+1)

Objectives

- To equip the students with advanced knowledge about aquaculture, its development and future role in human nutrition. This will enable the young students to understand principles of aquaculture and its relationship with biological systems which is important for better planning and management of aquatic resources in Pakistan
- To teach about different aquaculture species, their rearing facilities and management by using advanced techniques

Course Contents

The concept of aquaculture; principles of aquaculture management. Aquaculture in raceways, cages and enclosures, comparative aquaculture economics of a cage, raceway and enclosure. Use of wastewaters in

aquaculture. Mari-culture: Substrate system, sea water ponds. Aquaculture in fresh and brackish waters. Aquaculture in practice: Culture of algae, seaweeds, mollusks and crustaceans. Integration of aquaculture with agriculture poultry and livestock farming. Culture of freshwater prawns and shrimps: History of development, present status, breeding requirements, incubation and hatching of eggs, rearing of larvae and juveniles. Artificial feeds for aquaculture: Feed constituents, diet formulation and processing. Role of biotechnology in sustainable aquaculture development.

Practicals

1. Determination of water quality for aquaculture
2. Determination of metals (Cd, Zn, Co, Mn, Fe) in water, plankton and fish
3. Fish feed formulation and processing

Books Recommended

1. Metha, V. 2009. Fisheries and Aquaculture Biotechnology. 2nd Ed. Campus Books International, New Delhi, India.
2. Sharma, O. P. 2009. Handbook of Fisheries and Aquaculture. Agrotech Publishing Academy, Udaipur, New Delhi, India.
3. Stickney, R. R. 2009. Aquaculture: An Introductory Text. CABI Publishing, London, UK.
4. Pandey, B. N., S. Deshpande and P. N. Pandey. 2007. Aquaculture. APH Publishing Corporation, New Delhi, India.
5. Parker, R. O. 2004. Aquaculture Science 4th Ed. Delmar Learning, London, UK.
6. Chakraborty, C. and A. K. Sadhu. 2001. Biology, Hatchery and Culture Technology of Tiger Prawn and Giant Freshwater Prawn. Dya Publishing House, New Delhi, India.

PRINCIPLES OF FISH BIOLOGY

Cr: 3(2+1)

Objectives

- to enable students in obtaining complete understanding about freshwater as well as marine fishes in general and freshwater culturable fishes in particular.
- to impart knowledge of morphology, anatomy, classification and understanding of various feeding groups found in different water bodies.

Course Contents

Fish morphology: Head (size, shape, and orientation); Scales (types, arrangements, coloration, scale less fishes); Operculum; Fins, fin rays and fin spine (dorsal, pectoral, caudal, anal); Barbel (upper lip barbels, lower lip barbels); **Anatomy:** Skeleton (skull, backbone, spines); Brain and spinal cord; Gills (Number, size, arrangements); Vital organs (heart, liver, kidney); Viscera and mesenteries (swim bladder, stomach, spleen, pancreas, intestine, gonads).

Systematic: Identification of fishes up to; Families; Order; Genus; 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 museums

Books Recommended

1. Kestin, S. C. and Warris, P.D. (Editors). 2002 Kestin Farmed Fish Quality Blackwell Science, Oxford, UK.
2. Woo, P.T.K 1995. Fish diseases and disorder. Vol 1. Protozoan and metazoan infections.. CABI Publisher.
3. Brenabe, G. Aquaculture, 1992. Vol. I. Blackwell Publishing, Oxford. UK.
4. Huet M. 1973. Text book of fish culture: breeding and cultivation. Blackwell Publishing Company.

FISH PHYSIOLOGY AND BREEDING

Cr: 3(2+1)

Objectives

- to provide sufficient knowledge about all physiological phenomena in fishes.
- to provide practical information to obtain better growth during extensive or semi-intensive culture.
- to impart knowledge about breeding of most culturable freshwater fishes by manipulating reproductive and endocrinological aspects during natural season as well as off seasons

Course Contents

Fish nutrition: Digestive system; Stomach less fishes; Stomach fishes; Digestion and absorption; Food; Plant origin; Animal origin; Feeding; Fresh food; Dry concentrates; Pelleted food.

Transportation: Blood; Blood cells (Erythrocytes, leukocytes, Platelets and plasma); Circulation; Arterial system; Venous system; Capillaries; Transport of food material.

Respiration: Gills; Lungs; Skin; Swimbladder; Homeostasis.

Excretion: Kidneys; Hypo-osmotic urine; Hyper-osmotic urine; Osmoregulation.

Reproduction: Gonads; Testes and ovaries; Maturation; Reproductive cells (egg and sperm); Artificial fertilization of sex cells.

Breeding: Natural (seasonal); Artificial; Hormonal induced breeding; Temperature & photoperiod; control induced breeding.

Growth: Extensive culture (due to the consumption of natural food); Semi-intensive culture (due to natural & artificial food); Intensive culture (due to only dry concentrates).

Fish health: Water quality; Hygiene of fish culture facilities; Hygiene of equipment used in fish culture.

Diseases and their control: Viral; Bacterial; Fungal; Parasitic; Protozoan; Helminths (trematodes, cestodes, nematodes, acanthocephalons); Crustaceans (cladocera); Annelids (leeches); Arthropods (water ticks, water flea, water mites).

Fish migration: To nursery ground; To maturation grounds; Freshwater to marine water; Marine water to freshwater.

Fish behaviour: Learning and memory; Light response for maturation; Courtship behaviour; Aquarium fish behavior

Practicals

1. Study of gut contents,
2. Study of feeding modification and adaptation in fish,
3. Study of respiratory adaptation in fish, S
4. Study of blood cells and their counts in normal and diseased fish,
5. Study of water quality parameters (DO, NH₃, hardness, alkalinity, turbidity, transparency, temperature, salinity),
6. Study of various forms of swimbladder as hydrostatic organ, Study fecundity of various fish species, Study the effects of reproductive hormone (GnRH) on fish maturation, Diagnosis of bacterial infection in infected fish,
7. Study of fish parasites,
8. Visit to various fish seed hatcheries during breeding seasons

Books Recommended

1. Kestin, S. C. and Warris, P.D. (Editors). 2002, Kestin farmed fish quality, Blackwell Science, oxford, UK.
2. Saksena, D.N. 1999. Ichthyology: recent research advances. Oscar Publications. India.
3. Woo, P.T.K 1995. Fish diseases and disorder. Vol 1. Protozoan and metazoan infections. CABI Publisher.
4. Brenabe, G. 1992. Aquaculture, Vol. I. Blackwell Publishing, Oxford. UK.
5. Maseke C. 1987. Fish aquaculture. Pergamon Press, Oxford. UK.
6. Huet M. 1973. Text book of fish culture: breeding and cultivation. Blackwell Publishing Company
7. Hoar, W.S. 1971. Fish physiology. Academic Press. UK.
8. Hoar, W.S. 1969. Fish reproduction. Academic Press. UK.
9. Matty, A.J. 1985. Fish endocrinology. Timber Press, UK.
10. Gorbman, A. 1983. Comparative Endocrinology. 1st Edition. John Wiley & Sons. UK.

IMMUNOLOGY

Cr 4(3+1)

Objectives

The course aims to

- Give understanding of the basic concepts of immunology and its importance in biological sciences
- Provide information about immunological mechanisms against different diseases
- Give understanding of immunization, immunological tolerance etc.

Course Contents

Immunology: Immunobiology, Immunophysiology, Immunopathology.

Immunity: Natural and acquired immunity, Active and passive immunity.

Antigens and elicitation of immune responses: antigens and their types, antigenicity and immunogenicity, factors important for immunogenicity of an antigen, cell mediated and humoral: nature of antigens, genetic constitution of individuals and route of administration.

Immunoglobulins: Synthesis of antibodies, Theories of antibodies synthesis.

Detection and application of antigen-antibody reactions: *in vivo* and *in vitro* reactions.

Monoclonal antibodies: Importance, synthesis, isolation and applications

Major histocompatibility complex: types and importance, diversity in

MHC proteins.

Cellular basis of immune response: Origin of lymphocytes, Primary and secondary lymphoid organs, Specific response of individual lymphocytes to antigenic stimulation, Histological features of immune response.

Hypersensitivity: Immediate hypersensitivity (anaphylaxis, antibody dependent cytotoxicity, Immune-complex mediated disease and stimulatory hypersensitivity), Delayed type or cell mediated hypersensitivity.

Immunological tolerance and autoimmunity: Tolerance, autoimmune diseases and types, factors responsible for autoimmunity.

Transplantation immunology, Tumor immunology, Immunity against infectious diseases, Immuno deficiency diseases, Immunity and malnutrition.

Immunization; Immunization procedures, Vaccines and their types.

Practicals

1. Study of different types of leucocytes in: Blood, Bone marrow, Spleen and Thymus in mammals.
2. Estimations of total serum proteins, albumins and globulin concentrations in mammalian blood.
3. Differentiation of globulin proteins in blood serum of mouse by electrophoresis.
4. Diagnosis of immunoglobulin proteins by enzyme linked immunosorbant assay (ELISA).
5. Isolation of lymphocytes and resetting technique.
6. Antigen-antibody reaction by agglutination and precipitation reaction.
7. Antigen antibody reaction by using adjuvant.
8. Diagnosis of typhoid fever by Widal test.
9. Visit to pathological laboratory and report writing.

Books Recommended

1. Essential immunology. Roitt, I. 1990. 2nd ed. Black well Scientific Publications. Oxford, UK.
2. Stites, D. P., Stobo, J. D., Fudenberg, H. H. and Wells, J. V. 1990. Basic and clinical immunology. Lange Medical Publications, USA.
3. Essentials of haematology. Hoff - Brand, A. B. and Pedit, J. E. 1981. Black well Scientific Publications. Oxford, UK.

FUNDAMENTALS OF MICROBIOLOGY

Cr: 3(2+1)

Objectives

The course is designed to

- Enable the students to work with micro-organisms.

- Understand the basic techniques of sterilization, culturing and isolation of bacteria and fungi
- Determine different characteristics of the micro-organisms.

Course Contents

Introduction: History of microbiology, Microbes influencing our lives, Characterization and identification of microorganisms.

Virology: Structure of virus, Characteristics of virus, Virus-host cell interaction, viral replication, Transformation, Transmission of transforming viruses, Mechanism of pathogenicity; virus cultivation and propagation.

Morphology and fine structure of bacteria: Size, Shape and arrangement of bacterial cells, motility, Capsules, Structure and composition of cell wall, Cytoplasmic membrane, Protoplasts, Endospore, pili.

Cultivation of Bacteria: Nutritional requirements, Nutritional types of bacteria, Bacteriological media, Physical conditions required for growth.

Pure culture and growth characteristics: Pure culture, Methods of isolating pure culture, maintenance and preservation of pure culture, Cultural characteristics.

Growth and Metabolism: Growth of microbial population, measurement of microbial growth, growth rate, growth curve, determination of number of cells by direct microscopic count, Plate count method, membrane filter count, Turbidimetric method, determination of cell mass by measurement of growth.

Food microbiology: Microbial spoilage of foods, Food poisoning, Food infection, Factors effecting the spoilage of food (water, pH, oxygen, nutrients, physical structure of food), Botlism food poisoning, Mycotoxins, Food preservation (drying, refrigeration, irradiation, canning).

Medical microbiology: Sources and communicability of diseases, Communicable diseases, Non-communicable diseases, Chain of infection, Etiological agents, Specificity, Source and reservoirs of etiological agents, Methods of transmission.

Normal microbial flora: Significance of normal microbial flora, Origin of normal Microbial flora, Microbial flora of skin, Microbial flora of gastrointestinal tract, Microbial flora of genito-urinary tract, Sterile sides of human body, Mechanism of bacterial pathogenity.

Microbial Ecology: Distribution and activities of microorganisms in natural systems, Role of bacteria in elemental cycles and plant interaction of microbial communities with their biotic and abiotic environment microbial role in global carbon cycle.

Soil microbiology: Soil environment, Microbial flora of soil, Bacteria, Fungi, Algae, Rhizosphere, Biogeochemical activities of microorganisms in soil.

Air microbiology: Microbial content of air, Indoor air, Outdoor air.

Water microbiology: Microbiology of sea, Lakes and ponds, Rivers and streams, Microbes of domestic water, Microbes of sewage water.

Practicals

1. Isolation of microorganisms from air.
2. Isolation of microorganisms from water.
3. Isolation of microorganisms from soil.
4. To study the morphology of moulds.
5. To study physical characteristics of bacterial colonies.
6. To study bacteria of different morphologies through simple, gram, endospore, flagellar and capsular stainings
7. Different techniques for the isolation of microorganisms.
8. Gram staining of mouth flora.
9. To study bacterial motility by hanging drop method.
10. Negative staining of bacteria.
11. Acid fast staining of bacteria.
12. To study different sterilization techniques. Isolation of spore forming bacteria from powdered milk .
13. To study viable counting of bacteria.

Books Recommended

1. Medical Microbiology. Khan, A. M. 2001. 151 ed. Time Publishers Pakistan.
2. Environmental Microbiology Vamam, A. H. and Malcolm, G. M. 2000. 1st ed. Manson Publishing Ltd. USA.
3. Introductory Microbiology. Fredrick, C. R. and Charles, E. M. 1983. 151 ed. Merrill Publishing Company USA.
4. Microbiology. Pelczar, M. J. Chan, E. C. and King, N. R. 1986. 51^h ed. McGraw-Hill, Inc. New York.
5. Laboratory Experiments in Microbiology. Johnson, T. R. and Case, C. L. 1992. 3rd ed. The Benjamin/Cummings Publishing Company, USA.
6. Plant and microbial biotechnology Research, NO.3. Wang, K., Herrera-Eastrella A. and Montagu, M. V. 1995. Cambridge University, Press, UK.

INSECTS OF VETERINARY AND MEDICAL IMPORTANCE

Cr 3(2+1)

Objectives

- to provide knowledge about insect vectors, disease borne pests of veterinary and human importance
- to understand their life cycles as they carry viruses and other

- organisms during transmission of diseases
- to impart knowledge about their control

Course Contents

General introduction to medical and veterinary entomology: phylum arthropoda, salient features of insects, classification, general morphology and physiology of insects, modifications in mouthparts and appendages of insects, metamorphosis and its types.

Insects of medical and veterinary importance: mosquitoes, human louse, houseflies, fleas, bugs, mites and ticks: life cycles, diseases and their control. Insect venoms; bees, wasps, ants. Insect toxins, arthropod allergens. Insect pest management: definition, principles and methods of insects control, components of pest management, techniques, general measures to control insects, economics of pest management.

Practicals

1. Techniques of collection and preservation of insects.
2. Collection, identification and classification of insects of veterinary and medical importance.
3. Preparation of slides of mouthparts and appendages of different Insects.
4. Morphometric studies of different Insects and their life cycle.
5. Field studies and report writing to observe different Insects and their life cycles.

Books Recommended

1. Roy, D. N. and Brown, A.W.A .2004. Entomology. Biotech .Books, New Delhi.
2. Chandler, A.C. and Read, C.P. 1961. Introduction to Parasitology. 10th ed. Wiley Toppan, New York, USA
3. Rozendael, J. A. 1999. Vector ConlJ19l. A I. T. B. S. publishers, New Delhi.
4. Service, M.W. 1996. Medical Entomology. Chapman and Hall, USA
5. Pedigo, L. P. 2003. Entomology and Pest Management. 4th ed. Pearson Education, Singapore, Pvt. Ltd.

HEMATOLOGY

Cr: 3(2+1)

Objectives

- to provide knowledge about blood formation, morphology, physiology and biochemistry of blood cells, basic mechanisms and types
- to impart knowledge about advanced techniques in studying serological and hematological techniques, blood coagulation
- to gain insight into blood related diseases

Course Contents

Blood cell formation, Erythropoiesis and general aspects of anemia, hyperchromic anemia and iron overload, Megaloblastic anemia and other megaloblastic anemia, Hemolytic anemia. Genetic disorders of Hemoglobin. Leukopoiesis, Lymphocytes and their benign disorders, granulocytes and monocytes. Platelets, blood coagulation and hemostasis, bleeding disorders caused by vascular and platelet disorders.

Practicals

1. Total erythrocyte and lymphocyte counts
2. Study of granulocytes and leukocytes
3. Differential leukocytes
4. Comparison of blood counts of diseased (Anemia) and healthy individuals.
5. Morphological alterations in erythrocytes in various disease conditions like sickle cell anemia etc.

Books Recommended

1. Hoffbrand, A.V. and Hoffbrand, I.E. 2002. Essential Haematology. Peltit and PAH Moss
2. Dacie and Lewis. 2002. Haematology.

RESTORATION ECOLOGY AND SUSTAINABLE DEVELOPMENT

Cr: 3(2+1)

Objectives

- to enable the students to identify the main candidates (wetlands, lakes, rivers, forests, etc) for conservation.
- to train the students to develop approaches for conservation such as designing and
- management of protected areas.
- to make the students able to play the role of an active conservation biologist.

Course Contents

Conservation at the community level: Protected Areas: Existing protected areas, the effectiveness of protected areas, Establishment priorities for protection, International agreements. Designing protected Areas: Reserve size, minimizing edge and fragmentation effects, Habitat corridors, Landscape ecology and Park design. Managing protected areas: Habitat management, Park management and people. Outside protected

areas: Wildlife outside parks, Strategies for success, Ecosystem management. Restoration ecology: Restoration ecology in practice. Main candidates for ecological restoration: Wet lands, Lakes, urban areas, Prairies, Tropical dry forests. Restoration ecology and the future of conservation. Government action: local legislation, national legislation.

Conservation and sustainable development: Traditional societies and sustainable development; Conservation ethics of traditional societies, Local people and their governments, Biological diversity and cultural diversity, Conservation efforts involving traditional societies. International approaches to conservation and sustainable development: The Earth summit, Funding sustainable development programmes, International funding, Funding in developing countries, International development banks and ecosystem damage. An agenda for the future. The role of conservation biologist.

Practicals

1. To study the principles of reserve design.
2. To study the classification of protected areas (IUCN 1994).
3. Visits to the national parks of Pakistan and report writing.
4. The Ramsar convention on wetlands for Pakistan.
5. To review and study the measures of protecting precious biodiversity in Pakistan with particular reference to national and international conservation programmes.
6. To study and review the threats to biodiversity of Himalayan forests.
7. To study different types of *Ex situ* conservation strategies.

Books Recommended

1. Primack, R. B. 2000. *A Primer of Conservation Biology*. 2nd ed. Sinauer Associates Inc. Publishers Sunderland, USA.
2. Cox, C. B. and Morre, P. D. 2000. *Biogeography: An ecological and evolutionary approach*. 6th ed. Life Sciences King's College London, UK.
3. Mirza, Z. B. 1998. *Illustrated Handbook of Biodiversity of Pakistan*. Printopack. Rawalpindi, Pakistan.
4. Gaston, K. J. and Spicer, J. I. 1998. *Biodiversity An Introduction*. 15th ed. Blackwell Science Ltd. UK.
5. McKinny, M. L. and Schoch, M. R. 1998. *Environmental science: System and solution*. 1st ed. Jones and Bartlett Publications, USA.
6. Hussain, S.S. 1992. *Pakistan Manual of Plant Ecology*. 1st ed. National Book Foundation, Pakistan.
7. Bradbury, I. K. 1998. *The Biosphere*. 1st ed. John Wiley and Sons Inc. UK

SPECIAL SUBJECTS

MICROBIOLOGY AND BIOTECHNOLOGY

Cr 4(3+1)

Objectives

- to teach the students techniques regarding isolation and characterization of bacteria.
- to will also help the students to understand the role of the bacteria in the environment, health and agriculture.

Course Contents

History of microbiology,
Screening of microorganisms from environmental samples,
Characterization and classification of microorganisms, cultivation, microbial growth dynamics and kinetics,
Development of pure cultures and their preservation, inoculum development (size and physiological states), mixed cultures and substrate systems,
Types of fermentors, types of bioreactors, strain improvement through recombinant DNA technology, scale up theory,
Applied biotechnology: case studies for industry, environment, health, and agriculture.

Practicals

1. Study of bacteria, yeasts and molds, and protozoa,
2. microscopy, preparation and sterilization of culture media,
3. isolation of pure cultures, microbial enumeration and growth estimations,
4. cultural preservation techniques, development of synchronized inocula for industrial use

Books Recommended

1. Pelczar Jr., chan, E. C. S. and Krieg, M. R., 1986. Microbiology, McGraw Hill, London.
2. Medigan, M. T., Mantinko, J. M. and Parker, J., 1997. Brock Biology of Microorganisms, Prentice Hall, International, Inc. USA
3. Peltier., G. L. A Laboratory Manual of Microbiology.
4. Benson, H. J. 1994. Microbiological Applications, Wm. C. Brown Publishers, USA.
5. Rehm, J. J., 1988. Biotechnology Fundamentals, VCH Publishers, New York.
6. Lee, B. H., 1996. Fundamentals of Food Biotechnology, VCH Publishers, New York.

INTRODUCTION TO ENVIRONMENT

Cr 4(3+1)

Objectives

- to enable students to understand interrelationship between various components of the environment.
- to provide knowledge about basic concepts of matter, energy, birth of universe, solar system and origin of earth,.
- to provide knowledge about environmental geology and environment and life and human activity are considered for understanding of environment and its trans disciplinary integration.

Course Contents

Environment; Introduction and definitions. Environmental systems; Atmosphere, Lithosphere, Hydrosphere, Biosphere, Origin and their interrelationships.

Environmental factors; Physical, chemical and biological factors.

Variety of life and environment (brief account).

Environment and human interactions. Environmental pollution; types, sources, causes and effects (brief overview).

Environmental issues and challenges; Deforestation, water logging, salinity, drought and desertification, Loss of natural habitat, Depletion of resources,

Population and genetic diversity.

Environment and sustainable development.

Issues of social environment; Population growth, urbanization, migration, and poverty, Lifestyle and environment.

Practicals

1. Study of environment in the university campus.
2. Adaptation of animals to various environmental conditions: i) Aquatic ii) Terrestrial iii) Arboreal iv) Fossoreal v) Cursoreal vi) Parasitic
3. Adaptation of plants to various environmental conditions (i) Xerophytic (ii) Mesophytic (iii) Hydrophytic
4. To determine (i) brightness of light by using LUX meter (ii) Intensity of light by using Pyronometer
5. Study of various soil profiles and determination of their moisture contents.
6. Determination of speed of air at different time intervals by using anemometer.
7. Analyzing the quality of different water samples by physical and chemical tests.

8. Study of various types of rocks and fossils.
9. To determine the amount of rain fall in different times by using simple rain gauge.
10. Visit to meteorological department and report writing.

Books Recommended

1. otkin, D. and Keller, E. Environmental Science (Earth as a living planet). 2000. 1st ed. B. John Wiley and Sons Inc. New York, USA.
2. Nebel, B. J. and Wright, R. T. Environmental Science (The way the world works). 1998. 1st ed. Prentice Hall International Inc. London, UK.
3. de Blij, H. J. and Muller, P.O. Physical Geography of the Global Environment. 1993. 1st ed. John Wiley and Sons Inc. New York, USA.
4. Strahler, A. and Strahler, A. 1997. Physical Geography (Science and systems of the human environment). 1st ed. John Wiley and Sons Inc. New York, USA.

ENVIRONMENTAL ISSUES

Cr 3(2+1)

Objectives

- to provide review of the different environmental issues including ecological, conservation, pollution, resources, population and socio-economic issues of Pakistan.
- To impart knowledge about management and planning issues using case studies.
- to enable the students to identify and analyze various environmental issues

Course Contents

Human population: Human population explosion, environmental and social impacts of growing population and affluence, addressing population problems.

Food production and its distribution, hunger, malnutrition and famine.

Pest and pest control need and approach to pest control, integrated pest management.

Water Pollution: Human impact on water resources, Eutrophication, Combating eutrophication.

Sewage Pollution: Sewage hazards and sewage managements.

Hazardous Chemical pollution: Nature of chemical risks, pollution sources and control.

Major atmospheric Changes; Acid deposition, global warming/ cooling, greenhouse effect, Ozone depletion.

Solid Waste: Landfills, incineration, management and solutions.

Energy resources: Energy sources and uses; issues related to fossil fuel and nuclear power, alternate energy resources.

Environmental Issues in Pakistan: Ecological issues: Soil erosion, deforestation, issues related to irrigation system, natural hazards. Issues related to conservation of habitat and biodiversity: Major threats to biodiversity in Pakistan, Conservation strategies.

Industrial pollution: Sources and remediation.

Population issues: Socio-economic issues in Pakistan.

Practicals

1. Study of the various characteristics of the population with the help of the statistical data (Age profile, family size and educational status, etc).
2. Study of the types of the pesticides and their characteristics.
3. Study of the relationship between relative humidity and temperature of Lahore for a particular time period.
4. Estimation of total particulate matter in air by using air sampler.
5. Determination of Sodium and Potassium in various water samples using flame photometer.
6. Determination of Chromium, Lead and Copper in industrial effluent.
7. To study the urban environment and urban environmental issues.
8. To study the eutrophic conditions in various ponds.
9. To study noise level at different places in city (Main road crossings, Railway station, Hospital) using noise level meter.
10. To study the level of occurrence of various diseases among families of (i) Class students (ii) Low income groups (iii) High income groups.

Books Recommended

1. Botkin, D. B. and Keller, E. A. 2000. Environmental Science (Earth as a living planet). 3rd ed. John Wiley and Sons Inc. New York, USA.
2. Nebel, B. J. and Wright, R. T. 1998. Environmental Science (The way the world works). 1st ed. Prentice Hall International Inc. London, UK.
3. Bradbury, 1. K. 1998. The Biosphere. 2nd ed. John Wiley and Sons Inc. UK.
4. McKinney, M. L. and Schoch, R. M. 1998. Environmental Science (Systems and solutions). Jones and Bartlett Publications Inc. USA.
5. Ahmad, R. Z. 2000. Pakistan- A Descriptive Atlas (A comprehensive geo-politics course). 1st ed. Feroze sons Pvt. Ltd. Lahore Pakistan.
6. Khan, F. K. 1993. A Geography of Pakistan Environment (Environment, people and economy). 1st ed . Oxford University Press. New York USA.
7. Daily newspapers for current issues.

WEBSITES

[http://wu\)w.panasia.org.sg/tcdc/pakistan](http://wu)w.panasia.org.sg/tcdc/pakistan)
<http://urwww.wwfpak.org/biodiversity>
<http://www.populationconnection.org>
<http://www.epa.org.pk>
<http://www.unep.org>

BASIC HUMAN GENETICS SPECIAL

Cr 4(3+1)

Objectives

- To provide an overview of human genetic concepts and clinical disorders
- To teach students how to apply the knowledge of medical genetics to a variety of clinical genetic diseases

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

Books Recommended

1. Strachan, T., A. P. Read, Human Molecular Genetics, 3rd edition, Garland Science/Taylor & 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.

MOLECULAR GENETICS

Cr 4(3+1)

Objectives

- to understand the molecular basis for transcription, translation, replication and gene regulation
- to understand molecular mechanisms in prokaryotes and eukaryotes
- to understand modern methods and applications of molecular analysis of genetic diseases

Course Contents

Plant and animal viruses (DNA and RNA)

Transposition: transposable elements, detection of transposition in bacteria, types of bacterial transposons, modes of transposition in bacteria. Genetic phenomena mediated by transposons, transposable elements in prokaryotes and eukaryotes.

Gene expression in pro- and eukaryotes.

Genetic transformation (all kinds). Regulation of simple and complex transcription unit.

Current developments in molecular genetics: molecular techniques viz. Southern, Northern and Western blotting, PCR, RFLP, AFLP's, RAPDs, Micro-sattelites, SNPs.

Practicals

1. Isolation of nucleic acids
2. Qualitative and quantitative measurement of concentration, digestion with specific restriction enzymes and gel electrophoresis.
3. Plasmid isolation and characterization.
4. Denaturation and renaturation of DNA.
5. Orientation with different molecular techniques including PCR, RFLP, AFLPs, RAPDs, etc.

Books Recommended

1. Alberts, B., A. Johnson, J. Lewis, M. Raff, K. Roberts, and P. Walter. Molecular Biology of the Cell, 4th Ed. Garland Publishing Inc. New York. 2002.
2. Watson, J.D., T.A. Baker, S.P. Bell, A. Gann, M. Levine, and R. Losick. Molecular biology of the gene. Pearson Education. 2004.
3. Snyder, L. and W. Chapness. Molecular Genetics of bacteria. ASM, Press, 2003.
4. Lewin, B. Gene-VIII. Oxford University Press, Oxford, UK. 2004.

PRINCIPLES AND KINETICS OF TOXICOLOGY Cr 4(3+1)

Objectives

- to provide knowledge and understanding about the nature and mode of action of different categories of toxicants
- to provide knowledge about the procedural protocols used in toxicological studies
- to enable the students to understand the differential effects of variety of toxicants on different cellular sites

Course Contents

Measuring toxicity and assessing risk: Introduction; chemistry of toxicants; toxicity testing methods; routes of exposure; determining the responses to varying doses of substances; time of exposure; the LD50 experiments; toxicity, hazards and risks.

Toxicokinetics: Introduction; pharmacokinetics and toxicokinetics; absorption: the oral, respiratory and dermal route of exposure, distribution, elimination, toxicokinetic models: mathematical models of elimination; absorption and bioavailability; contrasting kinetics of lipophilic substances.

Biotransformation: Introduction; Primary biotransformation (phase I reaction) Hydrolysis, oxidation, reduction, Secondary metabolism (phase II reaction) Glucuridination, Glutathione conjugation, acetylation and other phase II reactions, factors influencing metabolism.

Cellular sites of action:

Introduction, interaction of toxicants with proteins, effect of toxicants on enzymes, receptors and ion channels, voltage activated ion channels and transport proteins;, Effects of toxicants on lipids and nucleic acids, Mechanism of cell death; apoptosis, necrosis, stress, repair and recovery.

Practicals

1. Study of Biototoxicity assay for LC₅₀.
2. Study the effects of different teratogenic chemicals on the development of human/rat embryo.
3. Study the effect of Ethanol on the development of chick embryo with different doses.
4. Study the effect of Xylene on the development of chick embryo.

Book Recommended

1. Principles of Toxicology, Karen E. Stine and Thomas M. Brown, CRC press, Taylor and Francis Group.
2. Toxicology, Hans Marquardt, Siegfried, G. Schafer, Roger McClellan, Frank welsch, 1999,2004, Academic press, San Diego.

3. Principles of toxicology testing, Frank A. Barile, CRC Press Taylor and Francis Group.
4. M. Lois Murphy, C. P Dagg and David A. Karnofsky, Comparison of teratogenic chemicals in the rat and chick embryos. *Pediatrics*, 19:701-714

BIODIVERSITY AND WILDLIFE ELECTIVE **Cr 3(2+1)**

Objectives

- to enable student to understand biodiversity levels, functions and its importance
- to acknowledge Wildlife of Pakistan and its importance
- to learn Wildlife census techniques

Course Contents

Biodiversity: Definition, Types, Levels, Status of Biodiversity; Importance

Natural Resources and Biodiversity: Ecological aspects of Biodiversity, Impacts on Biodiversity, Loss of Biodiversity, Protection/Conservation of Biodiversity.

Wildlife: Introduction, important wild animals of Pakistan, Wildlife importance, Wildlife Management.

Ecozones of Pakistan: wildlife and its distribution in different major ecozones of Pakistan.

Wildlife census techniques: Modern census techniques for Mammals and Birds, diversity indices.

Practicals

1. Procedures for studying species richness, Simpson Index, Shannon and Weiner Function.
2. Population of some local subterranean animals.
3. Bird's population Census Techniques.
4. Mammal's population Census Techniques.
5. Study of Wildlife habitats.

Books Recommended

1. Kumar & Asija, 2000 Biodiversity, Principles and Conservation.
2. Mary Jenking and Ann Boyce, 1987. The Diversity of Life.
3. A. R. Rehmani and Salim Ali: Birds Censing Techniques.

**MODEL SCHEME OF STUDIES FOR
MS ZOOLOGY (2 YEAR)**

Semester-I

Course Title	Credits
Core Course-I (Advanced Analytical Techniques)	3/4
Course (Univ. Option)	3/4
Course (Univ. Option)	3/4
Course (Univ. Option)	3
	12

Semester-II

Course Title	Credits
Core Course-II (Applied Biostatistics)	3/4
Course (Univ. Option)	3/4
Course (Univ. Option)	3/4
Course (Univ. Option)	3
	12

Semester-III & IV

Course Title	Credits
Research and thesis	6*/10**
Seminar**	2**
	6*/12**
TOTAL CREDITS 30*(Flexible from 30-36**)	30*/36**

Course work= 24 credits (compulsory) Core and Special (as per university options)

Research & Thesis= Minimum 6 credits (Compulsory)

- **Semester 1=** There can be 3 courses of 4 credits or 4 courses of 3 credits (total=12 credits)
- **Semester 2=** There can be 3 courses of 4 credits or 4 courses of 3 credits (total=12 credits)
- **Semester 3 & 4=** Research and thesis (minimum 6 credits*)

OR

As per university (Total credits for MS degree 30-36)**

In case of 36 credits= Sem-1 (12 credits), Sem-2 (12 credits)

Sem- 3 & 4 (2 credits Seminar + 10 credits Research & thesis)

COURSES FOR MS PROGRAM IN ZOOLOGY

(Courses may be added as per specialization)

MS Compulsory Courses

1. Advanced Analytical Techniques*
2. Applied Biostatistics
3. Seminar

MS Specialized Courses

1. Advances in Immunology
2. Advances in Aquaculture
3. Advances in Cell Biology
4. Advances in Ecology
5. Advances in Helminthology and Protozoology
6. Advances in Protozoology
7. Advances in Helminthology
8. Advanced Cell and Molecular Biology*
9. Advances In Wildlife*
10. Applied Genetics*
11. Applied Microbiology*
12. Applied Reproductive Physiology
13. Aqua Culture Biotechnology
14. Aquaculture
15. Aquaculture and Fisheries*
16. Aquaculture Biotechnology
17. Aquaculture System Management
18. Bacterial Genetics*
19. Biology of Birds and Mammals In Pakistan*
20. Biological Toxicology*
21. Cellular and Molecular Physiology
22. Classification of Insects and Pest Management
23. Clinical Bacteriology
24. Clinical Endocrinology
25. Clinical Immunology
26. Clinical Teratology*
27. **Conservation Biology of Wildlife***
28. Diagnostic Parasitology
29. Environmental Toxicology
30. Epidemiology of Animal Parasite
31. Fish and Aquatic Toxicology

32. Fish Nutrition and Health
33. Fish Requirements*
34. Fishing Gear Technology
35. Freshwater Biology
36. General Pharmacognosy
37. General Toxicology
38. Herpetology
39. Human Genetics*
40. Industrial Biotechnology
41. Lab and Biosafety*
42. Medical Biotechnology*
43. Medical and Veterinary Parasitology
44. Medical Microbiology*
45. Medical Parasitology*
46. Medical Virology
47. Mendelian Genetics
48. Molecular Endocrinology
49. Molecular Entomology*
50. Molecular Evolution
51. Molecular Parasitology
52. Molecular Physiology*
53. Pharmaceutical Microbiology
54. Principles of Wildlife Management*
55. Recombinant DNA Technology
56. Reproductive Physiology
57. Research Methodology
58. Research Methods in Entomology*
59. Stem Cell Technology
60. Toxicology
61. Wildlife Conservation and Management
62. Wildlife Management
63. Wildlife of Pakistan
64. Wildlife Techniques and Data Analysis

ADVANCED ANALYTICAL TECHNIQUES

Objectives

This course aims to demonstrate the knowledge and skill to select and use the appropriate spectrophotometric, chromatographic and electrochemical instrumentation for a specific chemical analysis.

Course Contents

UV Spectroscopy/Separations, Quantitative Infrared Spectroscopy, Flame Atomic Absorption Spectroscopy, Direct Potentiometry, Spectrofluorimetry: Determination of Fluid Volumes by Dye Dilution Techniques, TLC: Drug Monitoring Techniques, Column Techniques: Separation of Transition Metal Cations, Gas Chromatography, High Performance Liquid Chromatography, principles of IR-spectrometry and its use for compound identification; understanding of the working mechanism of the basic components of spectrometric and mass-spectrometric instrumentation, Amino acid sequencers, Balances, Bioreactors, Blotting Apparatus, Centrifuges, DNA Sequencers, Electroporation Instrument, Isoelectric Focusing Apparatus, Lyophilizer, Microarray Technology, Microscopy, Microtomy, Nuclear Magnetic Resonance Instrument, principles and application.

Books Recommended

1. Chemical Analysis: Modern instrumentation, methods and techniques, Francis Rouessac and Annick Rouessac, John Wiley & Sons, 2000, ISBN 0-471-97261-4.
2. Principles of Instrumental Analysis (5th ed), Douglas A. Skoog, F. James Holler and Timothy A. Nieman, Brooks Cole, 1997, ISBN 0-03-002078-6.
3. Spectrometrische analysetechnieken, M.T.C. de Loos - Vollebregt, Heron reeks - Bohn Stafleu Van Loghum, 2004, ISBN 90-313-4142-8.

MOLECULAR ENTOMOLOGY

Objectives:

To provide the modern molecular concepts of Insect Genome System and its applications in Bio-diversity studies.

Course Contents

Introduction; insect genomes; nucleus, chromosomes, DNA and RNA; Gene structure and function; gene transcription and translation; concept of introns

and exons; central dogma of molecular biology; polymerase chain reaction (PCR), gene cloning and sequencing; restriction analysis, gene libraries; DNA for insect species identifications and insect population diversity; DNA for phylogenetic analysis and construction of phylogenies; RAPD, RFLP and PCR-RFLP; linkage and chromosomal mapping, genes regulatory processes, mutagenesis; molecular basis of insect functions (insect behavior, insecticidal resistance), gene knock-ins and knock-outs by RNA interference, DNA and protein sequence alignments and use of bioinformatics tools.

Practicals

1. Demonstration of insect DNA extractions, PCR amplification,
2. gene cloning and plasmid DNA extractions,
3. DNA hybridization (Southern and northern blots); RAPD,
4. RFLP analysis techniques, use of Bio-Informatics software tools.

Books Recommended

1. Gilbert, L. 2005. Comprehensive Molecular Insect Science.1-7 Vol.
2. Glick, B.R. and Pasternek, J..J. 1998. Molecular Biotechnology: Principles and Applications of Recombinant DNA.ASM Press. Washington D.C.
3. Hall, B.G. 2007. Phylogenetic Trees Made Easy: A How to Manual. 3rd Ed. Sinauer Associates.
4. Handler, A. M. James, A.A. (Eds.).2004. Insect Transgenesis: Methods and Applications, Comprehensive review of insect gene transfer, its methodologies, applications and risk assessment and regulatory issues. CRC Press.
5. Hoy, M.A.2000. Insect Transgenesis: Methods and Application. CRC Press.

RESEARCH METHODS IN ENTOMOLOGY

Objectives

To enable students get familiarized with modern equipment used in Entomological Research and provide concept of software in data analysis.

Course Contents

Introduction; techniques and apparatus employed in entomological research: temporary and permanent mounts, microtomy, use of ocular grid, micrometry and scientific photography; bio-assay techniques; atomic absorption spectrophotometer, gas chromatography, high performance liquid chromatography, UV-visual spectrophotometer, amino acid analyzer,

electrophoresis, PCR, recombinant DNA techniques, ultra-centrifugation, scanning and transmission, electron microscopy and computer software in entomology; methods of sampling, analysis of data and report writing; lab/field experimental techniques.

Practicals

1. Insect sampling, collection and preservation techniques;
2. culturing devices; exercises in microtomy,
3. preparation of permanent slides, software for morphometrics and data analysis;
4. scientific photography; electron microscopy; maintenance and measurement of microclimate;
5. use of different equipment in entomological experiments, tabulation, analysis and interpretation of data; bioassay;
6. demonstration of insect DNA amplification through PCR methods.

Books Recommended

1. Bancroft, J.D. and Stevens, A. 1990. Theory and Practice of Histological Techniques. Chaschill Livingstone, London.
2. Binns, M.R. 2000. Sampling and Monitoring in Crop Protection. CABI Publishing Company
3. Cappiello, A. 2007. Advance in LC-MS Instrumentation. Elsevier Publishers, USA.
4. Erlich, H. 1992. PCR Technology: Principles and Applications for Amplification. W.H. Freeman & Company, New York.
5. Singh, P. and Moore, R.F. 1985. Handbook of Insect Rearing. Vol, I & II, Elsevier, U.S.A.

TOXICOLOGY

Objectives

The course provides knowledge and understanding about the different carcinogenic, mutagenic and teratogenic agents and their mode of action and the effects of different chemicals on living cell.

Course Contents

Introduction to Principles of Toxicology: The science of poison, early fundamental development, Types of toxicology, Common terms and Nomenclature, Applications of toxicology: Research, Regulatory toxicology, Forensic toxicology, Clinical toxicology, Classification of toxic agents according to use: Pesticides, food and industrial additives, Therapeutic drugs, Sources of toxins: Botanical, Environmental.

Effects of Chemicals: Toxicological effects: General classification, Chemical allergies, Immediate versus delayed hypersensitivity, Local versus systemic effects, Mutagenic and carcinogenic effects, Biochemical properties, Exposure: Route: Oral administration, Intranasal administration, Inhalation, Dermal and Parenteral routes, Duration and frequency, Accumulation: According to physiological compartment, According to chemical structure, Chemical interactions, Dose-Response relationship, Criteria for measurement

Toxicokinetics: Relationship to pharmacokinetics: Applications to toxicology testing, Absorption: Ionic and non-ionic principles, Henderson-Hasselbach equation, Absorption in nasal and respiratory mucosa, Distribution: Fluid compartments, Plasma protein binding, Lipids, Liver and kidney, Blood-brain barrier, Biotransformation: Principles of detoxification, Biochemical pathways, Enzyme systems, Elimination: Urinary excretion, Fecal elimination, Pulmonary elimination, Mammary gland secretion, other secretion

Descriptive Animal Toxicology: Correlation with human exposure, Animal welfare and US animal welfare act, Chemicals: Selection of chemicals, Route of administration, Species differentiation: Selection of appropriate animal species, Methodologies

Acute Toxicology: Objectives of acute toxicology, LD₅₀ and acute toxicology, Organization of studies, Range finding tests: Up-and-down procedure (UDP), Fixed dose procedure (FDP), Acute toxin class method (ATCM), Classical LD₅₀: Oral, Dermal and inhalation LD₅₀, Other considerations with LD₅₀ determinations, Applications of LD₅₀.

Practicals

1. Study of Biototoxicity assay for Lc50.
2. Study the effects of different teratogenic chemicals on the development of human/rat embryo.
3. Study the effect of Ethanol on the development of chick embryo with different doses.
4. Study the effect of Xylene on the development of chick embryo

Books Recommended

1. Toxicology, Hans Marquardt, Siegfried, G. Schafer, Roger McClellan, Frank welsch, 1999,2004, Academic press, San Diego.
2. Principles of toxicology testing, Frank A. Barile, CRC Press Taylor and Francis Group.
3. M. Lois Murphy, C. P Dagg and David A. Karnofsky, Comparison of teratogenic chemicals in the rat and chick embryos. *Pediatrics*, 19:701-714.

BIOLOGICAL TOXICOLOGY

Objectives

The course provides knowledge and understanding about the different carcinogenic, mutagenic and teratogenic agents and their mode of action and the effects of different chemicals on living cell. They will also learn about the role and mode of action of different toxicants on different organ systems.

Course Contents

Reproductive toxicology and teratology: Effects of toxicants on male and female reproductive system; protective mechanisms, interference with cell division, cytotoxicity and infertility, interference with hormonal control. Effects of toxicants on development; teratogens and teratogenesis, effects of dose exposure level and timing of exposure, examples and mechanism of teratogenicity.

Respiratory Toxicology: General principles for the effects of toxicants on the system, defense mechanism, measuring the exposure levels, deposition of gases and particulates. Immediate response to respiratory toxicants; free radical induced damage, the irritant response, involvement of immune response. Immediate response; upper and lower airways. Delayed and cumulative response to toxicants; asthma and immune- related chronic condition, COPD; bronchitis and emphysema; fibrosis and pneumoconiosis, lung cancer.

Cardiovascular Toxicology: Effects of toxicants on heart; arrhythmias, cardiomyopathies and other effects, myocardial infarction. Effects of toxicants on the vascular system; Atherosclerosis, vascular spasm and blood pressure. Effects of toxicants on blood; anemias, hemolysis and related disorders and effects on hemoglobin.

Neurotoxicology: General principles of effects of toxicants, BBB. Effects on electrical conduction, synaptic function (acetylcholine, Biogenic amines, amino acid neurotransmitters and neuroactive peptides), axonopathies (axon transport, proximal and distal axonopathies), myelinopathies, direct effects on neurons; excitotoxicity, other neurotoxicants.

Hepatic Toxicology: Types of toxicant induced injury; fatty liver, necrosis and apoptosis, cirrhosis and miscellaneous effects. Response to liver injury.

Renal Toxicology: General principles of effects on the system; damage to glomerulus, proximal and remainder of the tubule. Measurement of kidney function *in vivo* and *in vitro*.

Immunotoxicology: Effects of toxicants on immune system; toxic-induced allergies, autoimmunity and immunosuppression. AIDS and antiviral drugs.

Practicals

1. Study of Biototoxicity assay for LC₅₀.
2. Study the effects of different teratogenic chemicals on the development of human/rat embryo.
3. Study the effect of Ethanol on the development of chick embryo with different doses.
4. Study the effect of Xylene on the development of chick embryo.

Book Recommended

1. Principles of Toxicology, Karen E. Stine and Thomas M. Brown, CRC press, Taylor and Francis Group.
2. Toxicology, Hans Marquardt, Siegfried, G. Schafer, Roger McClellan, Frank welsch, 1999,2004, Academic press, San Diego.
3. Principles of toxicology testing, Frank A. Barile, CRC Press Taylor and Francis Group.
4. M. Lois Murphy, C. P Dagg and David A. Karnofsky, Comparison of teratogenic chemicals in the rat and chick embryos. *Pediatrics*, 19:701-714.

APPLIED MICROBIOLOGY

Objectives

The will provide:

- Information about the applications of microbiology in the different fields of life.
- Understanding of its applications in agricultural, industrial and/or environmental microbiology.
- Information on the role of microorganisms in biotechnology

Course Contents

Control of microorganisms: Fundamentals of 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: 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.

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

1. Bacteriological examination of water.
2. Isolation and identification of coliform bacteria and enteric pathogens. Isolation of pathogenic *Staphylococci*.
3. Normal throat flora and reaction on blood agar. Enumeration and identification of microorganisms in urinary tract infections.
4. Isolation and identification of microorganisms from the diseased ear.
5. Inhibition and destruction of microorganisms by physical agents.
6. Action of disinfectants on bacteria. Bacteriostatic action of certain dyes and drugs. Bacterial sensitivity tests (some contemporary antibiotics).
7. Bacterial examination of food, raw milk.
8. Survey of microorganisms' activities based industries.

Books Recommended

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 & Sons Inc.
3. Benson, H.J. MICROBIAL APPLICATIONS: LAB MANUAL IN GENERAL MICROBIOLOGY, 1994. WMC Brown Publishers, UK.
4. Pelczar Jr., Chan, E.C.S. and Krieg, M.R., MICROBIOLOGY, 1986. McGraw Hill, London.

MEDICAL BIOTECHNOLOGY

Course Contents

Introduction to the medical biotechnology: The role of medical biotechnology, Medical biotechnology; an interdisciplinary pursuit, Scope for use, Public perception, Medical biotechnology and developing world.

The principles of cloning DNA in medical biotechnology: General principles and strategies for cloning, Cloning tools, The enzymology of *in vitro* DNA recombination, Vectors used for cloning, Synthesis of DNA for cloning, Reaching the gene via mRNA and protein, Synthesis of complete gene, Reporter genes, Recombinant virus genes, The determination of

base sequence in DNA(brief account).

Gene cloning techniques for mammalian cells: Methods of transfection, (Ca⁺⁺ phosphate co-precipitation method, DEAE-Dextran method, Electroporation, Protoplast fusion. Liposomes as vectors for gene transfer, Direct transformation of mammalian cells; Microinjection. Requirement for gene expression. Expression of mammalian genes in prokaryotic and eukaryotic systems, Basic techniques of animal cell culture and their applications, Expression of cloned genes in animal cells: Transgenic Animals (brief account).

Molecular biological techniques for rapid diagnosis of diseases: Spectrophotometric and UV spectroscopic analysis of nucleic acids, Agarose gel electrophoresis, Pulsed/field gel electrophoresis, Hybridization, Foot printing, Reverse transcriptase, Site directed mutagenesis, Restriction fragment length polymorphism (RFLP), 2 - dimensional gel electrophoresis. DNA finger printing, Enzyme linked immunosorbant assay (ELISA), Diagnostic Polymerase chain reaction (PCR), Types of Polymerase chain reaction, Optimization of PCR conditions, Rapid amplification of cDNA ends (RACE), Other applications of PCR, Gene therapy.

Medical biotechnological approach to study various types of diseases (Infectious and Genetic): Tuberculosis, Typhoid, Hepatitis C, Thalassaemia, Chromosomal anomalies, Other mutations, Prenatal diagnosis of anaemias; a molecular basis for inherited disease, Mapping a genetic disease, Forensic science.

Applied medical biotechnology: Pharmaceutical and biopharmaceuticals, Vaccines and monoclonal antibodies, Preparation of monoclonal antibodies, Applications of monoclonal antibodies, Vaccine productions, Potential Vaccines: Hepatitis B, Whooping cough, Chlamydia, Herpes, AIDS, Vaccine for leprosy, Virus vaccines, Antigens purification, Study of new drug targets: Screening of antibiotics, Mode of action of selected antibiotics, Human insulin, Human growth hormone, Factors vm, Lymphokines (Interferon, interleukins) Somatostatin, Colony stimulating factor, Blood factor vm for hemophilia, Bovine growth hormone, Erythropoietin, Epidermal growth factor, Bone growth factors; Other proteins and other products: Tissue Plasminogen Activator (TP A), Human lung surfactant, Atrial natriuretic factor, Tumor necrosis factor; Cerebrase, Cancer.

Biosafety Regulation: Introduction to genetically manipulated organisms (GMOs), Release of genetically engineered microbes in the environment, Biosafety management, Debate on the safety work in medical biotechnology.

Practicals

1. Introduction to preparative procedures used in medical biotechnology.
2. Preparation of DNA.
3. Preparation of electrophoresis buffers.
4. Preparation and loading of agarose gel.
5. Sizing of DNA samples using λ -Hind III markers.
6. Plasmid minipreparation by alkaline lysis method.
7. Preparation of different buffers and concentrations for PCR reagents.
8. In vitro amplification of DNA by polymerase chain reaction (PCR).
9. Use of PCR for diagnosis of typhoid by *targetingfli C* gene.
10. PCR-ribotyping technique for typhoid fever.
11. Use of PCR for diagnosis of hepatitis B.
12. Use of PCR for diagnosis of tuberculosis.
13. Study of various mammalian genetic disorders by karyotyping techniques.
14. Western blotting of insulin protein.
15. ELISA based diagnostics.
16. Bioavailability of serum.
17. Production of polyclonal antisera.
18. Isolation of lymphocytes and resetting technique.
19. Visit of medical biotechnological lab.

Books Recommended

1. Biosafety management. Mitchell, R. 2000. 1st ed. Virginia Polytechnic Institute Publication. USA.
2. Principles of tissue Engineering. Lanza, R.P., Langer, R. and Vacanti, 1. 2000. 2nd Edition. Academic Press, California, USA.
3. Genetics: From Genes to Genomes. Hartwell, L.H., Hood, L., Goldberg, M.L., Reynolds, A.E., Silver, L.M. and Veres, R.C. 2008. 3rd edition. McGraw-Hill Companies, Inc. Avenue of Americans, New York.
4. Introduction to Genetic Analysis. Griffiths, A. J. F., Wessler, S.R., Lewontin, R.C. and Carroll, S. B. 2008. 9th edition. W.H. Freeman and company, USA, New York. Basic Biotechnology. Ed. Ratledge, C. and Kristiansen, Bjorn. 2006. 3rd edition. Cambridge University Press, New York.
5. Principles of Gene Manipulation and Genetics. Primrose, S.B. and Twyman, R. M. 2006. 7th edition. Blackwell Publishing, USA.

MEDICAL MICROBIOLOGY

Objectives

- To Enable the students to know about the nature of infectious diseases
- To Understand virulence and pathogenicity of microbes
- To Make students aware about the spread of infectious diseases and their control.

Course Contents

Microbiology and Medicine: antimicrobial agents, mode of action. Bacterial pathogens and associated diseases. Infective syndromes and diagnostic procedures. Strategy of antimicrobial therapy. Prophylactic immunization. Staphylococcus aureus skin and wound infections. Streptococcus, sore throat, scarlet fever, glomerulo-nephritis Streptococcus pneumoniae, S. viridans (Halitosis). Pneumococcus, respiratory infections. Neisseriameningitidis, Neisseria gonorrhoeae, Anthrax bacillus i.e., Bacillus anthracis, Clostridium tetani, C. perfringens (Gas gangrene), C. botulinum, Listeria monocytogenes, Corynebacterium diphtheriae, Diphtheria. Mycobacterium tuberculosis, M.leprae, Pseudomonas aeruginosa, Brucella: Bordetella pertussis, Legionella pneumophila, Escherichia coli, Salmonella typhae, Shigella. Klebsiella, Herpes simplex viruses. H5N1avian influenza virus, Dengue and dengue haemorrhagic fever, Rubella virus and Hepatitis viruses.

Practicals

1. Staining of microorganisms: Simple stains, positive staining; negative staining.
2. Demonstration of special structures by stains: Spore stain, Flagella stain. Differential stains: Gram stain, Metachromatic Granule stain, Acid fast stain.
3. 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
4. Laboratory diagnosis and control of infections: Streptococcus. Corynebacterium, Listeria, Mycobacterium.
5. The Entero bacteriaceae: Salmonella. Escherichia, Klebsiella and Clostridium. Blood tests: TLC, DLC, RBC.
6. Recognition of hemolytic bacteria.
7. Testing of antimicrobial agents including antibiotics

Books Recommended

1. Kenneth Ryan, C. George Ray, Nafees Ahmad, W. Lawrence Drew, James Plorde. 2010. Sherris Medical Microbiology, Fifth Edition. McGraw Hill Publishers, Washington DC
2. Cruickshank, R, Duguid, J.P., Hermion, B.P. and Swain, R.H.A., 2003. Medical Microbiology. Churchill Livingstone, N.Y.
3. Microbiology: A Human Perspective, 2001. Eugene W. Nester, Denise, G., Anderson, Martha, T., Nester, C., Evans Roberts, Nancy, N. McGraw Hill Higher Education.
4. MICROBIOLOGY PRINCIPLES AND EXPLORATIONS, 2001. Jacquelyn, G.G. Wiley John & Sons Inc.
5. Foundations in Microbiology. (1998). Talaro & Talaro. WCB Publishers, New York.

MEDICAL PARASITOLOGY

Objectives

The course will:

- Provide an overview of the major parasitic diseases of man and their vectors prevalent in Pakistan.
- Demonstrate understanding of the biology and the life cycles of the major parasites and of their vectors or intermediate hosts and to identify the major parasites, vectors and intermediate hosts;
- Understanding of the pathogenesis and pathology of the major parasitic diseases and the immune responses to these parasites;
- Appreciate the epidemiology of the major parasitic infection and methods available for chemotherapy and control.

Course Contents

Symbiosis to parasitism: parasite, host, community; Malaria; biological aspects; immunological and patho-physiological aspects in malaria; Leishmaniasis: disease spectra and immunopathology Chagas' disease; Opportunistic pathogens: Toxoplasmosis; Intestinal protozoa: Amebiasis and Giardiasis; Hepatosplenic, intestinal and urinary schistosomiasis; Fascioliasis; Echinococcosis; Cerebral and generalized cysticercosis; Ascariasis and visceral larva migrans; Intestinal nematodiasis: immunological mechanisms of worm expulsion; Cytokines: their roles in parasitic diseases; Lymphatic filariasis; Trichinosis; Significance of eosinophilia in helminthiasis ; Parasite-host cell molecular interaction

Practicals

1. Visiting patients, collection of material like Faeces,
2. Blood, Epidermal Cells,
3. Preparation and staining of slides for the various parasites,
4. identification of various stages of parasites, study of their life cycles.

Books Recommended

1. L.S. Roberts and J. Janovy Jr 2009. Foundations of Parasitology. 8th edition,. McGraw Hill, Boston.
2. Animal Agents and Vectors of Human Diseases by P.C. Beaver and R.C. Jung.
3. Hunter's Tropical Medicine (6th edition) by G. T. Strickland.
4. Immunobiology by Janeway, C.A. and Travers, P.

APPLIED GENETICS

Course Contents

Nucleic acids. Plant and animal viruses (DNA and RNA) and their importance in molecular biology.

Tumor viruses, retroviruses, conjugation, gene mapping, transformation and transduction, Integration of viral DNA, consequences of Integration.

Transposition: transposable elements, detection of transposition in bacteria, types of bacterial transposons, modes of transposition in bacteria. Genetic phenomena mediated by transposons, transposable elements in prokaryotes and eukaryotes.

Gene expression in pro- and eukaryotes.

Genetic transformation (all kinds). Regulation of simple and complex transcription unit.

Advances in genetics: molecular techniques viz. Southern, Northern and Western blotting, PCR, RFLP, AFLP's, RAPDs, Micro-sattelites, SNPs.

Practicals

1. Isolation of nucleic acids
2. Qualitative and quantitative measurement of concentration, digestion with specific restriction enzymes and gel electrophoresis.
3. Plasmid isolation and characterization.
4. Denaturation and renaturation of DNA.
5. Applications of different molecular techniques including PCR, RFLP, AFLPs, RAPDs, etc.

Recommended Books

1. Alberts, B., A. Johnson, J. Lewis, M. Raff, K. Roberts, and P. Walter. Molecular Biology of the Cell, 4th Ed. Garland Publishing Inc. New York. 2002.
2. Watson, J.D., T.A. Baker, S.P. Bell, A. Gann, M. Levine, and R. Losick. Molecular biology of the gene. Pearson Education. 2004.
3. Snyder, L. and W. Chapness. Molecular Genetics of bacteria. ASM, Press, 2003.
4. Lewin, B. Gene-VIII. Oxford University Press, Oxford, UK. 2004.

BACTERIAL GENETICS

Objectives

The continuity of the life from one generation to other generation is based on the mechanisms involving nucleus, chromosomes and genes etc.

Course Contents

Nucleic acids structure and functions.

DNA replication: replicon origins, events that occur at the replication fork, the structure and functions of DNA polymerases, and replication strategies.

Control of DNA replication: dichotomous replication in prokaryotes.

Control of gene expression in prokaryote: polycistrons, transcriptional initiation and termination, the operon, catabolite repression and attenuation control.

Protein synthesis - mRNA translation: Genetic code - non universality, codon usage. Events on ribosomes (c.f. prokaryotes), ribosome structure-function relationships, organelle and archaeobacterial systems.

Plasmids, episomes and transposons.

DNA mutagenesis and mutagenic agents, repair and mutation suppression.

Genetic recombination: generalized recombination, site specific recombination and illegitimate recombination.

Gene transfer mechanisms and their role in evolution.

Transformation, transduction, conjugation and cross-phylogenetic transfer.

Gene mapping by conjugation and transduction.

Circular chromosomal maps of bacteria.

Introduction to genetic rearrangements.

Practicals

1. Plasmid extraction.
2. Nucleic acid extraction (DNA & RNA).
3. Transformation, transduction, conjugation.
4. Catabolite repression through growth curve.

5. Beta galactosidase assay.

Books Recommended

1. Pierca, B. A., 2005. Genetics. A conceptual approach, W. H. Freeman and Company, NY.
2. Griffiths, A. J. F., Wessler, S. R., Lewontin, R. C., Gelbart, W. M., Suzuki, D.T. and Miller, J. H., 2005, Introduction to Genetic Analysis, W. H. Freeman and Company.
3. Hartl, D. L. and Jones, E. W., 2005, Genetics - Analysis of Genes and Genomes, Jones and Bartlett Publishers. Sudbury, U.S.A.
4. Ignacimuthu, S., 2005, Basic Bioinformatics, Narosa Publishing House, India.
5. Lwein, B., 2004, Gene VIII, Pearson Education Int.
6. Primrose, S. B., and Twyman, R. M., 2006. Principles of Gene Manipulation and Genomics. Blackwell Scientific Publications.
7. Wilson, J. and Hunt, T., 2004. Molecular Biology of the cell – the problems book, Garland publishing Inc.
8. Jack, J. P., 2005. An Introduction to Human Molecular Genetics, 2nd edition New Jersey.
9. Ringo, J., 2004. Fundamental Genetics, Cambridge University Press.

HUMAN GENETICS

Objectives

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

Course Contents

Human genome map. Impact of human genes on health.

Somatic cell Karyotyping. Human Karyotyping. Single gene traits inheritance: Study of Pedigree analysis for identification of various modes of inheritance.

Genetic defects in prenatal development; oncogenes and cancer, normal chromosomes, congenital malformations.

Metabolic variation and diseases: In-born errors of metabolism, Errors in transport system, Inherited variations.

Genetic linkage: family method, somatic cell hybridization, deletion mapping and duplication mapping.

Eugenics. Twin studies. Human genome project objectives and goals.

Practicals

1. Study of different qualitative and quantitative traits.
2. Pedigree analysis.
3. Analysis of sex chromosomes in Inter-phase nuclei.
4. Karyotyping of normal and abnormal human chromosomes.
5. Screening of metabolic and other disorders.
6. Dermatology of normal and mentally retarded individuals.
7. Problems solving on genetic counseling.

Books Recommended

1. Strachan, T., A. P. Read, Human Molecular Genetics, 3rd edition, Garland Science/Taylor & 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. Annual Review of Genomics and Human Genetics (Annual Review of Genomics and Human Genetics, Vol 2, Annual Reviews, 2001.

RECOMBINANT DNA TECHNOLOGY

Course Contents

An outline of DNA cloning experiment, cloning vectors including plasmids, bacteriophages, cosmids, YAC vectors, shuttle and expression n vectors; tumor inducing (Ti) plasmids; restriction enzymes; gene splicing, genomic and cDNA libraries, screening methods for gene libraries; Southern and Northern blotting; chromosome walking; site specific mutagenesis; potentials of recombinant DNA technology; PCR; production of proteins; tissue culture techniques; transgenic organisms and gene therapies; restriction fragment length polymorphisms and disease detection (e.g. cystic fibrosis); human genome project; stem cells and therapeutic cloning; social considerations.

Practicals

Plasmid isolation, Transformation techniques, PCR, Southern and Northern blotting; RFLP.

Books Recommended

1. Basic Biotechnology. C. R. Attedge, and B. Kristiansen, 2001. Cambridge University Press, U.K.

2. A Manual of Basic Technique. Freshney, R. Ian. 2000. Alan R. Liss, Inc., New York.
3. Application of Microbes in Biotechnology. Lee, Y.K. & C.L. Poh and H. M. Tan.1999. Springer-verlag.

MOLECULAR PHYSIOLOGY

Objectives

1. To understand physiological mechanism at molecular level.
2. To correlate molecular mechanism at organs and organism level.

Course Contents

Overview of resting membrane, action potential and synaptic transmission; structure and mechanisms in ion channels; Biosynthesis of neurotransmitters; Neurotransmitters action at synaptic receptors. Neurosecretions and neurotransmitters in higher nervous system actively. Molecular mechanisms in transduction of sensory stimuli into impulse; photochemistry and transduction of photoreceptor; Colour vision. Overview of endocrine glands, their hormones and roles; chemistry and biosynthesis of hormones of adenohypophysis, thyroid, parathyroid, endocrine pancreas, adrenal medulla and steroidogenic tissues; Metabolism of thyroid and steroidogenic tissues; Structure of hormone receptors; Mechanisms of action of a protein/peptide, a steroid and thyroid hormone; Hormonal regulation of metabolism; Molecular basis of muscular contraction; Molecular interaction at neuromuscular level; Molecular structure of cilia and flagella and mechanisms in movements. Automaticity and rhythmicity of myogenic heart; Regulation of cardiac activity; humeral regulation of circulation: Vasoconstriction and vasodilatation. Exchange of respiratory gases; Chemical regulation of respiration. Nature formation of various nitrogenous waste products; Glomerular filtration, reabsorption, and secretion mechanisms; Concentration of urine. Regulation of digestive secretions; Digestion and absorption of nutrients, Molecular mechanisms in adaptation to temperature extremes.

Practicals

1. Study of post synaptic receptor mechanisms in neuromuscular preparation of frogs.
2. Experiments to study the molecular responses to hormones.
3. Study of hormones receptors in differing hormonal circulation levels.
4. Ultra-structure study of muscle structure for muscle contraction.

5. Effect of chemicals and drugs on cardiac activity of prepared frogs.
6. Study of drugs on reflexes and local circulation models.
7. Respiratory function and oxygen consumption in acidosis and alkalosis in mouse.
8. Study of nature of nitrogenous wastes of animals inhabiting different environment.
9. Urine analysis in different physiological states. Absorption of glucose in inverted intestinal sac, effect of drugs on intestinal movements.
10. Muscular responses to pyrexia.

Books Recommended

1. Guyton, A.C. and Hall, J.E. 2010. Textbook of Medical Physiology, W.B.12th ed. Saunders Company, Philadelphia.
2. Randall, D., Burggren, W., French, K. and Fernald, R., 2002. Eckert Animal physiology; Mechanisms and Adaptations, 5th ed. W. H. Freeman and Company,
3. Bullock, J., Boole, J. and Wang, M.B., 2001. Physiology, 4th edition. Lippincott, Williams and Wilkins, Philadelphia.
4. Berne, R.M. and Levy, M.N. 2000. Principles of Physiology, 3rd edition. St., Lious, Mosby.
5. Tharp, G. and Woodman, D. 2002 Experiments in Physiology, 8th Edition, Prentice Hall, London.

FISH REQUIREMENTS

Objectives

- To teach the about the concepts of fin fish feed requirements and recent trends in feed formulation and manufacture
- To provide information about nutrient requirements of different commercially important fish species and their nutrient requirements under variable environmental conditions
- To enable the students to understand the recent trends in fish feed technology for economical yields

Course Contents

Introduction to fish nutrition, digestion and absorption of nutrients. Feeding types and anatomy. Energy, protein, lipids, carbohydrate, mineral and vitamin requirements of fish: factors affecting nutrient requirements of fish. Energy losses and partitioning in fish. The role of other dietary components viz. water, fiber, hormones, antibiotics, antioxidants, pigments, pellet binders

and feeding stimulants. Antinutrients and toxins. Forms and size of feed, feeding rates and feeding practices for different fish species. Special purpose feeding. Feed calculations, feed requirements and feed conversion ratios.

Books Recommended

1. Hefner, B., 2010. Nutrition of Pond Fishes. Cambridge University Press, UK.
2. Halver, J.E., Ronald, W.H. and Dniel, M.H. 2004. Fish Nutrition (4th ed.). Academic Press, N. York.
3. Pillay, T.V.R. 1999. Aquaculture: Principles and Practices. Fishing News Books, London.
4. N.C.R., 1998. Nutrient Requirements of Fish. National Academy Press, Washington D.C.

AQUACULTURE AND FISHERIES

Objectives

- To disseminate the history, needs and importance of fisheries and aquaculture
- To elaborate the basic components of pond fish culture
- To describe the cultureable fish species and their biology
- To impart knowledge regarding fish gears and post-harvest techniques

Course Contents

Introduction to fisheries and aquaculture, national and international trends, Fish morphology and diversity in size and shape. Distribution of fishes in Pakistan, commercial fishes, marine and freshwater. Types of ponds, planning construction and pond preparation. Pond fertilization, application, food and feeding habits of fishes, feeding types, artificial and natural fish food, artificial fish feeds. Fish habitat, ecology and extant of distribution, water quality parameters (abiotic: temperature, light, salinity, pH, turbidity, etc.) and their effects on fish health and production. Biotic parameters (plankton, insects, aquatic vegetation, etc) of ponds, lakes, rivers, and impacts on fish growth. Induced breeding. Fish diseases and their control. Fishing gears, fishing techniques, fishing communities. Fish preservation, processing transportation and marketing.

Practicals

1. Morphological characters of a typical fish,

2. Species identification, fin formula, key to identification of commercial fishes,
3. Dissection of common fish to study its various systems.
4. Practical demonstration of induced breeding,
5. Introduction to artificial feed ingredients.

Books Recommended

1. Sharma, O. P. 2009. Handbook of Fisheries and Aquaculture. Agrotech Publishing Academy, Udaipur, New Delhi, India.
2. Stickney, R. R. 2009. Aquaculture: An Introductory Text. CABI Publishing, London, UK.
3. Pillay, T.V.R. and M.N. Kutty 2005. Aquaculture: Principles and Practices. Blackwell Science Limited. New York.
4. Ali, S.S. 1999. An Introduction to Freshwater Fishery Biology. University Grants Commission, H-9 Islamabad.

CONSERVATION BIOLOGY OF WILDLIFE

Course Contents

Introduction to conservation biology; species diversity, ecosystem diversity, genetic diversity. Threats to biodiversity: mass extinction and global changes, ecosystem degradation and loss, overexploitation, deforestation, fragmentation and reduction in wildlife habitats, island biogeography, exotic species, inbreeding and outbreeding depressions, loss of genetic variability, environmental fluctuations, factors limiting the population size. Human factors; economic factors, politics and actions. The risks faced by small populations, Risk assessment, diagnosis of declines, treatment of declines, and role of economic and trades in wildlife conservation, role of national and international legislation in wildlife conservation. Population genetics, extinction, restoration ecology, management, and conservation policy. Conservation through population and ecosystem management. Role of zoos, national parks, sanctuaries and game reserves for maintaining the biological diversity. The mandate for the management and conservation of rare, over-abundant, and harvested wildlife populations.

Books Recommended

1. Caughley, G and A. Gunn. Conservation biology in theory and practice. Blackwell Science Publication.
2. Eric. G. Bolen and William L. Robinson. 1995. Wildlife Ecology and Management. 3rd Edition. Prentice Hall, Upper Saddle River, New Jersey.

3. Hosetti, B. B. and Venkateshwarlu, M. 2001. Trends in Wildlife Biodiversity, Conservation and Management. Daya Publishing House Delhi-11035.
4. Malcolm L. Hunter, Jr. 2001. Fundamentals of Conservation Biology, 2nd Edition. Blackwell Science Inc.
5. Mills, L.S. 2007. Conservation of Wildlife Populations: Demography, Genetics and Management. Blackwell Publishing, USA.
6. Richard B. Primack. 2002. Essentials of Conservation Biology. 3rd Edition. Sinauer Associates Inc. Publishers, Sunderland, Massachusetts, U.S.A.
7. Soule, M. E. 1987. Viable populations for Conservation. Cambridge University Press. Cambridge.
8. Soule, M.E. and B.A. Wilcox. 1980. Conservation Biology. Sinauer Associates Inc. Sunderland. Massachusetts.

ADVANCES IN WILDLIFE

Objectives

- Provide a foundation of modern concepts in wildlife science
- To elicit public support for conservation of wildlife & habitats through conservation awareness programmes and ecotourism

Course Contents

Wildlife of Pakistan, Identification, distribution, status, life cycle, conservation and management of reptiles, birds and mammals of major importance in Pakistan. Philosophy of wildlife conservation. Biodiversity and sustainability of wildlife. Wildlife rules and regulations in Pakistan & AJ&K National and international agencies involved in conservation and management of wildlife. Sanctuaries, Game Reserves and National Parks in Pakistan.

Practicals

1. Demonstration of distribution Birds & mammals of Pakistan (blank maps may be provided)
2. Study of Wildlife habitats.
3. Measurements of Animal Diversity.

Books Recommended

1. Roberts, T.J., (1991) Mammals of Pakistan Ernest benon Ltd, London
2. Birds Mammals, Reptiles Amphibians population censing Techniques.

3. Southwick, C.H (1976). Ecology and quality of our environment, D.van nostrand Co. New York.

BIOLOGY OF BIRDS AND MAMMALS IN PAKISTAN

Objectives

- The course will provides an comprehensive account of the biology and birds mammals that inhabitant

Course Contents

Structure, origin, evolution, reproduction and life history of birds, behavior, population regulation, general ecology, geography migration and orientation in birds. Introduction to classification, classification of avifauna of Pakistan. Characteristics, distribution, classification, reproduction and development, behaviour, population and economic relationship of mammal. The mammal fauna of Pakistan and its scientific and economic importance.

Practicals

1. Taxonomy of birds. Birds identification.
2. Bird census techniques.
3. Ecological notes on endemic and threatened birds of Pakistan.
4. Mist-nesting. Methods of birds migration.
5. Important areas of Pakistan. Identification of local mammalian fauna.
6. Ecological adaptation with respect to food and habit

Books Recommended

1. Bearman, M. and Madge, S., 1998. The Handbook of bird identification for Europe and the Western Palaearctic. Princeton Univ. Press, New Jersey.
2. Brook, M. and Birkhead, T., 1991. The Cambridge Encyclopedia of Ornithology. Cambridge University Press, Cambridge.
3. Grimmett, R., Inskipp, C. and Inskipp, T. 1998. Birds of the Indian Subcontinent. Christopher Helm Pub., London.
4. Svensson, L., 1970. Identification guide to European Passerines. Naturhistoriska Riksmuseet, Stockholm.
5. Rand, A.L., 1967. An Introduction to Ornithology. W.W. Norton & Company Inc., N.Y.
6. Roberts, T.J., 1991-1992. Birds of Pakistan. Vol. I & II. Oxford University Press, Karachi.

7. Bibby, C., Jones, M. and Mahan, S., 1998. Expedition field techniques: Bird surveys. Birdlife international, Cambridge.
8. Donald, R.G., 1964. Bird Migration. Doubleday & Co., N.Y.
9. Khan, A.A., 1999. Bibliography of the birds of Pakistan. Ornithological Society of Pakistan, Dera Ghazi Khan.
10. Hickmen, Roberts, and Larsen, 2001, Integrated principles of Zoology (11th Edition)

PRINCIPLES OF WILDLIFE MANAGEMENT

Objects

- The course will integrate areas of natural resource management within intellectual and Philosophical frame work based on the origins of wildlife management field ecology habitat requirement for specific species and habitat classification.
- The course will empower students with knowledge applicable to the management of any wildlife species.

Course Contents

History and basic concepts in management of wildlife resources i.e. Ecology, Population Dynamics, Biology, Conservation. Wildlife Ecology (Habitat factors & analysis, Ecological Succession and Wildlife, Weather, Climate and Wildlife). Population Dynamics (population analysis and manipulation, carrying capacity, perennial patterns of abundance). Wildlife Biology (wildlife and soils, food, nutrition and water requirements, cover requirements, movements, reproduction, behavior and physiology, mortality). Wildlife conservation (resource conservation and quality of life, values). Wildlife management (data bases requirements, applications of ecological principles, Art of wildlife management, Administration, Public awareness). Wildlife Damage Management (brief introduction of pest species and their impact).

Books Recommended

1. Bailey, J.A. 1984. Principals of Wildlife Management. John Wiley London.
2. Gilbert, F. F. and D. G. Dodds. 1987. The Philosophy and Practice of Wildlife Management. Robert E. Kreiger, Publishing Company, Malabar, Florida.
3. Giles, Jr. R. H. 1978. Wildlife Management. W. H. Freeman and Company, San Fransisco.

4. Peine, John D. 1999. Ecosystem Management for Sustainability: Principles and Practices. CRC Press.
5. Scott, 1995. Conservation of Biological Diversity; Perspectives and the Future for Wildlife Profession. Wildlife Society Bulletin.
6. Tiwaei, P.C. and Bhagwati, J. 1997. Wildlife in the Himalayan Foothills: Conservation and Management.

ADVANCED CELL AND MOLECULAR BIOLOGY

Objectives

To impart knowledge about:

- The cell and its organization of architecture and the unified role it plays for the ultimate sustainability of the organisms.
- Various ultra-structural, molecular and functional aspects of the cells.

Course Contents

Introduction to cell biology.

Difference between prokaryotes and eukaryotes.

Physico-chemical properties of protoplasm.

Ultra-structure, chemical composition and functions of cell wall, cell membrane, cellular organelles (mitochondria, endoplasmic reticulum, golgi apparatus, lysosome, glyoxysome, nucleus, ribosomes, etc.) cytoskeleton.

Chemical composition and molecular structure of chromosomes.

Cell cycle and apoptosis. Cell reproduction.

Signal transduction. Cell culture; *E. coli* and yeast as representative prokaryotic and eukaryotic models for molecular differentiation.

Chromosome Structure and Function

Molecular mechanism of Replication.

Transcription and Translation.

Transcriptional and translational regulation of gene expression.

Regulation of gene expression in prokaryotes and eukaryotes.

Types of recombination. Mutations and chromosomal aberrations.

DNA damage and repair. Gene sequencing. Principles of Recombinant DNA technology, Role of Recombinant DNA Technology in economic development. Human Genome Project. Stem Cell Research.

Practicals

1. Karyotyping.
2. Study of DNA damage by physical and chemical methods.

3. Case study of chromosomal abnormalities in human and agricultural specimen.
4. Ames test for identification of mutagenic agents.

Books Recommended

1. De Robertis, E. D. P and De Robertis Jr. E. M. F. 2001. Cell and Molecular Biology. 8th Edition. Lippincott, Williams and Wilkins Publishers.
2. Karp, G. 2000. Cell and Molecular Biology. Concepts and Experiments. John Wiley and Sons Publishers.
3. Lodish, H. 2001. Molecular and Cell Biology. W. H. Freeman and Co.
4. Gilmartin, P. M. and C. Bowler. 2002. Molecular Plant Biology. Vol 1 and 2. Oxford University Press. UK.
5. Watson J. D. 2004. Molecular Biology of the Gene. Pearson Education, Singapore.
6. Weaver, R. F. 2005. Molecular Biology. McGraw Hill, St. Louis.
7. Lodish, H., Matsudaira, P., Berk, A., Ploegh, H., Scott, M., Kaiser, C. A., Krieger, M., Bretscher, A., 2007. Molecular Cell Biology . W. H. Freeman Company.

LAB AND BIOSAFETY

Objectives

- To aware the students in the lab how to keep their surroundings clean and hygienic
- To protect themselves and others from the pathogens
- To differentiate between harmful and harmless chemicals used within the lab
- To know about biohazards, chemical hazards and radiation hazards

Course Contents

Introduction

General Duties and Responsibilities of President's Safety Committees
DHSE Managers; Statutory Occupational Health Committee; Supervisors or Principal Investigators; Waste Generators and Waste Contact Persons; Students or Employees

Laboratory Permits and Registration; Chemical Substances; Biological Substances; Radioactive Substances; General Safety and Compliance Requirements; Non-Compliance Enforcement Policy; Substance Acquisition, Storage, Transportation, Waste; Disposal and Minimization; Emergencies: Accidents, Incidents, Spills and Exposures

Laboratory Spill Response Materials; Your Right-to-know, Right-to-refuse and; Unresolved Concerns; Guide to Risk Assessment for Hazardous

Chemicals; Biosafety; Biohazards; Laboratory Acquired Infections; Blood borne Pathogens; Disinfection, Decontamination and Sterilization; Risk Assessment; Exposure Control Plans; Classification of Risk Groups and Containment; Levels; Laboratory Biosafety Guidelines;; Containment; Primary; Secondary; Personal Protection; Use of biosafety cabinet and; fume hood etc

Practicals

1. Use of fire extinguisher.
2. PPE (use of PPE)
3. Use of Fume hood
4. Use of biosafety cabinet.
5. Practical cleaning of a spill.
6. Arrangement of chemicals in the Lab.

Books and Manuals Recommended

1. Lab safety manual, 2006.
2. Smida, A., 2006. Lab safety manual. Department of health, safety and environment. University of Saskatchewan, Saskatoon, Canada.
3. Oles, A., 2005. Biosafety manual. Department of health, safety and environment. University of Saskatchewan, Saskatoon, Canada.

Important Biosafety Websites

1. Health, Safety Environment <http://www.usask.ca/DHSE>
2. Fire Safety Code
http://adminsrv.usask.ca/hse/Firesafety/fire_safety_code.htm
3. Health Canada's Laboratory Biosafety Guide lines
<http://www.hc-sc.gc.ca/hpb/lcdc/biosafety/docs/index.html>
4. Canadian Environmental Protection Agency
<http://www.ec.gc.ca/cepa/english/>
5. New Substance Notification Regulations
http://www.ec.gc.ca/cceb1/nsd/nsd_e.html
6. Import of Human Pathogens
http://www.hc-sc.gc.ca/hpb/lcdc/biosafety/pathogen/howto_e.html
7. Import of Plant and Animal Pathogens
<http://www.cfia-acia.agr.ca/english/plaveg/protect/pqir/aceisint.html>
8. Import Plant / animal Information
<http://www.cfia-acia.agr.ca/english/plaveg/oper/opere.shtml>
9. MSDS for Biological Agents
<http://www.hc-sc.gc.ca/hpb/lcdc/biosafety/msds/index.html>
10. Biowaste Disposal Manual

<http://www.adminsrv.usask.ca/hse/biologic/Biowaste.htm>

11. Transportation of Dangerous Goods
<http://www.tc.gc.ca/actsregs/TDG/TOCtdg.htm>
12. Safety Training Courses
http://www.adminsrv.usask.ca/hse/couse_offeringS.htm
13. Natural Sciences and Engineering Research Council Forms
http://www.nserc.ca/forms/formtable_e.htm
14. Chemical Waste Disposal Manual
<http://duke.usask.ca/~whiterv/chemwaste.html>

CLINICAL TERATOLOGY

Objectives

The increasing demand in the clinical genetics and developmental biology setting for information about Teratogenic exposures has created a need for genetic counselors to have the capabilities to appropriately address patient concerns. Teratology is the study of causes and effects of congenital malformations and developmental abnormalities. Teratogenesis refers to the production of defects in the fetus. A teratogenic agent is responsible for producing anatomical defects in an embryo that was previously differentiating normally. Teratogens include irradiation, chemicals (including drugs) and infectious agents.

The course will enable the students to identify specific areas in practical life where the science of teratology is being applied. Thus they can seek different job in various organizations such as clinical, molecular biological and medical genetics sections.

Course Contents

Teratogenesis: environmental assaults on human development. Teratogenic agents: Alcohol, Retinoic acid, Hydroflourocarbons and other degradation products used as refrigerants, Heroin, Heavy metals, Pathogens: *Rubella*, *Toxoplasma gondii*, *Treponema pallidum* (Syphilis bacterium); Endocrine disruptors: Diethylstilbestrol (drug used to prevent premature births); Nonylphenol (Plastic wrappings around food); Bisphenol A (water bottles, baby feeders); Tobacco and Cannabis; Testicular dysgenesis and declining sperm counts. Developmental biology and future of medicine: Germ-line gene therapy, stem cell therapy and regeneration therapy.

Practicals

Hospital visits to observe the cases of developmental abnormalities. Impact of various Teratogens on J774.2 macrophage like cell line *in vitro* i.e.,

Reactive oxygen species generation in response to various teratogens representing a potentially toxic insult, which lead to membrane dysfunction, lipid peroxidation, DNA damage and inactivation of proteins.

Books and Articles Recommended

1. **Gilbert, S.F. (2006).** Developmental Biology.
2. Makoto Ema, Masato Naya, Kikuo Yoshida and Ryuichi Nagaosa. (2010).
3. Reproductive and developmental toxicity of degradation products of refrigerants in experimental animals. *Reproductive Toxicology* Volume 29, Issue 1, January 2010, Pages 1-9.
4. Hatem A. Azim, Fedro A. Peccatori and Nicholas Pavlidis. (2010). A systematic Review C:\Users\akram\Documents\Teratology-cancers in pregnancy 2010.htm - hit2 on the use of cytotoxic, endocrine, targeted agents and immunotherapy during pregnancy. Part I: Solid tumors. *Cancer Treatment Reviews*. Volume 36, Issue 2, April 2010, Pages 101-109
5. P.L. Bedard and F. Cardoso, (2008), Recent advances in adjuvant systemic
6. therapy or early-stage breast cancer, *Ann Oncol***19** (Suppl 5) pp. 122–127
7. Christina M. Powers, Jerry Yen, Elwood A. Linney, Frederic J. Seidler,
8. Theodore A. Slotkin. (2010). Silver exposure in developing zebrafish (*Danio rerio*): Persistent effects on larval behavior and survival. *Neurotoxicology and Teratology*, Volume 32, Issue 3, May-June 2010, Pages 391-397
9. Matteo Cassina, Marco De Santis, Elena Cesari, Marion van Eijkeren, Matitiahu
10. Berkovitch, Giorgio Eleftheriou, Francesco Raffagnato, Elena Di Gianantonio,
11. Maurizio Clementi. (2010). First trimester diclofenac exposure and pregnancy outcome. *Reproductive Toxicology*, Available online 1 May 2010
12. Guidelines for Human Embryonic Stem Cell Research (2005).
13. <http://www.nap.edu/catalog/11278.html> (free download is available)
14. Understanding stem cells: An overview of the science and issues from the
15. National academies USA. Copyright © 2009.National Academy of Sciences. All rights reserved. 500 Fifth St. N.W., Washington, D.C. 20001 <http://www.nap.edu>

RECOMMENDATIONS

After discussions and detailed deliberations, the committee unanimously made following recommendations:

1. Institutions must make arrangements that adequate number of teachers is available to teach core courses and courses from the school of major for the BS degree course. It is strongly recommended that fresh Ph.Ds. also be appointed in affiliated colleges under Interim Placement Faculty Program (where BS program is introduced) to address the issue of qualified resource persons.
2. The system of online access to the academic resources i.e. journals, books and reports etc. must be provided to all universities, research institutions and affiliated colleges through institutional servers and beyond (preferably on the pattern of "turnitin.com").
3. Since teacher is the key person in teaching-learning process, it is imperative that he/she should be aware of or have means to be aware of the latest developments in Zoological Sciences. In order to ensure this, it is strongly recommended that all the Universities of Pakistan should hold refresher courses at graduate level.
4. Upgradation of laboratories and libraries is essential to cope with the revised curriculum for effective delivery, assessment and evaluation. Prescribed facilities must be made available for BS (4 Years) Zoology program.
5. As Zoology is a field-oriented science; it is essential that institutions make adequate arrangements and provide facilities for fieldwork at all levels.
6. University and college teachers be provided with opportunities / resources to visit foreign universities to update their knowledge and skill in accordance with the recent disciplines and research trends.
7. For efficient laboratory management, adequately trained technicians/ engineers (from grade 17 to 19) may be employed. They should be responsible for processing samples and maintenance of laboratory equipment.
8. All colleges and universities involved in Zoology teaching must submit PC-1 form to HEC/HED to procure funds to run BS (4 Years) Zoology program effectively.

9. Linkage in both teaching and research disciplines be encouraged between the universities, research organizations and industries.
10. At matric and F. Sc. level, Mathematics and Biology must be taught as compulsory subjects to provide students with wider option for admission to both Engineering and Medical Sciences.