WORKING PAPER

6TH MEETING

OF

THE BOARD OF STUDIES OF

ZOOLOGY

August 29, 2019

Department of Zoology

Shaheed Benazir Bhutto University Sheringal,

Dir Upper, Khyber Pakhtunkhwa Pakistan

2019

SHAHEED BENAZIR BHUTTO UNIVERSITY
FACULTY OF SCIENCE MAINCAMPUS, SHERINGAL,DIR UPPER,KP
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Department Of Zoology

Venue	Committee room, Guest House, Shaheed Benazir Bhutto University Sheringal, Dir Upper , Khyber Pakhtunkhwa		
Date	29-08-2019		
Time	10:00 AM		
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ANNEXURE-A

CONSTITUTION AND FUNCTIONS OF THE BOARD OF STUDIES

(According to the Shaheed Benazir Bhutto University Statutes)

The Board of Studies

1. There shall be a separate Board of Studies for each subject or groups, as may be prescribed by Bye-laws.

2. Each Board of Studies shall consist of:

i. The Chairperson or Director of the Teaching Department or Institute;
ii. All Professors and Associate Professors in the Teaching Department/Institute.
iii. Two University teachers, other than Professors or Associate Professors, to be appointed by the Academic Council.
iv. Three teachers other than the University teachers, to be appointed by the Vice Chancellor from affiliated colleges/ affiliated institutions; and
v. One Assistant Professor and one Lecturer to be appointed on rotation in order of merit from the department concerned.
3. The term of office of members of the Board of Studies, other than ex-officio members, shall be three years.

4. The quorum for meeting of the Board of Studies shall be one half of the total number of members, a fraction being counted as one.

5. The Chairman of the University Academic Department concerned shall be the chairman and convener of the Board of Studies.

6. The functions of the Board of Studies shall be to-

(a) Advise the authorities on all academic matters concerning instructions, publications, research and examinations in the subject or subjects concerned.

(b) Propose the Curricula and Syllabi for all degree, diploma and certificate courses in the subjects or subjects concerned.

(c) Suggest a panel of names of paper setters and examiners in the subject or subjects concerned.

(d) Recommend to the Board of Advanced Studies and Research (BASR) the names of the Supervisor, title and Synopsis of research thesis dissertation; and

(e) Perform such other functions as may be prescribed by the Bye-laws.

ANNEXURE-B

Members of the Board of Studies of Department of Zoology

S. No.	Name and Designation	Address	Constituency	Convener / Member
1.	Dr. Rahmat Ali Vice Chancellor	Shaheed Benazir Bhutto University (SBBU), Sheringal, Upper Dir, KP		Convener
2.	--	--	All Professors and Associate Professors: 6(2)(ii)	Member
3.	Dr. Midrar Ullah Khan, Registrar	Shaheed Benazir Bhutto University (SBBU), Sheringal, Upper Dir, KP	SBBU/Estb./ntf/17-6343, Dated 16-05-2017.	Secretary
4.	Dr. Muhammad Asif Nawaz AP	Department of Biotechnology, SBBU, Sheringal, Upper Dir, KP	SBBU/Acad/Ntf/18-108 Dated 03-09-2018	Member
5.	Dr. Muhammad Nawaz Rajpar AP	Department of Forestry, SBBU, Sheringal, Upper Dir, KP	SBBU/Acad/Ntf/18-108 Dated 03-09-2018	Member
6.	Rooh Ullah Lecturer/HOD	Department of Zoology, SBBU, Sheringal, Upper Dir, KP	6(2)(i)	Member
7.	Mr. Arif Jan, Lecturer	Department of Zoology, SBBU, Sheringal, Upper Dir, KP	6(2)(iii)	Member
8.	Mr. Atta Ullah Khan, AP	Department of Zoology, GDC Dir Upper	Three teachers other than university teachers from affiliated colleges/ institutions: 6(2)(iv)	Member
9.	Mr. Khair Rafiq, Lecturer	-Do-		Member
10.	Mr. Muhammad Bar	-Do-		Member

	Khan Lecturer			
11.	Mr. Ibrar Hussain, Deputy Director QEC	Shaheed Benazir Bhutto University (SBBU), Sheringal, Upper Dir, KP	SBBU/Estb./Ltr/16-5227, Dated 22-04-2016.	Member

ANNEXURE-C

Approval of the courses of study for BS Zoology (4 year)

Scheme of Studies of BS (4- year) Zoology			
Semester-I			
Course Category	**Course Code**	**Course Title**	**Credits**
Compulsory-I	ENG- 311	English-I (Functional English)	3(3+0)
Compulsory-II	ISL-312	Islamic Studies	2(2+0)
Compulsory-III	MCZ-313	Mathematics	3(3+0)
General- I	BOT-314	Botany-I (Diversity of Plants)	3(2+1)
General – II	CHEM-315	Chemistry-I (Organic Chemistry)	3(2+1)
Foundation-I	ZOO-316	Animal Diversity-I (Invertebrates)	4(3+1)
		Total Credits	18
Semester-II			
Course Category	**Course Code**	**Course Title**	**Credits**
Compulsory-IV	ENG- 321	English-II (Communication Skills)	3(3+0)
Compulsory-V	PS-322	Pakistan Studies	2(2+0)
General- III	BOT-323	Botany-II (Plant Systematics, Anatomy and Development / Embryology)	3(2+1)
General – IV	CHEM-324	Chemistry-II (Inorganic Chemistry)	3(2+1)
Foundation-II	ZOO-325	Cell Biology	3(2+1)
Foundation-III	ZOO-326	Animal Diversity-II (Chordates)	4(3+1)
		Total Credits	18
Semester-III			
Course Category	**Course Code**	**Course Title**	**Credits**
Compulsory-VI	ENG- 431	English-III: Technical writing and presentation skills	3(3+0)
Compulsory-VII	BCS-432	Introduction to Computer	3(1+2)

General – V	BOT-433	Botany-III (Plant Physiology & Ecology)	3(2+1)
General- VI	CHEM-434	Chemistry-III (Environmental Chemistry)	3(3+0)
General - VII	SOC-435	Social Sciences	2(2+0)
Foundation-IV	ZOO-436	Animal Form and Function-I	4(3+1)
		Total Credits	18
Semester-IV			
Course Category	**Course Code**	**Course Title**	**Credits**
Compulsory-VIII	ENG- 441	English-IV (Advanced Academic Reading and Writing)	3(3+0)
Major-I	ZOO- 442	Animal Behavior	3(3+0)
Major-II	ZOO- 443	Biological Techniques	3(1+2)
Foundation-V	ZOO- 444	Biochemistry-I	3(2+1)
Foundation-VI	ZOO- 445	Animal Form & Function-II	4(3+1)
General-VIII	PSY- 446	Psychology	2(2+0)
		Total Credits	18
Semester-V			
Course Category	**Course Code**	**Course Title**	**Credits**
Foundation-VII	ZOO- 551	Economic Zoology	3(2+1)
Foundation-VIII	ZOO-552	Biochemistry-II	3(2+1)
Major-III	ZOO-553	Physiology	4(3+1)
Major-IV	ZOO-554	Ecology	3(2+1)
Foundation-IX	ZOO-555	Evolution	2(2+0)
Foundation-X	ZOO-556	Principles of Systematics	3(2+1)
		Total Credits	18
Semester-VI			
Course Category	**Course Code**	**Course Title**	**Credits**

Major-V	ZOO-561	Research Methodology	2(2+0)
Compulsory-IX	BST-562	Biostatistics	3(2+1)
Major-VI	ZOO-563	Developmental Biology	4(3+1)
Major-VII	ZOO-564	Genetics	4(3+1)
Major-VIII	ZOO-565	Zoogeography and Palaeontology	3(2+1)
		Total Credits	16
Semester-VII			
Course Category	**Course Code**	**Course Title**	**Credits**
Major-IX	ZOO-671	Bioinformatics	3(1+2)
Major-X	ZOO-672	Molecular Biology	3(2+1)
Major-XI	ZOO-673	Wildlife	3(2+1)
Elective-II	ZOO-674	Parasitology-I	3(2+1)
Elective-III	ZOO-675	Entomology-I	3(2+1)
		Total Credits	15
Semester-VIII			
Course Category	**Course Code**	**Course Title**	**Credits**
Major-XII	ZOO-681	Special Paper-I / Thesis	3(2+1)/ 3(0+3)
Major-XIII	ZOO-682	Special Paper-II / Thesis	3(2+1)/ 3(0+3)
Elective-IV	ZOO-683	Applied Fisheries	3(2+1)
Elective-V	ZOO-684	Parasitology-II	3(2+1)
Elective-IV	ZOO-685	Entomology-II	3(2+1)
		Total Credits	15

Total Credits: 18+18+18+18+18+16+15+15=136

Detail of the Courses of study BS 4 year

Semester-I			
Course Category	**Course Code**	**Course Title**	**Credits**
Compulsory-I	ENG- 311	English-I (Functional English)	3(3+0)
Compulsory-II	ISL-312	Islamic Studies	2(2+0)
Compulsory-III	MCZ-313	Mathematics	3(3+0)
General- I	BOT-314	Botany-I (Diversity of Plants)	3(2+1)
General - II	CHEM-315	Chemistry-I (Organic Chemistry)	3(2+1)
Foundation-I	ZOO-316	Animal Diversity-I (Invertebrates)	4(3+1)
		Total Credits	18

Compulsory-I	ENG- 311	English-I (Functional English)	3(3+0)

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

Compulsory-II	ISL-312	Islamic Studies	2(2+0)

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 AlNabi (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.

Compulsory-III	MCZ-313	Mathematics	3(3+0)

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 equation, 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.

General- I	BOT-314	Botany – I (Diversity of Plants)	3(2+1)

Course Contents

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

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

Practicals:

Culturing, maintenance, preservation and staining of microorganisms. Study of morphology and reproductive structures of the types mentioned in theory.

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

General - II	CHEM-315	Chemistry-I (Organic Chemistry)	3(2+1)

Course Content:

Basic Concepts of Organic Chemistry:

Bonding and hybridization, localized and delocalized bonding, structure aromaticity, inductive effect, dipole moment, resonance and its rules, hyperconjugation, classification and nomenclature of organic compounds including IUPAC system, types of organic reactions (an overview).

Chemistry of Hydrocarbons: Saturated, unsaturated and aromatic hydrocarbons with emphasis on synthesis and free radical, electrophilic addition and electrophilic substitution reactions.

Chemistry of Functional Groups: Hydroxyl, ether and amino groups, preparation and properties of alcohols, phenols, ethers, and amines with focus on reaction mechanism and applications, carbonyl compounds, preparations and reaction mechanism of aldehydes and ketones and their applications, carboxylic acids and their derivatives, acidity of carboxylic acids and effect of substituents on their acidity, preparation and reactions of carboxylic acids and their derivatives including esters, amides, acid halides and acid anhydrides.

Practicals:

Qualitative analysis of compounds with different functional groups, synthesis of organic compounds using as a tool for understanding techniques like reflux, distillation, filtration, recrystallization and yield calculation, organic syntheses may include preparation of benzanilide from benzoyl chloride, succinic anhydride from succinic acid, phthalimide from phthalic anhydride, oximes and hydrazones from carbonyl compounds, and an ester from a carboxylic acid and alcohol etc.

Foundation-I	ZOO-316	Animal Diversity-I (Invertebrates)	4(3+1)

ANIMAL DIVERSITY-I (INVERTEBRATES)

Course Contents:

Note: The minimum details of the titles in the content must be of the principal book Zoology by Miller and Harley. This must be kept in view in teaching and assessments.

1. INTRODUCTION

a. Classification of Organisms:

2. ANIMAL-LIKE PROTISTS: THE PROTOZOA

a. Characteristics.
b. Classification up to class
c. Symbiotic Life-styles.
d. Locomotion in protozoa
e. Nutrition and Reproduction;
f. Economic importance of protozoa

3. MULTICELLULAR AND TISSUE LEVELS OF ORGANIZATION

Phylum Porifera

a. Characteristics and classification. Cell Types, Body Wall, and Skeletons;
b. types of canal system;
c. Reproduction.

Phylum Cnidaria (Coelenterate)

a. Characteristics.
b. Classification up to Class.
c. The body Wall and Nematocysts
d. Reproduction: Alteration of generations
f. Corals and coral reefs

Phylum Ctenophore;
a. Characteristics, body organization
4. THE TRIPLOBLASTIC ORGANIZATION
PHYLUM PLATYHELMINTHES (ACOELOMATE)
a. Characteristics.
b. Classification up to class
c. The Free-Living Flatworms and the Tapeworms, parasitic adaptations in platyhelminths
Phylum Nemertea; Characteristics
Phylum Gastrotrichea; Characteristics
5. PHYLUM ASCHELMINTHS (PSEUDOCOELOMATE)
a. General Characteristics
b. Classification up to class
b. Type: Ascaris lumbricoides
c. Characteristics of Phylum Rotifera and Phylum Kinorhyncha.
c. Economic importance of Nematodes
COELOMATIC ORGANIZATION
6. PHYLUM ANNELIDA
a. General Characteristics
b. Metamerism and Tagmatization,
c. Classification up to Class.
d. Locomotion, Feeding and the Digestive system, Gas Exchange and Circulation,
e. Nervous and Sensory Functions, Excretion,
f. Reproduction; Regeneration,
g. Development, in Polychaeta, Oligochaeta and Hirudinea.
7. PHYLUM MOLLUSCA
a. General Characteristics
b. Classification up to class.
c. Shell, Feeding, Digestion, Gas Exchange, Locomotion,
d. Reproduction and Development
e. Economic importance
8. PHYLUM ARTHROPODA
a. General Characteristics
b. Classification up to class.
c. Metamerism and Tagmatization;
d. The Exoskeleton;
e. Nutrition and digestive system
f. Reproduction: Development, Metamorphosis;
g. Economic importance of crustaceans and insects.
9. PHYLUM ECHINODERMS
a. General Characteristics
b. Classification up to class.
c. Maintenance Functions
d. Reproduction; Regeneration, Larval forms and phylogeny
SOME LESSER-KNOWN INVERTEBRATES;
a. The Lophophorates, Entoprocts, Cycliophores, and Cheatognaths.
Practical:

Note: *Classification of each members of each phylum up to order with adaptions in relation to habitat of the specimen. Preserved Specimen and or colored projection slide and or CD ROM projection of computer must be used.*

1. Study of Euglena, Amoeba, Entameba, Plasmodium, Trypanosome, Paramecium as representative of animal like Protists.
2. Study of prepared slides of sponges, spicules of sponges, and their various body forms. Study of representatives of classes of Phylum Porifera.
3. Study of principal representatives of classes of Phylum Coelenterate.
4. Study of principal representatives of classes of Phylum Platyhelminthes.
5. Study of representatives of phylum Rotifer, Phylum Nematode.
6. Study of principal representatives of classes of Phylum Mollusca.
7. Study of principal representatives of classes of Phylum Annelida.
8. Study of principal representatives of classes of groups of Phylum Arthropoda
9. Study of representatives of classes of phylum Echinodermta.
10. Preparation of permanent mount of Leucosolenia, Obelia, Hydra, Proglottid of Tapeworm, Parapodia of Nereis and Daphnia. Drawing and labeling.
11. Preparation of permanent slide of mouthpart of insects (after dissection). Drawing and labeling.
12. How to make grade-wise series for preparation of temporary and permanent slides.

Recommended Principal Reference Book:

1. Miller, A.S. and Harley, J.B. ; 1999 , 2002., 2007, 2009, 2012 & 2016 Zoology, 4th, 5th, 6th, 7th, 8th, 9th & 10th Edition (International), Singapore : McGraw Hill. Additional Readings:
2. Hickman, C.P., Roberts, L.C/, AND Larson, A., 2018. INTEGRATED PRINCIPLES OF ZOOLOGY, 15th Edition (International), Singapore: McGRAW-Hill.
3. Hickman, C.P., Roberts, L.C/, AND Larson, A., 2007. INTEGRATED PRINCIPLES OF ZOOLOGy, 12th & 13th Edition (International). Singapore: McGraw-Hill.
4. Pechenik, J.A., 2015. BIOLOGY OF INVERTEBRATES, 7th Edition, (International), Singapore: McGraw-Hill.
5. Kent, G. C. and Miller, S., 2001. COMPARATIVE ANATOMY OF VERTEBRATES New York: McGraw-Hill.
6. Campbell, N.A., 2002; BIOLOGY 6th Edition, Menlo Park, California; Benjamin ummings Publishing Company, Inc.

BOOKS FOR PRACTICAL

7. Miller, S.A., 2002. GENERAL ZOOLOGY LABORATORY MANUAL. 5th Edition International), Singapore: McGraw-Hill.
8. Hickman, C.P. and Kats, H.L., 2000. Laboratory Studies in integrated principal of zoology. Singapore: McGraw-Hill.

Semester-II			
Course Category	**Course Code**	**Course Title**	**Credits**
Compulsory-IV	ENG- 321	English-II (Communication Skills)	3(3+0)
Compulsory-V	PS-322	Pakistan Studies	2(2+0)
General- III	BOT-323	Botany-II (Plant Systematics, Anatomy and Development / Embryology)	3(2+1)

General - IV	CHEM-324	Chemistry-II (Inorganic Chemistry)	3(2+1)
Foundation-II	ZOO-325	Cell Biology	3(2+1)
Foundation-III	ZOO-326	Animal Diversity-II (Chordates)	4(3+1)
		Total Credits	18

Compulsory-IV	**ENG- 321**	**English-II (Communication Skills)**	**3(3+0)**

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-Chrisitine, Brinandm, S.,Grellet, F. 1993. Writing: Intermediate. Oxford Supplementary Skills. Fourth Impression.
2. Nolasco, R. 1992. Writing: Upper-Intermediate. Oxford 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 Riachard York.

Compulsory-V	PS-322	Pakistan Studies	2(2+0)

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.

General- III	BOT-323	Botany-II (Plant Systematics, Anatomy and Development /	3(2+1)

		Embryology)	

Course Outline:

a) Plant systematics

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

i. Ranunculaceae
ii. Brassicaceae (Cruciferae)
iii. Fabaceae (Leguminosae)
iv. Rosaceae
v. Euphorbiaceae
vi Cucurbitaceae
vii. Lamiaceae (Labiatae)
viii. Apiaceae (Umbelliferae)
ix. Asteraceae (Compositae)
x. Liliaceae (Sen. Lato)

b) Anatomy

1. Cell wall: structure and chemical composition
2. Concept, structure and function of various tissues like:

i. Parenchyma
ii. Collenchyma
iii. Sclerenchyma
iv. Phloem Epidermis (including stomata and trichomes)
v. Xylem

3. Meristem: types, stem and root apices
4. Vascular cambium
5. Structure and development of root, stem and leaf. Primary and secondary growth of dicot stem, periderm
6. Characteristics of wood: diffuse porous and ring porous, sap and heart wood, soft and hard wood, annual rings.

c) Development/Embryology

1. Early development of plant body:
2. Capsella bursa-pastoris
3. Structure and development of Anther Microsporogenesis, Microgametophyte
4. Structure of Ovule Megasporogenesis Megagametophyte

5. Endosperm formation
6. Parthenocarpy
7. Polyembryony

Lab Outline:

Plant Systematics

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

Anatomy and Embryology

1. Study of stomata and epidermis.
2. Tissues of primary body of plant.
3. Study of xylem 3-dimensional plane of wood.
4. T. S of angiosperm stem and leaf.
5. Anatomy of germinating seeds
6. Study of pollens

General - IV	CHEM-324	Chemistry-II (Inorganic Chemistry)	3(2+1)

Course Contents:

Chemical Bonding: Types of chemical bonding, ionic and covalent bonding, localized bond approach, theories of chemical bonding, valence bond theory (VBT), hybridization and resonance, prediction of molecular shapes using Valence Shell Electron Pair Repulsion (VSEPR) model, molecular orbital theory (MOT) applied to diatomic molecules, delocalized approach to bonding, bonding in electron deficient compounds, hydrogen bonding.

Acids and Bases: Brief concepts of chemical equilibrium, acids and bases including soft and hard acids and bases (SHAB), concept of relative strength of acids and bases, significance of pH, pKa, pKb and buffer solutions, theory of indicators, solubility, solubility product, common ion effect and their industrial applications.

p-Block Elements: Physical and chemical properties of p-block elements with emphasis on some representative compounds, inter-halogens, pseudo-halogens and polyhalides.

Practicals:

Lab safety and good laboratory practices, knowledge about material safety data sheets (MSD), disposal of chemical waste and first-aid practices, qualitative analysis of salt mixtures, quantitative analysis, acid- base titrations, preparation and standardization of acid and alkali solutions, redox titrations, preparation and standardization of potassium permanganate solution and its use for the determination of purity of commercial potassium oxalate or oxalic acid, preparation and standardization of sodium thiosulfate solution and its use in determination of copper in a given sample, gravimetric analysis, determination of barium in a given sample, determination of chloride in a given solution.

Foundation-II	ZOO-325	Cell Biology	3(2+1)

Course Outline:

1. Introduction cell structure and function

a. Cell theory
b. Comparison of plant and animal cells
c. Comparison of prokaryotic and eukaryotic cells

2. Cell membranes

a. Structural models
b. Chemical composition and function

3. Cell Organelles (structure and function)

a. Endoplasmic reticulum
b. Golgi Bodies
c. Mitochondria
d. Lysosomes
e. Peroxysomes
f. Ribosome

4. Nucleus

a. Structure and function
b. Nuclear membrane
c. Chromatin

5. Cytoskeleton

a. Structure and types
b. Function of cytoskeleton

6. Cellular transport

a. Diffusion and osmosis
b. Facilitated and active transport
c. Endocytosis and exocytosis

7. Cellular reproduction

a. Cell cycle
b. Mitosis
c. Meiosis

Practical:

1. Microscopy
2. Staining techniques (Gram staining)
3. Identification of cell organelles (prepared slides)
4. Preparation of temporary whole mount.
5. Preparation of permanent whole mount.
6. Squash preparation of onion root tip for mitotic stages.
7. Study of mitotic and meiotic stages (prepared slides)

Books Recommended:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D. 2017. Molecular Biology of the Cell. 6th Edition. Garland Publishing Inc., New York.

2. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher Hidde Ploegh, Angelika Amon, Kelsey C. Martin. 2016. Molecular Cell Biology. W. H. Freeman Publishers, Scientific American Inc.
3. Geoffrey M.C., Robert E.H. 2007. The cell: A Molecular Approach, Sinauer Associates, INC.
4. Karp, J. 2005. Celln and Molecular Biology, Concepts and Experiments, Jhon Wiley and Sons, INC.
5. De Robertis, E. D. P. 2017. Cell and Molecular Biology,8th edition, Lea & Febiger, New York.

Foundation-III	ZOO-326	Animal Diversity-II (Chordates)	4(3+1)

Course Outline:

1. Protochordates

a. Classification of protochordates.
b. Structure, anatomy and organ systems of Acorn worms, Urochodates and Cephalochodates
c. Reproduction; life histories and metamorphosis of protochodates.

2. Fishes:

a. Vertebrate Success in Water.
b. Classification of Chondrichthyes, Osteichthyes, Dipnoi and Holocephalli
c. Locomotory adaptations, nutrition and the digestive system, circulation, gas exchange, nervous and sensory functions, excretion and osmoregulation, reproduction and development of Chondrichthyes (Scoliodon) and Osteichthyes (Cyprinus carpio and Wallago attu).

3. Amphibians:

a. The first terrestrial vertebrates.
b. Characteristics of amphibians
c. Classification of amphibians and characteristics of order Caudata, Gymnophiona, and Anura.
d. Structure and locomotory adaptations, nutrition and the digestive system, circulation, gas exchange, temperature regulation, nervous and sensory functions, excretion and
e. Osmoregulation, reproduction, development and metamorphosis of caudate, anura and Gymnophiona.

4. Reptiles:

a. The First Amniotes and cladistic interpretation of the amniotic lineage. General characteristics of reptiles.
b. Characteristics of Order Testudines or Chelonia, Rhynchocephalia, Squamata, and Crocodilia
c. 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 of chelonia, squamata, Rhynchocephalia and crocodilian.

5. Birds:

a. Classification, Feathers, flight and endothermy.
b. Phylogenetic relationships; ancient birds and the evolution of flight.
c. Diversity of modern birds.
d. 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.

e. Migration and navigation.

6. Mammals:

a. Classification, Specialized teeth, endothermy, hair and viviparity.

b. Diversity of mammals.

c. 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:

1. Classification and study of lab specimens of hemichordates, fishes, amphibians, reptiles, birds and mammals.
2. Visit to PMNH for the study of diversity of chordates.

Text and Reference Books:

1. Campbell, N.A. Biology. 9th Ed. 2011. Menlo Park, California Benjamin/Cummings Publishing Company, Inc.

2. 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. Hickman, C.P., Roberts, L.S. and Larson, A. Integrated Principles of Zoology, 14th Edition (International), 2009. Singapore: McGraw-Hill.

5. Pechenik, J.A. Biology of Invertebrates, 4th Edition (International), 2000. Singapore: McGraw Hill.

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Semester-III			
Course Category	**Course Code**	**Course Title**	**Credits**
Compulsory-VI	ENG- 431	English-III: Technical writing and presentation skills	3(3+0)
Compulsory-VII	BCS-432	Introduction to Computer	3(1+2)
General - V	BOT-433	Botany-III (Plant Physiology & Ecology)	3(2+1)
General- VI	CHEM-434	Chemistry-III (Environmental Chemistry)	3(3+0)
General - VII	SOC-435	Social Sciences	2(2+0)
Foundation-IV	ZOO-436	Animal Form and Function-I	4(3+1)
		Total Credits	18

Compulsory-VI	ENG- 431	English-III: Technical writing and presentation skills	3(3+0)

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*

Technical Writing and Presentation Skills

a) Essay Writing and Academic Writing

Books Recommended:

1. Langan, J. 2004. College Writing Skills McGraw-Hill Higher Education.

2. Kirszner. L.G., Mandell, S. R. Patterns of College Writing. 4thEd. 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 norther Illinois University. (A reader that will give students exposure to the best of twentieth century literature).

Compulsory-VII	BCS-432	Introduction to Computer	3(1+2)

Brief history of computers and their applications: Major components of computer, computer and society, the social impact of computer age, computers in offices industry and education, office automation tools; word processing, graphic packages, data bases and spread sheets, current prints, research and prospects, legal and moral aspects of computer science, using internet

Laboratory work pertaining to above course
Books Recommended

1. Using information technology 2nd Ed, William Sawyer, Hutchinson
2. Introduction to computer by Peter Norton
3. Introduction to computer by P.K. Ceena
4. Dandamudi. S P. Fundamentals of Computer Organization and Design.2008. Springer

General - V	BOT-433	Botany-III (Plant Physiology & Ecology)	3(2+1)

Plant Physiology

Water relations: **Properties of water, water potential, Absorption of water**
Diffusion, Osmosis, osmotic potential, Stomata regulation
Mineral nutrition: Soil as a source of minerals. Essential mineral elements and their role plants metabolism. Deficiency symptoms of macronutrient
Photosynthesis: Introduction, Mechanism of photosynthesis; Differences between C_3 and C_4 plants, Factors affecting the process of photosynthesis
Respiration: Mechanism; Glycolysis, Krebs cycle and Electron transport. Anaerobic respiration. Respiratory quotients
Growth: Definition; role of auxins, gibberellins, cytokinins, abscisic acid and ethylene in controlling growth. Introduction to plant tissue culture
Photoperiodism: Definition, Classification of plants based on photoperiod
Dormancy**:** Definition and causes of seed and bud dormancy
Plant Movements: Classification of plant movements

Practical

1. Preparation of solutions of specific normality of acids/bases, salts, sugars, molal and molar solutions and their standardization
2. Determination of uptake of water by swelling seeds when placed in sodium chloride solution of different concentrations
3. Measurement of leaf water potential by the dye method
4. Determination of the temperature at which beetroot cells lose their permeability
5. Determination of the effects of environmental factors on the rate of transpiration of a leafy shoot by means of a porometer/by cobalt chloride paper method
6. Chemical tests for the Starch, Cellulose, Lignin and Proteins
7. Extraction of amylase from germinating wheat seeds and study of its effect on starch breakdown
8. Measurement of carbon dioxide evolution during respiration of germinating seeds by

the titration method

9. Measurement of light and temperature. Effect of light and temperature on seed germination

Books Recommended

1. Hopkins, W.B. 1999. Introduction to Plant Physiology. 2nd Ed. John Wiley and Sons. New York
2. Ihsan Illahi (1995). Plant Physiology, Biochemical Processes in Plants, UGC Press
3. Salisbury F.B. and Ross C.B. 1992. Plant physiology. 5th Edition. Wadsworth Publishing Co. Belmont CA
4. Lambers. H, Chapin.F.S, Pons.T.L. Plant Physiological Ecology.2008.

Ecology

Introduction, branches of ecology, levels of ecological organization, species, population, community and ecosystem, role of light, soil, water, temperature, topography and air as ecological factors, biotic factors, Concepts of Limiting factors, habitat and niche.

Populations; Population distribution and abundance, population dynamics, distribution limits, carrying capacity and environmental resistance

Community: organization, various concepts of community, community dynamics.

Ecosystem: structure and function, energy flow and material cycling within ecosystem. Biomes of the world, characteristics of urban, agricultural and industrial ecosystems.

Terrestrial and aquatic ecosystems in Pakistan, their distribution and potential threats to these ecosystems, plant geography and animal distribution.

Ecological production: primary and secondary productivity, productivity of different ecosystems, Systems ecology, ecological modeling, landscape ecology, landscape changes and their importance

Practicals

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

Books Recommended

1. Odum, E. P. 1994. FUNDAMENTALS OF ECOLOGY. 3rd Edition W.B. Saunders. Philadelphia

2. Molles, M.C. 2005 Ecology: CONCEPTS AND APPLICATIONS. 6th Edition, McGraw Hill, New York, USA

3. Dondson, S.I., Allen, T.F.N., Carpenter, S.R., Ives, A., Jeanne, R.L., Kitchell, J.F., Langston, N.E. and Turner, M.G., 1998. ECOLOGY. Oxford Univ. Press, UK

4. Slings by, D. And Cook, C., 1986. Practical Ecology. Mcmillan Education Ltd. UK

5. Chapman, J.L. And Reiss, M.J.1997. Ecology: Principles and Applications. Cambridge Univ. Press, Uk
6. Smith, R.L. 1980. Ecology and Field Biology, Harper and Row
7. Newman, I. 1993. Applied ecology. Black well scientific publications oxford. UK
8. Coxes, C.B and Morre, D. 2000. Biogeography: An Ecological and Evolutionary Approach, 6th Edition. Life Sciences King's College, London, UK
9. Molles .M. C. Ecology: Concepts and Applications, 4th Edition.2006. McGraw-Hill
10. Lambers. H, Chapin. F. S, Pons. T.L. Plant Physiological Ecology.2008. Springer
11. Valk. A. V. Herbaceous Plant Ecology: Recent Advances in Plant Ecology.2009. Springer

General- VI	CHEM-434	Chemistry-III (Environmental Chemistry)	3(3+0)

Course Contents:

Atmospheric Pollution:

The atmosphere, composition, temperature and pressure profile, role of free radicals in the atmosphere, temperature inversion and photochemical smog, particulate matter in the atmosphere, Industrial pollutants, atmospheric aerosols, acid-rain major sources, mechanism, control measures and effects on buildings and vegetation, global warming, major greenhouse gases, mechanism, control measures and global impact, the stratospheric ozone–the ozone hole, CFCs, ozone protection, biological consequences of ozone depletion.

Water Pollution:

Water pollution and waste water treatment, municipal, industrial and agricultural sources of pollution, heavy metals contamination of water, eutrophication, detergents and phosphates in water, water quality criteria, water purification: primary, secondary and advanced treatment, removal of nitrogen and phosphorous compounds from polluted water, organic matter in water and its decomposition.

Land pollution:

Soil and mineral resources, general principles of metal extraction, heavy metals contamination of soil, toxicity of heavy metals, bio-accumulation of heavy metals, organic matter in soil, macro and micro-nutrients in soil, ion-exchange in soil, soil pH and nutrients availability.

Green Chemistry:

Atom economy, integrated pest management control (IPMC), ionic liquids, super critical extraction technology, green synthesis, recycling, carbon dioxide sequestering, water based paints.

Recommended Books:

1. Baird, C. and Cann, M., *Environmental Chemistry,* 5th ed., W. H. Freeman & Company, (2012).
2. Dara, S. S. and Mihsra, D. D., *A Text Book of Environmental Chemistry and Pollution Control*, 9th ed., S. Chand & Co. Ltd., (2004).

3. **Singhi**, R. and Singh, V., *Green Chemistry for Environmental Remediation*, John-Willey & Sons, Inc., (2011).
4. Holloway, A. M. and Wayne, R. P., *Atmospheric Chemistry*, 1st ed., Royal Society of Chemistry, (2010).
5. Vaclavikova, M., Vitale, K., Gallios, G. P. and Ivanicova, L. *Water Treatment Technologies for Removal of High Toxicity Pollutants*, Springerlink, UK, (2010).
6. Manahan, S. E., *Environmental Chemistry,* 9th ed., CRC press, Taylor & Francis group, USA, (2009).
7. Girard, J. E., *Principles of Environmental Chemistry,* 2nd ed., Jones and Bartlett publishers, (2010).
8. Harrison, R. M., Monks, P., Farmer, J. G., Graham, M. C., Mora, S. J., Pulford, I. and Hulsal, C., *Principles of Environmental Chemistry,* 1st ed., Royal Society of Chemistry, (2007).
9. Matalack, A., *Introduction to Green Chemistry,* 2nd ed., CRC press, Taylor & Francis group, USA, (2010).
10. Wright, J., *Environmental Chemistry,* Routledge, (2003).
11. O'Neill, P., *Environmental Chemistry,* 3rd ed., Blackie Academic & Professional, (1998).

General - VII	SOC-435	Social Sciences	2(2+0)

1. Introduction
    a. Definition, Scope, and Subject Matter
    b. Sociology as a Science
    c. Historical back ground of Sociology
2. Basic Concepts
    a. Group, Community, Society
    b. Associations
        i. Non-Voluntary
        ii. Voluntary
    c. Organization
        i. Informal
        ii. Formal
    d. Social Interaction
        i. Levels of Social Interaction
        ii. Process of Social Interaction
            a) Cooperation
            b) Competition
            c) Conflict
            d) Accommodation
            e) Acculturation and diffusion
            f) Assimilation
            g) Amalgamation
3. Social Groups
    a. Definition and Functions
    b. Types of social groups

i. In and out groups
ii. Primary and Secondary group
iii. Reference groups
iv. Informal and Formal groups
v. Pressure groups

4. Socialization and Personality
    a. Personality, Factors in Personality Formation
    b. Socialization, Agencies of Socialization
    c. Role and Status

Recommended Books:

1. Anderson, Margaret and Howard F. Taylor. 2001. *Sociology the Essentials*. Australia: Wadsworth.
2. Brown, Ken 2004. *Sociology*. UK: Polity Press
3. Gidden, Anthony 2002. *Introduction to Sociology*. UK: Polity Press.
4. Macionis, John J. 2006. 10th Edition *Sociology* New Jersey: Prentice-Hall
5. Tischler, Henry L. 2002. *Introduction to Sociology* 7th ed. New York: The Harcourt Press.
6. Frank N Magill. 2003. *International Encyclopedia of Sociology*. U.S.A: Fitzroy Dearborn Publishers
7. Macionis, John J. 2005. *Sociology* 10th ed. South Asia: Pearson Education
8. Kerbo, Harold R. 1989. *Sociology: Social Structure and Social Conflict*. New York: Macmillan Publishing Company.
9. Koening Samuel. 1957. *Sociology: An Introduction to the Science of Society*. New York: Barnes and Nobel..
10. Lee, Alfred Mclung and Lee, Elizabeth Briant 1961. *Marriage and The family*. New York: Barnes and Noble, Inc.
11. Leslie, Gerald et al. 1973. *Order and Change: Introductory Sociology* Toronto: Oxford University Press.
12. Lenski, Gevbard and Lenski, Jeam. 1982. *Human Societies*. 4th edition New York: McGraw-Hill Book Company.

Foundation-IV	ZOO-436	Animal Form and Function-I	4(3+1)

Course Outline:

1. Protection, Support, and Movement:

a. Protection: the integumentary system of invertebrates and vertebrates;

b. Movement and support: the skeletal system of invertebrates and vertebrates;

c. Movement: non-muscular movement; an introduction to animal muscles; the muscular system of invertebrates and vertebrates

2. Communication I:

a. Nerves: Neurons: structure and function.

3. Communication II:

a. Senses: Sensory reception: baroreceptors, chemoreceptors, georeceptors, hygroreceptors, phonoreceptors, photoreceptors, proprioceptors, tactile receptors, and thermoreceptors of invertebrates

b. 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.

4. Communication III:

a. The Endocrine System and Chemical Messengers: Chemical messengers: hormones chemistry; and their feedback systems; mechanisms of hormone action

b. Hormones with principal function each of porifera, cnidarians, platyhelminthes, nemerteans, nematodes, molluscs, annelids, arthropods, and echinoderms invertebrates; an overview of the vertebrate endocrine system; endocrine systems of vertebrates, endocrine systems of birds and mammals

5. Circulation and Immunity:

a. Internal transport and circulatory systems in invertebrates

b. Characteristics of invertebrate coelomic fluid, hemolymph, and blood cells

c. 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

Practicals:

1. Study of insect chitin, fish scale, amphibian skin, reptilian scales, feathers and mammalian skin.

2. Study and notes of skeleton of Labeo (Labeo rohita), Frog (Hoplobatrachus tigerinus), Varanus (Varanus bengalensis), fowl (Gallus gallus domesticus) and rabbit (Oryctolagus cuniculus).

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

3. Earthworm or leech; cockroach, freshwater mussel, Channa or Catlacatla or Labeo or any other local fish, frog, pigeon and rat or mouse and rabbits dissections as per availability.

4. Study of heart, principal arteries and veins in a representative vertebrate (dissection of representative fish/mammals).

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

5. Kent, G.C., Miller, S. 2001. Comparative Anatomy of Vertebrates. New York: 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 Code**	**Course Title**	**Credits**
Compulsory-VIII	ENG- 441	English-IV (Advanced Academic Reading and Writing)	3(3+0)
Major-I	ZOO- 442	Animal Behavior	3(3+0)
Major-II	ZOO- 443	Biological Techniques	3(1+2)
Foundation-V	ZOO- 444	Biochemistry-I	3(2+1)
Foundation-VI	ZOO- 445	Animal Form & Function-II	4(3+1)
General-VIII	PSY- 446	Psychology	2(2+0
		Total Credits	18

Compulsory-VIII	ENG- 441	English-IV (Advanced Academic Reading and Writing)	3(3+0)

1. The art of listening

2. What is good listening?

3. Types of listening

- Appreciative
- Listening for pleasure or enjoyment
- Empathetic
- Comprehensive
- Critical

4. Tips for good listening

- Face the speaker
- Maintain eye contact
- Minimize the external distractions
- Respond appropriately
- Focus on what the speaker is saying
- Minimize the internal distractions
- Keep an open mind
- Avoid letting the speaker know how you handled a similar situation
- Even if the speaker is launching a complaint against you, wait until they finish to defend yourself
- Engage yourself
- Body language
- Silence
- Touching

- Some audio listening

5. Ways to become effective listener

- Setting the stage
- Appropriate Physical Environment
- Removal of distraction
- Be open and accessible
- Maintain relaxed, open posture that shows concentration
- Ensure mutual understanding reflect feelings
- Offer acknowledgement (say uh, huh)
- Paraphrase main ideas
- Interrupt to clarify
- Confirm next step

6. Barrier to Listening include

- Worry, fear, anger, grief and depression
- Individual bias and prejudice
- Semantics and language differences
- Noise and verbal "clutter"
- Preoccupation, boredom and shrinking attention spans
- Act distracted (look at your watch!)
- Tell your own story without acknowledging their
- Give no response
- Invalidate response, be negative
- Interrupt
- Criticize
- Diagnose what we said
- Give advice/solution quickly
- Change the subject
- Reassure without acknowledgment

7. Communication

- Communication skills
- Types of communications
- Importance and benefit of effective communication
- Components of communication
- Nonverbal communication
- Barriers to communication
- Difference between hearing and listening
- Essential of communication (Dos)
- Essential of communication (Don'ts)
- Ways to improve the communication
- Common ways to communicate with

8. Barrier to communication

- Noise
- Inappropriate medium
- Assumption/misconception

- Emotion
- Language difference
- Poor listening skill
- Distraction

9. Public speaking

- Talk, conversation, speech and rhetoric
- Speaking opportunities at work place, home daily life

10. PS and conversation

- Organization of thought
- Tailoring the message to the right audience
- Interesting start
- Consideration of audience feedback
- PS is structural
- PS requires normal language
- PS requires delivery method

11. The speech communication process

- Speaker
- Message
- Channel
- Listener
- Feedback
- Interference
- Situation

12. Analysis of audience

- PS is audience centered
- Kind of audience
- Psychology of audience
- Care of egocentrism of people
- Demographic analysis of audience
- Observable traits
- Age, gender, racial, ethical background, religion group

13. Situational audience analysis

- Unique traits of speaking situation
- Size
- Physical setting

14. Disposition toward the topic

- Interest , knowledge , attitude

15. Disposition towards the speaker

16. Disposition towards the occasion

17. Organization of speech

18. Connectives

- Transition
- Internal previews
- Internal summaries
- Signposts

19. Supporting material

- Example
- Statistics
- Testimony

20. Beginning and ending of speech

- Get attention and interest
- Reveal the topic
- Establish credibility and Goodwill
- Preview the body of the speech
- Signal the end of the speech
- Reinforce the central idea

21. Many more things to remember for effective speech

- Use language accurately
- Use language clearly
- Use language Vividly
    - Imagery
    - Concrete words
    - Simile
    - Metaphor
    - Rhythm
    - Parallelism
    - Repetition
    - Alliteration
    - Antithesis

22. Speech delivery

- Types of delivery
    - Read from manuscript
    - Reciting from memory
    - Impromptu
    - Extemporaneously

23. Vocalization of speech

- Volume- loudness or softness
- Pitch- speed rate at which you speak
- Pauses
- Variety
- Pronunciation

- Articulation
- Dialect

24. Interviewing

- The nature and type of interview
- Interview structure
- How to be interviewed for a job
- How to be interviewed for an information-gathering interview
- The responsibilities of an interviewer

25. Types of interviews

- Information gathering interview
- Appraisal interview
- Problem solving interview
- Persuasion interview

26. Structure of interview

- Opening
- Body
- Conclusion

How to be interviewed for a job?

- Be aware of your skills and abilities
- Prepare your resume
  - A written concise, organized description of your qualifications
  - Components
    - Personal information
    - Career objectives
    - Education and Objectives
    - education
    - experience
    - Honor and special accomplishments
    - Optional information
    - Identify the need of your employer
    - Listen respond and ask appropriate questions
    - Follow up after the interview
    - Ask appropriate questions

25. The right use of Diction

A	An	Accept	Except	Advice
Advise	Effect	Affect	Alright	Most
Amount	Between	Among	Amount	Number
As, As If, As Though	Like	Be sure and	Try and	Could of
Should of	Might of	Would of	Different than	Different from
Due to	Because of	Enthused/enthuse	Fewer	less

Hopefully	Irregardless	Lead	Led	Lend
Loan	Life	Lay	Principal	principle
Rise	Raise	Sit	Sat	Supposed to
Used to	Then	Than	Senior to	Junior to

26. Short stories reading and then presenting them in their own words in class

1. The gift of Magi (O, Henry)
2. The diamond necklace
3. over coat
4. His first flight
5. Rustam and suhrab

27. Common grammatical error

28. Successful strategies for group meeting

- Definition of group meetings
- Formation of a group meeting
- Background information on group meeting
- Purpose and kind of meeting
- Solving problem in meeting or groups
- Leadership responsibilities in meeting
- Participant responsibilities in meeting

29. Resume (Vita, Qualification Brief)

- Opening section
- Education
- Work experience
- Achievements
- Awards
- Service activities
- Personal data
- References
- Sample resume

30. Letters. Emails and memos

31. Watching some movies or listening material from ILETS or TOFEL courses based on thematic or important course related issues and then writing as assignment or doing some quiz on them.

Major-I	ZOO- 442	Animal Behavior	3(3+0)

Course Outline (Contents)

1. Introduction

 Behaviour and its types

 Proximate and ultimate causes of behavour.

 Development of behavior and impact of neural and physiological mechanisms; role of external and internal stimuli and animal responses. Physiology of behavior in changed environments.

 Hormones and behavior in animals.

 Innate behavior and innate releasing mechanisms; built in programmed performance by offspring to that of parents. Innate behavior of three spined stickle back fish.
 Learned behavior and its mechanisms; quick learners' vs slow learners. Concept of animal cognition; key to understand and develop multiple behavioural choices. Ecological and genetics to maintain animal behavior. Concept of territoriality and defense in animals.
 Circadian rhythms and concept of bio-rhythmicity in animals. Maintenance of internal biological clock to perform various diurnal and nocturnal periodicities.
 Costs and benefit ratios in behavior; successful foragers and winners of predator-prey relationships. Altruism and parental sacrifice to nurture the young.
 Competition for resources; survival of the most suitable individuals; evolutionary arms races in behavior.
 Social organization in animals and concept of group living; benefits and losses. Aggression, appeasement and selfish individuals. Social organization in insects and mammals.
 Communication in animals: Visual, Bioacoustic, electrical, chemical and tactile.
 Various types of chemical signals in animals' behavior and their importance in ecosystems.

TEXT AND REFERENCE BOOKS:

1. Dngatkin, L. A. 2012. Principles of Animal Behavior.W.W. Nortan and Co.New York.
2. Alcock, J. 2010. Animal behavior, an evolutionary approach. 9th Edition. Sinauer Publishers.
3. Scott, G. 2009. Essential Animal Behavior. Wiley publishers
4. Scott, G. 2005.Essential Animal Behavior. Blackwell Pub. New York.
5. Goodenough, J., McGuire, B., Wallace, R.A. 2001.Perspective on Animal Behavior. John Wiley & Sons, New York.

Major-II	**ZOO- 443**	**Biological Techniques**	**3(1+2)**

Contact Hours	Credit Hours
Theory= 16	Theory= 1.0
Practical = 64	Practical = 2.0
Total= 80	Total= 3.0

Course Contents:

1. Microscopy:

a. Principles of light microscopy. Magnification, Resolution,
b. Types of microscopy (Bright field, Dark field, Phase Contrast)
c. Confocal Microscopy

d. Electron microscope: Scanning electron microscope and Transmission electron microscope (SEM and TEM).

2. Standard unit system for weight, length, volume and Micrometery:

a. Different Measurement systems (length; surface; weight, volume, temperature), Calculations and related conversions

b. Concentrations- percent volume; ppt; ppm - molarity, normality, molality

c. Preparation of stock solutions of various strengths

d. Use of stage and ocular micrometers

e. Calibration of ocular micrometer and measurement of size animal and plant cell and nuclei

3. Specimen preparation for optical microscopy:

a. Introduction to Microtomy and its types

b. Tissue Fixation, dehydration, clearing, embedding, Section cutting (transverse, longitudinal section)

c. Tissue mounting (dry mount, wet mount)

d. Staining: Hematoxylin and Eosin staining

4. Separation and purification techniques:

a. Cell fractionation

b. Centrifugation and its types

c. Filtration and its types,

5. Chromatography:

a. Chromatography: Principle, applications, types,

b. Paper chromatography and thin layer chromatography

c. Column chromatography

d. High pressure liquid chromatography.

e. Electrophoresis: Principle, applications and types (Agarose and PAGE).

6. Spectrophotometry:

a. Principle, applications, types

b. Visible/UV spectrophotometry

7. Basic principles of Sampling and Preservation:

a. Sampling from soil, water, air, plants and animals

b. Preservation of dry and wet specimens.

c. Preservation techniques. lyophilization, preservation in ethanol, formalin etc.

8. DNA sequencing

a. Polymerase chain reaction (PCR), principle and application

b. DNA sequencing (Sanger and Maxam Gilbert).

Practicals:

1. Preparation of slides (dry mount and wet mount)
2. Observation of wet mounts of human cheek cells employing bright and dark field microscopy
3. Measurement of cell size: bacterial and eukaryotic Cell
4. Recording of microscopic observations with the help of camera lucida
5. Liquid handling: proper use of pipettes and micropipettes

6. Hematoxylin and Eosin staining
7. Gram's staining,
8. Handling of centrifuge machines
9. Paper Chromatography
10. Thin layer chromatography of amino acids
11. Spectrophotometric estimation of glucose
12. Collection and Preservation of representative animals of various phyla

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: ForTechnician. CRC Press LLC. USA.
6. Slingsby, D., Cock, C.1986. Practical ecology. McMillan Education Ltd. London.
7. Rob Reed/ David HOLMES, Jonathan Weyers/ Allan Jones Pearson, Practical skill in bio-molecular sciences.
8. Gallagher, S.R. and Wiley E.A. 2008. Current protocols essential laboratory Techniques. John Wiley & Sons Inc, USA.
9. Jones, A. Reed, R and Weyers, J. 1994. Practical skills in Biology. Longman Singapore Publishers (Pte) Ltd.

Foundation-V	ZOO- 444	Biochemistry-I	3(2+1)

Course Contents

1. Introduction to Macromolecules

a. Structure, types and role of various building blocks their respective macromolecules.

b. Carbohydrates: Introduction; Classification Stereoisomerism in carbohydrate, Structure, types and role of monosaccharides, oligosaccharides and polysaccharides; Glycosaminoglycans and glycoconjugates;

c. Carbohydrates as an information carrier molecule.

2. Amino acids, peptides & proteins:

a. Types of amino acids & their classification;

b. Uncommon amino acids; Acid/base behavior of amino acids.

c. Titration curves in amino acids and their importance:

d. Peptides & proteins;

e. Biologically active peptides & polypeptides;

f. Amino acid sequence in proteins & their importance; Conjugated proteins;

2.1. Purification Techniques for Proteins

a. An outline of purification techniques for proteins; column chromatography, electrophoresis; Isoelectric focusing;

2.2. Organization of proteins:

a. Structural levels of proteins; Covalent structure of proteins;

b. function of some structural & functional proteins; Hemoglobin, Cytochrome-c: Chymotrypsin, alpha Keratin and Collagen;

c. Proproteins, their examples and role;

3. Enzymes

a. Enzymes, their importance, classification & nomenclature, Function & inhibition.

4. Lipids:

a. Introduction & classification of lipids; Fatty acids, their types; Storage lipids;

4.1. Classification and important characteristics;

a. Triacyclglycerols; waxes Structural/membrane lipids; Glycerophospholipids with Ether and Ester linkages Galactolipids & Sulfolipds: Sphingolipids their types & importance: Sterols, their structure, types & functions. Examples of Functional diversity of Lipids as Signaling molecules, Cofactors, Electron carrier, antioxidants, pigments etc.

5. Nucleic acids

a. Nucleic acids and their types; Structure and role of various Bases in nucleic acids,

b. Nucleoside & Nucleotides;

c. Structure of DNA and RNA molecules;

d. Organization and Chemistry of Double helical structure of DNA with their details.

Practical:

1. Preparation of standard curve for glucose by ortho-Toluidine method.
2. Estimation of glucose from blood serum or any other fluid using ortho Toluidine technique.
3. Tests for detection of carbohydrates in alkaline medium.
4. Tests for detection of carbohydrates in acidic medium.
5. Tests for detection of Disaccharides.
6. Tests to demonstrate relative instability of glycosidic linkage in carbohydrates.
7. Detection of Non-Reducing sugars in the presence of reducing sugars.
8. Demonstration of Acid Hydrolysis of Polysaccharide.
9. Determination of pKa values of an amino acid by preparation of titration curves.
10. Preparation of standard curve of proteins by Biuret method.
11. Estimation of blood serum proteins or any unknown concentration of protein using Biuret technique.

Books Recommended:

1. Lehninger principle of biochemistry by David L.Nelson and Michael M.Cox , 7th latest edition,ISBN-10:1-4641-2611-9,ISBN-13:978-14641-2611-6
2. Biochemistry by Jeremy M. Berg, John L. Tymoczko; Lubert Stryer ,ISBN-10:1429229365,ISBN-13:97814229229364
3. Berg, J. M.,Tymoczko,J. L., Lubert Stryer. 2010. Biochemistry. 7th Ed.

4. Lodish, H., Berk, A., Zipursky, S. L., Paul. M., Baltimore D, Darnell, J. 2012. Molecular Cell Biology.
5. David L. Nelson, and Michael M. Cox, 2000. Lehninger Principles of Biochemistry, 3rd Ed., Macmillan Worth Publishers, New York.
6. Murray, R.K., Granner, D.K., Mayer, P.A. and Rodwells, V.W., 2000. Voet. D., Voet, J.G., and Pratt, C.W., 1999. Fundamentals of Biochemistry, John Wiley and Sons, Inc., New York.
7. Zubay, G.,1995. Biochemistry, 4th Ed., Wm. C. Brown Publishers, Inc., Oxford, England.
8. Stryer, L., 1995. Biochemistry, 6th Ed., W.H. Freeman and Company, New York.
9. Nelson, D. L., Cox, M. M. 2012. Lehninger Principles of Biochemistry. McMillan Worth Publishers, New York.
10. McKee, T., McKee, J.R. 2003.Biochemistry:
11. The Molecular Basis of Life. 3rd Edition, McGraw-Hill
12. Lodish, H., Berk, A., Zipursky, S. L., Paul.M., Baltimore D,Darnell, J. 2012. Molecular Cell Biology.
13. McKee, T., McKee, J.R. 2003.Biochemistry:
14. The Molecular Basis of Life. 3rd Edition, McGraw-Hill
15. Molecular cell biology W.H Freeman by Lodish, Berk, Krieger, Scott, Bretscher,Ploegh and Matsudaira 8th edition/latest edition,ISBN:1464183392,ISBN-13:97814641183393

Text book for Practical:

1. Plummer, David T., 1990. An Introduction to Practical Biochemistry, 4th Ed. McGraw-Hill Book Company, London.
2. Wilson, K and Walker, J., 1994. Practical Biochemistry: Principles and Techniques, 4th Ed., Cambridge University Press.
3. Sawhney, S.K and Singh, R., 2008. Introductory Practical Biochemistry, Narosa Publishing House, New Delhi, India.

Foundation-VI	ZOO- 445	Animal Form & Function-II	4(3+1)

Course Outline:

1. Nutrition and Digestion:

a. Evolution of nutrition; the metabolic fates of nutrients in heterotrophs; digestion

b. Animal strategies for getting and using food, diversity in digestive structures of invertebrates.

c. The mammalian digestive system: gastrointestinal motility and its control

d. 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 gall bladder in digestion.

2. Temperature and Body Fluid Regulation:

a. 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

b. Control of Water and Solutes (Osmoregulation and Excretion); Invertebrate and Vertebrate

c. Excretory Systems; How Vertebrates Achieve Osmoregulation; Vertebrate Kidney Variations; Mechanism in Metanephric Kidney Functions. Reproduction and Development

3. Reproduction:

a. Asexual reproduction in invertebrates; advantages and disadvantages of asexual reproduction;

b. Sexual reproduction in invertebrates; advantages and disadvantages of sexual reproduction; sexual reproduction in vertebrates; reproductive strategies; examples of reproduction among various vertebrate classes;

c. The human male reproductive system: spermatogenesis, transport and hormonal control, reproductive function;

d. 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.

Practicals:

1. Study of excretory system in an invertebrate and a vertebrate representative (Model).
2. Study of dissection system in invertebrate and a vertebrate representative (Dissection).
3. Dissection and study of male and female reproductive system in vertebrates and invertebrates.

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

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., 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. Kent, G.C., Miller, S. 2001. Comparative Anatomy of Vertebrates. NewYork: McGraw-Hill.
6. Hickman, C.P., Kats, H.L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw-Hill

General-VIII	PSY- 446	Psychology	2(2+0

Course Contents

Understanding Psychology

Psychology: Scientific perspective
Historical perspective
Schools of psychology
Methods of psychology
Ethical issues
Fields of psychology and their application

Biological Basis of Behaviour

Neuron and its function
Central nervous system
Peripheral nervous system
Endocrine system

Sensation and Perception

Senses: Vision, audition, smell, taste and kinesthetic
Introduction to perception

Learning

Definition of learning
Types of learning: Classical and operant conditioning
Punishment and its effects
Latent and observational learning

Memory

Definition and types of memory
Processes and techniques of improving memory
Forgetting: Nature and causes

Cognition and Language

Concept of cognition
Problem solving
Judgment and decision making
Language development
Language and cognition
Language and culture

Intelligence and Creativity

Concept of intelligence
Theories of intelligence
Assessment of intelligence
Mental retardation
Concept of creativity and its stages

Motivation and Emotion

Introduction to motivation
Factors affecting motivation
Introduction to emotions
Types of emotions

Personality

Defining personality

Personality assessment

Recommended Books

1. Atkinson R. C., & Smith, E. E. (2000).*Introduction to psychology* (13th ed.). NY: Harcourt Brace College Publishers.
2. Coon, D., &Mutterer, J. (2008).*Introduction to psychology: Gateways to mind and behavior*(12th ed.). USA: Wadsworth Cengage Learning.
3. Fernald, L. D., & Fernald, P.S (2005).*Introduction* to psychology. USA; WMC Brown Publishers.
4. Fredrickson, B., Nolen-Hoeksema, S., Loftus, G., & Wagenaar, W. (2009). *Atkinson & Hilgard's introduction to psychology* (15th ed.). USA: Wadsworth.
5. Glassman, W.E. (2000). *Approaches* to psychology.Open University Press. Hayes, N. (2000). *Foundation of psychology* (3rd ed.). UK: Thomson Learning.
6. Kalat, J. W. (2010). *Introduction to psychology*.USA: Cengage Learning, Inc. Lahey, B. B. (2004). *Psychology*: *An introduction* (8th ed.). UK: McGraw-Hill Companies
7. Inc. Leahey,T. H. (1992). *A history of psychology: Main currents in psychological thought.* New Jersey: Prentice-Hall International,
8. Inc.Myers, D. G. (2011).*Psychology* (10th ed.). USA: Wadsworth Publishers.
9. Ormord, J. E. (1995). *Educational psychology: Developing learners*. USA: Prentice Hall, Inc.
10. Rathus, S. (2011). *Psychology: Concepts and connections* (10th ed.). USA:Wadsworth Cengage Learning.

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Year III Semester-V			
Course Category	**Course Code**	**Course Title**	**Credits**
Foundation-VII	ZOO- 551	Economic Zoology	3(2+1)
Foundation-VIII	ZOO-552	Biochemistry-II	3(2+1)
Major-III	ZOO-553	Physiology	4(3+1)
Major-IV	ZOO-554	Ecology	3(2+1)
Foundation-IX	ZOO-555	Evolution	2(2+0)
Foundation-X	ZOO-556	Principles of Systematics	3(2+1)
		Total Credits	18

Foundation-VII	ZOO- 551	Economic Zoology	3(2+1)

Course Outline:

- Basic concepts in Economic Zoology.
- Parasitic protozoans and human disease. Economic importance of protozoa.
- Vectors of human and domestic animals.
- Ecto- and Endo-parasites of fish, poultry, cattle and Man (Crustacea, Helminthes and Arachnida).
- Pests of pulse crops. Pests of oil seed crops. Stored grain pests. Pests of cotton. Pests of vegetables. Pests of fruits. Pests of tea. Apiculture, and Sericulture, Lac insect culture and Pearl culture
- Aquaculture and Fisheries (Edible Fresh water, Pond and Marine fish, Prawns, Pearl oysters). Economic importance of fishes.
- Bird farming (Poultry, Quail, Turkey, Ostrich and Pigeon.

Practical:

1. To study the prepared slides of various types of ecto- and endo-parasites.
2. To observe and study Museum specimens of vertebrate and invertebrate pests of important crops and stored grains in Pakistan.
3. To visit Honey Bee farm. Write a report on their observations.
4. Visit to Sericulture farm in a nearby locality and write report on their observations.
5. Study visit to fish Hatchery, Nursery ponds, Stocking ponds, Commercial fish breeding farms and report writing.
6. Identification of important species of Fish and their natural animal.
7. Visit to any bird farm and write a report on their observations.

Recommended Books

1. Economic Zoology. Ravindranathan, K. R. 2003. 1st ed. Dominent Publishers and Distributers. New Delhi. India
2. Principles of Wildlife Management. Bailey, J. A. 1986. John Wiley and Sons Inc.USA.
3. Wildlife ecology and management. Robinson, W. L. and Bolen, E. G.1984. McMillan Publishing Company. Cambridge, UK.
4. A Primer of Conservation of Biology. Primack R. B. 2000. 2nd ed. Sinauer Associates Inc. USA.
5. Animal biodiversity of Pakistan. Mirza, Z. B. 1998. 1st ed: Printopack, Rawalpindi. Pakistan.
6. Ahmad, R. and Muzaffar, N., 1987. Rearing of Silkworm. Misc. Pub. Pak. Agric. Res. Council, pp. 53.
7. Akhtar, M. and Muzaffar, N., 2008. Introduction to Apiculture, Department of Zoology, Punjab University Press, 36 pp.
8. Anon, 1986. The Hive and the Honeybee. Dadant & Sons. Illinois, USA, pp. 740.
9. Anon, 1999. FAO Bulletins on Sericulture Nos. 1 & 2. FAO Office, Rome, Italy.
10. Blackiston, H., 2001. Beekeeping for Dummies. Wiley Publishing, Inc. Indiana, USA, pp. 303.
11. Shukla, G.S. and Upadhayay, V.B., 1997. Economic Zoology, 3rd Ed. Rastogi Publications, Mearut, India, pp. 369.

Foundation-VIII	ZOO-552	Biochemistry-II	3(2+1)

Course Contents

1. Bioenergetics

a. Concept of Free Energy; Standard Free Energy change:
b. Energy rich compounds and their role in metabolism.

2. Metabolism

a. Detailed description of Glycolysis and Catabolism of other Hexoses;
b. Regulation and Bioenergetics of Glycolysis. Anabolic role of Glycolysis;
c. Fate of Pyruvate under Aerobic and Anaerobic conditions, Lactate and Alcoholic Fermentation;
d. Gluconeogenesis, its Regulation and significance in the tissues; Feeder Pathways in Glycolysis; Utilization of other carbohydrates in Glycolysis;
e. Phosphorolysis of Glycogen and Starch; Regulation of Glycogen metabolism; Utilization of dietary polysaccharides (Starch) and Disaccharides (Sucrose and Galactose). Biosynthesis of Glycogen, Starch and Sucrose;
f. Pentose phosphate pathway of Glucose oxidation and its major role in the animal tissues.
g. Citric acid (TCA) cycle: Conversion of Pyruvate to Acetyl CoA, Pyruvate dehydrogenase, a multi-enzyme complex;
h. 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.

3. Lipid metabolism

a. Digestion, mobilization and transport of Fats; Biosynthesis of Triacylglycerol;

b. Utilization of Triacylglycerol; Oxidation of Fatty acids; Activation of Fatty acids and their transportation to mitochondria;

c. Beta (ß)-Oxidation; Bioenergetics of ß-oxidation; Omega (ω)-Oxidation pathway;

d. Biosynthesis of Saturated Fatty acid, Supply of raw material for palmitic acid synthesis; Fatty acid synthetase (FAS) multienzyme complex;

e. Models of FAS system in Bacteria, Plants, vertebrate tissue and Yeast cell; Biosynthesis of unsaturated Fatty acids, Aerobic and Anaerobic pathways. Ketone bodies and their biosynthesis, utilization and role in the tissues;

4. Cholesterol metabolism

a. Cholesterol biosynthesis and its Regulation; Steroid hormones, their types and main functions; Prostaglandins, their types, synthesis, inhibition and main functions.

5. Nitrogen metabolism

a. Metabolic fate of amino acids; Catabolism of amino acids; Deamination and Transamination;

b. Role of glutamate, glutamine and alanine in transport of ammonia in tissues;

c. Nitrogen excretion and urea cycle; Regulation of urea cycle;

d. Pathways of amino acid degradation showing entry points in Citric acid cycle; Decarboxylation of amino acids to biological amines.

e. Biosynthesis of some amino acids; Incorporation of ammonia in glutamate and glutamine;

f. Purine and Pyrimidine biosynthesis showing the sources of various atoms in both molecules.

Practical:

1. Preparation of standard curve of proteins using Lowry's technique.
2. Estimation of tissue (liver) proteins using Lowry's technique.
3. Estimation of Free Amino Acids in Biological samples colorimetrically.
4. Separation and identification of various amino acids by paper chromatography.
5. Separation of proteins by Polycrylamide Gel Electrophoresis (PAGE).
6. Preparation of standard curve and estimation of DNA by colorimetric analysis using Diphenylamine method.
7. Preparation of standard curve and estimation of total RNA by colorimetric analysis using Orctinol method.
8. Quantitative analysis of Amylase activity from blood serum or liver.
9. Effect of temperature and pH on enzymatic rate of reaction.

Books Recommended:

1. Plummer, David T., 1990. An Introduction to Practical Biochemistry, 4th Edition McGraw-Hill Book Company, London.

2. Wilson, K and Walker, J., 1994. Practical Biochemistry: Principles and Techniques, 4th Edition, Cambridge University Press.

3. Alexander, R.R. and Griffiths, J.M. 1993. Basic biochemical methods. Wiley Liss,New York.
4. Sawhney, S. K. and Singh, R.,2006. Introductory Practical Biochemistry, 2nd Edition,Narosa Publishing House.
5. Oser, B. L., (Latest Edition). Hawk's Physiological Chemistry, McGraw Hill Book Company.
6. David L. Nelson and Michael M. Cox, 2005. Lehninger Principles of Biochemistry 4th Edition, Macmillan Worth Publishers, New York.

Additional Readings:

1. LubertStryer, 1995. Biochemistry, 4th Edition, W.H. Freeman & Company, New York.
2. Murray, R. K., Granner, D. K., Mayer, P.A. and Rodwells, V. W., 2000. Harper's Biochemistry, McGraw Hill Bok Company, New York.
3. Elliott, W. H. and Elliot, D. C., 2002. Biochemistry and Molecular Biology, Oxford Medical Publications, Oxford University Press.
4. Voet, D., Voet, J. G. and Pratt, C.W., 1999. Biochemistry, John Wiley & Sons.
5. Zubay, G. 1993. Biochemistry, Wm. C. Brown Publishers, Oxford.

Major-III	ZOO-553	Physiology	4(3+1)

Course Outlines

Concept of Physiology

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

Membrane Physiology:

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

Nerve and Muscle Physiology:

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

Endocrine Physiology:

1. Hormones of invertebrates and specifically of arthropods for the functions in their modes of life.
2. Hormones of various vertebrates' endocrine organs and comparison of their roles in adaptability of mode of life.

3. Mechanisms of hormone actions, hormone receptors, signal transduction and hormonal coordination.

Cardiovascular Physiology:

1. Electrical activity of heart; self-excitability and auto-rhythmicity of myogenic heart.
2. Neurogenic heart and their expression.
3. Electrocardiography and Kymography.
4. Hemodynamics, Relationship between blood flow, pressure and resistance. Their role in performance of the function in variety of vertebrates.
5. Control of cardiac activity, cardiac output and peripheral circulation.

Respiratory Physiology:

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

Excretory Physiology:

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

Physiology of Nutrition:

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

Practicals:

Respiration and Circulation

1. Study of respiratory pigments in various animals and haemoglobins in various vertebrates.
2. Normal cardiac activity in amphibian model, effect of temperature, effect of drug, heart block, tetanization of heart.
3. Measurement and effects of various factors on blood pressure. Blood pressure alteration in exercise.
4. Oxygen consumption in fish and effect of temperature (by dissolved oxygen meter) and terrestrial animal (mouse). Oxygen consumption (by respirometer),

Nerve and Muscle

1. Study of salient features of electromyography
2. Study of excitable and contractile properties of a nerve-muscle preparation.

Nervous System:

1. Study of brains in different animals in relation to complexity of functions.
2. Study of human brain model and different areas eliciting behaviours.

3. Videos study on 1 and 2 studies.

Hormones System:

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

Text/Reference Books:

1. **Principles of Animal Physiology Third Edition** Moyes, Christopher D.^Schulte, Patricia M. Publisher: Pearson; 3rd edition, 2015.
2. **Eckert Animal Physiology** Fifth Edition David Randall, Warren Burggren, Kathleen French W. H. Freeman; 2001.
3. **Animal Physiology**: From Genes to Organisms 2nd Edition Lauralee Sherwood, Hillar Klandorf, Paul Yancey Brooks Cole; 2012.
4. **Animal Physiology** 4th Edition Richard W. Hill, Gordon A. Wyse, Margaret Anderson Sinauer Associates, Oxford University Press, 2016.

Major-IV	ZOO-554	Ecology	3(2+1)

Course Outline:

1. Energy

a. Basic Concepts of and Types of Ecology
b. Laws of thermodynamics, primary and secondary productions
c. Trophic levels and energy variation with increasing trophic levels, energy flow, food chains and food webs.

2. Biogeochemical cycle:

a. Nitrogen, Phosphorus, Sulpher, Water, Carbon and nutrient.

3. Limiting factors

a. Basic Concepts, Temperature, Soil, Water and Humidity, Light and Fire.

4. Global ecosystems:

a. Atmosphere, Hydrosphere, Lithosphere and Ecosphere.
b. An overview of Ecosystem with special reference to Ecological Niche, basic concepts and types
c. Major ecosystem of world, Forest, Grassland, Desert, Tundra and Agricultural ecosystems.
d. Marine, Estuarine, Freshwater and Wetlands

5. Population ecology

Basic population characters, Growth and Growth Curves, Population Dynamics and Regulations.

6. Community ecology

Basic concepts, Community Analysis, Ecotones, Inter-population Interactions

7. Applied Ecology: resources and their ecological management;

8. Mineral, Agricultural Desalination, Weather Modification, Forest and Range Management, Landscape and Land use

9. Pollution:

10. Definition, Types, Water, Air, Land and Noise, Sources and Management.

11. **Radiation ecology**: Global Environmental Changes (ozone depletion, acid rain, greenhouse effect and global warming, Koyota protocol, Radioactivity leakage, Environmental laws).

12. Exotic and Invasive Species

a. Desertification, Deforestation, exotic and invasive species

Practical:

1. Population Sampling Techniques (Quadrate, Line Transact, Point count, Focal Scan and Capture and Recapture Method).
2. Study of different Ecosystems (Fresh Water, Terrestrial, Marine /Mountain/ Desert).
3. Ecological Notes.
4. Measurements of physical Factors of different Ecosystems.
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

Text and Reference Books:

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. AppliedEcology. Black Well Scientific Publications Oxford. UK.
7. Slingsby, D., Cook, C., 1986. Practical Ecology. McMillan Education Ltd. UK.

Foundation-IX	ZOO-555	Evolution	2(2+0)

Course Contents:

- Theories of Evolution: theories to explain diversity of life– modern synthetic theory, factors initiating elementary evolutionary changes (micro-evolution) and change of gene frequencies.
- Mutation pressure, selection pressure, immigration and crossbreeding, genetic drift. Role of isolation in evolution: factors of large evolutionary changes (macroevolution).concepts of allometry, orthogenesis, adaptive radiation.
- Modern concept of Natural Selection: levels of selection, selection patterns, some examples of Natural Selection.

- Impacts 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 and recapitulation theory.
- Study of preserved invertebrate species and their classification to species levels.

Text and Reference Books:

1. Strickberger. M.W.2012. Evolution. Jones & Barrett Publishers. Gower Street, London, England.
2. Ridley, M. 1993. Evolution. Blackwell Scientific Publications, New York, USA.
3. Moody, P.A. 1989. Introduction to Evolution, Harper and Row, Publishers, NewYork
4. Wiley, E. O. and Lieberman, B. S. 2011. Phylogenetics: Theory and Practical Practice of Phylogenetic systematics. 2nd Ed. Wiley-Blackwell.
5. Mayer, E. Principles of Systematic Zoology. 1994. McGraw-Hill, New York.

Foundation-X	ZOO-556	Principles of Systematics	3(2+1)

Course Contents:

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

Practicals:

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

Books Recommended:

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

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

Semester-VI			
Course Category	**Course Code**	**Course Title**	**Credits**
Major-V	ZOO-561	Research Methodology	2(2+0)
Compulsory-IX	BST-562	Biostatistics	3(2+1)
Major-VI	ZOO-563	Developmental Biology	4(3+1)
Major-VII	ZOO-564	Genetics	4(3+1)
Major-VIII	ZOO-565	Zoogeography and Palaeontology	3(2+1)
		Total Credits	16

Major-V	ZOO-561	Research Methodology	2(2+0)

Course Contents:

1. Introduction:

a. Objectives of Research, Motivations

2. Research Process:

a. Research methods vs. research methodology, scientific method

b. Types of research, general steps involved in research

c. Problems of research in Pakistan

3. Topic Selection:

a. Problem identification for research, criteria and evaluation

4. Literature review:

a. Importance and sources

b. Referencing and citation and Bibliography

c. plagiarism

5. Research Design:

a. Parts, important features, important concepts in research design

6. Aims and objectives:

a. Research objectives, qualities of research objectives

7. Material and methods:

a. Bioethics, sampling, data collection and data analysis, sampling requirements, scales of measurement, error of measurement and its sources

8. Data Analysis:

a. Processing, statistics in research, hypothesis testing, t-tests and ANOVA

9. Scientific Writing:

a. Difference between thesis/report/synopsis/research proposal.

b. Parts of synopsis/project proposal, parts of thesis/report

10. Budgeting: Cost estimates for a research project, funding sources e.g. USAID, HEC, DoST, HED, PMRC, WWF, PSF etc.

Text and Reference Books:

1. Paul Leedy, 2004, Practical Research: Planning and Design (8th Edition), Jeanne Ellis Ormrod
2. Creswell, J. W. (2013). Research Design Quantitatvive Qualitative and Mixed Methods Approaches. Sage.
3. Hess-Biber, S. N. and P. Leavy. (2004). Approaches to Qualitative Research, A Reader on Theory and Practice. New York, Oxford University Press.
4. Khan, J.A. (2008). Research Methodology. New Delhi: APH Publishing.
5. Kothari, C.R., & Gaurav, G. (2014). Research Methodology: Methods and Techniques. New Delhi: New Age International.
6. Kumar, R. (2011). Research Methodology: A Step By Step Guide for Beginners. Cornwall: SAGE Publications, Inc.
7. Laurel, B. (2003). Design Research, Methods and Perspectives. London England, The MIT Press.
8. Walliman, N. (2005).Your Research Project, 2nd Edition, A step by step guide for the first-time researcher. New Delhi, Vistaar Publications

Compulsory-IX	BST-562	Biostatistics	3(2+1)

Course Contents:

1. Introduction:

a. Definition, branches of statistics,
b. Scope and importance of statistics

2. Data:

a. Population and sample, variable, categorical and non-categorical data,
b. Scales of measurements, errors of measurements

3. Presentation of data:

a. Descriptive statistics
b. Tabulation of data
c. Parts of table and construction of table.
d. Diagrams and graphs, pictogram, historigram, line chart, histogram, applications and uses of histogram
e. Construction of histogram, comparison of data using histogram,
f. Bar chart, multiple bar chart, pie chart, gantt chart, timeline, infograph, pedigree chart

4. Frequency distribution:

a. Empirical FD, relative FD, Cumulative FD, class frequency, class limits, class boundaries, class mark, class interval, midpoints.

5. Measures of Central Tendency:

a. Types of averages, arithmetic mean for grouped and ungrouped data, harmonic mean for grouped and ungrouped data, geometric mean for grouped and ungrouped data, median, quartiles, deciles, percentiles and mode.

b. Advantages and disadvantages of arithmetic mean, harmonic mean, geometric mean, median and mode.

6. Measures of Dispersion:

a. Range, grouped and ungrouped data, coefficient of range

b. Mean deviation of grouped and ungrouped data. Coefficient of mean deviation.

c. Standard deviation and variance of grouped and ungrouped data, variance and standard deviation of population and sample data.

7. Probability:

a. Definition, properties, experiment and random experiment, event, outcome, trial, multiplication rule, sample space and sample point, mutually exclusive event, combinations and permutations, probability distribution, binomial experiment

8. Tests of Significance:

a. Hypothesis testing

b. Steps of hypothesis testing

c. Z-test

d. t-test, types,

e. Chi-square

f. ANOVA, its uses and LSD

g. Correlation

h. Regression

Practicals / Tutorials:

1. Data collection, arrangement and frequency table
2. Data presentation in table, graphs (simple bar chart, multiple bar chart, component bar chart)
3. Construction of timeline, pedigree chart, organogram, Gantt chart, infogram
4. Calculating arithmetic mean, harmonic mean and geometric mean, median and mode from ungrouped and grouped data
5. Calculating mean deviation, standard deviation and variance from ungrouped and grouped data
6. Probability distribution
7. z-test
8. T-test
9. ANOVA
10. Correlation
11. Regression

Text and Reference Books:

1. Field A. (2013) Discovering Statistics with IBM SPSS Statistics. 4th Edition. SAGE Publication Ltd.

2. Belle V. B, Fisher, L.D., Heagerty, P.J., Lumley, T. (2004) Biostatistics– A methodology for the health sciences. 2nd Edition. Wiley-Interscience

3. Quinn, G. (2002) Experimental Design and Data Analysis for Biologists. Cambridge University Press

4. Campbell, M.J., Swinscow, T.D.V. (2009) Statistics at Square One. 11th Edition. BMJ Books.

Major-VI	ZOO-563	Developmental Biology	4(3+1)

Course Outline:

1. Introduction

a. History and Basic Concepts of developmental biology

b. Principal features of developmental biology and embryology with special emphasis on vertebrate models

c. Origin of sexual reproduction

d. Developmental patterns

2. Spermatogenesis

a. Mammalian spermatogenesis as model for all vertebrates

b. Spermiogenesis or (spermateliosis)

c. The role of Sertoli and Leydig cells in spermatogenesis

d. Hormonal control of spermatogenesis

3. Primates Menstrual cycle

1. Oogenesis

a. Mechanism of oogenesis among various classes of vertebrates.

b. Vitellogenesis

c. Hormonal control of Vitellogenesis and oogenesis

4. Fertilization

a. External & Internal Fertilization

b. Species-specific recognition of sperm and egg

c. Fusion of male and female gametes

d. Polyspermy: slow and fast blocks to polyspermy

e. Activation of egg metabolism

5. IN VITRO Fertilization (IVF)

a. History, Steps and advantages of IVF

b. Disadvantages and risk factors

6. Cleavage & Blastulation

a. Patterns of embryonic cleavage and blastulation among different vertebrate classes

b. Mechanism of cleavage.

7. Gastrulation

a. Fate maps

b. Gastrulation in amphibians, birds and mammals

8. Early Vertebrate Development

a. Neurulation, ectoderm, mesoderm and endoderm formation

9. Placenta and extraembryonic membranes

10 Cellular Basis of Morphogenesis

a. Differential cell affinity, cell adhesion molecules

b. Organogenesis

c. Mechanism of teratogenesis

11. Aging and Regeneration in vertebrates

Practical:

1. Study of the structure of gametes in some representative cases, i.e. frog, fish and mammal.
2. Hen's egg internal and external structural details
3. Microscopic analysis of hen's egg yolk, albumin and shell membranes
4. Study of cleavage and subsequent development from prepared slides and/or models in various animals i.e., frog, mammals and chick etc.
5. Study of fertilization, early development of frog/fish through induced spawning under laboratory conditions.
6. Study of developmental stages of nematodes through microscopic analysis of animal dung
7. Semen analysis
8. Dactylography and its uses in developmental biology

Text and Reference Books:

1. Gilbert, S. F. 2013. Developmental Biology, Sinauer Associates, Sunderland, MA.
2. Klaus, K. 2001. Biological Development. 2nd Ed., McGraw-Hill.
3. Scott F. Gilbert and Michael J.F. Barres. 2016. Developmental Biology. Sinauer Associates, Sunderland, MA.
4. Jamie. A. Davies. 2014. Life Unfolding: How the Human Body Creates Itself. Oxford University Press, USA
5. Balinsky, B. I. 1985. An Introduction to Embryology, Saunders.
6. Oppenheimer, S.S. 1984. Introduction to Embryonic Development, Allen and Bacon.
7. Saunders, J. W. 1982. Developmental Biology, McMillan and company.
8. Ham, R. G., Veomett, M. J. 1980. Mechanism of Development. C. V. Mosby Co.

Major-VII	ZOO-564	Genetics	4(3+1)

Course Contents:

1. Introduction

a. Classical, molecular and population Genetics: Scope and importance of genetics, Forward and reverse genetics. The basic principles of Inheritance (Mendelism): Monohybrid and Dihybrid crosses (Definition - characteristics criss-cross inheritance).
b. Multiple Alleles: blood groups and coat color in rabbits.
c. Genetics of Rh factor and Erythroblastosis Foetalis.

2. Chromosomal Basis of Inheritance:

a. Chromosomal theory of inheritance
b. Interaction of genes, Epistasis, Lethality and Pleiotropism.

3. Chromosomal Aberrations

a. Changes in chromosomal number, Euploidy, aneuploidy (Klinefelters syndrome, and Turners syndrome, Down syndrome and Edwards syndrome).
b. Structural changes, insertion, deletion (Cri du chat syndrome), duplication,
c. Inversion and translocation

4. Pedigree Analysis:

a. Normal human chromosome complement; Karyotyping.

b. Sex-determination and Sex-linkage:
c. Sex determination in animals and humans,
d. Sex linked (Hemophilia, muscular dystrophy, color blindness), sex influenced and sex limited traits,
e. Prenatal Diagnosis: Amniocentesis and choriovillus sampling -Ultrasound scanning and Fetoscopy. Genetic counselling, Eugenics and Euthenics

5. Chromosome mapping

a. Linkage, recombination (crossing over) and
b. Chromosome mapping in eukaryotes.

6. Molecular Genetics:

a. Gene Concept (classical and modern),
b. Genetics of Viruses and Bacteria,
c. Transposons,
d. Mutation and DNA repair
e. Molecular Genetic Analysis,
f. Regulation of Gene Expression in Prokaryotes,
g. Gene Regulation in Eukaryotes,
h. Genetic basis of diseases, like cancer,
i. Genetic control of animal development.
j. The genetic control of the Vertebrate Immune System,

7. Recombinant Technology

a. The Techniques of Molecular Genetics (elements of genetic engineering),
b. PCR

8. Human Genetics;

a. Single and Multifactorial Disorders:
b. Autosomal anomalies, Pseudoautosomal genes,
c. Single gene disorders: Gene mutation and disorders; autosomal single gene disorders (Sickle cell anemia, brachydactyly; inborn errors of metabolism such as Phenylketonuria, alkaptonuria).
d. Complex Inheritance Patterns, Polygenic traits- Cleft lip and cleft palate,

9. Population Genetics:

a. Hardy-Wienberg equilibrium,
b. Systematic and Dispersive pressures, Inbreeding and heterosis

Practical:

1. Drosophila culture techniques: preparation and maintenance of culture
2. Identification of male and female fruit fly and isolation of virgin females
3. Study of polytene chromosomes from the salivary glands of Drosophila melanogaster
4. Mutation induction in Drosophila
5. Human karyotyping from photographs prepared slides: paper cut out method
6. Preparation of human metaphase chromosomes from blood lymphocytes
7. Study of mitosis in plants by using onion root tip cells
8. Study of meiosis in the testes of male grasshopper
9. Extraction of genomic DNA from whole blood (lymphocytes)

10. Separation of heterogeneous population of bio-molecules through electrophoresis
11. Study of blood group polymorphisms in local population
12. Study of qualitative traits in humans: a survey of common physical heritable (monogenic) polymorphisms
13. Human Pedigree analysis problems (Determination of inheritance pattern of different human characters (Widows Peak, ear loop, etc), risk estimation and genetic counseling.
14. Study of quantitative traits in humans: finger prints as model of polygenic traits
15. Study of Barr bodies in human cell nucleus
16. Dermatoglyphics in normal and mentally retarded subjects
17. Probability problems. Tossing of coins. X2test
18. Study of transformed bacteria on the basis of antibiotic resistance
19. PCR

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. 2013. 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. 2015. Genetics. McMillan, New York. USA.(9780024181206)
6. PRINCIPALS OF GENETICS Gardner E.J., Simmons M.J. and Snistad A.P. (Latest available Addition)
7. Reference Books. Concepts of Genetics By Klug, W.S and Cummings M.R.
8. Willium S. Klug, 2014. Concept of Genetics, ISBN-11: 978-0321948915
9. Lewin's Gene XI BY Jocelyn E.Krebs et al. 2013, isbn-13:978-1449659851,ISBN-10:1449659853
10. Gene- XI by Lewin's,2013,ISBN:978-1449659851
11. Concepts of genetics 11th edition, William S.Klug,2014,ISBN-13:978-0321948915

Major-VIII	ZOO-565	Zoogeography and Palaeontology	3(2+1)

Course Outline:

1. Paleo geography

a. Theories of continental drift and plate tectonics
b. Pangea

2. Animal distribution

a. cosmopolitan distribution
b. discontinuous distribution
c. isolation distribution
d. bipolar distribution
e. endemic distribution
f. barriers and dispersal.

3. Zoogeographical regions:
a. Zoogeographic Division and Boundaries
b. Geographic Ranges, Physical Features
c. Climates,
d. Faunas And Affinities Of Palaearctic, Nearctic Regions, Oriental, Ethiopian, Australian, And Neotropical Regions
e. Insular Fauna
4. Zoogeography of Pakistan:
5. Paleontology:
The Planet Earth
a. History, age, shells of earth
b. atmosphere, hydrosphere, biosphere and lithosphere.
6. Rocks:
a. Types; lgneous rocks, sedimentary rocks and metamorphic rocks.
7. Fossil and Fossilization
a. Fossil types and uses of fossils, nature of fossils.
b. Fossilization
c. Invertebrates and Vertebrates Fossil
d. Biostratigraphy
e. Fossils of Pakistan
f. Paleontologically important areas of Pakistan.
8. Fossilization:
a. Geological time scale.
b. Pre-Cambrian life.
c. Post Cambrian life,
d. Paleozoic life
e. Mesozoic life
f. Cenozoic life.
9. Paleontological Techniques
a. Excavation techniques
b. Excavation tools and techniques
c. Transportation and processing of fossils.
d. Presentation of fossils
e. Pre requisites for paleontological excavation.
10. Geochronometry:
a. Uranium/Lead dating
b. radiocarbon dating, methods
c. index fossils
d. evolutionary history of man, elephant, horse and camel,
e. Paleoecology, Paleomagnetism.
Practical:
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.

Text and Reference Books:

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.

Year -IV Semester-VII			
Course Category	**Course Code**	**Course Title**	**Credits**
Major-IX	ZOO-671	Bioinformatics	3(1+2)
Major-X	ZOO-672	Molecular Biology	3(2+1)
Major-XI	ZOO-673	Wildlife	3(2+1)
Elective-II	ZOO-674	Parasitology I	3(2+1)
Elective-III	ZOO-675	Entomology-I	3(2+1)
		Total Credits	15

Major-IX	ZOO-671	Bioinformatics	3(1+2)

Course Contents:

1. Introduction:

a. Introduction to Bioinformatics, Scope of bioinformatics, useful websites

b. Aims of bioinformatics, disciplines related to bioinformatics, major tasks involved in bioinformatics analysis, bioinformatics tools

c. Human genome project

2. Biological databases

a. Data and types of data, data acquisition

b. Major DNA databases around the world, NCBI, BOLD, DDBJ

c. Major protein databases in the world, protein sequence databases, protein structure databases

d. Specialized databases, genome and organism databases

e. Non sequence databases, pubmed, pubmed health, OMIM

3. Genome mapping

Genetic and linkage mapping, physical mapping

4. Gene family:

a. Introduction, types, protein family, Globin family as an example, globin genes and chains, evolution of globin proteins in human, combination and types of globin proteins in human.

5. Data Retrieval:

a. Searching sequence databases

b. FASTA format

c. retrieval of nucleotide sequence data, retrieval of protein sequence and structure data, retrieval of literature and map data

6. Primer Designing:

a. Primer and probe, qualities of primer, general rules for primer designing
b. Websites used for primer designing

7. Sequence Alignment:

a. Importance and significance of alignment, methods for sequence alignment
b. Local and global alignment, pair-wise local alignment

8. BLAST: Introduction, types, uses, algorithm, BLAST Scores

9. Multiple Sequence Alignment:

a. Introduction, tools for MSA, uses and importance

10. Phylogenetic analysis:

a. Introduction, interpretation, rooted and unrooted tree,
b. phylogenetic methods, tree terminology, comparison of methods, software

Practicals / Tutorials:

1. Introduction to NCBI
2. Retrieving Literature from NCBI
3. Classification of an organism using NCBI
4. Retrieving FASTA sequence for nucleotide and protein
5. Retrieving disease gene information
6. Searching gene families
7. Primer Designing
8. BLASTing a nucleotide / amino acid sequence
9. Multiple Sequence Alignment using different amino acids / nucleotide sequences
10. Phylogenetic Analysis of different nucleotide / amino acid sequences
11. Microarrays data retrieval from the web

Text and Reference Books:

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. Pevsner, J. (2015) Bioinformatics and Functional Genomics. 3rd Edition. Willey-Blackwell
4. Lesk, A. (2014) Introduction to Bioinformatics. 4th Edition. Oxford University Press
5. Selzer, P., Marhofer, R. and Rohwer, A. (2008) Applied Bioinformatics: An Introduction. Springer publishing, Germany.
6. Primerose, S.B. (2004) Genomics: Applications in Human Biology. WilleyBlackwell
7. Westhead, D.R., Parish, J.H., Twyman, R.M. (2003) Instant Notes on Bioinformatics. Viva Books Private Limited.
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://www.rcsb.org
4. http://www.ensemble.org

Major-X	ZOO-672	Molecular Biology	3(2+1)

Course Outline:

1. Introduction

a. Introduction to nucleic acids
b. Chromosome structure, Chromatin,
c. DNA forms, structures and packaging
d. RNA types and structures

2. Replication

a. DNA replication in prokaryotes
b. DNA replication in eukaryotes
c. Enzymology of replication
d. DNA damage and repair

3. Transcription

a. Types of RNA polymerases in prokaryotes and eukaryotes
b. Synthesis of mRNA, rRNA and tRNA with special reference to enzymes involved
c. RNA processing
d. Split genes, concept of ribozymes
c. Genetic Code

4. Translation

a. Role of Ribosomes
b. Mechanism of translation in prokaryotes and eukaryotes
c. Various factors, and posttranslational processing

5. Mutation

a. Types of Mutations
b. Base-Analogue Mutagens
c. Chemical Mutagens

6. Gene expression and control

a. Control of gene expression in Prokaryotes.
b. Inducible and repressible operons.
c. Control of gene expression in eukaryotes.

Practicals:

1. Preparation of different stock solutions used in molecular biology (solution used in PCR, electrophoresis, DNA isolation, RNA isolation and Protein isolation.
2. Isolation of DNA from human blood.
3. Quantification of DNA and RNA through spectrophotometer.
4. DNA amplification through polymerase chain reaction.
5. Separation of different sized DNA fragments on agarose gel.

Text and Reference books:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D. 2017. Molecular Biology of the Cell. 6th Edition. Garland Publishing Inc., New York.

2. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey C. Martin. 2016. Molecular Cell Biology. W. H. Freeman Publishers, Scientific American Inc.
3. Geoffrey M.C., Robert E.H. 2007. The cell: A Molecular Approach, Sinauer Associates, INC.
4. Karp, J. 2005. Cell and Molecular Biology, Concepts and Experiments, Jhon Wiley and Sons, INC.
5. De Robertis, E.D. P. 2017. Cell and Molecular Biology, 8th edition, Lea & Febiger, New York.

Major-XI	ZOO-673	Wildlife	3(2+1)

Course Outline

1. Wildlife of Pakistan

a. Introduction
b. Important Definitions
c. Identification
d. Distribution
e. Status
f. Conservation and Management of fishes, amphibians, reptiles, birds and mammals of major importance in Pakistan

2. Philosophy and significance of wildlife conservation

3. Biodiversity and sustainability of wildlife.

4. Wildlife rules and regulations in Pakistan

a. Provincial Rules
b. Federal Management of Wildlife (NCCW)

5. National and International agencies involved in conservation and management of wildlife

a. National Organisations
b. International Organisations

6. Protected Areas in Pakistan

a. Sanctuaries
b. Game Reserves
c. National Parks

7. Ramsar convention

a. Wetlands
b. Ramsar Criteria
c. Ramsar Sites

8. Threatened species of Pakistan.

a. Vulnerable
b. Endangered
c. Critically Endangered

Practicals:

1. Visit to protected areas of Pakistan (Captive, Semi-captive and Wild Areas)
2. Ecological Indices

3. Animal Distribution Maps

Text and Reference Books:

1. Miller, A.S. and Harley, J.B., 1999 & 2002. Zoology, Latest Edition (International). Singapore: McGraw-Hill.
2. Ali. S.S. 2005 Wildlife of Pakistan.
3. Odum, E.P., 1994. Fundamentals of Ecology, W.B. Saunders.
4. Smith, R.L. 1980. Ecology and Field Biology, Harper and Row.
6. Roberts, T. J., 1991, 1992. The Birds of Pakistan, Vol. I1 and II. Oxford UniversityPress
7. Roberts, T. J., 1997. The Mammals of Pakistan, Oxford University Press
8. Robinson, W.L. and Bolen, E.G., 1984. Wildlife Ecology and Management. McMillan, Cambridge.
9. Wildlife of the Punjab, Punjab Wildlife Department.
10. Khan M. S. 2011, Amphibian and Reptiles of Pakistan
11. Mirza Z.B. 2011 Biodiversity of Pakistan

Elective-II	ZOO-674	Parasitology I	3(2+1)

Course Contents:

Protozoology

Introduction, Systematic, geographical distribution, habitats, biology, pathogenesis, important symptoms, mode of transmission laboratory methods of diagnosis, and control of protozoa of medical and veterinary importance like **Amoebae**; Pathogenic, Non Pathogenic and Opportunistic amoebae. **Flagellates;** Intestinal, Oral and Genital flagellates, Blood and tissue flagellates. **Sporozoans**, **Ciliates** and **Microsporidians**.

Pathology

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.

Practical

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

Books Recommended:

1. Chandler, A.C. and Read, C.P., (1961). Introduction to Parasitology. Int.Ed. Wiley Poppan, New York.
2. Chandrasoma , P. and Taylor, C.R.(1997). Concise Pathology. Prentice Hali International Inc. New Jercy USA.
3. Dixon, M. E. Aid to Pathology. Churchill Livingstone, Edinburgh London and New York.
4. Facust, E. C. and Russell, P. F. (2001). Craig and Faust's clinical Parasitology. Lea and Febiger, 8th edition London
5. Levine, N. D. Protozoan Parasites of domestic animals and of man. Durgers publishing Burgers publishing Co: Minnesota.

6. Markell, E.K. Mo. Vogo. (1999). Medical Parasitology. W. B. Sundress Co: Philadelphia.
7. Noble, E.R and Noble, G.A. (1982). Parasitology: the biology of animal parasites. Lea and Febiger, Philadelphia.
8. Olsen, O. W. (1974). Animal Parasites: their life cycle and ecology. University Park Press Baltimore
9. Peters, W and Gills, H.M. (1989). A color atlas of Tropical medicine and Parasitology. Wolfe Medical Publications Ltd., Netherlands.
10. Robbins, S. L. Basic Pathology. W. B. Saunders Co: London, Toronto.
11. Roberts,L.S. and Jonovy ,J.Jr., (2005). Foundation of Parasitology. W. Brown Publishers, Chicasgo, USA.
12. Soulsby: E. J. L. (1981). Textbook of veterinary clinical Parasitology Vol: 1 Blackwell Scientific Publication, London.
13. Schmidt, G. D. and Robbert, T. S. (2001). Foundation of Parasitology. The C.V. Mosby Company, Saint Louise
14. Smyth, J. D. (1994). Introduction to Animal Parasitology, 3rd edition. Cambridge University Press, Cambridge.
15. Thomson, A.D. and Cotton, R.E. (1980). Lecture Notes on Pathology. Blackwell Publication, Oxford London.

Elective-III	ZOO-675	Entomology-I	3(2+1)

Course Outline:

1. **Introduction**

a. Evolutionary history of insects
b. Phylogenetic arrangement of orders and families

2. **Classification of insect orders: General account of apterygota**

Subclass: Apterygota
a. Order Collembola
b. Order Diplura
c. Order Zygentoma
d. Order Protura
e. Order: Archaeognatha

3. **Subclass: Exopterygota**

a. Order Dermaptera
b. Order Dictyoptera
c. Order Embiidina
d. Order Neuroptera
e. Order Strepsiptera
f. Order Mantophasmatodea
g. Order Mecoptera
h. Order Orthoptera
i. Order Phasmatodea

j. Order Phthiraptera
k. Order Plecoptera
l. Order Psocoptera
m. Order Siphonaptera
n. Order Zoraptera
o. Order Megaloptera
p. Order Raphidioptera
q. Order Ephemeroptera
r. Order Odonata
4. **Endopterygota**
a. Order Megaloptera
b. Order Hymenoptera
c. Order Coleoptera
d. Order Lepidoptera
e. Order Trichoptera
f. Order Siphonaptera
g. Order Diptera
h. Order Neuroptera
i. Order Mecoptera
j. Order Raphidioptera
k. Order Strepsiptera
5. **Knowledge of insect pests of**
a. Rice
b. Cotton
c. Sugarcane
d. Wheat
6. **Brief account of different insect pest management strategies as**:
a. Cultural Control
b. Physical and Mechanical Control
c. Host Plant Resistance
d. Biological Control
e. Chemical Control
f. Other approaches

Practical:

1. Field visits for collection of different developmental stages of insects belonging to different orders.
2. Identification and classification of collected specimens.
3. Field visits and report writing of insect fauna of different crops.
4. Field visits for survey of different control strategies being practiced for control of insect pests.
5. Museum visits

Practical:

1. Written (Long Questions, Short Questions, MCQs, identification etc) 40%

2. Collection of Insects 30%
3. Assignments 20%
4. Report Writing 10%

Text and Reference Books:

1. Atwal, A.S., 2015. Agricultural Pests of Southeast Asia and their Management. Kalyani Publishers, Ludhiana.
2. Ambrose, D.P., 2015. The Insects: Structure Functions and Biodiversity. Kalyani publishers, Ludhiana, India.
3. Chapman, R. F., 2013. The Insects-Structure and Function. 5th Edition. Cambridge University Press, New York.
4. Gullan, P. J. and Cranstan, P. S., 2014. The Insects: An Outline of Entomology. 4th edition. Wiley-Blackwell. A John Wiley & Sons, Ltd., Publication, UK.
5. Pedigo, L.P. and Marlin, E. R. 2009. Entomology and Pest Management, 6th Edition, Person Education Inc., Upper Saddle River, New Jersey 07458, U.S.A.

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Semester-VIII			
Course Category	**Course Code**	**Course Title**	**Credits**
Major-XII	ZOO-681	Special Paper-I / Thesis	3(2+1)/ 3(0+3)
Major-XIII	ZOO-682	Special Paper-II / Thesis	3(2+1)/ 3(0+3)
Elective-IV	ZOO-683	Applied Fisheries	3(2+1)
Elective-V	ZOO-684	Parasitology II	3(2+1)
Elective-IV	ZOO-685	Entomology-II	3(2+1)
		Total Credits	15

Major-XII	ZOO-681	Special Paper-I / Thesis	3(2+1) or 3(3+0) / 3(0+3)

Major-XIII	ZOO-682	Special Paper-II / Thesis	3(2+1) or 3(3+0) / 3(0+3)

Note: The department will offer research to only top 20% students, if they wish to take research. Research will not be compulsory upon the remaining students (80%). The research will be started from 7th semester and will be extended till 8th semester. Those who will not take research from among the top 20% students; they will be offered two special papers each of 3 credit hours. The special papers will be selected as per available experts in the department. List of special papers is appended in Annexure-D.

Elective-IV	ZOO-683	Applied Fisheries	3(2+1)

Course Contents:

History and significance of aquaculture; Study of management techniques and habitat improvement; Designing, construction, fertilization, manuring, stocking and harvesting of a fish pond; Study of native and exotic fishes of Pakistan; Shellfish and fin fish; Fishing gears and crafts/nets used in Pakistan; Fish ways; construction and importance. Bye products of fish industry; Methods of processing fish such as drying, salting smoking, curing, freezing etc; Study of fish parasites, common diseases and enemies of fishes. Pollution and its effect on fish population; Methods of population estimation by direct count, catch effort, mark re-capture method, tagging of fish; Artificial propagation induced spawning techniques; Marketing strategies; transport of fish and

seed; Major problems of fishermen in Pakistan;

Practical

1. Collection and identification of common zooplanktons
2. Study of gut contents of fish
3. Statistical analysis of fish growth, length-weight relationship
4. Study of farm fishes of KPK
5. Visit to a fish farm/hatchery to study installations/methods of breeding
6. Prepared slides of fish parasites
7. Analysis of physical properties (temperature, light, colour, turbidity, conductivity etc.) and chemical properties (pH, oxygen, carbon dioxide, salinity, dissolved solids/salts) of water;
8. General methods of age growth studies; reading of age from scales, opercula, otolith and back calculation from bones;
9. Study of larvae, fry and fingerlings of a common fish, regulation of fishing, enactment of fishery legislation.

Books Recommended:

1. Ali S.S.1999 Freshwater Fishery Biology, Naseem Book Depo, Hyderabad, Pakistan.
2. Rath, R.H.1993 Freshwater Aquaculture, Scientific Publishers, Delhi,India.
3. Rounsefell, G.A.and Everhart, W.H. 1953 Fisheries Science, John Wiely and Sons, New York
4. Mirza, M.R.and Bhatti, M.N.1993 Pakistan ki Machlian aur Mahi Parwari Ferozsons, Lahore

Elective-V	ZOO-684	Parasitology II	3(2+1)

Course contents: Basic principles and concepts in Parasitology, Taxonomy, etiology, biology, epidemiology, pathology and pathogenesis, diagnosis, life cycle, control and treatment of **Digenetic Trematodes**: *Schistosoma mansoni, S.japonicum, S.haematobium*, *Fasciola hepatica, Fasciolopsis buski, Paragonimus westermani, Colonorchis sinensis, Heterophyes heterophyes,* **Monogenetic trematodes**:*Dactylogyrus vastator, Gyrodactylus,* **Cestodes:** *Diphyllobothriam latum, Taenia saginata, T.solium, Echinococcus granulosus, Hymenolepis nana, Dipylidium caninum,* **Nematodes:** *Trichuris trichiura, Trichenella spiralis, Strongyloides stercoralis, Ancylostoma duodenale, Necator americanus, Ascaris lumbricoides, Toxocara canis, Enterobius vermicularis, Wuchereria bancrofti, Brugia malayi, Onchocerca volvulus, Loa loa* and *Dracunculus medinensis.*

Practicals

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

centrifugation technique, by Lugol's iodine staining technique

Books Recommended:

1. Robberts, L. Sand Janovy John Jr. (2005). Foundation of Parasitology. 7th edition. The C.V. Mosby Company, Saint Louise
2. Dixon, M. E. Aid to Pathology. Churchill Livingstone, Edinburgh London and New York.
3. Smyth, J. D. (1994). Introduction to Animal Parasitology, 3rd edition. CambridgeUniversity Press, Cambridge.
4. Peters, W and Gills, H.M. (1989). A color atlas of Tropical medicine and Parasitology. Wolfe Medical Publications Ltd., Netherlands.
5. Markell, E.K. Mo. Vogo. (1999). Medical Parasitology. W. B. Sundress Co: Philadelphia.
6. Facust, E. C. and Russell, P. F. (2001). Craig and Faust's clinical Parasitology. Lea and Febiger, 8th edition London
7. Soulsby: E. J. L. (1981). Textbook of veterinary clinical Parasitology Vol: 1 Blackwell Scientific Publication, London.

Elective-IV	ZOO-685	Entomology-II	3(2+1)

Course Contents:

Applied Entomology:

Principles of apiculture, sericulture and lac culture. Study and identification of pests of agriculture, stored grain and households. General characteristics, life cycles and habits of insects of medical and veterinary importance. Study of various insect-borne diseases.

Pest management

The principles of pest control/management viz., physical, mechanical, culture, legislative biological, genetic, chemical and integrated control. Relative merits of various types of insect control. Pest's management practices in Pakistan- oriental review.

Books Recommended:

1. Atwal, A. S. (1984) Agricultural pests of India and South East Asia. Kalyani Publishers Delhi
2. Imms, A.D. (1957) A General Textbook of Entomology. 9th ed. Revised by O. W.
3. Metcalf, G. L. & Flint, W.P. (1962) Destructive and useful insects. Mc Graw Hill New York.
4. Ross, H. H., Herms, W. E. & Janes, M. T. (1982) A text book of Entomology.John Wiley and sons, New York
5. Herms, W. E. & Janes, M. T. Medical Entomology. The Macmillan Co. New York
6. Carter, W.Insects in relation to plant diseases.
7. Green, M. B. Hartley, G.S. & West, T.P. Chemicals for crop protection and pest control, Pergamon Press, New York
8. De Bach, P. Biological control of insect pests and weeds. Chapman and Hall, London.
9. Matheson, R. (1950). Medical Entomology. Comstock Publishing Associates, N.Y.

Practical: Applied Entomology

Collection, identification and preservation of different pests and other insects of medical and veterinary importance. Study of sericulture and apiculture. Operation of various types of sprayers. Dusters, fumigation emulsions. Preparation of insecticide emulsions in different concentration. The record of laboratory and fieldwork will be maintained and presented at the time of examination.

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ANNEXURE-D

Approval of Additional (Special) Courses for BS

The courses listed below can be taught as elective or special subjects.

List of Additional Courses

Agriculture Biotechnology	2+1
Analysis Of Development	2+1
Aquaculture	2+1
Arachnology	2+1
Bacterial Genetics	2+1
Basic Human Genetics	2+1
Behavioral Ecology	2+1
Biodiversity of Inland Terrestrial Mollusks	2+1
Biological Oceanography	2+1
Biotechnology	2+1
Biotechnology in Aquaculture	2+1
Comparative Developmental Biology	2+1
Conservation Biology	2+1
Endocrinology-I	2+1
Fish Bioenergetics	2+1
Fish Ecology	2+1
Fish Endocrinology	2+1
Fish Health Management	2+1
Fish Feeding Management	2+1
Fish Physiology and Breeding	2+1
Fundamentals of Microbiology	2+1
General and Comparative Endocrinology	2+1
Ichthyology	2+1
Immunology	2+1
Limnology	2+1
Mammalogy	2+1
Molecular Genetics	2+1
Neurobiology	2+1
Ornithology	2+1
Pathological Endocrinology	2+1
Planktology	2+1
Principles of Fish Biology	2+1
Reproductive Biology	2+1
Restoration Ecology and Sustainable Development	2+1
Taxidermy	2+1
Teratology	2+1

Vector biology	2+1
Wildlife Parasitology	2+1

Detail of the additional Courses

Agriculture Biotechnology	**2+1**

Course Contents:

1. **Agriculture biotechnology**

a. Introduction and its applications in crop improvements

2. **Cell and plant tissue culture**

a. Introduction, types and methodology

b. Improvement of plants via plant cell culture;

3. **Plant molecular biomarkers**

4. **Gene Transformation**

a. Direct and indirect methods of plant and animal transformation

b. Gene gun method of transformation

c. *Agrobacterium* mediated transformation

d. chloroplast transformation

e. polyethylene glycol (PEG) mediated transformation;

5. **Transgenic crops**

a. Transgenic crops with herbicide

b. biotic and abiotic stress resistance

c. problems related to transgenic plants

6. **Genetically modified organisms (GMOs)**

a. Introduction

b. Field evaluation and commercialization of GMOs

c. Possible effects of releasing GMOs into the environment

7. **Bio-fertilizers**

a. Introduction, bio-pesticides and their types

b. Non-symbiotic nitrogen fixers

c. present and future prospects of biofertilizers.

Practical:

1. Preparation of Murashige and Skoog medium and stocks of macronutrients

2. Micronutrients, and hormones; selection of ex-plant, medium preparation andcallus induction

3. Culturing *Agrobacterium* and using it to infect plant callus

4. Selection of transformant's; regeneration of plantlets and acclimatization

5. PlantDNA extraction and PCR for detecting introduction of foreign DNA into plants.

Text and Reference Books:

1. Qaim M, 2010. Agricultural Biotechnology in Developing Countries: Towards Optimizing Benefits for Poor. Springer

2. Kemp Ken F, 2010. Genetic Modification of Plants: Agriculture, Horticultureand Forestry (Biotechnology in Agriculture and Forestry). Springer.

3. Herren RV, 2012. Introduction to Agricultural Biotechnology. 2nd Edition; Delmar Cengage Learning.
4. Slater A, 2008. Plant Biotechnology: The Genetic Manipulation of Plants. 2nd Edition; Oxford University Press, USA
5. Altman A, 2011. Plant Biotechnology and Agriculture: Prospects for the 21st Century. 1st Edition; Academic Press.

Analysis Of Development	**2+1**

Course Contents:

1. **Introduction:**
a. Historical review of embryology.
b. Uses of modern molecular techniques in Developmental biology**.**
c. Developmental patterns;
d. Sexual reproduction
e. Spermatogenesis, Oogenesis and Fertilization
2. Cleavage
a. Patterns of embryonic cleavage,
b. Mechanism of cleavage
3. Gastrulation:
a. Fate maps
b. Neurulation, ectoderm, mesoderm and endoderm.
4. **Morphogenesis:**
a. Cellular Basis of Morphogenesis:
b. Differential cell affinity,
c. Cell adhesion molecules;
5. **Mechanism of Cellular Differentiation:**
a. RNA processing,
b. Translational regulation of developmental process,
6. **Cell-fate by progressive determinants,**
a. Autonomous cell specification by cytoplasmic determinants,
7. Axis Development
a. Establishment of body axes and
b. Mechanism of teratogenesis;
8. Secondary Induction;
a. Organogenesis:
b. A brief account; Origin and Migration of Germ Cells in Vertebrates;
9. Factors controlling Growth.
a. Factors controlling Growth and Oncogenesis
b. Hormones as Mediators of Development;
c. Regeneration in Vertebrates.

Practical:

1. Preparation and study of serial sections of frog or chick embryos.
2. Application of microsurgical techniques on chick embryos in vitro.

3. Preparation and staining of histological slides.

Text Books:

1. Gilbert,S. F., 2008. Developmental Biology, Sinauer Associates, Sunderland, MA.
2. Scott F. Gilbert. 2000. Developmental Biology, Sinauer Associates Inc., Publishers, Massachusetts.
3. Bruce M. Carlson. 2000. Human Embryology and Developmental Biology, Mosby, London.
4. Oppenheimer. 1989. Introduction to Embryonic Development, S.S. Allen and Bacon.
5. Balinsky, B.I. 1985. An Introduction to Embryology, W.B. Saunders, New York.

Additional Readings:

1. Saunders, J. W., 1982. Development Biology, McMillan.
2. Oppenheimer, S.S., 1984. Introduction to Embryonic Development, Allen and Bacon.
3. Bodemer, C. W., 1968. Modern Embryology. Holt, Rinehart and Winston.
4. Ham, R. G. and Veomett, M. J., 1980. Mechanism of Development. C.V. Mosby Co.
5. Berril, N. J. and Karp, G., 1978. Development. McGraw Hill.

Aquaculture	**2+1**

Course Contents:

1. **Introduction**

a. Introduction to fish, fishery and aquaculture,
b. History and present status of aquaculture (National and International)
c. Introduction and biology of cultivable fin and shell fishes.
d. Introduction to aquatic resources of Pakistan (Lentic and lotic environment).

2. **Aquaculture (fin fish culture)**

a. Introduction and role of aquaculture, types of culture systems (Ponds, Raceways, cages, pen, raft and line culture).
b. Site selection, design and construction of fish ponds
c. Pond problems; aquatic vegetation and their control, fish predators, water quality and management, fish disease and their control.
d. Types of fish feed, characteristics of artificial feed, methods of feeding, types and use of fertilizers,
e. Artificial fish breeding techniques
f. Integrated aquaculture

3. Shell fish culture

a. Introduction of shrimp and prawn culture,
b. Crabs, molluscs, lobsters and scallops culture etc,

Practicals:

1. Collection and identification of various freshwater fish species
2. Visit and studying of fish pond Components.
3. Visit to fish hatchery and integrated fish farming.
4. Determination of Water quality parameters (Physical, chemical and biological)
5. Fish feed ingredients and formulation of fish feed
6. Artificial Fish breeding

7. Fish market visit
8. Visit to fish feed mill
9. Visit to head works/reservoirs etc.

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.
7. Gjedrem T. and Baranski M. 2009. Selective breeding in Aquaculture: An Introduction. Springer, USA
8. NIIR 2003. Hand Book on Fisheries & Aquaculture Technology. Asia Pacific Business Press Inc., Delhi.
9. Pillay, T. V. R. 2002. Aquaculture: Principles and Practices. Blackwell Sciences Limited. UK.
10. Huet, M. and Timmermans, J. (2002). Text book of Fish Culture. Blackwell Science Ltd. UK.
11. Shammi, Q.J. and Bhatnagar, S. 2002. Applied Fisheries, Agro bios, India.
12. Ali, S.S. 1999. Fresh Water Fisher Biology. Naseem Book Depot, Hyderabad. 5.

Arachnology	**2+1**

Course Contents:

1. Importance and applications of Arachnology.
2. Importance and its future perspectives.
3. History of arachnology, Introduction of arachnology according to history
4. Structure of the Arachnids
5. Characters of Arachnids
6. Classification position of class Arachnid
7. External and internal anatomy
8. Life history of Arachnids
9. Defense mechanisms.
10. Arachnid with relationship to man.
11. Role of Arachnids as a biological control
12. Arachnids families identification.

Practicals:

1. Systematic Collection.
2. Preservation.
3. Morphological characters of Arachnid.

4. Anatomy of Arachnid.
5. Writing description of identified (Araneae) Arachnid.
6. Preparation of identified specimen's slide.
7. Identification of specimens up to families with the help of keys.
8. Field survey for the collection of arachnids from different habitats

Recommended Books:

1. Foelix, R. 2011. Biology of spiders. OUP USA.
2. Levi, H. W. 1956. The spider genera Neottiura and Anelosimus in America (Araneae: Theridiidae). Transactions of the American Microscopical Society, 75(4), 407-422.
3. Herberstein, M. E. (Ed.). 2011. Spider behaviour: flexibility and
4. Bristowe, W. S. 1958. World of spiders...

Bacterial Genetics	**2+1**

Course Outline

1. Nucleic acids

a. Structure and functions

2. DNA replication

a. Replicon origins
b. Events that occur at the replication fork,
c. The structure and functions of DNA polymerases
d. Replication Strategies

3. **Control of DNA replication**

a. Dichotomous replication in prokaryotes
b. Control of gene expression in prokaryote
c. Polycistrons, transcriptional initiation and termination, the operon, catabolite repression and attenuation control.

4. **Protein synthesis**

a. mRNA translation: Genetic code - non universality, codon usage.
b. Events on ribosomes (c.f. prokaryotes)
c. Ribosome structure-function relationships
d. Organelle and archaebacterial systems.
e. Plasmids, episomes and transposons.

5. **DNA mutagenesis**

a. Mutagenic agents
b. Repair and mutation suppression

6. **Genetic recombination**

a. Generalizedrecombination
b. Site specific recombination and Illegitimate recombination.
c. Gene transfer mechanisms and their role in evolution
d. Transformation, transduction, conjugation and cross-phylogenic transfer.
e. Gene mapping by conjugation and transduction.
f. Circular chromosomal maps of bacteria.
g. Introduction to genetic rearrangements

Text and Reference books:

1. Pierca, B. A., 2005. Genetics.A conceptual approach, W. H. Freemanand 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 andGenomes, Jones and Bartlett Publishers. Sudbury, U.S.A.
4. Ignacimuthu, S., 2005, Basic Bioinformatics, Narosa PublishingHouse, India.
5. Lwein, B., 2004, Gene VIII, Pearson Education Int.
6. Primrose, S. B., and Twyman, R. M., 2006. Principles of GeneManipulation and Genomics.Blackwell Scientific Publications.
7. Wilson, J. and Hunt, T., 2004. Molecular Biology of the cell – theproblems book, Garland publishing Inc.
8. Jack, J. P., 2005. An Introduction to Human Molecular Genetics, 2ndedition New Jersey.
9. Ringo, J., 2004. Fundamental Genetics, Cambridge University Press

Basic Human Genetics

Basic Human Genetics	**2+1**

Course outline:

1. Introduction

a. Pedigree construction by using standard symbols.
b. Mode of Inheritance of genetic disorders
c. Autosomal dominant and autosomal recessive inheritance
d. X linked dominant and X linked recessive Inheritance.
e. Y linked inheritance.
f. Mitochondrial Inheritance

2. Genetic Linkage

a. Linkage Analysis
b. Genetic mapping
c. Physical mapping
d. Genetic linkage and LOD score calculation

3. Mutations

a. Missense mutations
b. Nonsense mutations
c. Silent mutations
d. Deletion mutation
e. Duplication mutations

4. Prenatal Screening

a. Ultrasonography
b. amniocentesis
c. Chorionic villi sampling
d. Fetoscopy

5 Introduction to human Genome Project

a. Application and proposed benefits of Human Genome project.

b. Ethical, legal and social Issues.

6 Chromosomal Abnormalities

a Aneuploidy

b Euploidy

Practical:

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

Text and Reference Books:

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.

Behavioral Ecology	**2+1**

Course outline:

1. **Animal behavior and Ecology**

a. Introduction

b. Gene and Behavior

c. Natural Selection and Behavior

d. Ecology and Evolution

2. **Hypothesis and Testing**

a. Comparative Approach

b. Adaptations

c. Social Organization and Experimental Studies

d. Economic Decisions Made by Individuals

e. Marginal Value Theorem and Reproductive Decisions

f. Economics of Prey Choice

g. Tradeoff and Optimality Models

3. **Competition for Resources in Individuals**

a. Competition by Exploitation

b. Competition by Resource Defense

4. **Merits and De-merits of living in Groups**

5. **Fighting Among Individuals**

a. Role of Resource Values and Fighting Ability

b. Fighting for Dominance

6. **Altruism**

7. **Kin Selection**

8. **Repository and Manipulation in Animals**

9. **Division of Labor and Specialized Helpers**

Practicals:

1. Visit to Zoo/Aviary/Peasantry/Breading-center/Recreational Park/ Aquarium to study the behavior of animals in different environmental conditions
2. Stimulation of ideal free distribution
3. Arm races in animals
4. Marginal value theorem
5. Tit for tat strategy

Books Recommended:

1. Krebs, J. R. and Davies, N. B., 2007. Behavioral ecology, an evolutionary approach. Blackwell Scientific publication
2. Dugatkin, L. A., 2001. Model System in Behavioral Ecology. Princeton university press.
3. Ridley, M., 1995. Animal Behavior: An Introduction to Behavioral Mechanisms, Development, and Ecology. Blackwell Scientific publication

Biodiversity of Inland Terrestrial Mollusks	**2+1**

Course Outline:

1. **Malacology**

a. A brief introduction to Malacology, Classification, Morphology, Biology and Ecology of common fresh water snails.

b. Role of mollusks in the transmission of common helminth parasites of livestock and poultry.

c. Principles of snail control and general control principles of parasites

2. **Choncology**

a. Description of Choncology, history of shell, parts of shell, diagnostic features of shell and associated structures and modern uses of Shell,

3. **Evolutionary perspective**

a. Evolutionary perspective; Phylogenetic relationship with other animals; Origin of Coelom

4. **Molluscan characteristics**:

a. Mechanism of feeding, digestion, gas-exchange, locomotion, reproduction and development in Gastropods and Bivalves

b. Slugs Characteristics and classification; Structure and function of Radula; Torsion and Detorsion in gastropods.

5. **Pearl culturing**

a. Pearl culturing, Economic importance of Molluscs Threats and Conservative strategies.

Practical:

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.

Text and Reference Books:

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.
5. General Parasitology, Cheng T.C. 1986., Second Edition (first published in India, 1999 by Replica Press Pvt. Ltd. Delhi 110-040, India), Academic Press Inc. USA
6. Helminths Arthropods and Protozoa of Domesticated Animals. Soulsby, E.J.L. 1982. Bailliere and Tindall, London, UK.
7. Veterinary Parasitology. Urquhart G.M., Armour J., Duncan J.L. Dunn A.M. and Jennings F.W., 1987 Longman Group UK Ltd., London, UK
8. Veterinary Helminthology, Dunn A.M., 1978. William Heinemann Medical Books LTD. London, UK
9. Malacology, Malek E.A. (1974). Burgess publishing Co. Minneapolis.
10. Introduction to Helminth Parasites of Animals and Birds in Bangladesh Rahman M.H., Ahmed S. and Mondal M.M.H. (1996). Sheba Printing Press, Dhaka, Bangladesh.

Biological Oceanography	**2+1**

(A COMPARATIVE PERSPECTIVE)

Course Contents:

1. **Introduction**

a. Oceanography
b. Ocean exploration,
c. Modern oceanography.

2. **The Properties of Sea Water**

a. Physical properties of oceans,
b. Temperature, Pressure, Salinity,
c. Density, Circulation, Colour, Sound,
d. Waves, Tides,
e. Chemical Properties of Oceans
f. Gases of seawater, Nutrients of seawater,
g. Major, minor and trace elements of seawater.

3. **Marine Ecology**

a. Zonation of marine environment,
b. Neratic & oceanic province,
c. Ocean basin floor, Ridges, Rise & trenches,
d. Coastal habitats,
e. Estuaries,
f. Coral reef,
g. Lagoons, Salt marshes,
h. Mangrove swamps,

i. Population of primary biotic division,
j. Classification of organisms,
k. Life on sandy shore,
l. Life on muddy shore
m. Life on rocky shores.

4. **The Plankton**

a. Terminology of plankton,
b. Methods of collection, Preservation, Analysis and identification,
c. Phytoplankton-Zooplankton relationship,
d. Diurnal vertical migration,
e. Hydrographic indicator species and organic production.

5. **The Nekton**

a. Marine reptiles,
b. Marine birds
c. Marine mammals.

6. **The Ocean Resources**

a. Law of the sea,
b. Mineral resources, Oil and natural gas, Gas hydrates, Minerals,
c. Ocean mining
d. Living resources
e. Fisheries
f. Mariculture

7. **The Human Presence in the Ocean**

a. Pollution,
b. Hydrocarbon in the sea,
c. Municipal and industrial effluent, Sewage,
d. Metals, Artificial biocides,
e. Ocean dredging and mining,
f. Over-fishing,
g. The ocean future.

Practicals:

1. Study of Specimens of Marine Environment.
2. Collection, Preservation, Sorting, Identification & Analysis of Plankton samples.
3. Field trips to Rocky, Sandy & Muddy Shores.

Books Recommended:

1. Charles B. Miller, Patricia A. Wheeler 2012. Biological Oceanography .John Wiley & Sons 464 pp
2. Briggs, J.C. 1974. Marine Zoogeography. McGraw-Hill, New York.
3. Castro, P., and Huber, M.E. 2007. Marine Biology, 6th Edition. McGraw-Hills, New York.
4. Castro, P., and Huber, M.E. 2005. Marine Biology, 5th Edition. McGraw-Hills, New York, USA-425PP.

5. Duxbary, A.B., and Duxbury, A.C. 1996. Fundamentals of Oceanography, 2nd Edition. Wn. C. Brown Publisher-308PP

Biotechnology	**2+1**

Course Content:

1. **Introduction**:

a. Definitions, classes, types of modern biotechnology

b. Historical perspective, timeline of important events in the field of biotechnology

2. **Genetics and Biotechnology**:

a. Genome, human genome, types and size of human genome, diversity of human genome

b. Short Tandem Repeats, nomenclature, uses of STRs, inheritance of STRs, allele, locus, genotype, phenotype

c. Polymerase Chain Reaction, principle, requirements, procedures and applications, Gel electrophoresis, definition, principle, steps/methods involved, DNA ladder, allelic ladder

3. **Biotechnology and Justice**:

a. Sources of DNA, Forensic DNA testing,

b. Principles, techniques, types and applications

4. **Genetic Engineering**

a. Introduction, Steps, Vectors and its types, characteristics of vectors

b. Plasmids and its types, pBR322, pUC19, Ti-Plasmid

c. Restriction Enzymes, Screening, Blue White Screen, Negative and Positive Control, Competent Cells, Insulin as an example, genetically modified organisms

d. Cloning, its types of cloning, cell cloning, molecular cloning, organism cloning, applications and uses

5. **Animal and Insect Biotechnology:**

a. Introduction, reasons for producing GM animals,

b. Genetic manipulation, mammalian cloning, somatic cell nuclear transfer, procedure and uses, GM hormones and vaccines, GM insects

6. **Bioprocess Technology:**

a. Introduction, requirements of bioreactors, types of bioreactors

b. Bacterial and mammalian cell culturing, production of novel antibiotics, steps for production of antibiotics, production of industrially important chemicals

7. **Biotechnology and Medicine**:

a. Applications, monoclonal antibodies, importance, steps for production of monoclonal antibodies

8. **Stem Cell Biotechnology:**

a. Introduction, sources – embryonicstem cells, adult stem cells

b. Types of stem cells based on potency, applications of stem cells.

9. **Public Perception of Biotechnology:**

a. Current issues in bioethics (Autopsy, GMOs, Stem Cells, Euthanasia, Organ Transplant, Human Cloning, IVF, Surrogacy and sperm donor, etc)

10. **Bioethics and Islamic Bioethics**:
a. Introduction and principles of bioethics,
b. Concept of bioethics in different religions, principles of Islamic bioethics

Practicals:

1. DNA Extraction from different sources
2. Quantification of DNA using gel electrophoresis and spectrophotometer
3. Amplification of DNA using PCR
4. PCR product measurement using gel electrophoresis
5. Gender typing of human and animal samples using PCR
6. Restriction fragment length polymorphism of samples
7. Species identification of different animal samples using PCR and RFLP

Text and Reference Books:

1. Clark, D.B., Pazdernik, N.J. (2015) Biotechnology. 2nd Edition. Academic Cell
2. Glick, B., Pasternak, J.J., Patten, C.L. (2009) Molecular Biotechnology: Principles and Applications of Recombinant DNA. 4th Edition. ASM Press.
3. Freeman, S., Quillin, K., Allison, L. (2013) Biological Science. 5th Edition. Pearson.
4. Schmid, R.D., Schmidt-Dannert, C., Hammelehle, R. (2016) Biotechnology: An Illustrated Primer. Willey-Blackwell.
5. Dehlinger, C.A. (2014) Molecular Biotechnology. Jones & Bartlett Learning
6. Brown, T.A. (2016) Gene Cloning and DNA Analysis: An Introduction. 7th Edition. Willey-Blackwell.
7. Butler, J.M. (2009) Fundamentals of Forensic DNA Typing. Academic Press.
8. Setlow J. K. (2000). Genetic Engineering: Principles and Methods. Kluwer Academic Publishers
9. Krishna.V.S. (2007) Bioethics and Biosafety in Biotechnology. New Age International
10. Furr, A.K. (2008) CRC Handbook of Laboratory Safety. 5th Edition. Boca Raton, FL, CRC Press
11. Smith, J. E. (2009). Biotechnology, 5th Edition, Cambridge University Press

Biotechnology in Aquaculture	**2+1**

Course Outline:

1. **Introduction**
a. History of Biotechnology in Aquaculture
b. Biotechnological approaches in Aquaculture
2. **Gynogenesis, Androgenesis andCloned Populations**
a. Induction of Gynogenesis and Androgenesis
b. Performance of Gynogens and Androgens
c. Reproduction
d. Monosex Populations
e. Cloned Populations.
3. **Biochemical and Molecular Markers**
a. Isozymes and Enzymes.
b. Restriction Fragment Length Polymorphism.
c. Single Nucleotide Polymorphisms.

d. Relative Costs of Different Markers
e. Relative Effectiveness of Markers
4. **Combining GeneticEnhancement Programmes**
a. Sex Reversal and Triploidy
b. Genetic Engineering and Crossbreeding
c. Genetic Engineering, Selection, Crossbreeding, Strains and Hybrids
5. **Food Safety of TransgenicAquatic Organisms**
a. International Guidelines
b. Labelling
6. **Environmental Risk of Aquatic Organisms fromGeneticBiotechnology**
a. Theoretical Risks
b. Environmental Risk Data on Transgenic Fish
c. Common Goals of Aquaculture and Genetic Conservation

Practicals:

1. DNA isolation from fish.
2. Electrophoresis, Agarose and polyacrylamind gel electrophoresis.
3. Demonstration of amplification of DNA through PCR.

Text and Reference Books:

1. Dunham, R.A., 2011. Aquaculture and Fisheries Biotechnology: Genetic approaches. CABI,UK.
2. Kumar, R., 2010. Biotechnology and Genetics in Fisheries and Aquaculture. Blackwell, USA.
3. Stickney, R.R., 2009. Aquaculture: An introductory Text. CABI Publishing, UK

Comparative Developmental Biology	**2+1**

Course Outline:

1. **Introduction to development Biology**
a. Scope, Science of developmental biology and its applications
b. Developmental patterns in metazoan.
2. **Germ Cell**
a Germ cell migration in amphibian, birds and mammals.
b. Differentiation of germ cells into sperm or egg.
3. **Spermatogenesis**
a. A detailed study of the spermatogenesis in vertebrates and gene expression during sperm development.
4. **Oogenesis**
a Oogenic meiosis
b. Maturation of oocyte in amphibian
c. Role of estrogen and progesterone in oogenesis
d. Gene transcription in oocyte
e. Vitellogenesis
5. **Fertilization**
a Contact recognition between sperm and egg
b. Acrosomal reaction

c. Gametes bindings and fusion (role of egg membranes)
d. Egg activation
6. **Creation of multicellularity**
a. Cleavage characteristics
b. Patterns of cleavage (radial holoblastic, bilateral holoblastic, spiral holoblasric, rotational holoblastic and meroblastic)
c. Gastrulation in avian and amphibians (frog and chick)
d. Concept of fate maps (chick and frog)
7. **Organizers and induction**
a. Primary embryonic induction
b. Regional specificity of induction
c. Molecular mechanism of primary embryonic induction
8. **Early vertebrate development**
a. Neuralation and development of ectoderm
b. Organization of mesoderm and endoderm
9. **Differentiation**
a Cell commitment and differentiation
b. Chemical basis of differentiation
10. **Organogenesis**
a. Development of rudimentary organs in amphibian and mammals
b. Cellular interactions during the development of limb, brain, eye, heart and liver
11. **Placenta**
a. Development of placenta and its different types
b. Placental hormones and their functions/ importance
12. **Multiple ovulation and Embryo transfer technology**
a. *In vitro* oocyte maturation
b. Cryopreservation
c. Embryo transfer technology

Practicals:

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

Text and Reference Books:

1. Gilbert, S. F. 2013. Developmental Biology, Sinauer Associates, Sunderland, MA.
2. Klaus, K. 2001. Biological Development. 2nd Ed., McGraw Hill.
3. Scott F. Gilbert and Michael J. F. Barres. 2016.Developmental Biology. Sinauer Associates, Sunderland, MA.

4. Jamie, A. Davies. 2014. Life Unfolding: How the Human Body Creates Itself. Oxford University Press, USA
5. Balinsky, B. I. 1985. An Introduction to Embryology, Saunders.
6. Oppenheimer, S.S. 1984. Introduction to Embryonic Development, Allen and Bacon.
7. Saunders, J. W. 1982. Developmental Biology, McMillan and company.
8. Ham, R. G., Veomett, M. J. 1980. Mechanism of Development. C. V. Mosby Co.

Conservation Biology	**2+1**

Course Outline:

1. Introduction to Conservation Biology:

a. Definition,
b. History and
c. Scope.

2. Biodiversity:

a. Species Diversity; Genetic Diversity; Ecosystem Diversity;
b. Measurement of Biological Diversity;
c. An overview of World's Biodiversity;
d. The Value of Biodiversity

3. Threats to Biodiversity:

a. Human Population Growth;
b. Habitat Destruction; Habitat Fragmentation;
c. Environmental Degradation and Pollution;
d. Global Climate Change;
e. Overexploitation;
f. Invasive Species

4. Extinctions:

a. Extinction and Mass Extinctions;
b. Rates of Extinction; Island Biogeography;
c. Vulnerability to Extinction;
d. Problems of Small Populations; Minimum Viable Population (MVP);
e. Loss of Genetic Diversity; Effective Population Size;
f. Demographic and Environmental Stochasticity

5. Conserving Populations and Species:

a. Applied Population Biology; Monitoring populations; Population viability analysis; Metapopulations,
b. International agreements for conservation of fauna and flora; Role of national and International Laws in Protection of Species;
c. Ex Situ Conservation Strategies; Zoos; Aquariums; Botanical gardens; Seed banks.
d. Protected Areas and their Establishment and categories;
e. Managing Protected Areas; Challenges to Protected Areas Management.
f. Unprotected Public and Private Lands
g. Ecosystem Management
h. Integration of Local Community in Conservation
i. Restoring Damaged Ecosystems

6. Sustainable Development:

a. Challenges Involve in Conservation and Sustainable Development at the Local Level

b. International Approaches to Sustainable Development

c. Funding for Conservation by the World Bank and international NGOs;

d. Conservation Education and the Role of Conservation Biologists

Practicals:

1. Conservation issues in protected areas of Pakistan.
2. Study of the role of local community in protected areas of Pakistan.
3. Challenges to sustainable development and their solution in Pakistan.

Text and Reference Books:

1. Richard B. Primack, 2012. A Primer of Conservation Biology; 5th Edition: Sinauer Associates, Inc. Publishers Sunderland, MA U.S.A.

2. Groom, M.J., G.K. Meffe and C.R. Carroll, 2006, Principles of Conservation Biology, 3rd edition, Sinauer Associates, Sunderland, MA.

3. Malcolm L. Hunter, Jr. 2001. Fundamentals of Conservation Biology, 2nd Edition. Blackwell Science Inc.

4. Mills, L.S. 2007. Conservation of Wildlife Populations: Demography, Genetics and Management. Blackwell Publishing, USA.

5. Richard B. Primack. 2002. Essentials of Conservation Biology. 3rd Edition. Sinauer Associates Inc. Publishers, Sunderland, Massachusetts, U.S.A.

Endocrinology-I	**2+1**

Course Contents:

1. **An overview of general concepts and principles of endocrinology**:

a. The endocrine system; Type of hormones; Endocrine and nervous system relationship;

b. General principles in function, interaction, nature, synthesis, transport of hormones;

c. General concept of feedback, biorhythms, pathology and assessment of endocrine function;

d. Evolution of endocrine system. RIA, RIMA, ELISA, bioassay and receptor assay

2. **Hypothalamus and pituitary**:

a. Hypothalamic hormones: Origin, chemistry and actions and mechanism of action;

b. Anterior pituitary & hormones: Hypothalamic pituitary regulation,

c. General chemistry, Physiological action, mechanism of action and metabolism of prolactin-growth hormone family,

d. glycoprotein hormone family, corticotrophins and other pro-opiomelanocortin peptides;

e. posterior pituitary: Release, regulation and actions of vasopressin and oxytocin.

f. Causes and effect of over and under production of hypothalamic and pituitary hormones

g. Hypothalamic, pituitary and thyroid, adrenocortical, gonadal and other axis.

3. **Thyroid gland**:

a. Anatomy and histology of gland; Formation and secretion of thyroid hormones; Thyroid hormones in peripheral tissues, Functionof thyroid hormone,

b. Mechanism of action; regulation and factors affecting thyroid function.
c. Causes and effect of Hypothyroidism and hyperthyroidism
4. **Calciotrophic and Mineral Metabolism Hormones**:
a. Chemistry, physiological actions, mechanism of action and
b. metabolism of parathyroid hormone,
c. Causes and effect of over and under production of hormone
d. Calcitonin and calciferols; action and mechanism of action
e. Homeostasis of calcium, phosphate and magnesium.
5. **Pancreatic Hormones and Regulatory Peptides of the Gut**:
a. Anatomy and histology for sources of the hormones; Chemistry,
b. Physiological roles and mechanism of action of insulin and glucagon;
c. Physiological roles of gut peptides.
d. Causes and effect of over and under secretion of pancreatic hormones
e. Glucose homeostasis
6. **Adrenal Medulla and Catecholamines**:
a. Chromaffin cell and organization; Structure of adrenal medulla;
b. Biosynthesis, storage, release and metabolism;
c. Adrenergic receptors and mechanism of action;
d. Disorder of Adrenal medulla (pheochromocytoma)
7. **Adrenal Cortex**:
a. Anatomy and Steroid biochemistry;
b. Physiological actions of corticoid hormones and mechanism of action;
c. Regulation and metabolism of glucocorticoids,
d. Mineralocorticoids and adrenal sex steroids.
e. Disorder of adrenal cortex hormones
8. **Testes: Androgenic tissue**:
a. Anatomy, structure, chemistry, synthesis and transport of hormone,
b. Metabolism, action and mechanism of action.
c. Testicular disorder
9. **Ovaries**:
a. Ovarian Anatomy, hormones: Steroid biochemistry and biosynthesis;
b. Transport, metabolism, action and mechanism of action.
c. Cyclic changes, menopause
d. Ovarian disorder
10. **Endocrinology of Pregnancy**:
a. Hormones in conception and implantation;
b. Hormonal actions and
c. Adaptation in pregnancy and parturition.
11. **Fetus Endocrinology**
a. Endocrinology of developing fetus
12. **Endocrinology of Lactation**:
a. Hormones in lactation.
13. **Endocrinology of development of growth**

a. Growth and Puberty
b. Disorders of growth and puberty
14. **Endocrinology of**
a Heart, Kidney,
b. Immune system:
c. Growth and pineal gland.
15. **Functional diversity of vertebrate hormo nes**
a. Functional diversity of hormones in different vertebrates
16. **Overview of Endocrine Mechanisms in Invertebrates**
a. Hormones of invertebrates
17. **Geriatric Endocrinology**
a. Endocrine and Associated Metabolism in aging: Specifically thyroid, glucose and calcium homeostasis

Practical:

1. Demonstration of endocrine glands and associated structures in dissections, transparencies, computer projections etc;
2. Histological and ultrastructure features of endocrine glands;
3. Experiments to demonstrate physiological roles of hormones of different endocrine glands;
4. Experiments to demonstrate regulation of hormones' releases.
5. Experiments to demonstrate functional diversity of hormones in different vertebrates.
6. Experiments on endocrine mechanism in vertebrates.
7. Experiment on recognition and response of receptors
8. Studies of disorders of pituitary by observing anatomical and histological features
9. Studies of thyroid status in deficient and excess hormone functions
10. Studies of type 1 and type 2 diabetes mellitus: Epidemiology of the types in population, studies of management of the type 2;
11. Model studies of Ovarian and Testicular disorders;
12. Model studies of obesity and aneroxia;
13. Studies of hormonal status in puberty and aging

Text Books:

1. Greenspan, F.S. and Strewler, G.J., 2011. Basic and clinical endocrinology, 9th Edition. Prentice Hall International Inc., London.
2. Bentley, P.J., 1998. Comparative Vertebrate Endocrinology. 3rd Ed. Cambridge University Press, Cambridge.
3. Sam A., Meeran K. Endocrinology and Diabetes. Lecture notes. Wiley-Blackwell (2009) (basic science and clinical context).
4. Laycock J, Meeran K. Integrative Endocrinology. Wiley-Blackwell (2013).
5. Rang H, Dale M and Ritter, J: Pharmacology, 4th ed., (1999). (relevant for drug information) 2nd Edition. The Oxford Textbook of Endocrinology and Diabetes DOI: 10.1093/med/ 9780199235292.003.0134
6. Yen & Jaffe's Reproductive Endocrinology: Physiology, Pathophysiology, and Clinical Management. Saunders – all editions are excellent (even the older editions)

7. Johnson MH. Essential Reproduction. 7th Ed. Wiley-Blackwell (2013) (relevant for some general background info on reproduction pitched for undergraduate students).
8. Chandra S. Negi, introduction to endocrinology
9. Charles Brook, Nicholas Marshall, essential endocrinology
10. Noris, vertebrate endocrinology

Additional Readings:

1. Wilson, J.D., Foster, D.W., Kronenberg, H.M. and Larsen, P.R., 1998. Williams textbook of endocrinology, 9th Edition. W.D. Saunders Company, Philadelphia.
2. DeDroot, L.J., Jameson, J.L. *et al*., 2012 Endocrinology, Vol.I, II & III, th Edition. W.B. Saunders, Philadelphia.
3. Giffin, J.E. and Ojeda, S.R., 2000. 4th Edition. Textbook of Endocrine Physiology. Oxford University Press, Oxford.
4. Neal, J.M., 2000. Basic Endocrinology: An interactive approach. Blackwell Science Inc., London.

Fish Bioenergetics	**2+1**

Course Outline:

1. **Introduction to Energetics and Energy Budget**
a. Energetics
b. Energy budget
c. Adaptive aspects of energy allocation
2. **Fish feed and their nutrition value**
a. Introduction to fish food and nutrition value
b. Diet composition and requirement
c. Protein, carbohydrate and lipid as an energy source
d. Vitamin and minerals requirements of fish
e. Dietary sources of vitamins and minerals
3. **Metabolism**
a. Carbohydrates metabolism
b. Amino acids metabolism
c. Lipid metabolism
d. Regulation of metabolism by hormones
e. Effects of biotic and abiotic factors on metabolism
4. **Growth**
a. Regulation of growth by hormones
b. Thyroid hormones
c. Growth hormone
d. Effects of biotic and abiotic factors on growth

Practical:

1. To study energy budge in fishes.
2. Qualitative assessment of fish feed.
3. Oxygen consumption in fish.
4. Visit to fish feed manufacturing industry
5. To study effects of biotic and abiotic factors on growth.

Text and Reference Books:

1. Fish Nutrition in Aquaculture. Sena S. De Silva and Trevor A. Anderson. Chapman & hall Aquaculture series 1 New York- Tokyo. Melbourne. Madras First edition 1995. Reprinted 2009.
2. The Biology of Fish Growth. A.H. weatherley and H.S.Gill. Academic Press Harcourt Brace Jovanovich, Publishers. London, Orlando, San diego, New York, Austin, boston, Sydney, Tokyo, Toronto. Toronto, 1986.
3. Cyprinid fishes. Systematics, Biology and exploitation. Ian J. Winfield and Joseph S. Nelson. Chapman & Hall London, New York. Tokyo, Melboune. Madras. First edition 1991.
4. Fish Energetics: New Perspectives. Peter Tytler& Peter Calow, Croom Helm London & Sydney. 1985.

Fish Ecology	**2+1**

1. **The Environment, Organisms and Relationships**
a. Introduction
b. Properties of water
c. Diversity of fishes
d. Relationship
2. **Effects of Abiotic Environmental Identities on Distribution**
a. Introduction
b. Effects of abiotic identities
c. Abiotic factors and the distribution of fishes in rivers and lakes
d. Abiotic factors and the distribution of fishes in estuaries
e. Abiotic factors and the distribution of fishes in littoral and sub-littoral marine waters.
f. Effect of abiotic factors on the distribution of open-sea species.
g. Adaptations of fish to abiotic environmental factors
3. **Biotic Factors and the Structure of Fish Communities**
a. Introduction
b. Classification of the interactions
c. Role of biotic factors and community structure
d. Biotic interactions and community structure in rivers and lakes
e. Biotic interactions and community structure in the sea
f. Competition and predation in freshwater communities
4. **Migration, Territoriality and Shoaling in Fishes**
a. Introduction
b. Swimming capacity and energy coasts
c. Patterns and site attachment and social interactions
d. Migration and colonization in fishes
e. Over-wintering migrations
f. Movement of water and modes of fish movements.
g. Diadromy
h. Homing

i. Implications for exploitation

5. **Feeding and Growth**

a. Introduction

b. Feeding ecology in freshwater environments

c. Feeding ecology in estuaries

d. Ecology of feeding of marine fishes

e. Detection and selection of food

f. Ecomorphology of feeding

g. Trophic categories of fishes

h. Utilization of food

i. Rate of food consumption

j. Growth

6. **Life-Histories and Population Dynamics**

a. Introduction

b. Life-history traits and the concept of trade-offs

c. Breeding pattern of fishes

d. Population characteristics

e. Dynamics of fish populations

f. Production

7. **Applied Ecology of Fishes**

a. Introduction

b. A classification of problems in applied ecology

c. Applied fish ecology of rivers

d. Applied ecology of lacustrine fishes

e. Applied fish ecology in the sea

Practical:

1. Collection, identification and preservation of fishes

2. Water sampling and water preservation techniques for physicochemical and biological analyses

3. Estimation of physical characteristics of water viz. temperature, density, light penetration and turbidity

4. Estimation of chemical characteristics of water viz. dissolved oxygen, carbon dioxide, pH, total alkalinity, total hardness, bicarbonates, chlorides, calcium, magnesium, salinity

5. Collection, preservation and study of fauna and flora of various water Bodies

6. Visit to various fish farms and report writing

Text and Reference Books:

1. Fish Ecology. R.J. Wootton, Blackie Academic & professional an imprint of Chapman &Hall, London, Weinheium. New York- Tokyo. Melbourne. Madras First edition 1992. Reprinted 1996

2. Fisheries Ecology. Tony J. Pitcher, The AVI publishing company inc. Westport, Connecticut 1982.

3. Ecology of Teleost Fishes. Robert J. Wootton. Chapman & Hall London. New York, Tokyo, Melboune. Madras. First edition 1990, reprinted with revisions 1991.
4. Environmental Biology of Fishes. Malcolm Jobling. Tokyo, Melboune. Madras. First edition 1995.
5. Ecology and Conservation of Fishes. Harold M. Tyus, CRC Press, Taylor and Francis Group, USA, 2011.

Fish Endocrinology	**2+1**

Course Contents:

1. **Fish endocrine system**
a. Differentiate between exocrine and endocrine system
b. Fish endocrine system and mechanism
c. The evolution of fish endocrinology
2. **Pituitary gland**
a. Origin
b. Functions
c. Neurohypophysis and its hormones
d. Adenohypophysis and its hormones
3. **Thyroid gland**
a. Introduction of thyroid gland
b. Functions in fish
4. **Pancreas**
a. Introduction to pancreas of fishes
b. Types in fish
c. Pancreatic glands
d. Pancreatic hormones
5. **Gastro-intestinal hormones**
a. Introduction
b. Types
c. Function
6. **Adrenal cortex (internal tissue), chromaffin tissues and corpuscles stannous**
a. Brief introduction
b. Important functions in fish
7. **Sex hormones**
a. Gonadal hormones in fish;
b. Testes and Ovaries (androgenic tissue: structure and chemistry; transport, metabolism and mechanism of action. Ovarian hormones: steroid biochemistry and biosynthesis; transport, metabolism and mechanism of action).
8. **Pheromones**
a. Brief introduction
b. Pheromones
c. Functions

Practical:

1. Demonstration of endocrine glands and associated structures in dissections, transparencies, computer projections etc
2. Histological and ultra-structure features of endocrine glands
3. Demonstration of physiological roles of hormones of different endocrine glands
4. Demonstration on functional diversity and endocrine mechanism of hormones in different vertebrates.

Recommended Books

1. Melmed, S., Polonsky, K. S., Larsen, P.R. and Kronenberg, H. M., 2016. WILLIAMS textbook of Endocrinology. 13th ed. Elsevier Inc, USA.
2. Norris, D.O. and Carr, J. A., 2013. Vertebrate Endocrinology .5th ed. Elsevier publishing, USA.
3. Papoutsoglou, S.E., 2012. Test book of Fish Endocrinology.Nova Science, USA.
4. Norris, D.O. and Carr, J.A., 2005. Endocrine Disruption. Oxford University Press. USA.
5. Reinecke, M., Zaccone, G., B.G. Kapoor, B.G., 2006. Fish Endocrinology. (2 volume set) 1st ed. CRS Press, USA.
6. Sloman, K.A., Balshine, S. and Wilson, R.W., 2005. Behaviour and Physiology of Fish. Academic Press. UK.

Fish Health Management	**2+1**

Course Contents:

a. Introduction to fish health management.
b. Elements of fish health management
c. General husbandry procedures, feeding, fish handling.
d. Facility and equipment management: overview of facility, layout plan, management of facility, management of equipment.
e. Bio-security and mitigation measures: equipment maintenance and disinfection, mitigation disease spread from infected or diseased fish.
f. Disease emergencies: fish disease outbreaks, fish health emergency procedures, determining the cause of outbreaks.
g. Monitoring and record keeping: fish health records, feeding, fish monitoring, water quality monitoring, fish production records, treatment records.
h. Common signs of diseased fish, modern techniques for investigation of disease.
i. Kinds of diseases: non-infectious diseases, infectious diseases, virus borne diseases, bacterial diseases, fungal diseases, fish vaccination.
j. Preventive measures, control of fish disease, disease resistance.
k. Methods of treatments, drug metabolism in fish, routes of drug administration, oral medication, injections.

Practical:

1. Collection and studying of disease fish samples.
2. Fish dissection.
3. Water quality parameters.
4. Dis-infection methods.
5. Fish treatment methods, oral medication, injection, clinical work-up.

6. Fish biopsy techniques.
7. Fish diseases diagnosis.
8. Fish hematology.
9. Blood smears etc.

Books Recommended:

1. DevashishKar. 2015. Epizootic Ulcerative Fish Disease Syndrome, ELSEVIER.
2. Patrick T. K. Woo, David W. Bruno Gregory. 2014. Diseases and Disorders of Finfish in Cage Culture. CABI Publishing.
3. P. T. K. Woo, John F. Leatherland, David W. Bruno. 2011. Fish diseases and Disorders. CABI Publishing.
4. Fish diseases and disorders, 2004. Leatherland, J.F. and Woo, P. T. K. CABI publishing
5. Leatherland, J.F. and Woo, P.T.K. 2004. Fish Diseases and Disorders. Vol.2. Non-Infectious Disorders. CABI Publishing.
6. Woo, P.T.K. and Bruno, D.W. 2003. Fish Disease and Disorders. Vol. 3. Viral, Bacterial and Fungal infections. CABI Publishing.
7. Woo, P.T.K., Bruno, D.W. and Lim, L.HS. 2002. Diseases and Disorders of Finfish in Cage Culture. CABI Publishing.
8. Roberts, R.J. 2001.*Fish Pathology*. Harcourt Publishers Limited. UK
9. Fish diseases, 1991. Wilhelm Schaperclaus. Oxonian press pvt ltd. New Delhi, India
10. Roberts, R.J. 1989. Fish pathology, Macmillan publishing Co. Inc. New York.
11. Edward J. Noga. Mosby 1996. Fish disease, diagnosis and treatment.

Fish Feeding Management	**2+1**

Course Contents

a. Need of supplementary/ artificial feeding of fish.
b. Scope of artificial feeding in fish.
c. Metabolism of feed nutrients (Protein, Lipid, Carbohydrate) in fish.
d. Feeding practices, Different types of feeders.
e. Diet preparation and processing techniques.
f. Estimation of apparent nutrient digestibility.
g. FCR and FCE indices.
h. Feed ration and frequency, judging fish feeding response.
i. Food acquisition and patterns of estimation of food requirements.
j. Feed processing and manufacturing: floating and sinking feed.
k. Feed packaging, transportation and storage problems of feed stuff.

Practical:

1. Collection and identification of fish feed ingredients.
2. Ration calculation for fish feeding based on body weight, body length etc.
3. Proximate analysis of feed and feed ingredients i.e. moisture, dry matter, crude protein, crude lipid, carbohydrates and ash contents.
4. Formulation of fish feed.
5. Feeding methods; introduction and demonstration of demand and belt feeders.

Books Recommended

1. Fitzsimmons, K., R.S.N. Janjua and M. Ashraf, 2015. *Aquaculture Handbook – Fish Farming and Nutrition in Pakistan.*
2. John Halver. 2013. Fish Nutrition, ELSEVIER.
3. Tom Lovell. 2013. Nutrition And Feeding of Fish, Springer.Ojha, J.S. 2006. Aquaculture Nutrition and Biochemistry. GeetaSomaniAgrotech Publishing Academy, Udaipur, India.
4. Lovell, T., 2012. Nutrition and Feeding of Fish. 2nd Ed. SpringerScience, USA
5. Pillay T V R, M N Kutty. 2005. Aquaculture: Principles and Practices.Balckwell Publishing. UK.
6. Reddy, M.S. and Sambasiva K.R.S. 1999. A Textbook of Aquaculture.Discovery Publishing House, N. Delhi.
7. Pillay, T.V.R. 1999. Aquaculture: Principals and Practices. FishingNews Books, London.

Fish Physiology and Breeding	**2+1**

Course Contents:

1. **Fish nutrition**

a. Digestive system;
b. Stomach less fishes;
c. Stomach fishes;
d. Digestion and absorption;
e. Food; Plant origin; Animal origin;
f. Feeding; Fresh food; Dry concentrates; Pelleted food.

2. **Transportation:**

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

3. **Respiration:**

a. Gills;
b. Lungs;
c. Skin;
d. Swim bladder;
e. Homeostasis.

4. **Excretion:**

a. Kidneys;
b. Hypo-osmotic urine;
c. Hyper-osmotic urine;
d. Osmoregulation.

5. **Reproduction:**

a. Gonads; Testes and ovaries;
b. Maturation;
c. Reproductive cells (egg and sperm);
d. Artificial fertilization of sex cells.

6. **Breeding:**

a. Natural (seasonal); Artificial;
b. Hormonal induced breeding;
c. Temperature & photoperiod;
d. control induced breeding.
7. **Growth:**
a. Extensive culture (due to the consumption of natural food);
b. Semi-intensive culture (due to natural & artificial food);
c. Intensive culture (due to only dry concentrates).
8. **Fish health:**
a. Water quality;
b. Hygiene of fish culture facilities;
c. Hygiene of equipments used in fish culture.
9. **Diseases and their control:**
a. Viral;
b. Bacterial;
c. Fungal;
d. Parasitic;
e. Protozoan;
f. Helminths (trematodes, cestodes, nematodes, acanthocephalons); Crustaceans (cladocera);
g. Annelids (leeches); Arthropods (water ticks, water flea, water mites).
10. **Fish migration:**
a. To nursery ground;
b. To maturation grounds;
c. Freshwater to marine water;
d. Marine water to freshwater.
11. **Fish behaviour:**
a. Learning and memory;
b. Light response for maturation;
c. Courtship behaviour;
d. 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, Study of blood cells and their counts in normal and diseased fish,
4. Study of water quality parameters (DO, NH3, hardness, alkalinity, turbidity, transparency, temperature, salinity),
5. Study of various forms of swimbladder as hydrostatic organ,
6. Study fecundity of various fish species,
7. Study the effects of reproductive hormone (GnRH) on fish maturation,
8. Diagnosis of bacterial infection in infected fish,
9. Study of fish parasites,

10. Visit to various fish seed hatcheries during breeding seasons

Books Recommended

1. Kestin, S. C. and Warris, P.D. (Editors). KESTIN FARMED FISH QUALITY, 2002, Blackwell Science, Oxford, UK.
2. Saksena, D.N. ICHTHYOLOGY: RECENT RESEARCH ADVANCES. 1999. Oscar Publications. India.
3. Woo, P.T.K FISH DISEASES AND DISORDER. Vol 1. PROTOZOAN AND METAZOAN INFECTIONS. 1995. CABI Publisher.
4. Brenabe, G. AQUACULTURE, Vol. I. 1992. Blackwell Publishing, Oxford. UK.
5. Maseke C. FISH AQUACULTURE. 1987. Pergamon Press, Oxford. UK.
6. Huet M. TEXT BOOK OF FISH CULTURE: BREEDING AND CULTIVATION. 1973. Blackwell Publishing Company
7. Hoars, W.S. FISH PHYSIOLOGY. 1971. Academic Press. UK.
8. Hoars, W.S. FISH REPRODUCTION. 1969. Academic Press. UK.
9. Matty, A.J. FISH ENDOCRINOLOGY. 1985. Timber Press, UK.
10 Gorbman, A. COMPARATIVE ENDOCRINOLOGY. 1st Edition. 1983. John Wiley & Sons. UK

Fundamentals of Microbiology	**2+1**

Course Outline:

1. **Introduction**

a. History of microbiology
b. Microbes influencing our lives
c. Characterization and identification of microorganisms

2. **Virology**

a. Structure of virus, Characteristics of virus, Virus-host cell interaction
b. Viral replication, Transformation, Transmission of transforming viruses
c. Mechanism of pathogenicity; virus cultivation and propagation

3. **Morphology and fine structure of bacteria**

a. Size, Shape and arrangement of bacterial cells, motility, Capsules
b. Structure and composition of cell wall, Cytoplasmic membrane, Protoplasts, Endospore, pili

4. **Cultivation of Bacteria, Pure culture and growth characteristics**

a. Nutritional requirements, Nutritional types of bacteria
b. Bacteriological media, Physical conditions required for growth
c. Pure culture, Methods of isolating pure culture, maintenance and preservation of pure culture, Cultural characteristics

5. **Growth and Metabolism**

a. Growth of microbial population, measurement of microbial growth, growth rate, growth curve
b. Determination of number of cells by direct microscopic count, Plate count method, membrane filter count, Turbidimetric method
c. Determination of cell mass by measurement of growth

6. **Food and Medical Microbiology**

a. Microbial spoilage of foods, Food poisoning, Food infection
b. Factors effecting the spoilage of food (water, pH, oxygen, nutrients, physical structure of food), Botulism food poisoning, Mycotoxins
c. Food preservation (drying, refrigeration, irradiation, canning, pasteurization).
d. Sources and communicability of diseases, Communicable diseases, Non-communicable diseases
e. Chain of infection, Etiological agents, Specificity, Source and reservoirs of etiological agents, Methods of transmission

7. **Normal Microbial Flora and Microbial Ecology**

a. 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
b. Sterile sides of human body, Mechanism of bacterial pathogenicity
c. Distribution and activities of microorganisms in natural systems, Role of bacteria in elemental cycles
d. Plant interaction of microbial communities with their biotic and abiotic environment microbial role in global carbon cycle

8. **Soil, Air and Water Microbiology**

a. Soil environment, Microbial flora of soil, Bacteria, Fungi, Algae, Rhizosphere, Biogeochemical activities of microorganisms in soil
b. Microbial content of air, Indoor air, Outdoor air
c. Microbiology of sea, lakes and ponds, rivers and streams, Microbes of domestic water, Microbes of sewage water.

Practical:

1. Sterilization Techniques (Dry/Wet)
2. Media Preparation
3. Isolation of microorganisms from air, water, soil and plants
4. Microbial Characterization
5. Gram Staining
6. Endospore, flagellar and capsular staining
7. Microbial Count

Text and Reference Books:

1. Microbiology: An Introduction, 12th ed. (2018) by Gerard J. Tortora, Berdell R. Funke, Christine L. Case.
2. Prescott's Microbiology,10th ed. (2017) by Joanne Willey, Linda Sherwood and Christopher J. Woolverton.
3. Environmental Microbiology: Fundamentals and Applications: Microbial Ecology (2015) by Jean-Claude Bertrand, Robert Matheron, Pierre Caumette, Philippe Lebaron, Télesphore Sime-Ngando.
4. Jawetz, Melnick & Adelberg's Medical Microbiology (2015) by Barbara Detrick, James H. McKerrow, Jeffery A. Hobden, Judy A. Sakanari, Karen C. Carroll, Stephen A. Morse, Steve Miller, Thomas G. Mitchell and Timothy A. Mietzner.

5. Laboratory Experiments in Microbiology, 11th ed. (2015) by Ted R. Johnson and Christine L. Case.
6. Brock Biology of Microorganisms, 14th ed. (2014) by Michael T. Madigan, John M. Martinko, Kelly S. Bender, Daniel H. Buckley, David A. Stahl and Thomas Brock.
7. Alcamo's Fundamentals of Microbiology, 9th Ed., (2012) by Jeffrey C Pommerville.
8. Bergey's Manual of Systematic Bacteriology(2012).
9. Microbiology Principles and Explorations (2001) by Jacquelyn, G.G.

General and Comparative Endocrinology	**2+1**

Course Contents:

a. **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.

b. **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, corticotiophins and other pro-opiomelanocortin peptides; posterior pituitary: Release, regulation and actions of varopressin and oxytocin.

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

d. **Calciotrophic and mineral metabolism hormones:**
Chemistry, physiological actions and metabolism of parathyroid hormone, calcitonin and calciferols; Homeostasis of calcium, phosphate and magnesium.

e. **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.

f. **Adrenal medulla and catecholamines:**
Chromaffin cell and organization; Structure of adrenal medulla; Biosynthesis, storage, release and metabolism; Adrenergic receptors.

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

h. **Hypothalamic-Hypophysical-Gonadal axis in Reproduction:**
Hormonal and neuronal factors and their interactions in ovarian, testicular and other reproductive targets functions.

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

j. **Ovaries:**
Ovarian hormones: Steroid biochemistry and biosynthesis; Transport, metabolism and mechanism of action. The interactions in developments in estrous and menstrual cycles.
k. **Endocrinology of pregnancy:**
Hormones in conception and implantation; Hormonal actions and adaptation in pregnancy and parturition. The interactions in transitions from childhood to reproductive and post-reproductive states.
l. **Endocirnology of lactation:**
Hormones in lactation.
m**. Endocrinology of heart, kidney, immune system:** Growth and pineal gland.
n. **Functional diversity of hormones in vertebrates.**
o. **Overview of endocrine mechanisms in invertebrates.**
Study of hormones of invertebrates in concepts of growth, metamorphosis, reproduction and pheromones.
Title: Lab. General and Comparative Endocrinology
Demonstration of endocrine glands and associated structures in dissections, transparencies, computer projections etc. Histological and ultrastructure 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. Through flow chart to demonstrate the feedback mechanism of hormonal homeostasis.
Text Books:
1. Greenspan, F.S. and Strewler, G.J., 2011. Basic and clinical endocrinology, 9th Edition. Prentice Hall International Inc., London.
2. Bentley, P.J., 1998. Comparative Vertebrate Endocrinology. 3rd Ed. Cambridge University Press, Cambridge.
3. Sam A., Meeran K. Endocrinology and Diabetes. Lecture notes. Wiley-Blackwell (2009) (basic science and clinical context).
4. Laycock J, Meeran K. Integrative Endocrinology. Wiley-Blackwell (2013).
5. Rang H, Dale M and Ritter, J: Pharmacology, 4th ed., (1999). (relevant for drug information) 2nd Edition. The Oxford Textbook of Endocrinology and Diabetes DOI: 10.1093/med/ 9780199235292.003.0134
6. Yen & Jaffe's Reproductive Endocrinology: Physiology, Pathophysiology, and Clinical Management. Saunders – all editions are excellent (even the older editions)
7. Johnson MH. Essential Reproduction. 7th Ed. Wiley-Blackwell (2013)
(relevant for some general background info on reproduction pitched for undergraduate students).
8. Chandra S. Negi, introduction to endocrinology
9. Charles Brook, Nicholas Marshall, essential endocrinology
10. Noris, vertebrate endocrinology
Additional Readings:

1. Wilson, J.D., Foster, D.W., Kronenberg, H.M. and Larsen, P.R., 1998. Williams textbook of endocrinology, 9th Edition. W.D. Saunders Company, Philadelphia.
2. DeDroot, L.J., Jameson, J.L. *et al*., 2012 Endocrinology, Vol.I, II & III, th Edition. W.B. Saunders, Philadelphia.
3. Giffin, J.E. and Ojeda, S.R., 2000. 4th Edition. Textbook of Endocrine Physiology. Oxford University Press, Oxford.
4. Neal, J.M., 2000. Basic Endocrinology: An interactive approach. Blackwell Science Inc., London.
5. Knobil, E. and Neill, J.D., *et al*., 1995. The Physiology of Reproduction, Vol.1&2; 2nd Edition, Raven Press, New York.
6. Evert, B.J. and Johnson, M.H., 2000. Essential Reproduction, 5th Edition. Blackwell Science Inc., Oxford.

Ichthyology	**2+1**

Course Contents:

1. **Classification and distribution of freshwater fishes**

a. Systematic position of fish in animal kingdom

b. Distribution of various commercial and noncommercial fishes of Pakistan

2. **Morphology of fishes**

a. External features of fishes

3. **Coordination of fishes**

a. Fish muscular system, locomotion and energetics of swimming.

b. Physiology of respiration and air breathing among fishes.

c. Cardiovascular system,

d. blood and its circulation and hydromineral balance: Osmoregulation, ionic regulation, stress responses, freezing resistance and acid-base balance.

e. 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.

f. Gas in the gas bladder: Loss, retention and secretion of gas.

g. Process of aestivation in fish.

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

Practical:

1. Collection and identification of some freshwater and marine water fishes.

2. Dissection of fishes for studying anatomical features (Reproductive, Digestive, Respiratory and circulatory systems).

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.

Immunology	**2+1**

Course Outline:

1. **Introduction**

a. Introduction to immunity.
b. Immune response
c. Infectious agents

2. **Innate Immunity and Inflammation**

a. Sentinel cells and circulating leukocytes
b. Inflammatory events and signaling
c. The formation of pus

3. **Microbial Recognition and Responses in Innate Immunity**

a. Pattern recognition receptors
b. Innate immune signaling
c. The complement system

4. **Antibodies**

a. Blymphocytes
b. Antibody structure and function

5. **Lymphocyte Development and Diversity**

a. Lymphocyte development
b. Clonal selection and expansion
c. Differences between B and T lymphocytes
d. The generation of lymphocyte receptor diversity

6. **T Cell Activation by Antigens**

a. The role of dendritic cells
b. The lymphatic system and delivery of antigen to lymph nodes
c. Adaptive immune activation in secondary lymphoid tissues
d. Antigen presentation

7. **T Cell-Dependent B Cell Responses**

a. T Cell activation of B cells
b. Isotype switching and affinity maturation

8. **Helper T Cells**

a. Helper T cell functions
b. The role of helper T cells in disease

9. **Cytotoxic T Cells**

a. Cytotoxic T cell functions
b. Selection and expansion of cytotoxic T cells
c. Therapies that target cytotoxic T cell functions

10. **Failures of the Immune System**

a. Immunodeficiency
b. Autoimmune diseases
c. Allergic diseases

11. **Immunology-Based Therapy of Diseases**

a. Transplantation and transfusion

Practical:

1. Antibody Purification and Conjugation
2. Immunofluorescence
3. Gel Techniques
4. ELISA
5. SDS PAGE/Western blots.

Text and Reference Books:

1. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Molecular Biology of the Cell (5th ed. 2008, Garland)
2. Thomas J Kindt, Richard A Goldsby, Barbara A Osborne, Janis Kuby: Immunology (2003, Freeman).
3. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt Roitt: Roitt's Essential Immunology (12th ed. 2012, Blackwell)
4. Abul Abbas , Andrew H. Lichtman, Shiv Pillai. Cellular and Molecular Immunology , 9th edition, 2017. Elsevier Pub Co.
5. Gerd R. Burmester, Antonio Pezzutto Color Atlas of Immunology, 2006. Thieme Stuttgart, New York.

Limnology	**2+1**

Course Contents:

1. **Introduction and scope of Limnology**

a. Introduction, History and scope
b. Structure of aquatic ecosystems
c. Origin of lotic and lentic waters, and estuaries
d. Zonation
e. Thermal stratification
f. Eutrophication

2. **Properties of freshwater**

a. Physical properties of water (temprature, light, color, turbidity, conductivity); chemical properties of water (pH, oxygen, CO2, salinity, dissolved solids, trace elements, nitrogen, phosphorous and sulphur cycles)
b. Biological properties, plankton (phytoplankton, zooplankton)
c. Methodology for collection
d. Preservation and identification;
e. Planktonic adaptations and diurnal migration;
f. Factors affecting planktonic productivity

3. **Lake formation**

a. Lake formation and basin morphometry
b. Processes of Lake Eutrophication
c. Sedimentation and acidification
d. Biological productivity in lakes
e. Lakes of Pakistan
f. Lakes Conservation and Management.

Practicals:

1. Survey of lotic and lentic water bodies,
2. Water analysis of various types of inland water bodies,
3. Phytoplankton- methods of collection, identification, estimation of standing crop,
4. Study of temporary and permanent mounts of phytoplankton, Zooplankton collection, preservation and study of zooplankton mounts, Benthos collection
5. Collection, preservation and study of fauna and flora of various water bodies
6. Study of a lake ecosystem
7. Field visit to different Lakes.

Text Books:

1. Horne, A.J. and Golman, C. R. 2000. Limnology. McGraw-Hill. Science.
2. Wetzen, R. G. and Likens, G.E. 2000. Limnological Analysis. 3rd Ed. Springer-Verleg. New York.
3. Agarwal, S.C. 1999. Limnology. A.P.H. Public New Delhi.

Reference Books

1. Horne, A.J. and Golman, C. R. 2000. Limnology. McGraw-Hill. Science.
2. Wetzen, R. G. and Likens, G.E. 2000. Limnological Analysis. 3rd Ed. Springer-Verleg. New York.
3. Agarwal, S.C. 1999. Limnology. A.P.H. Public New Delhi.
4. Boyd, C.E. 2000. Water Quality in Ponds for Aquaculture. Auburn University, Alabama, USA.
5. Boyd, C.E. and Tucker, C.S. 2000. Water Quality and Pond Soil Analyses for Aquaculture. Auburn University, Alabama, USA.
6. Lamert.1997.. Limnology. Oxford. University, UK.Mishra, R. 2002.Fresh Water Environment. Anmol Publication Pvt. Ltd., New Delhi.
7. Kestin,S.C. and Warris, P.D. 2001.Farmed fish quality. Fishing News Books, Blackwell Science Ltd.
8. Kumar, A .2003. Aquatic Ecosystems. A.P.H. Publishing Corporation, New Delhi.

Mammalogy	**2+1**

Course Outlines:

a. **Introduction and history** of mammalogy; basic characteristics of mammals; diversified habitats for mammals in Pakistan and various continents.

b. **Mammalian phylogeny**; dentition and dental formulae, cranial characteristics, evolution of mammals. Concepts of viviparity and ovo-viviparity.

c. **Concept of biogeography**; mammalian radiations, biogeography of mammals of Pakistan, occurrence, habits and varied habitats, importance to ecosystems and negative values.

d. **Food and feeding strategies; preferred food sources** of mammals, foraging habits, diurnal and

e. nocturnal feeding regimes of mammals; ecological constraints and mammalian adaptations. Concepts

f. of stenophagy and euryphagy.

g. **Population dynamics of mammals; rates of natality, mortality, immigration and emigration**

h. **Population modeling concepts** in mammals; mammalian crowding and scuffles with respect to various environments.
i. **Communication and social organization**; chemical signaling in mammals, types and causes of occurrence, communication skills and emergence of mammalian call notes.
j. **Mammalian Adaptations**; concept of torpor formation, aestivation, hibernation, acoustic laterlis systems in mammals. Concept of molecular basis of mammalian adaptations.
k. **Behavior of mammals**; home range, territoriality, predation pressure, evolutionary arms races and competition for resources.

Practical:

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

Text and Reference Books:

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 Yor

Molecular Genetics	**2+1**

Course Outline:

1. **Introduction**
a. Genome organization of various organisms
b. DNA and RNA viruses.
c. Transposable Elements.
2. **Gene Regulation**
a. Gene regulation in Prokaryotes
b. Gene regulation in Eukaryotes
3. **Post Transcriptional Modifications**
a. Capping and Poly A tail addition
b. RNA splicing
c. RNA editing.
4. **DNA Damage**
a. Single strand break
b. Double strand breal
c. Oxidative damage
d. Pyrimdine dimer formation
5.**DNA Repair Mechanism**

a. BER
b. NER
c. Photo reactivation
6. **Study of Molecular Techniques**
a. Southern blotting
b. Western blotting
c. Northern blotting
d. RFLP
e. RAPDS
f. Microsatellite DNA

Practical:

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.

Text and Reference 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.
3. Molecular biology of the gene. Pearson Education. 2004.
4. Snyder, L. and W. Chapness. Molecular Genetics of bacteria. ASM, Press, 2003.
5. Lewin, B. Gene-VIII. Oxford University Press, Oxford, UK. 2004.

Neurobiology	**2+1**

Course Outline:

1. **Organization of the nervous system**
a. The organization of the nervous system; neurons, types of neurons, nerves
2. **Electrical signals of nerve cells**
a. Membrane permeability; Channels and transporters; Nerve Impulse
3. **Synaptic Transmission**;
a. Neurotransmitters; their receptors and effects; Intracellular signal transduction;
4. **Sensory somatic system**:
a. The somatic sensory system; Pain;
5. **Vision**
a. Vision; molecular basis of photoreception, central visual pathways; Neural basis of visual perception, types of eyes, photoreceptor and phototransduction, retinal circuits, visual cortex.
6. **Hearing**
a. Nature of Sound, The auditory system; the vestibular system; Lateral line organs and electroreceptor, The mammalian ear, the auditory nerve fibers. Brainstem auditory pathways, Auditory cortex.

7. **The chemical senses;**
a. Taste system, Olfactory system
8. **Motor Neurons/system**
a. Lower motor neuron circuits and motor control;
b. Upper motor neuron control of the brainstem and spinal cord;
c. Modulation of movement by the basal ganglia and the cerebellum;
d. Eye movements and sensory motor integration; the visceral motor system;
9. **Brain development**
a. brain development; construction of neural circuits; modification of brain circuits as result of experience; plasticity of mature synapses and circuits;
10. **Association Cortices**
a. The association cortices; Language and lateralization; sleep and wakefulness; emotions; sex, sexuality and brain; human memory.

Practical:

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

Books Recommended:

1. Neurobiology by Gordon M. Shepherd 3rd ed. ISBN-13: 978-0195088434, ISBN-10: 0195088433
2. The Neuroscience of Intelligence (Cambridge Fundamentals of Neuroscience in Psychology) Paperback – December 28, 2016 by Richard J. Haier
3. Brain & Behavior: An Introduction to Behavioral Neuroscience 5th Edition by Bob Garrett (Author), Gerald Hough 5th edition, ISBN-13: 978-1506349206, ISBN-10: 150634920X
4. Neuroscience ABCs: Human Brain Physiology Guide [Print Replica] Kindle Edition
5. by Robert Lavine (Author), Publications Staff National Institute of Mental Health (Author)
6. Beatty, J. (2001). The human brain. Sage Publications, Inc.
7. Conn, P. M. (1995). Neuroscience in medicine. J. B. Lippincott Co.
8. Haines, D, E. (1997). Fundamental Neuroscience. Churchill Livingstone. Inc.
9. FitzGerald,M.J.T and Jean Folan- Curran (2002).Clinical neuroanatomy and related neuroscience.Harcourt Publishers Limited.

10. Levitan, I. B. and Kaczmarek, L. K. (1997). The neuron: cell and molecular biology. Oxford University Press. Inc.
11. Matthews, G. G. (1998). Neurobiology. Blackwell Science.
12. Purves, D., Augstine, G. J., Fitzpatrick, D., Katz, L. C., LaManta, A-S., McNamara, J. O., Williams, S. M. (2001). Neuroscience. Sinauer Associates, Inc.
13. Shepherd, G. M. (1994). Neurobiology. Oxford University Press, Inc.
14. Revest, P. and Longstaff. (1998). Molecular neurosciences. BIOS Scientific Publishers. Ltd.
15. Rafael Yuste and Arthur Konnerth (2005). Imaging in neuroscience and development a laboratory manual. Cold spring Laboratory press.

Ornithology	**2+1**

Course Outlines:

a. **Introduction** to ornithology; basic ecology and themes of study.
b. **Classification and taxonomy** of birds up to orders and species
c. **Evolution** of birds; evolution of bird flight, aerodynamics and aerial movements. Bird ancestry; development of feathers, types and their structure; plumage analysis.
d. **Biology of fossil birds**; study of the representative birds viz. *Archaeopteryx, Archaeornithes* and *Neoornithes*. Comparison with the present existing birds.
e. **Behavioural studies of birds**: song and sound dialects in birds; types of songs; preferred season and time for bird pleasure calls; distress calls. Courtship behavior in birds, bird foraging, nesting and roosting activities. Learned and imprinting mechanisms in birds; brood parasitism and importance.
f. **Predator**-Prey relationships, mobbing impacts; foraging and territoriality scuffles; predator avoidance.
g. **Physiology of birds**: types of food; mastication; digestion; metabolism, skeletal system; circulatory and nervous system. Role of kidneys in birds.
h. **Bird conservation strategies**; sanctuaries and importance of urban zoos in bird life.

Practical:

1. Identification characteristics and taxonomy of birds to orders and families.
2. Dissection of sparrow, pigeon or common myna.
3. Study of gut contents of birds to assess their feeding habits.
4. Bird watching and preparation of ethograms

Text and Reference Books:

1. Howell, S. N. G. (2010). Peterson Reference Guide to Molt in North American Birds (Peterson Reference Guides. Amazon Co.
2. A.J.Urfi (2009). Birds of India: A Literary Companion, OUP.
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. Kaiser, G. W. (2008). The Inner Bird: Anatomy and Evolution. Amazon Co.
5. *Handbook of Bird Biology* (2014). Cornell Lab. Ornithology. Princeton University Press. New Jersey, USA.

Pathological Endocrinology	**2+1**

Course Outline:

Introduction:
The Endocrine system provides a critical means of communication within the body and maintains a constant internal environment in the face of an ever-changing external environment. It is thus essential for survival and adaptation throughout life and plays a key role in the balance between health and disease. Endocrine study is obtain transferable skills essential for academic success and future careers: these include writing good science; searching, storing and understanding the literature; data interpretation and critical analysis will develop these skills in the context of basic and clinical science relating to endocrinology: this focuses on the essential elements of the hypothalamic-pituitary endocrine axes and communication pathways between the brain and periphery which underpin basic endocrine concepts and their clinical significance.

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, immunoradiometeric, immunochemiluminometeric 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, cortiophin regulation; Pituitary Disorders: Prolactinomas, acromegaly, Cushing's syndrome. Diabetes inspidus, 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, anroxia 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. Overview of the clinical states in endocrine gland and molecular aspects in their diseases with details of model studies in thyroid diseases, diabetes, obesity and lipid metabolism. Endocrine-Responsive Cancer. Humoral Manifestations of Malignancy.

Lab. Clinical and Pathological Endocrinology

Credit Hour: 1

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

Textbook:

1. Greenspan, F.S. and Strewler, G.J., 2002. Basic and clinical endocrinology, 5th Edition. Prentice Hall International Inc., London.

Additional Readings:

1. Wilson, J.D., Foster, D.W., Kronenberg, H.M. and Larsen, P.R., 1998. Williams textbook of endocrinology, 9th Edition. W.D. Saunders Company, Philadelphia.

2. DeDroot, L.J., Jameson, J.L. *et al*., 2001. Endocrinology, Vol.I, II & III, 4th Edition. W.B. Saunders, Philadelphia.

3. Giffin, J.E. and Ojeda, S.R., 2000. 4th Edition. Textbook of Endocrine Physiology. Oxford University Press, Oxford.

4. Neal, J.M., 2000. Basic Endocrinology: An interactive approach. Blackwell Science Inc., London.

Planktology	**2+1**

Course Outlines:

Introduction

a. Methods of collection and Preservations,
b. Types of plankton on the basis of the size,
c. Distribution, food and life cycle.
d. Meroplankton, Holoplankton: " R" selected species and " K" selected species.

Planktonic organisms and Larval stages

a. Bacterioplankton, Protists, Porifera
b. Cnidarians, Ctenophora,
c. Helminthes, Polycheata,
d. Crustacea, Mollusca
e. Echinodermata, Chaetognatha,
f. Protochordates and Pisces.

Diel Bathymeteric migration

a. Diurnal vertical migration, Theories and factors.
b. Factors that influence the distribution of Zooplankton:
c. Predation, Reproduction, Community interactions,
d. PH, heavy metals, Calcium and Aluminum,
e. Hydrographic indicator species,
f. Plankton spectrography,
g. Organic production mass morality and behavior,
h. Bioluminiscence,

i. Economic importance of Plankton, Phytoplankton and Zooplankton relationship, Adaptation factors of Zooplankton.

Communities of Zooplankton

a. Biomass and abundance of zooplankton communities,

b. Nutrients like nitrogen and Phosphorus affect on the prey of Zooplankton: Algae, Protozoa, Bacteria;

c. Mortality ,

d. Physical and Biological controls: Competition, , food, supply, availability of places, seasonal variation.

Practicals:

1. Nets and Gears.
2. Collection of Plankton.
3. Preservatives of Planktonic samples.
4. Sorting and Plankton.
5. Identification and analysis of plankton samples taken at regular intervals from the coastal Areas of Arabian Sea.
6. Permanently stained slide preparation and staining techniques.

Books Recommended:

1. Iain M. Suthers ,2009 Plankton: A Guide to Their Ecology and Monitoring for Water Quality 256 pages

2. Christian Sardet, 2015 Plankton: Wonders of the Drifting World 219 pp

3. A.C. Pierrot. Bults, S. Van Der Spoel. 1981 Zoogeography and Diversity of Plankton.

4. Cristopher D. Todd, M, S. Laverack , Geoff Boxshall, 1996. Coastal Marine Zooplankton A practical manual for students.

5. De Boyd. L. Smith and Kevin B. Johnson , 2003. A guide to Marine coastal Plankton and Marine Invertebrates larvae.

6. Fincham, A.A. 1984. Basic marine Biology. British Museum (Natural History) Cambridge University Press.

7. Hardy, Sir. A. 1971. The open sea: Its natural history. The World of plankton: 335 Collins (New Naturalist).

8. John. E.G. Raymont, 1983. Plankton and productivity in the Oceans.

9. Zooplankton. Vol.2.

10. John Wickstead, 1976. Marine Zooplankton.

11. Makoto Omori, 1991. Methods in Marine Zooplankton Ecology.

12. Newell, G.E. and R.C; 1977. Marine plankton. A practical guide: 244. Hutchinson.

13. Roger Harris, 2000. ICESS: Zooplankton Methodology Manual.

14. Sverdrup, H.U.M.W. Johnson and R.H. Fleming 1961. The Oceans.

15. UNESCO; 1976. Zooplankton fixation and preservation Monographs on Oceanography Methodology, No.4.

Principles of Fish Biology	**2+1**

Course Contents:

1. **Systematic:** Identification of fishes up to; Families; Order; Genus; Species.

2. **Fish morphology:** Head (size, shape, and orientation); Scales (types, arrangements, coloration, scale less fishes); Operculum; Fins, fin rays andfin spine (dorsal, pectoral, caudal, anal); Barbel (upper lip barbels, lower lipbarbels).
3. **Anatomy:** Skeleton (skull, backbone, spines); Brain and spinalcord; Gills (Number, size, arrangements);Vital organs (heart, liver, kidney);Viscera and mesenteries (swim bladder, stomach, spleen, pancreas, intestine, gonads).
4. **Feeding groups of fishes**; Herbivore; Plankton eater; Larvivore; Carnivore; Voracious.
5. **Ecology of fishes:** Freshwater; Brackish water; Marine water.

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.
4. Studying quality of various water bodies.

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.

Reproductive Biology	**2+1**

Course Outline:

a. Introduction

a. Reproductive Biology Around Us – Overview

b. Anatomy of female reproductive system

c. Anatomy of male reproductive system

d. Reproductive Endocrinology

e. **Pituitary and hypothalamus**

6. **Reproductive cycles**

a. Puberty and seasonality of breeding

b. Estrous cycle and menstrual cycle

- **Disorders of sexual development**
- **Folliculogenesis**
- **Spermatogenesis**
- **Fertilization and early embryonic development**
- **Implantation and placentation**
- **Parturition & Post-Partum recovery**
- **Obesity & Reproduction**
- **Regulation of Fertility in Humans**
- **Reproductive Aging**
- **Lactation**

 Addictions & Reproduction
 Endocrinology of Stress in Reproduction
 Course wrap up

Practical:

7. Demonstration of male reproductive organs in vertebrates.
8. Demonstration of female reproductive organs in vertebrates.
9. Histological studies of ovaries
10. Histological studies of testes
11. Histological studies of endocrine gland

Text and Reference Books:

1. Pathways to Pregnancy and Parturition by P. L. Senger. 3rd edition (2012). Published by Current Conceptions Incorporated USA.
2. Andrology by E. Nieschlag, H. M. Behre and S. Nieschlag**.** 3rd edition (2010). Published by Springer, USA.
3. Knobil & Neill's Physiology of Reproduction by *T. M. Plant and A. J. Zeleznik*. 4th edition (2014). Published by Springer, USA.
4. Endocrinology: Adult and Pediatric (Vol II) by J. L. Jameson and L. J. De Groot. 7th edition (2015). Published by Elsevier - Health Sciences Division.

Restoration Ecology and Sustainable Development	**2+1**

Course Outline:

1. Introduction to ecological restoration

a. What is Ecological Restoration
b. Role of restoration ecology in conservation
c. Ecological disturbance and impairment
d. Challenges to ecological restoration

2. Practices in Restoration of different environments

a. Steps in designing and implementing ecological restorations
b. Restoration of damaged ecosystems (marine, wetlands and terrestrial) and endangered populations
c. Management of species invasions
d. Local, national and international legislations that drive restoration practices.
e. Animal Reintroduction

3. **Protected Areas Management:**

a. Existing protected areas and their effectiveness
b. Designing protected Areas: minimizing edge and fragmentation effects, habitat corridors, landscape ecology.
c. Managing protected areas: Habitat and species management, management of people.
d. Managing biodiversity outside protected areas.

4. **Conservation and Sustainable Development:**

a. What is Sustainable Development?
b. Traditional societies and sustainable development;
c. Conservation ethics of traditional societies,

d. Biological diversity and cultural diversity,
e. Conservation efforts involving traditional societies.
f. International approaches to conservation and sustainable development:
g. Ecotourism for sustainable development

Practicals:

1. Visits to the national parks of Pakistan and report writing.
2. To study and review the threats to regional biodiversity.
3. To study the effectiveness of different In-situ and Ex *situ* conservation strategies for the ecological restoration in Pakistan.

Text and Reference Books

1. Galatowitsch, 2012. Ecological Restoration, Sinauer Associates, Sunderland, MA.
2. Howell et al. 2012. Introduction to Restoration Ecology. Island Press, Washington.
3. Van Andel, J. and J. Aronson. 2006. Restoration ecology. Blackwell Science Publishing, Oxford, UK.
4. Groom, M.J., G.K. Meffe and C.R. Carroll, 2006, Principles of Conservation Biology, 3rd edition, Sinauer Associates, Sunderland, MA.
5. Falk, D. A., M. A. Palmer, and J. B. Zedler. 2006. Foundations of restoration ecology. Island Press, Washington, USA.
6. Jordan, W. R., M. E. Giplin, and H. J. D. Aber, editors. 1987. Restoration ecology: a synthetic approach to ecological research. Cambridge University Press. Cambridge, UK.

Taxidermy	**2+1**

Course Outline:

1. Introduction

a. Definition
b. scope and importance; daily life, hobby, zoos, wildlife, sport hunting and science (natural history museums)

2. **Materials and equipment**

a. Chemicals and solutions
b. Skinning and mounting tools

3. **Techniques**

a. Skinning
b. Dehydration
c. Tanning
d. preparing and mounting of reptiles, birds and mammals
e. mounting of heads of mammals (deer, markhoretc)
f. mounting of skeletons
g. resin embedding
h. preparation of head casts.

4. Transportation and status

a. Laws of transportation of skins across the continents
b. Status of taxidermy in the modern time today
c. Alternatives of taxidermy.

5. **Wet preservation**

a. Materials and methods
b. Pinning
c. Curation of stuffing
d. Mountings
e. Wet materials preservatives for different specimens.

Practicals:

1. Complete mounting of a small mammal specimen (domestic or wild, as is convenient)
2. Complete mounting of a bird
3. Practical demonstration of resin embedding (videos may be shown in support)
4. Wet preservation demonstration through different invertebrate and vertebrate specimens
5. Study trip to a place taxidermy is done by skilled professionals (Pakistan Museum of Natural History Islamabad or as is convenient)

Books Recommended:

1. Pray, L.L. (1943). Taxidermy. The Macmillan Company.
2. Simpkins, J. (1974). Techniques of biological preparations. Blackie and Sons Limitted, Bishopbrigs, Glasgow G64 2NZ.
3. British Museum (Natural History), Instructions for Collectors No 1 Mammala and No 2 Birds.
4. Wagstaffe, R. and Fidler, J.H. (1968). The preservation of natural history specimens Volume Vertebrates. Witherby. Video presentations from youtube can be helpful.

Teratology	**2+1**

Course Outline:

1. Introduction to teratology

a. Teratology: an overview
b. Impact of Planned and Unplanned Pregnancy on teratological development
c. Mechanism of teratogenesis

2. Effect of Ionizing radiations

a. Atomic bomb survivors in Japan
b. Impact of radiation before or immediately after implantation of the embryo into the uterine wall
c. Higher doses of radiation during all stages of intrauterine development

3. Hypoxia, hyperthermia and industrial exposure

a. Activation of stress protein
b. *Hypoxic exposure* impact on during chorio-vitalline membrane development

4. Teratogenic effects of substances of abuse

a. Ethanol
b. Heroin
c. Cocaine and heavy smoking

5. Effects of maternal infections in pregnancy

a. Zika virus
b. Rubella

c. Toxoplasmosis

6. Effects of maternal diabetes on the developing embryo and fetus

7. Effects of systemic lupus erythematosus (SLE) and other autoimmune diseases and effects of anemia during pregnancy

8. Impact of various medications on development

a. Antiepileptic drugs

b. Anticancer drugs

c. Antithyroid medicines

d. Psychoactive medication

Text and Reference Books:

1. Berry, C.L and Poswillo, D.E. (2014). Teratology: Trends and Applications. Springer Verlag, New York, Heidelberg

2. Ronan R. O'Rahilly and Fabiola Müller. (2001). Human Embryology & Teratology, Wiley-Liss Publishers 3rd EditionISBN-13: 978-0471382256

3. Naira R. Matevosyan. (2017). Lectures in Teratology. CreateSpace Independent Publishing Company New York: ISBN-13: 978-1548510381

4. Scott F. Gilbert and Michael J. F. Barres. (2016).Developmental Biology. Sinauer Associates, Sunderland, MA.

5. Rogers, J.M., Kavlock, R.J. (1996). "Developmental toxicology". In C.D. Klaassen (ed.): *Casarett&Doull's Toxicology*, (5th ed.). p.301-331. New York: McGraw-Hill. ISBN 0-07-105476-6.

6. ThallBastow, B.D, Holmes, J.L. (2016)."Teratology and drug use during pregnancy".*Medscape*. WebMD. Retrieved 24 February 2016

Vector biology	**2+1**

Course Outline:

1. **Vector Biology and Control**

a. Key aspects of vector taxonomy

b. Evolution

c. Biology and Behavior.

2. **An introduction to the life-cycles of vectors**

a. Ecology

b. Role in transmission of various diseases

3. **Major groups of arthropod-borne pathogens and vectors**

a. Basic components of arbopathogen disease cycles

b. Principles of pathogen transmission dynamics

4. **Emergent pathogens**

a. Vector genetics

b. Vaccines for vector-borne disease

c. Traditional and modern disease control strategies

d. Venomous Arthropods.

5. **Biology and Ecology of some vectors of medical importance (order Diptera)**

a. Mosquitoes (*Anopheles culicine*), Black flies sand flies, biting midges, horse flies, deer flies and clegs, tsetse flies, house flies, myiasia producing flies (blow flies, blue bottles, green bottles, flesh flies, warable flies and bot flies).
b. Morphology, anatomy, distribution, breeding habits, life-cycle and seasonal prevalence of the species
c. Brief account of diseases spread by these vectors
d. Methods of control
e. Modern trends in their biological and chemical control.

Text and Reference Books:

1. 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.
2. Hoy, M.A.2000. Insect Transgenesis: Methods and Application. CRC Press.
3. Pedigo, L. P. 2003. Entomology and Pest Management. 4th ed. Pearson Education, Singapore, Pvt. Ltd.
4. Roy, D. N. and Brown, A.W.A .2004. Entomology. Biotech .Books,
New Delhi.
5. Peter, W. Atkinson., 2010. Vector Biology, Ecology and Control.Springer Dordrecht Heidelberg, London, New York.
6. William, H. Marquardt, *et al.,* 2004. Biology of Disease Vectors.2nd Edition.
7. William Charles Marquardt, Richard S. Demaree, Jr., Robert Burton Grieve., 2000. Parasitology & Vector Biology.2nd Edition.

Wildlife Parasitology	**2+1**

Course Outline:

1. An overview of Wildlife in Pakistan
2. Parasites of wild animals and birds
3. Role of wild animals and birds in dissemination of parasitic disease of domestic animals and man
4. Pathogenesis
5. Diagnosis and control of ecto and endo-parasites of wild animals and birds.

Text and Reference Books:

1. Fowler, M.E., 1990. Zoo and Wild Animal Medicine Current Theraphy Saunders, W.B. Company, Philadelphia, USA.
2. Levine, N.D., 1990. Veterinary Protozoology. The lowa State University press. Ames, Lowa, USA.
3. Soulsby, E.J.L., 1986 Helminths. Arthropods. And Protozoa of Domesticated Animals. 7th Ed. Bailliere and Tindall, London.
4. Davis, J.W. and R.C. Anderson. 1971. Parasitic Disease of wild Mammals, The lowa State University Press, Amess, USA.

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ANNEXURE-E

Approval of the courses of study for MPhil / MS Zoology

The following compulsory and optional subjects of MPhil are suggested for approval. There will be no option in compulsory subject. The department will offer courses in each semester as per available subject experts.

Course Category	**Course Code**	**Course Title**	**Cr. Hrs.**	**Semester**
Compulsory	ZOO-711	Advanced Biological Techniques	3(3+0)	I/II
Compulsory	ZOO-712	Applied Biostatistics	3(3+0)	I/II
Uni. Option	ZOO-713	Advanced insect Ecology	3(3+0)	I/II
Uni. Option	ZOO-714	Advance Mammalogy	3(3+0)	I/II
Uni. Option	ZOO-715	Advances in Cancer Biology	3(3+0)	I/II
Uni. Option	ZOO-716	Advances in Ecology	3(3+0)	I/II
Uni. Option	ZOO-717	Advanced Enzymology	3(3+0)	I/II
Uni. Option	ZOO-718	Advanced Instrumental Techniques	3(3+0)	I/II
Uni. Option	ZOO-719	Advanced Molecular Genetics	3(3+0)	I/II
Uni. Option	ZOO-720	Advanced Ornithology	3(3+0)	I/II
Uni. Option	ZOO-721	Advanced Physiology	3(3+0)	I/II
Uni. Option	ZOO-722	Advanced Aquaculture	3(3+0)	I/II
Uni. Option	ZOO-723	Advances in Bioinformatics	3(3+0)	I/II
Uni. Option	ZOO-724	Advances in Cell Biology	3(3+0)	I/II
Uni. Option	ZOO-725	Advances in Forensic Biology	3(3+0)	I/II
Uni. Option	ZOO-726	Advances in Helminthology	3(3+0)	I/II
Uni. Option	ZOO-727	Advances in Immunology	3(3+0)	I/II
Uni. Option	ZOO-728	Advances in Research	3(3+0)	I/II

		Methodology		
Uni. Option	ZOO-729	Aerosol and Environmental Health	3(3+0)	I/II
Uni. Option	ZOO-730	Applied Entomology	3(3+0)	I/II
Uni. Option	ZOO-731	Animal Physiology	3(3+0)	I/II
Uni. Option	ZOO-732	Applied Genetics	3(3+0)	I/II
Uni. Option	ZOO-733	Applied Microbiology	3(3+0)	I/II
Uni. Option	ZOO-734	Applied Parasitology	3(3+0)	I/II
Uni. Option	ZOO-735	Applied Reproductive Physiology	3(3+0)	I/II
Uni. Option	ZOO-736	Apiculture	3(3+0)	I/II
Uni. Option	ZOO-737	Aquaculture	3(3+0)	I/II
Uni. Option	ZOO-738	Aquaculture and Fisheries	3(3+0)	I/II
Uni. Option	ZOO-739	Aquaculture Biotechnology	3(3+0)	I/II
Uni. Option	ZOO-740	Biological Toxicology	3(3+0)	I/II
Uni. Option	ZOO-741	Biology of Ornamental fish and aquaria management	3(3+0)	I/II
Uni. Option	ZOO-742	Cancer Genetics	3(3+0)	I/II
Uni. Option	ZOO-743	Chemical Oceanography	3(3+0)	I/II
Uni. Option	ZOO-744	Clinical Immunology	3(3+0)	I/II
Uni. Option	ZOO-745	Clinical Teratology	3(3+0)	I/II
Uni. Option	ZOO-746	Conservation Biology	3(3+0)	I/II
Uni. Option	ZOO-747	Conservation Biology of Wildlife	3(3+0)	I/II
Uni. Option	ZOO-748	Desert Zoology	3(3+0)	I/II
Uni. Option	ZOO-749	Ecotourium Planning and management	3(3+0)	I/II
Uni. Option	ZOO-750	Fish and Aquatic Toxicology	3(3+0)	I/II

Uni. Option	ZOO-751	Fish Breeding and hatchery management	3(3+0)	I/II
Uni. Option	ZOO-752	Fish Nutrition and Health	3(3+0)	I/II
Uni. Option	ZOO-753	Fish Requirements	3(3+0)	I/II
Uni. Option	ZOO-754	Fish Parasitology	3(3+0)	I/II
Uni. Option	ZOO-755	Fish Processing and value addition	3(3+0)	I/II
Uni. Option	ZOO-756	Fisheries Extension Education	3(3+0)	I/II
Uni. Option	ZOO-757	Fishing Gear Technology	3(3+0)	I/II
Uni. Option	ZOO-758	Forensic Entomology	3(3+0)	I/II
Uni. Option	ZOO-759	Freshwater Biology	3(3+0)	I/II
Uni. Option	ZOO-760	Gene Therapy	3(3+0)	I/II
Uni. Option	ZOO-761	Genomics and proteomics	3(3+0)	I/II
Uni. Option	ZOO-762	Herpetology	3(3+0)	I/II
Uni. Option	ZOO-763	Human Genetics	3(3+0)	I/II
Uni. Option	ZOO-764	Industrial Biotechnology	3(3+0)	I/II
Uni. Option	ZOO-765	Insect Toxicology	3(3+0)	I/II
Uni. Option	ZOO-766	Lac Insects	3(3+0)	I/II
Uni. Option	ZOO-767	Medical Entomology	3(3+0)	I/II
Uni. Option	ZOO-768	Medical Virology	3(3+0)	I/II
Uni. Option	ZOO-770	Mericulture Technology	3(3+0)	I/II
Uni. Option	ZOO-771	Molecular Evolution	3(3+0)	I/II
Uni. Option	ZOO-772	Molecular Immunology	3(3+0)	I/II
Uni. Option	ZOO-773	Principles of aquaculture	3(3+0)	I/II
Uni. Option	ZOO-777	Recombinant DNA Technology	3(3+0)	I/II
Uni. Option	ZOO-775	Reproductive Physiology	3(3+0)	I/II
Uni. Option	ZOO-776	Research Methods in	3(3+0)	I/II

		Entomology		
Uni. Option	ZOO-777	Sericulture	3(3+0)	I/II
Uni. Option	ZOO-778	Toxicology	3(3+0)	I/II
Uni. Option	ZOO-779	Vaccinology	3(3+0)	I/II
Uni. Option	ZOO-780	Wetlands Management	3(3+0)	I/II
Uni. Option	ZOO-781	Wildlife Conservation and Management	3(3+0)	I/II
Uni. Option	ZOO-782	Wildlife of Pakistan	3(3+0)	I/II
Compulsory	ZOO-811	Seminar	2(2+0)	III / IV
Compulsory	ZOO-812	Research and Thesis	6(0+6)	III & IV
Total Credits=32 (Flexible from 30 to 36)				

Detail of MPhil Courses

ZOO-711	**ADVANCED BIOLOGICAL TECHNIQUES**	3.0

Course Outlines:

UV Spectroscopy/Separations, Flame Atomic Absorption Spectroscopy, Spectrofluorimetry, Thin Layer Chromatography (TLC), Gas Chromatography, High Performance Liquid Chromatography (HPLC), Amino acid sequencing, Blotting techniques, Centrifugation techniques, PCR, DNA Sequencing, Electrophoresis, Isoelectric Focusing Apparatus, Lyophilizer, Microarray Technology, Microscopy, Microtomy, Nuclear Magnetic Resonance Instrument, principles and application, Geographic Information Systems and Remote sensing, ELISA, Cell culture.

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.

ZOO-712	Applied Biostatistics	3.0

Course Outline:

Descriptive statistics: Measure of central tendency and dispersion, frequency distribution, data representation using tables, graphs and charts. Probability: Concept, definition and types of probability, Bayes theorem. Distribution and confidence

interval: The Binomial distribution, the Poisson distribution, the normal distribution and 95% confidence interval for mean. Sampling Technique: Population, sample, different sampling techniques Hypothesis testing: Introduction to hypothesis, one and two samples testing, interpretation of P-value, ANOVA and multiple comparisons, non-parametric testing, chi-square test of independence. Correlation and regression: Concept and type of correlations and association, simple and multiple linear regressions.

Reference Books

Zar, J.H.(2003) Biostatistical Analysis, Fourth Edition, Pearson Education (Singapore) Prentice Hall International (UK) Limited. London, UK.

Muhammad F., 2000 Statistical Methods and Data Analysis, Kitab Markaz, Bhawana Bazar Faisalabad, Pakistan.Choudhry, M. R.(2001). Modern Statistics (Vol-I & II). Polymer Publications, Urdu Bazaar, Lahore. Steel, R. G. D, J. H.

Dickey, D.A (1997) Principles and Procedures of Statistics A Biometrical Approach Third Edition. WCB Mc. Graw Hill, New York, USA

ZOO-713	. **Advance insect ecology**	3.0

Course Outline:

Scope of Insect ecology.

a. Introduction to insect ecology: Insects in ecosystems, Adaptations of Insects, Life history strategies.

b. Responses to abiotic conditions.

c. Resource acquisition.

d. Insects and Landscape: affects of landscape modification on insects.

e. Insects and Climate: affects of climate change on insect species, Insect invasions & climate change.

f. Biodiversity: Insect conservation, Insect extinctions.

g. Insect populations: Population Dynamics, Population sampling methods.

h. Insect communities: Community Interactions: (1) Insect-plant interactions, Plant defenses and insect counter-defenses, Insect herbivores, Natural Enemies of insect herbivores with emphasis on Ichneuomonidae and Braconidae, Insect defenses against enemies (2) Predator-prey interactions (3) host-parasite interactions (4) Mutualisms (5) Pollinators-plant interactions: co-evolution of plants & pollinators (6) Insect and pathogens (7) Ecology based Insect pest management.

i. Behavioral ecology: Social organization in insects, Insect communication, Insect societies (with emphasis on societies of ants, termites and bees).

Practical:

1. Sampling methods
2. Diversity Indices
3. Density estimates
4. Field surveys

Text and Reference Books:

1. Schowalter, T.D., 2017. Insect Ecology: An Ecosystem Approach. Academic Press.633pp.
2. Price, P.W., Denno, R.F., Eubanks, M.D., Finke, D.L., and Kaplan, I., 2011. Insect Ecology: Behavior, Populations, and Communities. Cambridge University Press.
3. Speight, M.R., Hunter, M.D., & Watt, A.D. (2008). Ecology of Insects: Concepts and Applications. Wiley-Blackwell.
4. Denno, R. F. and Eubanks, M. D. 2011. Insect Ecology: Behavior, Populations and Communities. Cambridge University Press, New York.USA.
5. Gullan, P. J. and Cranstan, P. S., 2014. The Insects: An Outline of Entomology. 4th edition. Wiley-Blackwell. A John Wiley & Sons, Ltd., Publication, UK.
6. Ambrose, D.P., 2015. The Insects: Structure Functions and Biodiversity. Kalyani publishers, Ludhiana, India.
7. Rockwood, L.L. 2006. Introduction to Population Ecology. Wiley, John and Sons.
8. Bourtzis, K. and Miller, T. 2003. Insects Symbiosis. CRC Press.
9. Vandermeer, J.H. and Goldberg, D.E. 2003. Population Ecology: First Principles, Princeton University Press.
10. Southwood, T.R.E. and Henderson, P.A. 2000. Ecological Methods. 3rd Ed. Blackwell Science.
11. Grimaldi, D. and Engel, M.S. 2005. Evolution of Insects. Cambridge University Press.

ZOO-714		**Advance Mammalogy**	3.0

Course outline:

a. Mammals of Pakistan

a. Introduction
b. Important Definitions
c. Descriptions
d. Identification
e. Characteristics
f. Origin and Classification
g. Distribution
h. Status

b. Mammalian Behavior and Ecology.

c. Evolution and dental characteristics

d. Mammalian structure and function

a. Provincial Rules
b. Federal Management of Wildlife (NCCW)

e. Mammalian reproductive physiology: Adaptive responses tochanging environments.

a. Introduction
b. Environmental constraints on Mammalian Reproduction
c. Mammalian responses to Environmental Information

f. Environmental adaptations for mammals

g. Selection and Survival

h. Habitat selection and Migration
i. Mammalian conservation
Practicals:
1. Methods for studying mammals
2. Trapping and marking
3. Observational methods
4. Laboratory and museum methods
5. Systematic methods
Books Recommended:
1. Feldhammer, G.A., Drickamer, L.C., Vessey, S.H., Merritt, J.F. and Krajewski 2007. Mammalogy, Adaptation, Diversity, Ecology 3rd ed. The Johns Hopkins University Press, Baltimore.
2. Vaughan, T. A., Ryan, J. M. and Czaplewski, N.J. 2000. Mammalogy 4th ed. Brooks/cole Thomson learning, USA.
3. Davis, David 1963. Principles of Mammalogy
4. Gelder, 1969 Biology of Mammals. Reinhold Publishers Corporation, New York.
5. Miller and Harly, 1999. Zoology (4th Edition). McGraw Hill, New York.
6. Hickman, Roberts, and Larsen, 2001, Integrated principles of Zoology (11th Edition). McGraw-Hill, New York.
7. Genoways, H. H., 1987. Current Mammalogy. Springer Science+ Business Media, LLC

ZOO-715	Advanced Cancer biology	3.0

Course Outline:
1. **Introduction**
a. Introduction of Cancer
b. General features and types of cancers,
c. The nature of Cancer,
d. Arise of Cancer from normal and specialized cells.
e. Monoclonal growth of tumor cells.
f. Physical and chemical carcinogens
g. Mutagens causing cancers.
2. **Tumor Viruses**
a. RNA viruses
b. DNA Viruses causing cancer.
c. Transformation of cells by tumor viruses.
3. **Cellular oncogenes:**
a. Oncogenes in the cell
b. Proto-oncogenes,
c. Activation of proto-oncogenes,
d. myc oncogene
4. **Growth factors, Receptors, and Cancer**

a. Receptors and their ligands,
b. Growth factor genes,
c. EGF receptor,
d. TGF
5. **Signaling Circuitry programs**
a. Introduction to signaling pathway,
b. The Ras protein
c. Tyrosine phosphorylation
d. Cascade of kinases.
6. **Cell Cycle**
a. Cell cycle,
b. Cell cycle regulation,
c. Tumor suppressor genes,
d. Apoptosis.
e. Significance of apoptosis
f. Extrinsic and Intrinsic apoptosis.

Practical:

1. Study of prepared slides of cancer cells,
2. Slides showing conversion of epithelia in to metaplastic/ hyperplastic/dysplastic conditions.

Text and Reference Books:

1. Zhang, W., & Fuller, G. N. (Eds.). (2004). Genomic and Molecular Neuro-Oncology. Jones & Bartlett Learning.
2. Cooper, G. M. (1995). Oncogenes. Jones & Bartlett Learning.
3. Hicky, R., Clark, R. L., & Cumbley, R. W. (1986). Year book of cancer. Chicago: Year book.
4. Weinberg, R. (2013). The biology of cancer. Garland science.
5. Hejmadi, M. (2009). Introduction to cancer biology. Bookboon.

ZOO-716	**Advanced Ecology**	3+0

Course Outlines (contents):

a. **Basic themes of ecology;** types of ecology, ecosystem classification, terrestrial, freshwater, desert and marine. Organismal ecology including the protists and invertebrates with their classification and characteristics.

b. **Aquatic Environment**: water cycle and its properties, role of light in aquatic environments; water as solvent; dissolved oxygen contents, acidity and water movements and water balance.

c. **Terrestrial ecosystems:** biogeo-chemical cycles in environment, role of forest plantations, types of forests; tropical, tropical-rain forests and coniferous forests to house animals fauna.

d. **Animal adaptations:**Animal adaptations to the environment role of temperature in maintenance of animals, life history patterns, nutritional constraints and animal development.

e. **Climate changes:** global wind circulation, precipitation, ocean currents, regional climates, microclimates and their effects on animals. Animal survival values and adaptations to climate changes in various environments.

f. **Population trends:** animals surviving in various environments, factors affecting growth rates, causes of mortality, natality and logistic equations to explain their sustainability.Concepts of animal tussles; intra and inter-specific competitions.

g. **Community Dynamics**: primary and secondary succession; landscape ecology and its importance. Ecosystem energetics and concept of bioenergetics in ecology.

h. **Habitat Loss;** fragmentation ecology, biodiversity values and loss, conservation strategies in environments in response to restoration ecology**.**

Practical:

1. Field visits for assessment of animal communities in variable habitats.
2. Ecological techniques to learn sampling methods for animals' viz. mark-recapture methods, landscape analysis.
3. Forecasting methods in landscape ecology
4. Importance of radio-telemetry techniques to determine animal community populations.

Text and Reference Books:

1. Molles, M.M. 2015. Ecology; Concepts and Applications. McGraw-Hill Books; Inc., New Mexico, USA.
2. Bonan, G. 2015. Ecological Climatology. Cambridge Univ. Press, Cambridge, UK.
3. Dodds, W.K., M.R. Whiles. 2010. Freshwater Ecology. Acad. Press, Netherlands.
4. Nordell, S., T. Valone. 2017. Animal Behaviour. Freeman Press, New York, USA.
5. Speight, M.R., M.D. Hunter, A.D. Watt. 2008. Ecology of Insects. Wiley-Blackwell Co., USA.

ZOO-717		***Advanced Enzymology***	*3.0*

Course Outline:

1. Introduction and History of Enzymes

a. Historical aspects

b. Discovery and chemistry of enzymes

c. Function and importance

d. Enzymes in Biotechnology

2. **Characteristics and Properties**

a. Catalytic power and specificity

b. Enzyme-substrate interactions

c. Lock and key model

d. Induce fit model

e. Transition state model

f. Quantum tunnelling model

g. Enzymes as proteins
h. Non-protein cofactors-metal ions
i. Organic cofactors

3. Multi-substrates Reactions and Substrate Binding Analysis

a. Multi-substrates reactions
b. Ordered and random mechanisms
c. Sequential and Non-sequential mechanisms
d. Substrate binding analysis

4. Determination of Enzyme-Substrate Dissociation Constants

a. Equilibrium dialysis
b. Equilibrium gel filtration
c. Ultracentrifugation
d. Spectroscopic methods

5. Experimental analysis of catalytic and kinetic mechanisms

a. Spectrometry, X-ray crystallography, stopped flow, isotope effects, structure/reactivity relationships).
b. Mathematical data analysis (regression analysis, model discrimination).
c. Modelling of enzymatic reactions. Stereo chemistry (mechanisms). Structure/function relationships (protein folding, mutagenesis, enzyme inhibition.
d. Catalytic mechanism, catalytic antibodies, catalytic nucleic acids ribozymes, catalytic DNA.

6. Enzyme Purification and Assay

a. Enzyme units of activity
b. Turnover number and properties
c. Purification and assessment
d. Methods for measurements

7. Enzyme Engineering and Design

a. Substitution
b. Insertion
c. Hybrid proteins
d. Genes for novel enzymes
e. Engineering more stable enzymes
f. Incorporation of non-natural amino acids into enzymes
g. Protein engineering by combinatorial methods
h. DNA shuffling

Text and Reference Books:

1. Bisswange, H., 2011. Practical Enzymology. Wiley-VCH. Publishers.
2. Bowden, A.C., 2012. Fundamentals of Enzyme Kinetics 4th Edition. Wiley-Blackwell.
3. Okotore, R.O., 2015. Essentials of Enzymology. Publisher XLIBRIS.
4. Sauro, M.H., 2012. Enzyme Kinetics for Systems Biology Ambrosius Publishing
5. Voet, D., Voet, J. G. and Pratt, C. W., 2002. Fundamentals of Biochemistry; John Willey and Sons. Inc., New York

6. Mckee, T. and Mckee, J. R. 2011. Biochemistry, the Molecular Basis of Life. 5th edition, Oxford University Press, New York.

ZOO-718	**Advanced Instrumental Techniques**	3.0

Course Outline:

a. Spectroscopy
b. Chromatography
c. Electrophoresis
d. Immunological techniques
e. Radioisotope techniques
f. Biosensors

Text and Reference Books:

1. *Principles of laboratory techniques and methods*. MeenaShrivastava and Rajesh Singh Yadav.
2. Chemical analysis: Modern instrumentation, methods and techniques, Francis Rouessac and Annick Rou Fessac, Jhon Wiley & Sons, 2000, ISBN 0-471-97261-4.
3. *Principles of instrumental analysis* (5thed), Douglas A. Skoog, F. James Holler and Timothy A. Nieman, Brooks Cole, 1997, ISBN 0-03-002078-6.
4. *Spectrometrischeanalysetechnieken*, M.T.C. de Loos- Vollebregt, Heron reeks- Bohn Stafleu Van Loghum, 2004, ISBN 90-313-4142-8.

ZOO-719	**Advanced Molecular Genetic**	3.0

Course Outline:

1. Genome structure

a. Human mitochondrial genome
b. Human Nuclear genome
c. Protein Coding gene
d. RNA genes

2. Gene Families

a. Solitary gene and gene family
b. Gene superfamily.
c. Pseudogens
d. Retrogenes
e. Cluster gene families
f. Interspersed gene families

3. Transposable Genetic Elements

a. LINES
b. SINES
c. Fossil Transposons

2. Repeat Instability and Genetic Disorders

a. TRED1
b. TRED2
c. Fragile X- Syndroem

d. Mytonic Dystrophy

3. DNA Methylation and Cancer

a. Differential methylation and cancer

b. Imprinting

c. Epigenetics and its implications in the genome

d. Telomere and Telomerase and their role in cancer and aging

e. RNA interference

f. RNA i mediated pathways in nucleus

4. Study of Molecular Techniques

a. Southern blotting

b. Western blotting

c. Northern blotting

d. RFLP

e. RAPDS

f. Microsatellite DNA

Text and Reference 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.

3. Molecular biology of the gene.Pearson Education. 2004.

4. Snyder, L. and W. Chapness. Molecular Genetics of bacteria. ASM, Press, 2003.

5. Lewin, B. Gene-VIII. Oxford University Press, Oxford, UK. 2004.

ZOO-720	**Advanced Ornithology**	3.0

Course Outlines (contents):

a. **Systematics:** classification and phylogeny, species concept, taxonomic characters and cladistics, convergent evolution in birds and molecular phylogenetic techniques.

b. **Bird structure and function:** feather structure and growth, types, as ornaments, tail shape and length with function, tracts, maintenance, moults and plumages in birds.

c. **Avian brain;** importance, intelligence, eye anatomy and vision senses, hearing and echolocation with taste and smell mechanisms.

d. **Details of bird physiology:** energetics and bio-energetics, circulation, flight adaptations, physiological requirements of flight, nutrition and metabolic pathways.

e. **Breeding behavior:** avian mating systems, effects of environmental constraints on mating; predation pressure and egg-laying and incubation. Concept of brood parasitism and economic consequences.

f. **Altruism:** parental care; sacrifice on fledglings, energy costs and mortality by parents to nurture the young. Cooperative breeding birds and inbreeding in avian species.

g. **Growth and development: developing mechanisms of birds, solitary birds and colonial birds, concept of** social structure in birds. Sexual selection, courtship and various displays in birds impacted by environment.

h. **Communal studies:** avian community structures, habitats selection, foraging success, migration (temporary and permanent); use of microsatellites to determine their parentage relatedness with kins based on evolutionary history**.**

Practical::

1. Weekly visits to bird habitats in the selected study sites to assess the various bird species population index.
2. Incorporation of sampling methods viz. quadrat, transect, line transect, survey within short landscape using point method.
3. Randomized complete block design method, precision method and estimation of roosts and nests with their characteristics.

Text and Reference Books:

1. Fitter, J., D. Merton. 2017. Birds of New Zealand. Prentice Hall Press, England
2. Lovett, I.J., J.W. Fitzpatrick. 2015. Handbook of Ornithology. 3rd Edition, W.B. Saunders Inc., USA.
3. Birkhead, T. 2011. The Wisdom of Birds. McMillan & Co., Inc., USA.
4. Proctor, N. 2015. Manual of Ornithology. Cambridge Univ. Press, Cambridge, UK.
5. Scott, G. 2010. Essentials of Ornithology, Oxford Univ. Press, London, England.

ZOO-721	**Advanced physiology**	3.0

Course Outline:

6. **Membrane Potentials**

a. Membrane channels and their permeation machinery.
b. Channel blockers
c. Mechanisms in resting membrane potentials. Local circuit current flow
d. Electrogenic ion pump and ionic mechanism in action potentials.
e. Diffusional potentials. Nernst equation, Donnan equilibrium
f. Ionic mechanisms in action potentials
g. Properties of action potential.
h. Propagation of action potential in neurons.

7. **Synaptic transmission**

a. Structure and function of electrical synapse structure and function of chemical synapse,
b. Mechanism of Docking, priming and fusion of synaptic vesicles, snare complex
c. Role of MUNC-18 and MUNC-13 in synaptic transmission and limitations of electrical synapses.
d. Non synaptic Chemical transmission through varicosities.
e. Neurotransmitters (Biogenic amines, neuropeptides and opiates) Synaptic receptors; excitatory
f. Postsynaptic potentials.
g. Inhibitory postsynaptic potentials.
h. Presynaptic inhibitions, afferent collateral inhibition,
i. Recurrent inhibition,

j. Integration at synapses.
k. Facilitation, Posttetanic Potentiation.
8. **Receptor Physiolgy**
a. Spinothalamic tract, ascending and descending neural tracts.
b. Mechanoreception and hair cell mechanism.
c. pain receptors and ascending and descending pathways for pain signal.
d. Ultra structure of photo receptors, photochemistry, color vision.
e. Structure and physiology of taste receptors and olfactory receptors
f. Physiological stress due to diminished receptor activity.
9. **Hormones**
a. Mechanism of hormone action.
b. Steroid hormones and their action.
c. Non steroid hormones and their action.
d. Role of insect hormones in molting.
e. Negative feedback mechanism of hormonal control (Insulin, Glucagon, regulation of blood calcium level)
f. Mechanisms of hormonal stress.
g. Cyclic AMP as secondary messenger.
10. **Respiration**
a. Neural and chemical control of respiration. Role of nucleus of tractus solitaries and other nuclei of brain stem in the regulation of repiration.
b. Bohr's effect and Haldane effect
c. Oxygen –hemoglobin dissociation curve and factors affecting this curve
d. Respiratory responses in extreme conditions as hypoxia.
e. Hypercapnia in air breathing divers.
f. Anaesthesia and periodic breathing, Shunt pathways and effect of anesthesia on hemodynamics.
11. **Osmoregulation and Excretion**
a. Osmoregulation in aquatic and terrestrial environment.
b. Vertebrate nephron as osmoregulatory organ.
c. Physiological anatomy of excretory system.
d. Glomerular filtration, Tubular absorption and secretion.
e. Nitrogenous waste products.
f. Patterns of nitrogenous excretion and their phylogenetic development.
g. Renal lesions and glomerular nephritis.
h. Role of kidneys in long term regulation of blood pressure.
i. Hypertension and renal lesions.
12. **Muscle contraction**
a. Structural basis of muscle contraction of skeletal, smooth and cardiac muscle fiber
b. Molecular structures of contractile components and their interaction.

c. Sarcoplasmic reticulum and voltage sensors in T-tubule.
d. Cross bridge chemistry, sliding filament model and walk long theory.
13. **Temperature relations**
a. Stages of sleep and mechanism of sleep induction
b. Physiology of torpor and stress level during torpor and hibernation and arousal problems.
14. **Rhythmicity of heart**
a. Excitatory and conductive system of heart.
b. Control of blood flow and blood pressure.
c. Sick sinus syndrome.
d. ECG , vectoral analysis of ECG and ecography.
e. Balloon angioplasty and bypass suregory.
f. MAHA
15. **Physiology of Digestion**
a. Movements in GIT.
b. Absorption of water and nutrients in GIT. Malabsorption syndrome, Tropical sprue
c. Regulation of digestive secretions.
d. Neural control of GIT potential

Text and Reference Books:

1. Guyton, A.C. and Hall, J.E. 2010: Text book of Medical Physiology, 11th Edition. W.B. Saunders Company,Philadelphia
2. Hill, R.W., Wyse, G.A. and Anderson, M., 2016: Animal Physiology. 4th Ed. Sinauer Associates, Inc. New York
3. John E. Hall., 2015: Guyton and Hall textbook of Medical Physiology. 13th Ed. Elesvier
4. Moyes, C.D. and Schulte,P.M. 2015: Principles of Animal Physiology. 3rd Ed. Pearson New York
5. Randall, D., Burggren, W., French, K. and Fernald, R. Eckert. 2002: Animal Physiology. 5th Edition. W.H. Freeman and Company, New York
6. Widmaier, E., Raff, H. and Strang , K. 2013: Vander's Human Physiology: The Mechanisms of Body Function. 13th Ed. McGraw-Hill Education
7. Withers, P.C. 1992: Comparative Animal Physiology. Saunders College Publishing, Philadelphia.

ZOO-722	**Advances in Aquaculture**	3.0

Course Contents:

1.Introduction
a. Aquaculture basics
b. History;
c. Principles
d. Future prospects

2. Management of aquaculture

a. Management levels in cultural practices
b. Criteria for selection of aquatic plants and animal species
c. Management of aquaculture systems (ponds, cages, raceways)

3.Shell fish culture

a. Major cultivated species of shrimps and prawn
b. Shrimp culture system
c. Reproduction of shrimps
d. Oyster culture
e. Cray fish and crabs culture

4. **Integrated aquaculture**

a. Integrated aquaculture definitions
b. Scope
c. Principles and practices of different integrated aquaculture systems
d. Economic importance of integrated fish farming
e. Aquaculture economics and marketing
f. Sustainability and development
g. Environment and aquaculture interaction

5. **Aquaculture sustainability**

a. Aquaculture sustainability and food security,
b. Sustainable use of living resources (marine & inland);
c. Effects of aquaculture wastes on ecological systems,
d. Environment and health issues,
e. Impact of aquaculture and risks posed by escape of exotic invasive species.

6. **Fish breeding and diseases**

a. Fish breeding techniques
b. Fish diseases

Practicals:

1. Study of important aquatic plants
2. Different aquaculture systems and fish feed ingredients
3. Visit to fish farm and installations
4. Identifications of important shell fishes (shrimp, prawn, crab, oyster, mussels etc) and their aquaculture systems.
5. Field tours
6. Field trials (waste viz vegetables/ visits of different integrated fish farms in Pakistan
7. Preparation of feasibility reports of different integration.

Text Books:

1. Ali, S.S. 1999. Fresh Water Fisher Biology. Naseem Book Depot, Hyderabad
2. Pillay, T.V.R. 2002. Aquaculture: Principles and Practices. Blackwell Science Ltd.
3. Arrignon, J. 1999. Management of freshwater fisheries. Oxford and I.B.H Pub.
4. Kumar, H.D. 2003. Sustainability and Management of Aquaculture and Fisheries Daya Publishing House, New Delhi. Qasim, S. Z. and DinabundhuSahro.

Reference Books

1. Bhatti, M.N. and Mirza, M.R.1995. Jadeed Fish Culture. Feroz Sons, Lahore.
2. Huet, M. and Timmermans, J. Text book of Fish Culture. Blakwell Science Ltd.
3. Shammi, Q.J. and Bhatnagar, S. 2002. Applied Fisheries, Agrobios, India.
4. NIIR 2003. Hand Book on Fisheries & Aquaculture Technology. Asia Pacific Business Press Inc., Delhi.
5. Sedgwick, S.D.1990. Trout Farming Hand Book. Blackwell Science Ltd.
6. Hussain, S.M. 2002. Encyclopedia of Fish Culture, Vol I& II. A.P.H. Publishing Corporation, New Delhi.
7. Hameed, M.S. and Boopendranath, M .R. 2000. Modern Fishing Gear Technology. Daya Publishing House, Delhi.
8. Parker, R. 2002. Aquaculture Science. Delmar Thomson Learning. USA.
9. Sahoo, D. and Qasim. S.Z. 2002. Sustainable Aquaculture. A.P.H. Publishing Corporation, New Delhi.
10. Sustainable Aquaculture. A. P. H. Publishing Corporation, Darya Gang, New Delhi.
11. Calder, I. 2000. The Blue Revolution: Land Use and Integrated Water Resource Management. Earthscan, Publications.
12. Davenport, J. 2003. Aquaculture: The Ecological Issues. Blackwell Publishing.
13. Midlen, A., Redding, T. and Reading, T. A., 1998. Environmental Management for Aquaculture. Chapman & Hall, UK

ZOO-723	**Advances in Bioinformetic**	3.0

Course Outlines:

1**. Introduction**:

a. Introduction toBioinformatics, Scope of bioinformatics, useful websites

2. **Biological databases**

a. Data and information, databases, data acquisition

3. **Genome mapping**

a. Genetic and linkage mapping, physical mapping, QTL mapping, Association mapping

7. **Gene family**:

a. Introduction, types, protein family, Globin family as an example, globin genes and chains, evolution of globin proteins in human, combination and types of globin proteins in human

8. **Data Retrieval:**

a. Searching sequence databases, FASTA format, retrieval of nucleotide sequence data, retrieval of protein sequence and structure data, retrieval of literature and map data

9. **Primer Designing:**

a. Primer and probe, qualities of primer, general rules for primer designing

b. Websites used for primer designing

10. Synthetic gene designing:

a. Sequence retrieval, codon code optimization, primer designing

11. **Sequence Alignment**:

a. Importance and significance of alignment, methods for sequence alignment
b. Local and global alignment, pair-wise local alignment, uses of local alignment
12. **BLAST**: Introduction, types, uses, algorithm, BLAST Scores
13**. Amino Acid Matrices**:
a. Amino acids and their symbols, amino acid scoring matrices
b. PAM and BLOSUM, comparison of PAM and BLOSUM
14**. Multiple Sequence Alignment:**
a. Introduction, tools for MSA, uses and importance
15. **Phylogenetic analysis**:
a. Introduction, interpretation, rooted and unrooted tree,
b. phylogenetic methods, tree terminology, comparison of methods, software
16. **Protein Structure Prediction**:
a. Homology modelling, threading, *ab initio* modelling,
b. Motivation to acquire structure
c. Protein 3D structure, software/databases
17. **Molecular Docking**:
a. Introduction, steps, importance and uses
18. **Microarrays:**
a. Gene expression, differential expression,
b. DNA chips, principle of microarray, types, steps of a microarray experiment, qualitative interpretation of results, applications of microarray, advantages and disadvantages of microarray
19. **Next Generation Sequences data analysis**
20. **Real time PCR data analysis**

Practicals:

1. Introduction to NCBI
2. Retrieving Literature from NCBI
3. Classification of an organism using NCBI
4. Retrieving FASTA sequence for nucleotide and protein
5. Retrieving disease gene information
6. Searching gene families
7. Primer Designing
8. BLASTing a nucleotide / amino acid sequence
9. Multiple Sequence Alignment using different amino acids / nucleotide sequences
10. Phylogenetic Analysis of different nucleotide / amino acid sequences
11. Microarrays data retrieval from the web

Text and Reference Books

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. Pevsner, J. (2015) Bioinformatics and Functional Genomics. 3rd Edition. Willey-Blackwell
4. Lesk, A. (2014) Introduction to Bioinformatics. 4th Edition. Oxford University Press
5. Selzer, P., Marhofer, R. and Rohwer, A. (2008) Applied Bioinformatics: An Introduction. Springer publishing, Germany.
6. Primerose, S.B. (2004) Genomics: Applications in Human Biology. Willey-Blackwell
7. Westhead, D.R., Parish, J.H., Twyman, R.M. (2003) Instant Notes on Bioinformatics. Viva Books Private Limited.
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

5. http://www.ncbi.nlm.nih.gov
6. http://www.ebi.ac.uk
7. http://www.rcsb.org
8. http://www.ensemble.org

ZOO-724	**Advances in Cell Biology**	3.0

Course Outline:

1. **Introduction to Growth Control and Cell Cycle:**

a. Mitotic spindle formation and centrosome biology Contractile ring formation and ingression (actin polymerization and/or myosin activation).
b. Prokaryotic division (i.e. ftsZ ring formation, mreB in sculpting cell shape).
c. Mitotic exit network Plant cell division Cell migration and its regulation.
d. Epigenetic mechanisms.
e. Cellular polarity (e.g. mechanisms of planar cell polarity, epithelial organization).
f. Organelle division (mitochondria or lysosomes).
g. Organelle fragmenting during division (ER or golgi).
h. Membrane remodeling (changes in curvature during cell rounding/division, secretory 3 events to add new membrane or changes in phospholipid composition).
i. Cell Differentiation and development.
j. Apoptosis.

2. **Nucleic Acid and Protein Structure and Function:**

a. Chromatin structure Chromatin modifications (changes upon during M phase).
b. Regulation of cellular functions by ubiquitination. Selected examples of regulation of cellular function by protein phosphorylation or other post-translational modifications.
c. Signal transduction.
d. DNA replication/repair.

3. **Cell Membranes and Cytoskeleton:**

a. Cytoskeleton, cell signaling.

b. Compartments and protein sorting.
c. Regulation of cell shape and migration.
d. Cell division, apoptosis and autophagy.
e. Cell-cell interactions, the secretory pathway.
f. Phagocytosis, nuclear import and export.
4. **Structure and Function of the Eukaryote Cell Nucleus:**
a. Regulation of the gene expression to the changes in chromatin associated with the activation and silencing of genes.
b. Three-dimensional organization of the nucleus.
c. Signal transduction through reversible phosphorylation.
5. **Introduction to Cancer Cell Biology:**
a. Regulation of the cell cycles in normal and cancer cells.
b. Control of angiogenesis in cancer.
c. Autophagy.
6. **Biological Transport Mechanisms:**
a. The role of ion canals and Ca2+ signaling in synapse.
b. Sensory neurons and the regulation of contraction.
c. Exocytosis; lipid second messengers.
d. Analysis of structure-function relationships of canals.
e. Molecular biology of the beta cells of the pancreas.
f. Protein Sorting and transport.
g. Cell Adhesion and motility.
7. **Laws of Thermodynamics:**
a. How cells manipulate them to regulate their volume.
b. High-resolution imaging techniques in cell biology.

Books Recommended:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D. 2017. Molecular Biology of the Cell. 6th Edition. Garland Publishing Inc., New York.
2. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey C. Martin. 2016. Molecular Cell Biology. W. H. Freeman Publishers, Scientific American Inc.
3. De Robertis, E. D. P. 2017. Cell and Molecular Biology, 8th edition, Lea & Febiger, New York.
4. E. Edward Bittar and Michael Pusch. 2006. Advances in Molecular and Cell Biology. Volume 38
5. K.R. Miller 1987. Advances in Cell Biology, 1st Edition. Elsevier Science.

ZOO-725	**Advances In Forensic Biology**	3.0

Course Outline:

1. Biological material – collection, characterization and storage
a. Sources of biological evidence
b. Collection and handling of material at the crime scene

c. Identification and characterization of biological evidence
d. Evidence collection
e. Sexual and physical assault
f. Presumptive testing
g. Storage of biological material

2. Serology Testing

a. Identification of Semen
b. Acid Phosphatase Screening
c. Alternate Light Source or Ultraviolet (UV) Light
d. Microscopic Identification of Spermatozoa
e. Protein Confirmation of Semen

3. Identification of Blood

a. Presumptive Testing for Blood
b. Species Testing of Blood.
c. ABO Blood Typing
d. Blood Spatter Interpretation

4. DNA Testing

a. DNA Extraction
b. Differential DNA Extraction
c. DNA Quantification
d. Restriction Fragment Length Polymorphism (RFLP)
e. Early PCR-Based Methods
f. Tandem Repeat (STR) Analysis
g. Mitochondrial DNA (mtDNA) Sequencing
h. Y-Chromosome STR Analysis
i. Single-Nucleotide Polymorphism (SNP) Analysis

Practical:

1. DNA Extraction
2. DNA Quantification
3. The polymerase chain reaction.
4. Presumptive Testing for Blood
5. Species Testing of Blood
6. ABO Blood Typing
7. Low Copy Number (LCN) DNA Testing

Text and Reference books:

1. Goodwin W, Linacre A, Hadi S. An introduction to forensic genetics. John Wiley & Sons; 2011.
2. Mozayani, A. and Noziglia,.The forensic laboratory handbook procedures and practice. Springer Science. 2010.
3. Siegel, J.A. and Mirakovits, K. Forensic science: the basics. CRC Press.2015.
4. Saferstein, R.,. *Criminalistics*. Pearson Education.

ZOO-726	**Advances in Helminthology**	3.0

Course Outline:

a. **Introduction to the phylum Platyhelminthes**. **Trematoda, Aspidohothria**

b. **Digenians**

c. **Digenians strigeiformes**; *Schistosoma haematobium, S. japonicum, S. mansoni* (Schistosomiasis)

d. **Digeneans Echinostomiformes**: *Fasciola hepatica, F gigantica, Paramphistomum cervi, Megalodiscus temperatus*.

e. **Digeneans, Plagiorchiformes and opisthorchiformes**: *Paragonimus westermani, Clonorchis sinensis, Heterophyesheterophyes, Prosthogonimus macrochis*.

f. **Monogenea**

g. **Polystomum integraruum**. Form, function, classification, life cycle

h. **Cestoidea**, form function, life cycle and classification of the tapeworms

i. **Cyclophyllidae**: *Taenia solium, Taeniarhynchus saginata, T. pissiformis* (Taeniasis), *Taenia multiceps, Echinococcus granulosus, E. multilocularis, E. vogeli, Hymenolepis nana, H. diminuta, Raillietina* species, *Diphylidium caninum, Moniezia* species, *Mesocestoides* species

j. **Phylum Nematoda, Form, Function and Classification**

k. **Trichurida and Dioctophymatida**; enoplean parasites (*Trichuris trichiura*), *Capillaria hepatica, Anatrichosoma ocularis,*

l. **Rhabdlitida**; *Strongyloides stercoralis, Strongylida, bursate rhabolitidians*, *Bunostomum, Necator americanus, Ancyclostoma duodenale*, *Synagamus trachea, Haemonchus contortus, Trichostrongylus* species, *Ostertagia* species, *Prostrongylus rufescens*

m. **Ascaridida**, **intestinal large round worms**; *Ascaris lumbricoides, Toxocara canis, Lagochilasascaris minor, Heterakis gallinarum, Ascaridia galli*.

n. **Oxyrurida, the pinworms**; *Enterobius vermicularis*. Nematodes, Spirurida, a potpoorri, *Gnathostoma doloresi*.

o. **Filaroidea; the filarial worms**, *Wuchereria bancrofti, Brugia malayi, Loa loa, Mansonella perstans, M. ozzardi, Onchocerca volvulus, Dirofilaria immitis*

p. **Camallanina, the Guinea worms and others**; *Dracunculus mediensis*. Phylum Acanthocephla, Thorny headed worms. Forms, function and classifications; *Macrocanthorhynchus hirudinaceus*.

q. **Helminth Zoonoses** (Trematode, Cestodes and nematode zoonoses).

Practicals:

1. Methods for collection, transportation, fixation and preservation of flukes, tapeworms and round worms.
2. Methods for collection and examination of faeces, urine and sputum for the presence of eggs/larvae of various helminthes.
3. Methods for examination and staining of blood film for helminthes.
4. Identification of important members of class Trematoda, Cestoda, Nematoda and Acanthocephala. Practical demonstration of helminthes at slaughter houses.

Text and Reference Books:

1. K.D. Chatterjee. (2015). Parasitology: Protozoology and Helminthology 13th Edition.
2. Robberts, L. Sand Janovy John Jr. 2015. Foundation of Parasitology 9th edition. McGraw-Hill, Boston.
3. Schmidt, G. D. and Robbert, T. S. (2001). Foundation of Parasitology. The C.V. Mosby Company, Saint Louise.
4. Facust, E. C. and Russell, P. F. (2001). Craig and Faust's clinical Parasitology. Lea and Febiger, 8th edition London.
5. Wright, D. Bowman. 2009. WB Saunders Company Georgis' Parasitology For Veterinarians, WB Saunders Company, 9th edition.

ZOO-727	**Advances in Immunology**	3.0

Course Outline:

1. **Introduction**

a. Components of the immune system

b. Antigens and Pathogens

2. **Innate Immunity and Inflammation**

a. Different types of leukocytes

b. Inflammation and Fever

3. **Recognition and Responses to foreign antigens**

a. Pattern recognition receptors

b. Innate immune signaling

c. The complement system

d. Complement activation pathways

4. **Antibodies**

a. B lymphocytes

b. Antibody structure and function

c. Monoclonal and polyclonal antibodies

d. Hybridoma technology

5. **Lymphocyte Development and Diversity**

e. Lymphocyte development

f. Clonal selection and expansion

g. Differences between B and T lymphocytes

h. The generation of lymphocyte receptor diversity

6. **T Cell Activation by Antigens**

a. Antigen presentation

b. The role of dendritic cells

c. The lymphatic system and delivery of antigen to lymph nodes

d. Adaptive immune activation in secondary lymphoid tissues

7. **T Cell-Dependent B Cell Responses**

a. T Cell activation of B cells

b. Isotype switching and affinity maturation

c. Helper T cell functions

d. The role of helper T cells in disease
e. Cytotoxic T cell functions
f. Selection and expansion of cytotoxic T cells
g. Therapies that target cytotoxic T cell functions
8. **Hematological Diseases**
a. Acute Leukemias
b. Overview of Lymphoma Classification
c. Hodgkin's disease
d. T-Cell Lymphomas
e. B-Cell Lymphomas
f. Plasma Cell Dyscrasias
g. Multiple Myeloma
h. Cryoglulinemia
i. Amyloidsis
9. **Tumor Immunology**
a. Detection and identification of Tumor Antigens
b. Immune Escape Mechanisms of Tumor Antigens
c. Immunotherapeutic Strategies (I)
d. Immunotherapeutic Strategies (II)
10. **Transplantation of Autologous**
a. Bone Marrow/Heatopoietic Stem Cells
b. Transplantation of Allogenic bone Marrow/Hematopietic Stem Cells
c. Clinical Aspects of Organ Transplantation

Text and Reference Books:

c. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Molecular Biology of the Cell (5th ed. 2008, Garland)
d. Thomas J Kindt, Richard A Goldsby, Barbara A Osborne, Janis Kuby: Immunology (2003, Freeman).
e. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt Roitt: Roitt's Essential Immunology (12th ed. 2012, Blackwell)
f. Abul Abbas , Andrew H. Lichtman, Shiv Pillai. Cellular and Molecular Immunology , 9th edition, 2017. Elsevier Pub Co.
g. Gerd R. Burmester, Antonio Pezzutto Color Atlas of Immunology, 2006. Thieme Stuttgart, New York.

JOURNALS RECOMMEDED:

□□Annual Review Of Immunology, Journal Of Immunology
□□EuropeanJournaL Of Immunology, Immunology Today, Advances In Immunology
□□CRC Critical Reviews in Immunology and Human Gene Therapy

ZOO-728	**ADVANCES IN RESEARCH METHODOLOGY**	3.0

Course Contents:

1. **Introduction:**
b. Objectives of Research, Motivations
2. **Research Process:**
a. Research methods vs. research methodology, scientific method
b. Types of research, general steps involved in research
c. Problems of research in Pakistan
3. **Topic Selection:**
a. Problem identification for research, criteria and evaluation
4. **Literature Review:**
a. Importance and sources
b. Referencing and citation and bibliography
c. Plagiarism
5. **Research Design:**
b. Parts, important features, important concepts in research design,
6. **Aims and Objectives:**
a. Research objectives, qualities of research objectives
7. **Material and Methods:**
a. Bioethics, sampling, sampling designs, data collection and data analysis, sampling requirements, scales of measurement, error of measurement and its sources
8. **Data Analysis:**
a. Processing, statistics in research, hypothesis testing, t-tests and ANOVA
9. **Statistical Software**
a. SPSS, SAS, SATA, Python and R etc.
10. **Data Presentation**
a. Tabulation, graphical presentation
b. Presentation software
11. **Scientific Writing:**
a. Difference between thesis/report/synopsis/research proposal
b. Parts of synopsis/project proposal, parts of thesis/report
12. **Reference management software**
a. Endnote, Reference Manager, Mendeley etc.
13. **Budgeting:**
a. Cost estimates for a research project, funding sources e.g. USAID, HEC, MOST, HED, PMRC, WWF, PSF etc.

Text and Reference Books:

1. Paul Leedy, 2004, Practical Research: Planning and Design (8th Edition), Jeanne Ellis Ormrod
2. Creswell, J. W. (2013). Research Design Quantitative Qualitative and Mixed Methods Approaches. Sage.
3. Hess-Biber, S. N. and P. Leavy. (2004). Approaches to Qualitative Research, A Reader on Theory and Practice. New York, Oxford University Press.

4. Khan, J.A. (2008). Research Methodology. New Delhi: APH Publishing.
5. Kothari, C.R., & Gaurav, G. (2014). Research Methodology: Methods and Techniques. New Delhi: New Age International.
6. Kumar, R. (2011). Research Methodology: A Step By Step Guide for Beginners. Cornwall: SAGE Publications, Inc.
7. Laurel, B. (2003). Design Research, Methods and Perspectives. London England, The MIT Press.
8. Walliman, N. (2005).Your Research Project, 2nd Edition, A step by step guide for the first-time researcher. New Delhi, Vistaar Publications

ZOO-729	**Aerosol and environmental health**	3.0

Course Outline:

1. **Introduction to air pollution**

a. General Introduction
b. Important Definitions
c. Aerosols and Bio-aerosol
d. Indoor and outdoor Air quality
e. Pollutants and their Sources

2. **Instrumentation and Analysis**

a. Instrumentation for sampling and monitoring Aerosols
b. Levels and limits of pollutants in air
c. Bio-aerosol sampling and analysis

3. **Relationship between indoor and outdoor air quality**
4. **Global warming and its implications on humans**
5. **Other pollutants**

a. Introduction
b. Properties
c. Sources

6. **Measures to reduce the sources and impact of Air pollution**

a. Involvement of National and international organizations
b. Public awareness
c. Role of government institutions

Practicals:

1. Measurement of PM10, PM2.5 and PM1 in indoor and outdoor environment.
2. Assessment of other pollutants in the air

Books Recommended:

1. Ali. Z. Colbeck, I, and Nasir, Z. A. 2010. Basics of air pollution monitoring, HEC-BC Link publication.
2. Welburn, A. 2007. Air pollution and climate change: 2nd edition; Longman Scientific and Technical
3. Colbeck, I. 1998. Physical and Chemical Properties of Aerosols, Blackie Academic & Professional
4. Hinds, W. C. 1999. Aerosol Technology (2nd edition), John Wiley & Sons

5. Ruzer L.S. And Harley, N. H. 2005. Aerosols Handbook, CRC Press
6. Vincent, J. H. 2007. Aerosol Sampling: Science, Standards, Instrumentation and Applications, John Wiley
7. Gurjar, B. R., Molina, C. T. and Ojha, C. S.P. 2010. Air Pollution, CRC-Press
8. Tarlo, S. M., Cullinan, P. and Nency, B. 2010. Occupational and Environmental Lung Disease, Wiley-Blackwell.

Z30-730	**APPLIED ENTOMOLOGY**	3.0

Course Outline:

Introduction; causes of success and economic importance of insects; principles and methods of insect control i.e. cultural, biological, physical, mechanical, reproductive, legislative, chemical and bio-technological control; introduction to IPM; insecticides, their classification, formulations and application equipments; identification, life histories, mode of damage and control of important insect pests of various crops, fruits, vegetables, stored grains, household, termites and locust; introduction to entomological industries: apiculture, sericulture and lac-culture.

Practical:

1. Collection, identification and mode of damage of insect pests of various crops,
Fruits
Vegetables,
Stored grains and household
2. Insecticide formulations, their dilutions and safe handling;
3. Use of application equipments, instructions for apiculture, sericulture and lac-culture.

Text and Reference Books:

1. Atwal, A.S. 2005. Agricultural Pests of Southeast Asia and their Management. Kalyani Publishers, Ludhiana.
2. Awastheir, V.B. 2009. Introduction to General and Applied Entomology. Scientific Publisher, Jodhpur, India. 13
3. Duncton, P.A. 2007. The Insect: Beneficial and Harmful Aspects. Kalyani Publishers Ludhiana.
4. Gullan, P. J. and Cranstan, P. S. 2010. The Insects: An Outline of Entomology. 4th edition. Wiley-Blackwell. A John Wiley & Sons, Ltd., Publication, UK.
5. Lohar, M. K. 2001. Applied Entomology, 2nd Ed. Department of Entomology, Sindh Agriculture University Tandojam Sindh, Pakistan.
6. Mathews, G.A. 2004. Pesticide Application Methods, 3 rd. Ed. John Wiley & Sons, Inc. N.Y. 7. Pedigo, L.P. and Marlin, E. R. 2009. Entomology and Pest Management, 6 th Edition, Person Education Inc., Upper Saddle River, New Jersey 07458, U.S.A.
7. Pfadt, E.R. 1985. Fundamentals of Applied Entomology, 4 th Ed. The McMillan Co., N. Y.
8. Robinson, D.H. 2006. Entomology Principles and Practices. Agro-bios.
9. Shah, H.A. and Saleem, M.A. 2002, Applied Entomology, 3rd Ed. Izhar Sons Printers, Lahore.

10. Srivastava, K.P. 2005. Text Book of Applied Entomology. Kalyani Publishers, New Delhi. 12. Romoser, W. S. and Stoffolano, J. G. 1998, The Science of Entomology, WCB McGraw-Hill.

ZOO-731	**Animal Physiology**	3.0

Course Outline:

1. **Membrane Potentials**

a. Membrane channels

b. Mechanisms in resting membrane potentials

c. Electrogenic ion pump.

d. Diffusional potentials. Nernst equation

e. Ionic mechanisms in action potentials

f. Properties of action potential.

g. Propagation of action potential in neurons.

2. **Synaptic transmission**

a. Structure and function of electrical synapse structure and function of chemical synapse .

b. Non synaptic Chemical transmission.

c. Neurotransmitters; Synaptic receptors; excitatory postsynaptic potentials.

d. Inhibitory postsynaptic potentials.

e. Presynaptic inhibitions; Integration at synapses.

f. Facilitation, Posttetanic Potentiation.

3. **Receptor Physiolgy**

a. Mechanoreception and hair cell mechanism.

b. Pain receptors and ascending and descending pathways for pain signal.

c. Ultra structure of photo receptors, photochemistry, color vision.

Structure and physiology of taste receptors and olfactory receptors

4. **Hormones**

a. Mechanism of hormone action.

b. Steroid hormones and their action.

c. Non steroid hormones and their action

d. Negative feedback mechanism of hormonal control (Insulin, Glucagon, regulation of blood calcium level)

e. Insect hormones.

f. Cyclic AMP as secondary messenger.

5. **Respiration**

a. Neural and chemical control of respiration.

b. Bohr's effect and Haldane effect

c. Oxygen –hemoglobin dissociation curve and factors affecting this curve

d. Respiratory responses in extreme conditions as hypoxia.

e. Hypercapnia in air breathing divers.

f. Anaesthesia and periodic breathing. Shunt pathways

6. **Osmoregulation and Excretion**

a. Osmoregulation in aquatic and terrestrial environment.

b. Vertebrate nephron as osmoregulatory organ.

c. Physiological anatomy.

d. Glomerular filtration, Tubular absorption and secretion.

e. Nitrogenous waste products.

f. Patterns of nitrogenous excretion and their phylogenetic development.

g. Renal lesions

7. **Muscle contraction**

a. Structural basis of muscle contraction.

b. Molecular structures of contractile components and their interaction.

c. Sarcoplasmic reticulum

d. Cross bridge chemistry and sliding filament model

8. **Temperature relations**

a. Temperature relations of ectotherms

b. Temperature relations of endotherms

c. Stages of sleep

d. Torpor, hibernation and winter sleep

9. **Rhythmicity of heart**

a. Excitatory and conductive system of heart.

b. Control of blood flow and blood pressure.

c. Sick sinus syndrome.

d. ECG and hemodynamics.

10. **Physiology of Digestion**

a. Movements in GIT.

b. Absorption of water and nutrients in GIT.

c. Regulation of digestive secretions.

d. Neural control of GIT potential

Text and Reference Books:

1. Guyton, A.C. and Hall, J.E. 2010: Text book of Medical Physiology, 11th Edition. W.B. SaundersCompany,Philadelphia

2. Hill, R.W., Wyse, G.A. and Anderson, M., 2016: Animal Physiology. 4th Ed. Sinauer Associates, Inc. New York

3. John E. Hall., 2015: Guyton and Hall textbook of Medical Physiology. 13th Ed. Elesvier

4. Moyes, C.D. and Schulte,P.M. 2015: Principles of Animal Physiology. 3rd Ed. Pearson New York

5. Randall, D., Burggren, W., French, K. and Fernald, R. Eckert. 2002: Animal Physiology. 5th Edition. W.H. Freeman and Company, New York

6. Widmaier, E., Raff, H. and Strang , K. 2013: Vander's Human Physiology: The Mechanisms of Body Function. 13th Ed. McGraw-Hill Education
7. Withers, P.C. 1992: Comparative Animal Physiology. Saunders College Publishing, Philadelphia.

ZOO-732	**Applied Genetics**	3.0

Course Outline:

1. **Nucleic acids.**

a. Plant and animal viruses
b. Tumor viruses
c. Retroviruses

2.**Genetic Transformation**

a. Conjugation
b. Transformation
c. Transduction
d. Integration of viral DNA

3. **Transposition**

a. Transposable Elements
b. Detection of Transposition In Bacteria
c. Types of Bacterial Transposons
d. Modes of Transposition In Bacteria

4. **Gene expression**

a. Regulation of Gene expression in Prokaryotes
b. Regulation of gene expression in Eukaryotes

5. **Quantitative Genetics of Human Behavior**

a. Intelligence
b. Personality

6. **A genetic perspective on development**

a. Maternal effect genes
b. Determination of dorsal-ventral and anterior posterior axis
c. Body segmentation
d. Organ formation

Text and Reference 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.
3. Molecular biology of the gene.Pearson Education. 2004.
4. Snyder, L. and W. Chapness. Molecular Genetics of bacteria. ASM, Press, 2003.
5. Lewin, B. Gene-VIII. Oxford University Press, Oxford, UK. 2004.

ZOO-733	**Applied Microbiology**	3.0

Course Outline:

1. **Control of microorganisms**

a. Fundamentals of microbial control by physical and chemical agents

b. Antibiotics and other chemotherapeutic agents

c. Microorganisms and diseases:

i. Host-microbe interactions

ii. Resistance and immunity

iii. Air, food and water-borne human infections

iv. Human contact diseases

v. Infectious diseases of animals

d. Environmental microbiology:

e. Microbiology of air, water and soil

f. Microbiology of domestic water and sewage

g. Microbiology of food, milk and milk products

2. **Industrial Microbiology**

a. Introduction: Scope and characteristics of industrial microbiology

b. Microorganisms commonly used in microbial industry and biotechnology

c. Overproduction of metabolites of industrial microorganisms

d. Production of fermented foods

e. Production of microbial insecticides

f. Production of *Rhizobium* inoculants

g. Production of organic acids and industrial alcohol

h. Production of amino acids by fermentation

i. Production of vaccines, antibiotics and therapeutic agents

j. Biocatalysts: Immobilized enzymes and immobilized cells

k. Mining Microbiology: Ore leaching (Bioleaching) by microorganisms

l. Bioremediation and treatment of industrial wastes

m. Biotechnology and its role in modern human comforts

3. **Microbial Ecology**

a. Microbial diversity, populations, communities and ecosystems

b. Microbes in natural habitats; air, water, deep-sea hydrothermal vents, soil and symbionts

c. Animal and plant microbiomes

d. Rumen microbial ecosystem

e. Microbial leaching, organic matter decomposition and heterotrophy

f. Biodegradation of Xenobiotics

g. Biogeochemical cycles- microbial engines of the Earth system

4. **Microbe-microbe interactions and signaling (quorum sensing)**

a. Microbial activity measurement in soil

b. Applications of microbial ecology

Practical:

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. Quantitative and qualitative methods: Fluorescent microscopy and molecular techniques (PCR)
9. Survey of microorganisms' activities based industries

Text and Reference Books:

1. Microbiology: An Introduction, 12th ed. (2018) by Gerard J. Tortora, Berdell R. Funke, Christine L. Case.
2. Prescott's Microbiology, 10th ed. (2017) by Joanne Willey, Linda Sherwood and Christopher J. Woolverton.
3. Laboratory Experiments in Microbiology, 11th ed. (2015) by Ted R. Johnson and Christine L. Case.
4. Brock Biology of Microorganisms, 14th ed. (2014) by Michael T. Madigan, John M. Martinko, Kelly S. Bender, Daniel H. Buckley, David A. Stahl and Thomas Brock.
5. Processes in Microbial Ecology (2012) by David L. Kirchman, Publisher: Oxford University Press.
6. Microbes and Evolution: The World that Darwin Never Saw (2012) Edited by R. Kolter and S. Maloy.
7. Processes in Microbial Ecology, 1st ed.(2012) by David L. Kirchman.
8. Modern Industrial Microbiology and Biotechnology (2007) by Nduka Okafor, Department of Biological Sciences Clemson University, Clemson South Carolina USA Science Publishers, United States of America.
9. Microbiological Applications : Laboratory Manual in General Microbiology, Short Version, 8th ed. (2002) by Benson, Harold J., McGraw-Hill, Boston, MA.

ZOO-734	**Applied Parasitology**	3.0

Course Outline:

1. **Chemicals and reagents used in preservation of parasitic materials**

a. Collection, processing and identification of parasites

b. Recovery of parasite eggs, oocysts and larvae from faecal specimens

c. Determination of parasite resistance to pesticidal chemicals and chemotherapeutic drugs.

2. **Control and Vaccine Development Against Parasitic Infections.**

3. **Chemotherapeutic agents used against parasitic infections**

a. eg. anthelmintics, insecticides etc.

b. The mode of action of chemotherapeutic agents.

c. The mechanisms of parasite resistance to drugs.

4. **Methods of Vaccine Development**

a. Various approaches will be discussed for example: Helminths use of 3 types of antigens viz: Irradiation-attenuated live helminths,

b. Somatic extracts of helminthes

c. Metabolic or excretory/secretory (E/S) antigens produced by the in vitro culture of helminths.

d. Genetic engineering. the application of genetically engineered vaccines will be discussed. Cultivation of Parasites tissue culture techniques, cryopreservation

Text and Reference Books:

1. William Charles Marquardt, Richard S. Demaree, Jr., Robert Burton Grieve., 2000. Parasitology & Vector Biology. 2nd Edition.

2. Chandler, A.C. and Read, C.P. 1961. Introduction to Parasitology. 10th ed. Wiley Toppan, New York, USA

3. 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.

4. Erlich, H. 1992. PCR Technology: Principles and Applications for Amplification. W.H. Freeman & Company, New York.

ZOO-735	**Applied Reproductive Physiology**	3.0

Course Outline:

1. **Assisted Reproductive techniques: an overview**

2. **Semen Collection & Evaluation**

a. Semen collection methods

b. Initial assessment : Appearance, volume & concentration

c. Sperm motility: Computer Aided Sperm Analysis

d. Sperm Morphology

e. Acrosome status

f. Chromatin integrity

3. **Semen cryopreservation**

a. Properties of Semen Extenders

b. The cryopreservation technique

c. Application in farm animals & endangered species and humans

4. **Artificial insemination**

a. Introduction and history of Artificial insemination
b. Artificial insemination procedures
5. **Estrus synchronization**
6. **In vitro fertilization (IVF)and in vitro embryo production (IVEP)**
a. IVEP & Transfer for genetic improvement of farm animals
b. IVF and ICSI for treatment of infertility in human
7. **Superovulation and Embryos transfer**
8. **Assisted Reproductive techniques for conservation of endangered species**
a. Sperm cryobanking
b. Embryo freezing
9. **Causes of sterility in domestic animals.**
10. **Infertility in Male**
11. **Infertility in female**
12. **Sperm sexing for sex pre-selection.**
13. **Contraception**
14. **Student's presentation: recent research paper/ review article in the field**
15. **Student presentation: recent research paper/ review article in the field**
16. **Student presentation: recent research paper/ review article in the field**

Practical:
1. Morphological & morphometric studies of sperm in buffalo/cattle.
2. Morphological &morphometric studies of ova in buffalo/cattle.
3. Collection and cryopreservation of sperm in farm animals.
4. Artificial insemination in buffalo/cattle.
5. Motility assessment of sperm.
6. Staining of live and dead sperm.
7. Acrosomal analysis of sperm.
8. Aspiration and in vitro maturation of oocytes

Text and Reference Books:
1. Andrology by E. Nieschlag, H. M. Behre and S. Nieschlag**.** 3rd edition (2010). Published by Springer, USA.
2. Knobil & Neill's Physiology of Reproduction by *T. M. Plant and A. J. Zeleznik*. 4th edition (2014). Published by Springer, USA.
3. Reproduction in Farm Animals by E. S. E. Hafez and B. Hafez. 7th edition (2013). Published by Wiley-Blackwell, NY. USA.
4. Applied Animal Reproduction by H. J. Bearden, J. W. Fuquay and S. T. Willard. 6th edition (2004). Published by Pearson Prentice Hall, USA.

ZOO-736	**Apiculture**	3.0

Course Outline:

Introduction, importance, scope of apiculture industry, bee species and their biology, morphology, behavior and products, bee flora their distribution and flowering time; beekeeping equipments, seasonal management, uniting, dividing and preparation for shifting colonies; bee stings, queen rearing and swarming; pest and diseases of bees and their management; honey extraction; factors affecting honey yield; importance of bees in pollination; honey, its properties and uses; granulation, fermentation and storage of honey, uses of other bee products; beekeeping as an enterprise.

Practical:

1. Demonstration of bee colonies.
2. Observation of colonies and different casts.
3. Beekeeping equipment.
4. Preparation of frames and comb foundation for their hives.
5. Colony inspection; visit to apiaries.

Text and Reference Books:

1. Ahmad, R. 1979. A Guide to Bee Keeping in Pakistan. Extension Book.
2. Devillers, J., Phame, M. and Delegue, M. 2002. Honey Bees.
3. Goodwin, R.N. and Van Eaton, C. 1999. Elimination of American Foulbrood without the use of Drugs. A Practical Manual for Bee Keepers. National Bee Keepers Association of New Zealand, Napier, New Zealand.
4. Hooper, T. 1991. Guide to Bees and Honey. BAS Printers Ltd. Hampshir, U.K

ZOO-737	**Aquaculture**	3.0

Course Contents:

1. **Introduction**

a. Introduction to fish, fishery and aquaculture.
b. History and present status of aquaculture (National and International).
c. Introduction and biology of cultivable fin and shell fishes.
d. Introduction to aquatic resources of Pakistan (Lentic and lotic environment).

2. **Aquaculture (fin fish culture)**

a. Introduction and role of aquaculture, types of culture systems (Ponds, Raceways, cages, pen, raft and line culture).
b. Site selection, design and construction of fish ponds.
c. Pond problems; aquatic vegetation and their control, fish predators, water quality and management, fish disease and their control.
d. Types of fish feed, characteristics of artificial feed, methods of feeding, types and use of fertilizers.
e. Artificial fish breeding techniques
f. Integrated aquaculture

3. **Shell fish culture**

a. Introduction of shrimp and prawn culture, crabs, lobsters and scallops culture etc.
b. Mari-culture: Substrate system, sea water ponds. Aquaculture in fresh and brackish waters.
c. Aquaculture in practice: Culture of algae, seaweeds.

Practical:
1. Collection and identification of various freshwater fish species
2. Visit and studying of fish pond Components.
3. Visit to fish hatchery and integrated fish farming.
4. Determination of Water quality parameters (Physical, chemical and biological)
5. Fish feed ingredients and formulation of fish feed
6. Artificial Fish breeding
7. Fish market visit
8. Visit to fish feed mill
9. Visit to head works/reservoirs etc.

Books Recommended:

1. Stickney R.R. 2016. Aquaculture an introductory text, CABI.
2. Fitzsimmons, K., R.S.N. Janjua and M. Ashraf, 2015. *Aquaculture Handbook – Fish Farming and Nutrition in Pakistan.*
3. Metha, V. 2009. Fisheries and Aquaculture Biotechnology. 2nd Ed. Campus Books International, New Delhi, India.
4. Sharma, O. P. 2009. Handbook of Fisheries and Aquaculture. Agrotech Publishing Academy, Udaipur, New Delhi, India.
5. Stickney, R. R. 2009. Aquaculture: An Introductory Text. CABI Publishing, London, UK.
6. Ali, S.S. and Narejo, N.T., 2009. Fundamentals of Ichthyology. Sindh University Press, Jamshoro.
7. Pandey, B. N., S. Deshpande and P. N. Pandey. 2007. Aquaculture. APH Publishing Corporation, New Delhi, India.
8. Pillay, T. V. R. 2005. Aquaculture: Principles and Practices. 2nd Ed. Blackwell Sciences Limited. UK.
9. Parker, R. O. 2004. Aquaculture Science 4th Ed. Delmar Learning, London, UK.
10. NIIR 2003. Hand Book on Fisheries & Aquaculture Technology. Asia Pacific Business Press Inc., Delhi.
11. Huet, M. and Timmermans, J. (2002). Text book of Fish Culture. Blackwell Science Ltd. UK.
12. Shammi, Q.J. and Bhatnagar, S. 2002. Applied Fisheries, Agro bios, India.
13. Ali, S.S. 1999. Fresh Water Fisher Biology. Naseem Book Depot, Hyderabad.

ZOO-738	**Aquaculture and Fisheries**	3.0

Course Outlines:

a. 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.
b. Types of ponds, planning construction and pond preparation. Pond fertilization, dosage and methods of application.
c. Food and feeding habits of fishes, feed types, artificial and natural fish feeds, feeding strategies of artificial fish feeds.
d. Aquatic habitats, ecology and extant of distribution, Water quality parameters (abiotic: temperature, light, salinity, pH, turbidity etc.) and their effects on fish health and production.
e. Biotic parameters (plankton, insects, aquatic vegetation etc.) of ponds, lakes, rivers, and impacts on fish growth.
f. Induced breeding techniques.
g. Fish diseases and their control.
h. Fishing gears, fishing techniques, fishing communities.
i. Fisheries co-management.
j. Fish preservation, processing, transportation and marketing.

Practical:

1. Morphological characters of a typical fish
2. Identification of commercially important fish species, meristic counts, fin formula, scale formula etc.
3. Dissection of common fish to study its various systems.
4. Practical demonstration of induced fish breeding.
5. Introduction to artificial feed ingredients.
6. Fish disease diagnosis and identification.
7. Demonstration of fishing gears and methods of fish capture.

Books Recommended:

1. Stickney R.R. 2016. Aquaculture an introductory text, CABI. Publishing, London, UK.
2. Fitzsimmons, K., R.S.N. Janjua and M. Ashraf, 2015. *Aquaculture Handbook – Fish Farming and Nutrition in Pakistan.*
3. Sharma, O. P. 2009. Handbook of Fisheries and Aquaculture. Agrotech Publishing Academy, Udaipur, New Delhi, India.
4. Stickney, R. R. 2009. Aquaculture: An Introductory Text. CABI Publishing, London, UK.
5. Pillay, T.V.R. and M.N. Kutty 2005. Aquaculture: Principles and Practices. Blackwell Science Limited. New York.
6. Ali, S.S. 1999. An Introduction to Freshwater Fishery Biology. University Grants Commission, H-9 Islamabad.

ZOO-739	**AquaCulture Biotechnology**	3.0

Course Outline:

1. **Introduction**

a. History of Biotechnology in Aquaculture
b. Biotechnological approaches in Aquaculture
2. **Gynogenesis, Androgenesis and Cloned Populations**
a. Induction of Gynogenesis and Androgenesis
b. Performance of Gynogens and Androgens
c. Reproduction
d. Monosex Populations
e. Cloned Populations.
3. **Biochemical and Molecular Markers**
a. Isozymes and Enzymes.
b. Restriction Fragment Length Polymorphism.
c. Single Nucleotide Polymorphisms.
d. Relative Costs of Different Markers
e. Relative Effectiveness of Markers

4. **Gene-transfer Technique in Fish**
a. Promoters
b. Integration
c. Transmission of Transgenes
d. Transgene Expression of Growth-hormone and Reporter Genes
e. Performance of Transgenic Fish
f. Disease resistance
5. **Commercial Application ofFishBiotechnology**
a. 876Polyploidy
b. Sex Reversal and Breeding
c. Genetic Engineering

6. **Combining Genetic Enhancement Programmes**
a. Sex Reversal and Triploidy
b. Genetic Engineering and Crossbreeding
c. Genetic Engineering, Selection, Crossbreeding, Strains and Hybrids
7. **Food Safety of TransgenicAquatic Organisms**
a. International Guidelines
b. Labelling
8. **Environmental Risk of Aquatic Organisms from Genetic Biotechnology**
a. Theoretical Risks
b. Environmental Risk Data on Transgenic Fish
c. Common Goals of Aquaculture and Genetic Conservation

Practicals:

1. DNA isolation from fish.
2. Electrophoresis, Agarose and polyacrylamind gel electrophoresis.

3. Demonstration of amplification of DNA through PCR.

Text and Reference Books:

1. Dunham, R., 2011. Aquaculture and Fisheries Biotechnology. 2nd ed. CABI, UK.

2. Beaumont, A., Boudry, P. and Hoare, K., 2010. Biotechnology and Genetics in Fisheries and Aquaculture. Blackwell, USA.

3. Liu, Z. J., 2007. Aquaculture Genome Technologies. Blackwell, USA.

4. Montet, D. and Ray, R. C., 2009. Aquaculture Microbiology and Biotechnology. Science Publishers, USA.

5. Overturf, K., 2009. Molecular Research in Aquaculture. Blackwell, USA.

6. Pandian, T.J., Strüssmann, C.A. and Marian, M.P., 2005. Fish Genetics and Aquaculture Biotechnology. CRC Press, USA.

ZOO-740	**Biological Toxicology**	3.0

Course Outlines:

1. **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 teratogenity.

2. **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.

3. **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.

4. **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.

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

6. **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.*

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

Practical:

1. Study of Biotoxicity 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. Karen E. Stine and Thomas M. Brown, 2015. Principles of Toxicology, CRC press, Taylor and Francis Group.
2. Frank A. Barile, 2007. Principles of toxicology testing, CRC Press Taylor and Francis Group.
3. Hans Marquardt, Siegfried, G. Schafer, Roger Mcclellan, Frank welsch, 1999, 2004, Toxicology, Academic press, San Diego.
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.

ZOO-741	**Biology of ornamental fish and aquaria management**	3.0

Course Outlines:

1. Introduction to ornamental fish culture.
2. Commercially important ornamental fishes: Exotic and indigenous.
3. Food and feeding habits.
4. Food and feeding management.
5. Culture of live food organisms.
6. Preparation of artificial feed for ornamental fish species.
7. Breeding of live bearer, breeding of egg laying species.
8. Selection of spawning tanks.
9. Diseases of ornamental fishes and prophylactic measures.
10. Techniques in genetic improvement of ornamental fishes.
11. Species used for genetic improvement.
12. Important consideration and management practices in ornamental fishes.
13. Transportation of ornamental fishes.
14. Ornamental fishes trades.
15. Trade regulation and wildlife Act.
16. Fabrication of aquarium, material required for construction of aquarium.
17. Methods for construction of aquarium.
18. Setting up of aquarium.
19. Aquarium accessories and equipment on small and large scale units.
20. Aeration in aquarium, filtration.
21. Water quality management.
22. Aquarium plants.

Practical:

1. Identification of commercially important live bearer ornamental fishes.
2. Identification of commercially important egg laying ornamental fishes.
3. Identification of commercially important common ornamental fishes.
4. Identification of commercially important common ornamental aquatic plants.
5. Fabrication of glass tanks, setting of glass aquarium, aquarium accessories and equipment.
6. Preparation of ornamental fish feed
7. Setting of aerators, filters and heater.
8. Disease of ornamental fishes and prophylactic measures
9. Breeding setup for live bearer ornamental fishes
10. Breeding setup for egg laying ornamental fishes
11. Visit to ornamental fish farms.

Recommended Books /Readings

1. Hargreaves, V. 2007. The Complete Book of the Freshwater Aquarium: A Comprehensive Reference Guide to More Than 600 Freshwater Fish and Plants.
2. Sexana, A. 2003. Aquarium Management. Daya Publishing House, Delhi
3. Petrovicky, I.1998. Aquarium Fishes of the World. Arch Cape Press. New York
4. Tekriwal, K.L., Rao, A.A and Dawes, J.1999. Ornamental Aquarium Fishes of India. TFH Publication
5. Penzes, C.P and Tolg, I.1985. Goldfish and Ornamental. Barron Educational Series
6. Sandford, G. 2000. Aquarium Owner Guide.DK Publishing
7. Schliewen, U. 1988. Aquarium Fishes: How to care for them. Barron Juveniles
8. Robert, H.E.2009. Fundamental of Ornamental Fish Health. Published by Wiley Blackwell
9. Robert, H.E.2009. Ornamental Fish. Published by Wiley Blackwell
10. Dholakia, A.D.2010. Ornamental Fish culture and Aquarium Management. Amazon Publisher
11. Wildgoose, W.H. 2001. BASAVA Manual of Ornamental Fish. Published by Wiley Blackwell.
12. Mahapatra, B.K., S.Datta, GhPhailan and S. Dasgupta. 2015. Ornamental Fish Breeding, Culture and Trade. Published by Director, KAR-CIFE Mumbai.

ZOO-742	**Cancer Genetics**	3.0

1. **Introduction**

a. Genetic basis of cancer.
b. Oncogenes,
c. Proto-oncogenes
d. Tumor Suppressor Genes.

2. **Cell Cycle Control Genes**

a. Types of Cyclins

b. CDKs,
c. pRb,
d. E2F transcription factor,
e. Myconcoprotein
3. **DNA Repair Pathways**
a. Genes involved in Repair pathways.
b. p53
c. Mdm2
d. ARF

4. **Oncogenes and cancer metastasis:**

How faulty genes lead to cancer.
a. Proto-oncogenes.
b. Tumor suppressor genes.
c. DNA repair genes.
d. Metastasis suppressor genes.
e. Genetic instability and cancer.
5. **Apoptosis:**
a. Introduction to apoptosis,
b. Proapoptotic genes,
c. Antiapoptotic genes,
d. How cell maintains balance between pro and antiapoptotic genes
6. **Genetic Screening for Cancer.**
a. SNP and Cancer.
b. Case Studies:
c. P53
d. BRCA1
e. RRCA2

Text and Reference Books:

1. Alberts, B., Bray, D., Hopkin, K., Johnson, A., Lewis, J., Raff, M.,& Walter, P. (2013). Essential cell biology. Garland Scienceiology. Garland Science
2. Berg, J. M., Tymoczko, J. L., &Stryer, L. (2002). Biochemistry, W. H.Lewin, (Latest Edition). Genes VIII.
3. Krebs, J. E., Lewin, B., Goldstein, E. S., & Kilpatrick, S. T. (2014). Lewin's genes XI. Jones & Bartlett Publishers.
4. Articles Published in Nature Review Cell & Molecular Biology. (Latest Edition).
5. Articles Published in Nature Review Immunology. (Latest Edition).

ZOO-743	**CHEMICAL OCEANOGRAPHY**	3.0

Course Outlines:
5. **Introduction**

a. History of Chemical oceanography.
b. Chemical composition of sea water; major constituents,
c. Law of constancy of major ion ratios
d. Oxidation state and Redox reactions,
e. Redox and PH diagrams, alkalinity and PH. Ion speciation,
f. Geochemical reservoirs and transport of material to the oceans.
g. Air-sea exchange.

6. **Dissolved gases and nutrients**

a. Dissolved gases in sea water,
b. Geochemical cycles: nitrogen, sulfur, phosphorus, silicon and carbon cycle.
c. Distribution of nutrients in sea water.

7. **Trace elements in Oceans**

a. Oceanic residence time; Distribution of trace elements in sea water;
b. Oceanic water mass tracers, Radio-isotopic tracers; Stable isotopic tracers.

4. **Estuarine chemistry**

a. Esturies: Classification and mixing processes.
b. Biological modeling of estuaries.

11. **Marine geochemistry**

a. Formation of deep sea sediments. Sedimentation rates.
b. Classification of marine sediments.
c. Distribution of organic matter and its role in ocean chemistry.

Practicals:

1. Introduction to instruments used in chemical analysis.
2. Analysis of water parameter: Dissolved oxygen and nutrients (NH4, NO2 and PO4) in different samples of sea waters.
3. Analysis of heavy metal in metal in marine sediments/ marine animals.
4. Grain size analysis of marine sediments.
5. Detection of moisture contents and organic matter in marine sediments.
6. Estimation of organic load in sea water by filtration techniques.
7. Field visit for collection of marine sediments and sea water from different localities.

Books Recommended:

1. Frank J. Miller 2016 Chemical Oceanography, 4th Edition, CRC press 591pp.

2. Michael E. Q. Pilson 2013 An Introduction to the Chemistry of the Sea 2nd Edition. Cambridge university press 516pp
3. Jorge L. Sarmiento 2006 Ocean Biogeochemical Dynamics. Princeton University press 495 pp
4. Chester, R.1990. Marine Geochemistry, Unwin Hyman , London,
5. Garrison, T. 2005. Oceanography: An invitation to Marine Science. 5th edition. Thomson Learning, Incorporation.
6. Millero, F.1996. Chemical Oceanography, CRC Press, Boca Raton, Fla.

7. Pislon, M.E.Q.1998. An introduction to the Chemistry of the sea, Prentice

Hall, Upper Saddle River, N.J ;431.
8. Riley, J. P. and G. Skirrow, Ed.1974. Chemical Oceanography. New York, Academic Press.

ZOO-744	**Clinical Immunology**	3.0

Course Outline:

1. **Musculoskeletal Diseases**

a. Clinical features of Rheumatoid Arthritis
b. Synovial Changes in Rheumatoid Arthritis
c. Pathogenesis of Rheumatoid Arthritis
d. Juvenile Chronic Arthritis
e. Clinical Features of Spondylartheritis
f. Gout, Polychondritis and Bechet,s Syndrome

2. **Skin Diseases**

a. Urticaria
b. Contact Allergies
c. Atopic Dermatitis
d. Leukocytoclastic Vasculitis
e. Psoriasis
f. Bullous Skin Disease

3. **Gastrointestinal Diseases**

a. Atrophic Gastritis
b. Whipple,s Disease and Sprue
c. Chronic Inflammatory Bowl,s Disease

4. **Respiratory Diseases**

a. Bronchial Asthma and Allergic Rhinitis
b. Sarcoidosis
c. Idiopathic Pulmonary Fibrosis
d. Extrinsic Allergy
e. Alveolitis and Tuberculosis

5. **Renal Diseases**

a. Immunological Mechanisms of
o Glomerulonephritis (I)
o Glomerulonephritis (II)
b. Interstitial Nephritis

6. **Metabolic Diseases**

a. Autoimmune Thyroid Disease
b. Diabetic Mellitus type I
c. Diabetic Mellitus type II

d. Autoimmune Polyglandular Syndrome

7. **Heart Disease**

a. Rheumatoid fever

b. Myocarditis

c. Post-infection Syndrome

8. **Neurological Diseases**

a. Multiple Sclerosis

b. Autoantibody Mediated Diseases

c. Myasthenia Gravis

d. Lambert-Eton Syndrome

9. **Ophthalmic Diseases**

a. Anatomy and Pathology

b. Extraocular Inflammations

c. Uveitis (I)

d. Uveitis (II)

e. Ocular Manifestation of Systemic Disease

10. **Reproductive Immunology**

a. Immunological basis of reproductive disorders

b. Immunological tolerance and reproductive immunology

11. **Gene Therapy**

a. Modern Approaches and Tools for Gene Therapy

b. Applications of gene therapy in Immunology

Text and Reference Books:

1. Richard, A., Goldsby, Thomas, J., Kindt and Barbara, A., Osborn. 2009. Kuby's Immunology, 7th Ed. W.H. Freeman & Company, New York.

2. Murphy, K and Weaver, C. 2016. Immunobiology by Janeway, 9th Ed. Garland Science Taylor and Francis Group, New York and London

3. Annual Reviews of Immunology and Journal of Immunology. The editions available in Pakistan

ZOO-745	**Clinical Teratology**	3.0

Course Outlines:

1. Teratogenesis introduction
2. Environmental assaults on human development
3. Teratogenic agents: Alcohol, Retinoic acid, Hydroflourocarbonsand others
4. Role of degradation products used as refrigerants in teratogenesis
5. Possible role of drugs and neuro-toxicants such as Heroin in congenital defects
6. Heavy metal as teratogens
7. Pathogens: *Rubella, Toxoplasma gondii, Treponema pallidum* (Syphilis bacterium) inflicting teratogenesis
8. Endocrine disruptors such as diethylstilbestrol (drug used to prevent premature births) causing inborn defects

9. Possible roles of Nonylphenol(Plastic wrappings around food) andBisphenol(a water bottles, baby feeders) in prenatal and postnatal developmental errors
10. Tobacco and Cannabis causing embryonic and postembryonic disruptions
11. Alcoholism and fetal alcohol syndrome
12. Antimalarial and antiprotozoal medicines as developmental disruptors
13. Role of tranquilizers, anti-nauseant and anti-hyperglycemic medicines in embryonic development
14. Oxidative stress and embryonic development
15. Ectopic pregnancies
16. Placental errors, Breach babies
17. Polyhydromenosis and oligohydomenosis
18. Major inborn defects like imperforated anus, cardiac sepatal defects, intestinal atresia, cleft lip and cleft palate
19. Organ ectopia, hydrocephaly, microcephaly
20. Congenial neural tube and nervous system defects
21. Testicular dysgenesis and declining sperm counts.
22. Developmental biology and future of medicine
23. Germ-line gene therapy
24. Stem cell therapy
25. Regenerative medicine
26. Regeneration therapy
27. In utero surgeries
28. Neonatal surgeries
29. Biophysical organ transplants
30. Regenerative organs and organoids
31. Fraternal and monozygotic twining
32. Organ twining

Practicals:

1. Hospital visits to observe the cases of developmental abnormalities.
2. Impact of various Teratogens on J774.2 macrophage like cell line *in vitro*
3. *P*otentially toxic insult of r*eactive oxygen species* generation in response to various teratogens
4. Various environmental toxicants causing membrane dysfunction, **lipid** peroxidation, DNA damage and inactivation of proteins.

Books and Articles Recommended:

a. Gilbert, S.F. (2006). Developmental Biology Carlson BM (2014) Human Embryology and Developmental Biology, 5th Edition, Mosby Elsevier.
3. Moore K, Persaud T V N, Torchia M (2015) The Developing Human Clinically Oriented Embryology 10th Edition. Elsevier inc
4. Ema M, Naya M, Yoshida K and Nagaosa R. (2010).Reproductive and developmental toxicity of degradation productsof refrigerants in experimental animals. Reproductive ToxicologyVolume 29, Issue 1, January 2010, Pages 1-9**.**

5. Azim HA, PeccatoriFA and Pavlidis N. (2010). A systematic Review C:\Users\akram\Documents\Teratology-cancers in pregnancy 2010.htm - hit2 on the use of cytotoxic, endocrine, targeted agents and immunotherapyduring pregnancy. Part I: Solid tumors. Cancer Treatment Reviews.Volume 36, Issue 2, April 2010, Pages 101-109
6. Bedard PL and Cardoso F. (2008), Recent advances in adjuvant systemictherapy or early-stage breast cancer, *Ann Oncol*19 (Suppl 5) pp. 122–127

7. Powers CM, Yen J, Linney EA,Seidler FJ, Slotkin TA. (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*
8. Cassina M, De-Santis M, Cesari E, van-Eijkeren M, Berkovitch M, Eleftheriou G, Raffagnato F, Di-Gianantonio E,Clementi M. (2010). First trimester diclofenac exposure and pregnancy outcome.*Reproductive Toxicology*, *Available online 1 May 2010*
9. Guidelines for Human Embryonic Stem Cell Research (2005). http://www.nap.edu/catalog/11278.html (free download is available)
10. Understanding stem cells: An overview of the science and issues from thenational academies USA. Copyright © 2009.National Academy of Sciences. All rights reserved. 500 Fifth St. N.W., Washington, D.C. 20001 http://www.nap.edu

ZOO-746	**Conservation Biology**	3.0

Course Outline:

1. **Introduction to Conservation Biology:**

a. Definition,

b. History and

c. Scope.

2. **Biodiversity:**

a. Species Diversity; Genetic Diversity; Ecosystem Diversity;

b. Measurement of Biological Diversity;

c. AnOverview of World's Biodiversity;

d. The Value of Biodiversity

3. **Threats to Biodiversity:**

a. Human Population Growth;

b. Habitat Destruction; Habitat Fragmentation;

c. Environmental Degradation and Pollution;

d. Global Climate Change;

e. Overexploitation;

f. Invasive Species

4. **Extinctions:**

a. Extinction and Mass Extinctions;

b. Rates of Extinction; Island Biogeography;
c. Vulnerability to Extinction;
d. Problems of Small Populations; Minimum Viable Population (MVP);
e. Loss of Genetic Diversity; Effective Population Size;
f. Demographic and Environmental Stochasticity
5. **Conserving Populations and Species:**
a. Applied Population Biology; Monitoring populations; Population viability analysis; Metapopulations,
b. International agreements for conservation of fauna and flora; Role of national and International Laws in Protection of Species;
c. Ex Situ Conservation Strategies; Zoos; Aquariums; Botanical gardens; Seed banks.
d. ProtectedAreas and theirEstablishment and categories;
e. Managing Protected Areas; Challenges to Protected Areas Management.
f. Unprotected Public and Private Lands
g. Ecosystem Management
h. Integration of Local Community in Conservation
i. Restoring Damaged Ecosystems
6. **Sustainable Development:**
a. Challenges Involve in Conservation and Sustainable Development at the Local Level
b. International Approaches to SustainableDevelopment
c. Funding for Conservation by the World Bank and international NGOs;
d. Conservation Education and the Role of Conservation Biologists

Practicals:

1. Conservation issues in protected areas of Pakistan.
2. Study of the role of local community in protected areas of Pakistan.
3. Challenges to sustainable development and their solution in Pakistan.

Text and Reference Books:

1. Richard B. Primack, 2012. A Primer of Conservation Biology; 5th Edition: Sinauer Associates, Inc. Publishers Sunderland, MA U.S.A.
2. Groom, M.J., G.K. Meffe and C.R. Carroll, 2006, Principles of Conservation Biology, 3rd edition, Sinauer Associates, Sunderland, MA.
3. Malcolm L. Hunter, Jr. 2001. Fundamentals of Conservation Biology, 2nd Edition. Blackwell Science Inc.
4. Mills, L.S. 2007. Conservation of Wildlife Populations: Demography, Genetics and Management. Blackwell Publishing, USA.
5. Richard B. Primack. 2002. Essentials of Conservation Biology. 3rd Edition. Sinauer Associates Inc. Publishers, Sunderland, Massachusetts, U.S.A.

ZOO-747	**Conservation Biology of Wildlife**	3.0

Course Outline

1. **Introduction:**

a. An Overview of the Wildlife Biodiversity

b. The Importance of Wildlife Biodiversity
c. Conservation values and ethics
d. Techniques involved in Measurement of Biological Diversity;
2. **Threats and challenges involved in Wildlife conservations**
a. Mass Extinction and Global Climate Changes,
b. Habitat Degradation and Loss,
c. Habitat Fragmentation
d. Island Biogeography,
e. Overexploitation,
f. Species invasion
g. Inbreeding and Outbreeding Depressions,
h. Loss of Genetic Variability,
i. Human factors; economic factors, politics and cultures.
3. **Assessment of Extinction Vulnerability of Wild Populations:**
a. Monitoring techniques for wildlife populations **Text and Reference Books:**
1. Richard B. Primack, 2012. A Primer of Conservation Biology; 5th Edition: Sinauer Associates, Inc. Publishers Sunderland, MA U.S.A.
2. Groom, M.J., G.K. Meffe and C.R. Carroll, 2006, Principles of Conservation Biology, 3rd edition, Sinauer Associates, Sunderland, MA.

3. Caughley, G. and A. Gunn. Conservation biology in theory and practice. Blackwell Science Publication.
4. Eric. G. Bolen and William L. Robinson. 1995. Wildlife Ecology and Management. 3rd Edition. Prentice Hall, Upper Saddle River, New Jersey.
5. Hosetti, B. B. and Venkateshwarlu, M. 2001. Trends in Wildlife Biodiversity, Conservation and Management. Daya Publishing House Delhi-11035.
6. Malcolm L. Hunter, Jr. 2001. Fundamentals of Conservation Biology, 2nd Edition. Blackwell Science Inc.
7. Mills, L.S. 2007. Conservation of Wildlife Populations: Demography, Genetics and Management. Blackwell Publishing, USA.
8. Richard B. Primack. 2002. Essentials of Conservation Biology. 3rd Edition. Sinauer Associates Inc. Publishers, Sunderland, Massachusetts, U.S.A.
9. Soule, M. E. 1987. Viable populations for Conservation. Cambridge University Press. Cambridge.
10. Soule, M.E. and B.A. Wilcox. 1980. Conservation Biology. Sinauer Associates Inc. Sunderland. Massachusetts.
b. Risk assessment, diagnosis of declines,
c. Population viability analysis;
4. **Approaches to conserve wildlife**
a. Species and Landscape Approaches to Conservation
b. Ecosystem Approaches to Conservation
c. Protected Areas and their management

d. Restoration of Damaged Ecosystems and Endangered Populations
e. Sustainable Development

ZOO-748	**Desert Zoology**	3.0

Course Contents:

1. **Origin of desert life**

a. Exhibited features including soil, water, temperature, atmospheric pressure and oceanic role.

2. **Desert Ecology:**

a. Introduction to local habitats,
b. identification of local animals
c. Morphological and physiological adaptations of desert organisms
d. Principles of classifying and naming species.

3. **Desert biomes**: (Hot and Dry, semiarid, Costal and Cold).

a. Desertification its Causes and impacts on animals. Deserts of Pakistan.
b. Conservation of Animals:
c. Advantages and disadvantages of Deserts,
d. Major threats/risk factors and management strategies to conserve the animals in deserts.

Practical:

1. Field trips of deserts
2. Collection of samples.
3. Visits of National Parks
4. Identification of indigenous fauna

Recommended Books:

1. D. Ward, 2016. The Biology of Deserts. Oxford University Press. 416p.
2. G. W Brown, 2013.Desert Biology: Special Topics on the Physical and Biological
3. Aspects of Arid Regions. Elsevier. 148322371X, 9781483223711. 654P.
4. W. G. Whitford, 2002. Ecology of Desert Systems. Academic Press. 343 pages

ZOO-749	**Ecotourium Planning and management**	3.0

Course Outline

1. **Origin of eco-tourism**
2. **Tourism and Protected Areas**
3. **Tourism as a tool for conservation** a. Support of protected areas
b. Global trends affecting tourism
c. Principles and direction for tourism in protected areas
4. **SWOT analysis**
5. **Tools for visitor management**
c. Economics of tourism in protected areas
d. Financial aspects of tourism in protected areas

6. **Negative impacts of tourism**
7. **Challenges of tourism and their management**

Practicals:

1. SWOT analysis
2. Elements of Eco-tourism planning
3. Identification of tourism potential
4. Conventional and participatory approaches
5. Sustainable tourism planning model

Recommended Books:

1. Bushell. R & Eagles, P. F. J. 2007. "Tourism and Protected Areas: Benefits beyond boundaries" edited by CABI International.
2. Lind berg, K. 1991. Policies for maximizing Nature Tourism's ecology and Economic Benefits. Washington, World Resources Institute.
3. Hawkins L. K. and E. Doneld. 1993. Ecotourism: A Guide for Planers and Managers, Vermont.
4. Eagles, P. F. J: McCool, S. F: and Haynes, C. D: (2002) "Sustainable Tourism in Protected Areas: Guidelines for Planning and Management". Best Practice Protected Area Guidelines Series No. 8, series editor;
Phillips, A. World Commission on Protected Areas (WCPA). IUCN – The World Conservation Union.
5. Ceballos-Lascuráin, H: (1996) "Tourism, Ecotourism, and Protected areas", IUCN Protected Areas Programme (IV World Congress on National Parks and Protected Areas)
6. Nurphy, P. E. 1985. Tourism: A community Approach. The ecotourism Society.
7. World Tourism Organization (1992) Guidelines: Development of National Parks and Protected areas for Tourism. Aadrid

ZOO-750	**Fish and Aquatic Toxicology**	3.0

Course Outline:

1. **Introduction to Aquatic Toxicology**

a. History of Aquatic Toxicology
b. Main Present and Future Challenges
c. Classification and Types of Toxicity
d. Effects of Aquatic Toxicology on Organisms
e. Bioindicators and Biomarkers

2. **Sources and Causes of Aquatic Contamination**

a. Major Sources of Pollutants
b. Transport of Pollutants in the Environment
c. Metals, Metalloids, and Organometallic Compounds
d. Other Inorganic Compounds, Including Factors Causing Eutrophication
e. Organic Compounds
f. Nanomaterials

g. Radiation
h. Genetic Modification

3. **Uptake, Distribution, Detoxification and Excretion of Compounds in Aquatic Organisms**

a. Uptake of Compounds by Organisms
b. Distribution and Storage Sites of Chemicals in Organisms
c. Biotransformation and Detoxification
d. Cellular Excretion
e. Excretion from Gills, Kidney and Other Excretory Organs
f. Excretion in Bile Via the Intestine
g. Excretion From Multicellular Plants and Algae

4. **General Principles of Toxicology in Fishes**

a. Bioavailability of Chemical Contaminants in Aquatic Systems
b. Toxicokinetics in Fishes
c. Toxicodynamics in Fishes
d. Biotransformation in Fishes
e. Bioaccumulation of Toxicity in Fishes
f. General approaches to diagnosis and treatment of toxicity

5. **Toxicity in Fishes**

a. Toxicity caused by metal and non-metals,
b. Phytotoxins
c. Drug toxicity and toxicity caused by agrochemicals.
d. Mycotoxins
e. Bacterial toxins

6. **Key Target System in Fish and Organismal Effects**

a. Liver Toxicity in Fishes
b. The Osmoregulatory System of Fish
c. Toxic Responses of the Fish Nervous System
d. The Endocrine System
e. The Immune System of Fish: A Target Organ of Toxicity
f. Chemical Carcinogenesis in Fishes
g. Toxicity Resistance in Fishes

Practical:

1. Study of eutrophication
2. Study of behavioral responses of aquatic organisms to toxicants
3. Spot tests for metals
4. Demonstration of drug toxicity

5. Detection of heavy metal poisoning
6. Study of biotoxicity assay for LC50
7. Case studies in toxicology

Text and Reference Books:

1. Marquardt, H., Schafer, S.G., Mcclellan, R. and Welsch, F., 1999.*Toxicology*, Academic press, San Diego.
2. Rand, G.M., *Fundamentals Of Aquatic Toxicology: Effects, Environmental Fate And Risk Assessment.* 2nd Edition.
3. Nikinmaa, M., 2014. *An Introduction to Aquatic Toxicology*. 1st Edition. Academic Press.
4. Giulio, R.T.D. and Hinton, D.E., 2008. *The Toxicology of Fishes*. CRC Press, Taylor and Francis Group.
5. Whitacre, D. M. (Editor) 2012. *Reviews of EnvironmentalContamination and Toxicology*. Vol. 223. Spriger, Switzerland.

ZOO-751	**Fish Breeding and hatchery management**	3.0

Course Outline:

1. **Fish Breeding**

a. Sexuality in fishes
b. Sexual dimorphism; Reproductive cycle
c. Courtship and mating
d. Fecundity and spawning
e. Natural and Artificial propagation of fishes
f. Gonad anatomy and reproductive mechanisms
g. Development of gametes in male and female fish
h. Hormonal control of reproduction
i. Spawn quality and quantity indices
j. Sexual maturity and breeding season of various cultivable species
k. Fish egg and embryonic development
l. Parental care in fishes

2. **Brood Husbandry:**

a. Brood availability, transport
b. Selection of brood stock for rearing
c. Brood captive rearing and maturation
d. Nutritional and environmental requirement for broodstock
e. Nutritional and environmental manipulation for early maturation of brood stock
f. Brood health care and stress management

3. **Methods of breeding**

a. Criteria for selection of mature brood fish induce spawning
b. Wet and dry method of breeding
c. Factors affecting maturation and spawning in fishes

d. Fish pituitary gland, its structure, collection, preservation and preparation of extract for injection.
e. Synthetic hormones used for induced breeding of carps
f. Dosages and methods of injection
g. Collection and hatching of egg
h. Causes of mortalities of eggs and spawn and their remedies
i. Improvement of seed quality
4. **Fish Hatchery Management**
a. Criteria for site selection of hatchery and nursery
b. Types of hatchery
c. Design and construction of modern hatchery
d. Operation, management and hatchery technology for seed production of important fish species
e. Spawn rearing techniques and its nutritional requirements
f. Monitoring of different water quality parameters in fish hatcheries
g. Hatchery standards and bio-security
h. Disease management and their control in fish hatcheries
i. Better management practices
j. Use of anesthetics in fish breeding and transport
k. Seed packaging and transportation methods
l. Economics of seed production

Practical:

1. Study of maturity stages in fishes
2. Collection and preservation of fish pituitary gland
3. Calculation of fecundity
4. Brood-stock maintenance and selection of breeders for injection
5. Histological studies of ovary and testes
6. study of fish eggs and embryonic developmental stages
7. Water quality monitoring in fish hatcheries and nurseries
8. Use of disinfectants and antibiotics in fish breeding
9. Visit to different fish hatcheries

Text and Reference Books:

1. Pillay.T V R and M N Kutty, 2005, Aquaculture- principles and practices,Blackwell sciences, UK
2. Thomas.P.C et al, 2003. Breeding and seed production of finfish and shellfish,Daya publishing house, New delhi
3. Mathew Landau, 1992. Introduction to Aquaculture, John Wiley and sons, INC,New york
4. Jhingran. V G, 1991, Fish and Fisheries of India, Hindustan Publishers.
5. Rath, P K, 2000, Freshwater Aquaculture, Scientific Publishers, Jodhpur

6. Jhingran VG and Pullin R S V, 1985, Hatchery Manual for the Common, Chineseand Indian major carps, ICLARM
7. Sharma, O. P. 2009. Handbook of Fisheries and Aquaculture. Agrotech Publishing Academy, Udaipur, New Delhi, India
8. Hart, P. J. B. and J. D. Reynolds. 2008. Handbook of Fish Biology and Fisheries, Volume 2. Blackwell Science Ltd., New York, USA
9. Huet, M. 1998. Text Book of Fish Culture - Breeding and Cultivation of Fish. Fishing News, London, UK.

ZOO-752	**Fish Nutrition and Health**	3.0

Course Outlines:

1. **Introduction:** Introduction to nutrients (macronutrients and micronutrients) and their importance; carbohydrates, lipids, protein, amino acids, vitamins, minerals, carotenoids.

Nutritional energetic: digestion process in fish, energy partitioning, bioenergetics model, methods of digestibility determination, factors affecting digestibility, nutrient digestibility.

2. **Types of fish feed**: natural and artificial; production of live feed; classification of fish feed on the basis of nutrient composition and texture.
3. **Feed Additives and anti-nutritional factors:** Introduction to feed additives; other dietary components (water, fiber, hormones, antibiotics, pigments, pellet binders, stimulants). Anti-nutritional factors, types of anti-nutrients and their sources.
4. I**ntroduction to toxic agents and anti-oxidants:** Toxic agents, non-nutrient diet components; antioxidants in compounded feeds.
5. **Nutritional disorders:** Nutritional fish diseases; nutrients and immune response; feed rancidity.
6. **Feed Rationing and Frequency:** Feeding ratio; feeding frequency; feed conversion ratio; feed digestibility; pre-biotics and pro-biotics.
7. **Novel diets for aquaculture:** Encapsulated diets, medicinal diets and experimental diets.
8. **Aqua feed industry**: Introduction, economics of feed production and feeding; quality control in fish feed manufacturing; feed regulations.

Practical:

1. Introduction to various fish feed ingredients (plants and animal origin), feed additives.
2. Gut contents analysis.
3. Measuring feed conversion ratio and feed intake.
4. Calculation of specific growth rate of fish (SGR).
5. Proximate analysis of fish feed ingredients (Dry matter; moisture; crude protein; crude lipid; gross energy; ash content; etc).
6. Determination of Afllatoxins concentration in fish feed.

7. Analysis of anti-nutritional factors in fish feed ingredients.
8. Visit to fish feed mill.

Recommended Books:

1. John Halver. 2013. Fish Nutrition, ELSEVIER.
2. Lovell, T., 2012. Nutrition and Feeding of Fish. 2nd Ed. Springer Science, USA

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. Ojha, J.S. 2006. Aquaculture Nutrition and Biochemistry. GeetaSomaniAgrotech Publishing Academy, Udaipur, India.
6. Parker R. O., 2004. Aquaculture Science (4thedt.). Delmar Learning, London.
7. Halver, J.E. and Hardy, R.W. 2002. *Fish Nutrition.* Academic Press. Boston, London,
8. Hertrampf, J.W., Pascual, F.P. and Ong, S.L. 2002. *Handbook on Ingredients for Aquaculture Feeds***.** Kluwer Academic Publishers
9. Rajagopalsamy, C.B.T. and. Ramadhas. V. 2002. *Nutrient Dynamics in Freshwater Fish culture system.*Daya Publishing house, Delhi.
10. Rajagopalsamy, C.B.T. and. Ramadhas. V. 2002. *Nutrient Dynamics in Freshwater Fish culture system.*Daya Publishing house, Delhi.
11. Bhujel, R. C.; Yakupitiyage, A.; Turner, W. A. and Little, D. C. (2001). Selection of a Commercial Feed for Nile Tilapia (*Oreochromisniloticus*) Broodfish Breeding in Hapa-in-Pond systems. Aquaculture 194: 303-314.
12. Lovell, T. 1998. *Nutrition and Feeding of Fish.* Kluwer Academic Publishers Boston, London.
13. Brummett, R.E., (2000). Food organism availability and resource partitioning in organically or inorganically fertilized *Tilapiarendalli* ponds. Aquaculture, 183: 57-71New York
14. George F., H. P.S. Makkar and Klaus B. (2001) Antinutritional factors present in plant-derived alternate fish feed ingredients and their effects in fish. Aquaculture 199: 197–227
15. Hardy, R. W. (1999). Collaborative Opportunities between Fish nutrition and Other Disciplines in Aquaculture: An Overview. Aquaculture 177: 217-230.
16. Agricultural Software Consultants, Inc. (1997). MIXIT-WIN. Feed Formulation for Windows 95 or NT. Virginia.
17. De Silva, S. S. and Anderson, T.A. (1995). Fish Nutrition in Aquaculture, Chapman and Hall. London.
18. Desilva, S.S. and Anderson, T.A. 1995. *Fish Nutrition in Aquaculture.*Kluwer Academic Publishers
19. NRC, 1993. Nutrient Requirements of Fish. National Academic Press, Washington, D.C.
20. Lovell, T. *Nutrition and Feeding of Fish***.** Kluwer Academic Publishers, 2nd Edition

21. De Silva, S.S. and Davy, F.B., (1993). Fish nutrition research for semi-intensive culture systems in Asia. Asian Fisheries Society 5: 129-144.
22. Olvera-Novoa. M. A, Martinez-Palacios, C.A. and DE lEÓN, E.R. (1994). Nutrition of fish and crustaceans a laboratory manual. Food and Agriculture Organization of the United Nations – FAO Mexico City.
23. National Research Council (NRC), (1993). Nutrient Requirements of Domestic Animals. Nutrient Requirements of warm water fishes and shell fishes. Revised Edition. National Academy Press, Washington DC, USA, 114 p.

ZOO-753	**Fish Requirements**	3.0

Course Outlines:

1. Introduction to fish nutrition.
2. Digestion and absorption of nutrients.
3. Feeding types and anatomy.
4. Energy, protein, lipids, carbohydrate, mineral and vitamin requirements of fish.
5. Factors affecting nutrient requirements of fish.
6. Energy losses and partitioning in fish.
7. The role of other dietary components viz. water, fiber, hormones, antibiotics, antioxidants, pigments, pellet binders and feeding stimulants.
8. Anti-nutrients and toxins.
9. Forms and size of feed, feeding rates and feeding practices for different fish species.
10. Special purpose feeding.
11. Feed calculations, feed requirements and feed conversion ratios.
12. Feed ration and frequency, judging feeding response of cultured species, methods of feeding.

Recommended Books:

1. Fitzsimmons, K., R.S.N. Janjua and M. Ashraf, 2015. *Aquaculture Handbook – Fish Farming and Nutrition in Pakistan.*
2. John Halver. 2013. Fish Nutrition, ELSEVIER.
3. Lovell, T., 2012. Nutrition and Feeding of Fish. 2nd Ed. Springer Science, USA
4. Hepher, B., 2010. Nutrition of Pond Fishes. Cambridge University Press, UK.
5. Halver, J.E., Ronald, W.H. and Daniel, M.H. 2004. Fish Nutrition (4thed.). Academic Press, N. York.
6. Pillay, T.V.R. 1999. Aquaculture: Principles and Practices. Fishing News Books, London.
7. N.C.R., 1998. Nutrient Requirements of Fish. National Academy Press, Washington D.C.

ZOO-754	**FISH PARASITOLOGY**	3.0

Course Outlines:

1. **Introduction to fish parasitology**

a. Host and parasite

b. Types of host and parasite
c. Ectoparasite and endoparasite concepts
d. Overview and Adaptation,
e. association of parasites:
f. symbiosis,
g. commensalism,
h. mutualism,
i. parasitism.

2. **Fish parasites**

a. Classes of fish parasites:
b. Ecto-parasites,
c. Endo-parasites.
d. Identification of parasitic problems.
e. Methods of diagnosis, physical examination,
f. Pathogenesis,
g. Life cycles and treatment methods of following parasites:
h. Protozoa,
i. Monogenean trematodes,
j. Degenean trematodes,
k. Nematodes,
l. Cestodes,
m. Crustaceans,
n. Leeches.

3. **Medically important parasites**

a. The medically important parasites,
b. Protection and the treatment of fish parasites

Practicals:

1. Identification of parasites
2. Life cycles of parasites
3. Isolation of fish parasites from host
4. Treatment methods
5. Prevention and control measures

Recommended Books/Readings:

1. Patrick T. K. W and K. Buchmann. 2012 Fish parasites: pathobiology and protection. 2012. CABI Publishers
2. Bremner, HA 2002. Safety and Quality Issues in Fish Processing. Woodhead Publishing Limited, Cambridge, England
3. Buchmann, K. 2007. An introduction to practical methods in fish parasitology. CABI Publishers
4. Bresciani, J., E. Ariel, K. Pedersen, I. H. Dalsgaard. 2009. Fish Disease: an introduction. CABI Publishers.

ZOO-755	**Fish Processing and value addition**	3.0

Course Contents:

1. Introduction to fish processing and value addition.
2. Quality of fresh and frozen fish.
3. Methods of assessing and selecting for quality microbiology of products.
4. Identifying heavy metals in fish and shellfish.
5. Modern methods of fish handling and hygiene.
6. On board handling and on shore fish handling.
7. Icing procedures.
8. Transportation to fish markets.
9. Various ways of fish disposal.
10. Fish preservation and traditional processing methods (salting, curing, sun-drying, smoking, etc.), fish filleting and packing.
11. Shelf life of fish food products.
12. Packaging.
13. Deep freezing and thawing.
14. Chemistry of freezing.
15. Development of value added fish products; pickling, fish pastes, special processing procedures (minced fish, minced based value addition, fish surimi and surimi based products, gelatin).
16. Industrial fish processing; Fish meals, fish oils, fish protein concentrate.
17. Fishing by products.
18. International standards.
19. Food safety and laws.
20. Live fish handling, marketing.

Practical:

1. Biochemical analysis of various products.
2. Tests for freshness and food safety.
3. Detection of microorganisms; various techniques for microbial studies.
4. Fish filleting lines (filleting, trimming, processing, freezing equipment, vacuum packaging etc.).
5. Peroxides value determination.
6. pH value determination in meat.
7. Acid value determination.
8. Fish oil extraction procedure.

Recommended Books:

1. Barry Leonard. 2011. Fish and Fishery Products, DIANE Publishing.
2. Fish Products and Processing, 2007. W. Horner & R. Robles, Blackwell Publications

3. FDA. 2003. *Fish and Fisheries Products Hazards and Control Guidance*. US Food and Drug Administration
4. Bremner, H. a. 2002. *Safety and Quality issues in fish processing.* Woodhead publishing Limited, Cambridge, England.
5. Pearson, A.M. and Dutson,T.R. 2002. *HACCP in Meat, Poultry & Fish Processing.* Kluwer Academic Publishers
6. Bremner, H.A. 2002. *Safety and Quality issues in fish processing*. Woodhead Publishing Limited.
7. Connell, J.J. 2001.*Control of Fish Quality*. Blackwell Science
8. Kestin, S.C. and Warriss, P.D. 2001. *Farmed Fish Quality.* Fishing News Books, Blackwell Science Ltd.
9. Pearson, A. M. and Dutson, T.R. 1999. *HACCP in Meat, Poultry and Fish Processing*. *Advances in Meat Research Series. Vol. 10*. ASPEN publication.
10. Martin, R.E., Collette, R.L. and Slavin, J. 1997. Fish Inspection, Quality Control, and HACCP, A Global Focus. Technomic Publishing Co. Inc.
11. Hall, G.M. 1996. *Fish Processing Technology.* Kluwer Academic Publishers
12. Regestein, J.M. and Regestein C.E. 1997. Introduction to fish Technology. CBS Publishers & Distributors, New Delhi.
13. Regestein, J.M. and Regestein, C.E. 1997. *Introduction to fish Technology*. CBS Publishers & Distributors, New Delhi.

ZOO-756	**FISHERIES EXTENSION AND EDUCATION**	3.0

Course Outlines:

1. Overview of fisheries and aquaculture sector in Pakistan and world.
2. Scope and importance of fisheries and aquaculture extension.
3. Special characteristics of fisheries sector and its stakeholders.
4. Introduction to extension education, research, and service.
5. Overview of fisheries research, development and extension systems in Pakistan.
6. Critical review of philosophy, principles, concepts, and practices of fisheries extension systems and approaches.
7. Teaching, learning and colearning.
8. Fisheries extension – advantages and limitations of present welfare and subsidy oriented extension systems.
9. Development and extension approaches as practiced by public agencies like Department of Fisheries, NGOs, FAO, and by the private sector; participatory fisheries extension approaches.
10. Participatory approaches for aquatic resources management and development: need, importance and guiding principles.
11. Public-Private-Community Partnership.
12. Social change; social control, social problems and conflicts in fisheries; gender issues in fisheries; theories of learning, learning experience, learning situation.

13. Reviewing national and international case studies on participatory approach to aquaculture research and development.

Recommended Books:

1. Malhotra SP & Sinha VRP. 2007. *Indian Fisheries and Aquaculture in a Globalizing Economy*. Part II. Narendra Publ. House.
2. Ray, G. L. (2006). Extension, Communication and Management. 6th edition, Kalyani Publication (PD)
3. Ray GL. 2006. *Extension, Communication and Management*. 6th Ed. Kalyani.
4. Brown D, Derek S & Simon FS. 2005. *Mainstreaming Fisheries Co-Management in the Asia-Pacific*. Asia-Pacific Fishery Comm. Rep. Publ. 2005/24, FAO, United Nations Regional Office for Asia and the Pacific, Bangkok.
5. Robert SP. 2005. *Fisheries Co-Management: A Practical Hand Book*. CABI.
6. Chandrasekhar CS. (Ed.). 2004. *Privatization of Agricultural Extension in India*. MANAGE, Hyderabad.
7. Ramchandran C. 2004. *Teaching not To F(in)ish: A Constructivist Perspective on Reinventing a Responsible Marine Fisheries Extension System*. CMFRI, Kochi.
8. Edwards P, Little DC &Demaine H. 2002. *Rural Aquaculture*. CABI.
9. Rivera WM. 2000. *Agricultural Extension: Worldwide Institutional Evolution and Forces for Change*. Elsevier.
10. Kumar D. 1999. *Trickle Down System (TDS) of Aquaculture Extension for Rural Development*. RAP Publ.
11. Kumar D. 1996. *Aquaculture Extension Services Review: India*. FAO Fisheries Circular No. 906, Rome.
12. Chambers R, Arnold P &Thrupp LA. 1989. *Farmers First: Farmer Innovation and Agricultural Research*. Intermediate Technology Publ.
13. Chambers R. 1983. *Rural Development Putting the Last First*. Longman.

ZOO-757	**Fishing Gear Technology**	3.0

Course Outlines:

1. Capture fishery and its role in world food production.
2. Reasons for decline and development potential.
3. Stock assessment techniques.
4. Various fishing methods, account of fishing gears and crafts, their selectivity efficiency catch per unit effort (CPU).
5. Gears and crafts of Pakistan.
6. Post-harvest handling, transportation.
7. Processing technology and product development of fish and shellfish.
8. Methods of fish handling and processing (drying, salting, smoking, canning, freezing).
9. Fish by-products (fish meals, fish body oil, fish glue etc).
10. Regulation of fishing.
11. Enactment of fishery legislation with special reference to Pakistan.

12. Fisheries administration and organization.

Practical:

1. Collection and identification of commercial species of fish.
2. Fish stock assessment.
3. Study of common fishing gears and crafts of Pakistan.
4. Study of nets (composition, design and operation).
5. Study of boats and nets used for fishing in Pakistan.
6. Method of gear selectivity and efficiency.

Recommended Books:

1. Joesph, E. 2016. Fishing Gears and Fishing Methods (Review Paper).Academia Publisher.
2. Vin T. Sparano. 2015. Complete Guide to Fresh and Saltwater Fishing: Conventional Tackle. Fly Fishing. Spinning. Ice Fishing. Lures. Flies. Natural Baits. Knots. Filleting. Cooking. Game Fish Species. Boating, Univers.
3. Badapanda, K.C. 2013. Basic of Fisheries Sciences, VOL III. Fishing Crafts and Gear Technology. H.D. Nedendera Publishing House. Publishers and Distributors.
4. O. Gabriel, K. Lange, E. Dalinand A.Twendt. 2005. Fish Catching Method of the World. Blackwell Publishing Ltd.
5. Huet, M. and Timmermans, J .2000. Text Book of Fish Culture. Blackwell Science Hameed, M.S. and M.R. Boopendernath. 2000. Modern Fishing Gear Technology. Diya Publishing House India
6. Ali, S.S., 1999. Freshwater Fishery Biology. Naseem Book Depot, Hyderabad
7. Regenstein, T.M. and C.E. Regenstein.1997. Introduction to Fish Technology CBS Pub. N. Delhi, India.
8. Joe, M. and Carrie, M. 1997. Introduction to Fish Technology Chapman and Hall, USA.
9. Windsor, M and Barlow, S. 1981. Introduction to Fishery Byproduct. Fishing News Books Ltd. England.

ZOO-758	**Forensic entomology**	3.0

Course Outline:

a. History and scope of Forensic Entomology.

b. Study of various insect groups and other arthropods related to medico-legal investigations like puzzling events of murder, suicide, and trafficking determination of time or postmortem intervals and location of the death.

c. Review and survey of insect life histories, life cycle and faunal succession of arthropods related to medicolegal cases and survey of the insects involved in forensic science.

d. Review of classification of ages in decomposition of human and animal remains, uses of insect and arthropods in investigation of death and the duration of PMI.

e. Forensic entomology in public health, arthropods borne disease, litigation and role of forensic entomology in formulation of health policy.

Practical:

1. Sampling, rearing, and preservation techniques in forensic entomology
2. Study of the decomposition of corpses and dead bodies;
3. Survey, identification and biology of insects and arthropods of forensic importance.
4. Study and analysis of court room proceedings regarding medico-legal cases.
5. Data processing and preparation of project reports.

Text and Reference Books:

1. Byrd, J.H. and Costner, J.L. 2009. Forensic Entomology: The Utility of Arthropods in Legal Investigations, 2nd Edition, CRC Press, New York.

2. Catts, E.P. and Haskell N.H. 1990. Entomology and Death. A Procedural Guide. Joyce's Print Inc. Clemson, SC.

3. Goff, M. L. 2000. A fly for the prosecution: how insect evidence helps solve crimes. Harvard University Press, Cambridge.

4. Greenberg, B. and Kunich, J.C. 2002. Entomology and the Law: Flies as Forensic Indicators, Cambridge University Press, Cambridge. 5. Smith, K.G.V.1986. A Manual of Forensic Entomology, Comstock's Publishing Associates, Cornell University Press, Ithaca, N.Y.

ZOO-759	**Freshwater Biology**	3.0

Course Outlines:

1. **Introduction**

a. Brief description of freshwater resources of Pakistan

b. Biology of commercial food fishes of Pakistan (Morphology, anatomy, ecology and distribution)

2. **Fish Culture**

a. History of fish culture

b. Fish culture systems and types

c. Cultivable fishes of Pakistan

d. Criteria for farm site selection; Designing, construction

e. liming and fertilization of fish pond

f. Criteria for selection of fish species for culture

g. Stocking

h. feeding and maintenance of fish farms

i. Ingredients of supplementary fish feed

j. Introduction to integrated fish farming

k. Water quality monitoring and management in fish pond

3. **Food and feeding**

a. Food and feeding behavior and habits of fish

b. methods of qualitative and quantitative analyses of food

c. Factors affecting food consumption

4. **Growth**

a. Measurement of growth

b. Factors affecting growth rate

5. **Fish diseases**

a. Viral

b. Bacterial

c. Fungal

6. **Fish enemies and their control**

a. Insects

b. Fishes

c. Amphibians

d. Reptiles

e. Birds

f. Mammals

7. **Fertilizers**

a. Types of fertilizers (organic, inorganic and Organo-chemical)

8. **Fish handling and processing**

a. Methods for handling

b. processing and preservation of fish (drying, salting, curing, smoking and freezing)

Practicals:

1. Collection and Identification of commercially important fish of Pakistan.

2. Study of external features of fish.

3. Dissection of fish to expose its internal features, especially digestive, circulatory, respiratory, excretory and reproductive system.

4. Analyses of gut contents.

5. Assessment of age and growth of fish.

6. Visit of fish processing unit.

Text and Reference Books:

1. Moss, B.R., 2010. Ecology of Fresh Waters: A View for the Twenty-First Century. 4thed. Wiley-Blackwell, USA.

2. Bronmark, C. and Hansson, L., 2005. The Biology of Lakes and Ponds. Oxford University Press, UK.

3. J.G. Needham, J.G., 1962. Guide to the Study of Freshwater Biology 5thed. McGraw-Hill , USA. Maitland, P.S., 1990. Biology of Fresh Waters. Springer , USA

4. Ali, S.S. and Narejo, N.T., 2009. Fundamentals of Ichthyology. Sindh University Press, Jamshoro.

5. Ali, S.S., 1999. Freshwater Fisheries Biology. Naseem Book Depot, Pakistan.

6. Ricker, W.E., 2002. Methods of Assessment of Freshwater Fish Production. Blackwell Scientific Publications, USA.

7. Huet, M., 2010. Text Book of Fish Culture - Breeding and Cultivation of Fish. Fishing News, UK.

ZOO-760	**Gene Therapy**	3.0

Course Outline:

1 **Introduction**

a. Therapeutic nucleic acids

b. Somatic and germ line gene therapy

c. Gene replacement and gene addition

2. ***In vivo* gene therapy**

a *In vivo*, *ex vivo* and *in vitro* gene therapy

b. Transgenic animal models

c. Vehicles for gene transfer-viral vectors

3. **Viral vectors**

a. Lentivirus

b. Recombinant SV40 virus

c. Non-viral vectors

d. DNA vaccines

e. Liposomes and lipoplexes

f. Transposons

4. **Cancer gene therapy**

a Cancer gene therapy

b. RNA-DNA chimera

c. Gene therapies for Criglar-Najjar syndrome

5. **Gene Therapy and diseases-I**

a Cystic fibrosis

b. Duchnne muscular dystrophy

c. Bleeding disorders

d. Tyrosinemia

6. **Gene Therapy and diseases-II**

a. Severe combined immunodeficiency syndrome (SCID)

b. Gene therapy of non-heritable disorders

c. Recent advancement in Gene Therapy

7. **Clinical application of gene therapy**

a. Cystic fibrosis

b. Familialhypercholesterolemia

c. Infectious diseases

d. Human trials for gene therapy

e. Ethical and regulatory consideration

f. Future prospects-Gene therapy

Text and Reference Books:

1. Nancy, S. T. 2015. Gene and cell therapy: Therapeutic Mechanisms and strategies, 4th Edition. CRC Press, United States of America.

2. Sherman, D. 2014. Gene Transfer, Gene therapy and genetic pharmacology: Principles, delivery and pharmacological and biomedical applications, National Scientific Research Centre (CNSR) ICP Text Books France

3. Joseph, P. P. 2014. Gene therapy: treating disease by repairing genes. Info Base Publishing. United Kingdom.

4. Perin, E. C., Miller, L. W., Taylor, D. A., & Willerson, J. T. 2016. Stem cell and gene therapy for cardiovascular disease. Waltham, MA : Academic Press
5. Friedman, T. 1999. The Development of Human Gene Therapy. Cold Spring Harbor,NY: Cold Spring Harbor Lab. Press.
6. Knipe, D. M.&Howley, P. M. eds. 2001. Fields Virology. Philadelphia, PA: Lippincott Williams & Wilkins.
7. Hackett, N. R.&Crystal, R. G. 2000. Adenovirus vectors for gene therapy. In Gene Therapy, ed. NS Templeton, DD Lasic, pp.17-39. New York: Marcel Dekker

ZOO-761	**Genomics and proteomics**	3.0

Course Outline:

1. **Introduction**

a. The Human Genome
b. Contents and organization of genomes.
c. Hemoglobin. From gene to protein to disease.
d. Genomic features of model organisms.

2. **Contents and Organization of Genomes.**

a. Chromosomes, organelles and Plasmids
b. Genes
c. Dynamic components of genomes
d. Genome organization in Prokaryotes
e. Genome organization in Eukaryotes.

3. **Mapping, Sequencing and Annotation**

a. DNA sequencing
b. Fredrick Sanger and development of DNA sequencing.
c. Maxam Gilbert chemical cleavage method.
d. Automated DNA sequencing.

4. **Proteomics**

a. Protein structure and types
b. Protein folding patterns
c. Changes in folding patterns in protein evolution.

5. **Separation and Analysis of protein**

a. Poly acryalamide gel electrophoresis (PAGE)
b. SDS PAGE
c. Mass spectrometry.

6. **Protein Engineering**

a. Multiple Sequence Alignment
b. Clustal Omega
c. Ab initio

Text and Reference Books:

1. Arthur Lesk (3rd Edition). Introduction to Genomics by Oxford University Press, USA; 2016.
2. Arthur Lesk (3rd Edition). Introduction to Genomics by Oxford University Press, USA; 2017
3. Strachan, T., A. P. Read, Human Molecular Genetics, 3rd edition,Garland Science/Taylor & Francis. 2003.
4. Ehrlich P.R., Human Natures: Genes, Cultures, and the Human Prospect, 1st edition, Penguin USA Paper, 2002.
5. Relethford J. H., Genetics and the Search for Modern Human Origins,Wiley-Liss 2001.

ZOO-762	**Herpetology**	3.0

Course Outline:.

a. History of Amphibian and Reptilian biology,
b. Early amphibian origins. Characteristics, taxonomy and systematic,
c. Biogeography and mechanism of speciation,
d. Evolution, reproductive strategies.
e. Development, homeostasis and behavior in relation to biotic environment.
f. Food, feeding, defense and conservation.
g. Role of amphibians and reptiles containing pest populations.
h. Medicinal importance of reptiles and amphibians.
i. Economic values of reptiles and amphibians.

Practicals:

1. Identification of museum reptile and amphibian specimens.
2. Classification and taxonomic characteristics of reptiles.
3. Comparative study of skeleton of amphibians and reptiles.
4. Field visits national parks,zoos and different habitats.
5. Presentations of field reports/survey reports.

Recommended Books:

1. Stebbins, R. C. and Cohen, N. W. 2002. A Natural History of Amphibians. Princeton University Press, Princeton, N. Jersey.
2. Coleman, J. Freeman, W.H. and Olive, G. 1993. Introduction to Herpetology (3rd ed.), W.H. Freeman, N. York.
3. Vitt, L. J., & Caldwell, J. P. 2013. Herpetology: an introductory biology of amphibians and reptiles. Academic press.
4. Kerridge, R. (2014). Cold blood: Adventures with reptiles and amphibians. Random House. Wells, K. D. 2010. The ecology and behavior of amphibians. University of Chicago Press.
5. Wells,K.D. 2007.The Ecology and Behavior of Amphibians.University of Chicago Press.

ZOO-763	**Human Genetics**	3.0

Course Outline:

1. **Mapping of Human Genome**
a. Genetic Mapping
b. Physical Mapping
c. Genome Sequencing
d. Disease Isolation.
2. **Human Karyotyping**
a. Staining
b. Chromosomal banding
c. Digital karyotyping
d. Multicolor Fish mFish and Spectral Karyotype
e. Chromosomal Abnormalities
3.**Congenital Malformations**
a. Structural Malformations
b. Metabolic Malformations
c. Causes of Congenital Malformations
d. Screening of Congenital Malformations
4. **Oncogenes and Cancer**
a. Proto-oncogenes
b. Activation of Oncogenes
c. Classification of Oncogenes
5. **In born Errors of Metabolism**
a. Disorder of carbohydrate metabolism
b. Disorder of amino acid metabolism
c. Disorder of Urea cycle
6. **Twin Studies**
a. Monozygotic Twins
b. Dizygotic Twins
c. Concordance
7. **Treatment of Genetic Diseases**
a. The current state of Treatment of Genetic Diseases
b. Special Consideration in Treating Genetic Diseases
c. Treatment strategies
d. The Molecular Treatment of Diseases
8. **Prenatal Diagnosis**
a. Indication of Prenatal diagnosis by Invasive Testing
b. Methods of Prenatal Diagnosis
c. Laboratory Studies
d. Emerging Technologies for Prenatal Diagnosis
e. Prenatal Prevention and management of Genetic diseases
f. Genetic counseling for Prenatal diagnosis
9. **Genetic Counseling and Risk Assessment**

a. The process of Genetic Counseling
b. Determining Recurrence Risk
c. Application to Molecular genetics to determine Recurrence Risk
10. **Ethical Issues in Medical Genetics**
a. Ethical Dilemmas in Medical Genetics
b. Eugenic and Dysgenic effect of Medical Genetics
c. Genetics in Medicine

Text and Reference 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.
3. Molecular biology of the gene.Pearson Education. 2004.
4. Snyder, L. and W. Chapness. Molecular Genetics of bacteria. ASM, Press, 2003.
5. Lewin, B. Gene-VIII. Oxford University Press, Oxford, UK. 2004.
6. Nussbaum, Mclnnes and Willard. Thompson and Thompson Genetics In Medicine 7th Edition 2009.

ZOO-764	. **Industrial Biotechnology**	3.0

Course Learning Outcomes:

Upon successful completion of the course, the student will be able to:
1. **GAIN** the essential knowledge about microorganisms
2. **UNDERSTAND** the empirical role of microbes in relation to industry
3. **EXPLOIT** the dynamic skill of microbes in human life
4. **AUTHENTICATE** the pragmatic relationship of microbes with industry
5. **APPLY** the scientific knowledge in an effective and appropriate manner

Course Outline:

1. **Fermentation Microbiology and Biotechnology**
a. Fermentation: an ancient tradition
b. Developments in Metabolic and Biochemical Engineering
c. Bioreactors, types and designs
d. Upstream and Downstream processing
e. Scope and Future of Fermentation Microbiology
2. **Industrial Media and the Nutrition of Industrial Organisms**
a. The basic nutrient requirements of industrial media
b. Criteria for the choice of raw materials used in industrial media
c. Some Potential Sources of Components of Industrial Media
3. **Screening for Productive Strains and Strain Improvement**
a. Sources of microorganisms used in biotechnology
b. Isolation of organisms producing desired metabolites
c. Strain improvement
4. **Microbiology of industrial fermentation**
a. Current trends in the fermentation and pharmaceutical industry

b. Applications of batch-fed two-stage fermentation in the production of biopharmaceuticals
c. Microbial fermentations and the production of biopharmaceuticals
5. **Biopulping**
a. Enzymes for biopulping
b. Process design and kinetics
c. Use of Fungi in Pulping Wood
6. **Biofuels**
a. First-generation biofuels
b. Second generation biofuels (2G)
c. Third generation biofuels
d. Fourth generation biofuels
7. **Biotechnology Of Raw-Ore Processing**
a. Ores
b. Mineral
c. Mineraloid
d. Mineral processing
e. Bioleaching
8. **Microbial Enhanced Oil Recovery (MEOR)**
a. **Types of MEOR**
b. **The logic behind MEOR**
c. MEOR advantages and disadvantages
9. **Enzymes**
a. Types of major industrial enzymes and desired modifications
b. Substrate degradation and product formation
c. Enzyme characteristics and kinetics
d. Role and advantages in food production
10. **Single Cell Protein (SCP)**
a. Substrates for Single Cell Protein Production
b. Microorganisms Used in SCP Production
c. Use of Autotrophic Microorganisms in SCP Production
d. Safety of Single Cell Protein
e. Nutritional Value of Single Cell Protein

Text and Reference Books:

1. Modern Industrial Microbiology And Biotechnology by Nduka Okafor
2. Food Biotechnology by Kalidas Shetty, Gopinadhan Paliyath, Anthony Pometto and Robert E. Levin.
3. In introduction to Industrial Microbiology by K. Sukesh
4. Modern Industrial Microbiology and Biotechnology - CRC Press Book

ZOO-765	**Insect Toxicology**	3.0

Course Outline:

1. **Introduction to Toxicology**

a. History of Toxicology
b. Toxic Agents and Substances
c. Natural and Synthetic Pesticides
d. Dose and its impact on toxicity
2. **Classification of Insecticides**
a. History and Classification of Insecticides
b. Chlorinated Hydrocarbon Insecticides
c. Organophosphorus Insecticides, Carbamate Insecticides, Thiocyanate Insecticides, Dinitrophenols, Fluoroacetate Derivatives,
Acaricidal Chemicals, Fumigants, Inorganic Insecticides, Synergists, Hormone Mimics, Cuticle Formation Inhibitors, Microbial Insecticides
3. **Modes and Mechanisms of Action of Insecticides**
a. Insecticide Entry Routes into Insects
b. Effects on the Insect Nervous System, Electron Transport System, Enzyme Inhibition, Chitin and Cuticle, Behavior Modification
c. Insect Endocrinology
4. **Evaluation of Insecticide Toxicity**
a. Toxicity Tests against Insects
b. Methods for Testing Insect Toxicity (Injection, Dipping, Contact, Fumigation and Feeding Methods)
c. Estimating LD50, Biological and Biochemical Assays, Laboratory Bioassays and Field Assays Ames Test, Comet Assay
5. **Forensic Entomotoxicology**
Methods for detection of toxic substances in entomological specimens
6. **Problems in insect Toxicology**
a. Insecticide Resistance
b. Minimizing Human and Non-Target Species Toxicity
c. Protecting Pollinator Species
d. Effects of Insecticides on the Environment and Wildlife
e. Pesticide Residue in Food and Threats to Domestic Animals

Text and Reference Books:

1. Chemical Pesticides: Mode of Action and Toxicology. Stenersen, J. 2004. CRC Press, USA. ISBN 0-7484-0910-6.
2. Toxicology of Insecticides. Second Edition. Matsumura, F. 1975. Plenum Press, New York and London. ISBN 9781461344124.
3. Text Book of Insect Toxicology. Srivastava, R. P. and Saxena, R. C. 1989. Himanshu Publications. ISBN 8185167184, 9788185167183.
4. The Toxicology and Biochemistry of Insecticides. Yu, S. J. 2014. CRC Press. ISBN 9781482210606.

ZOO-766	**Lac Insects**	3.0

Course Outline:

1. Lac insect taxonomy, distribution and life cycle,

2. Lac host and crop management technology,
3. Processing of lac insects,
4. Bye-products of lac and their utilization,
5. Bionomics of lac insect, lac cultivation; Local practice, improved practice,
6. Propagation of lac insect, Inoculation period,
7. Harvesting of lac Natural enemies of lac insect and their management;
8. Lac host management;
9. Lac based production;
10. The problems and prospects of lac industry;
11. Lac and its Cultivation in Pakistan.

Practical:

1. Identification of life stages of lac insects
2. care and maintenance of host of lac insect
3. Identification of natural enemies of lac insect
4. visit to production units

Text and Reference Books:

1. Partiban S & David BV. 2007. Management of Household Pests and Public Health Pests. Namratha Publ.
2. Chennai. Singh S. 1975. Beekeeping in India. ICAR, New Delhi.
3. Chattopadyay S. 2011. Introduction to lac and ac culture. tech. Bull. FBTI .

ZOO-767	**Medical Entomology**	3.0

Course Outline:

1. General Introduction of arthropods of Medical Importance,
2. Problems caused,
3. Arthropods borne diseases,
4. Food Contaminants,
5. Toxins and Venoms,
6. Defense secretions and allergens.
7. **Introduction, lifecycle, medical importance and management strategies of**

a. Mosquitoes
b. Sandflies
c. Horse flies
d. Tsetse fly
e. Fleas
f. Lice
g. Bed bugs
h. Cockroaches
i. Houseflies
j. Black flies
k. Beetles

l. Butterflies and Moths
m. Bees and Wasps
n. Scorpions
o. Spiders
p. Ticks
q. Mites

Practical:

1. Field visits for sampling, collection of arthropods of medical importance.
2. Field visits for observation of prevalence of pest fauna of public health concern.

Text and Reference Books:

1. Mike Service, 2012. Medical Entomology for Students, Cambridge University Press.
2. Mullen, G. and Durden, L., 2009. Medical and Veterinary Entomology. 2nd Ed. Academic Press. San Diego, CA.
3. Ralph E William 2009, Veterinary Entomology: livestock & Companion Animals CRC press, 343 pp.
4. Marquardt, W.C., 2004. Biology of Disease Vectors, 2nd Ed., Elsevier AcademicPress.
5. Aldridge, B., 2004. Medical Entomology: Text Book of Public Health and Veterinary. Chapman and Hall, London.
6. Service, M., 2004. Medical Entomology for Students. Cambridge University Press.
7. Tyagi, 2003, Medical Entomology: A Hand book of medically Important Insects & other arthropods Scientific Publisher 262 pp.
8. Eldridge F. Bruce & Edman, J.D. 2003. Medical Entomology: A text book on Public Health and Veterinary problems caused by Arthropods. Kluwer Academic Publishers 672 pp.
9. Kettle, D.S., 1995. Medical and Veterinary Entomology. (2nd Ed.), CAB International, UK.
10. Busvine, J.R., 1980. Insects and Hygiene. 3rd Ed. Chapman and Hall, London.
11. Harwood, R.F. and James, M.T., 1979. Entomology in Human and Animal Health. 7thEd. Macmillan Publishing Co., Inc., N.Y.
12. James, M.T. and Hardwood, R.F., 1969. Herms Medical Entomology. The Macmillan Company Canada.

ZOO-768	**Medical Virology**	3.0

Course Outline:

1. **Introduction to virology:**

a. Introduction of viruses.
b. History of virology.
c. Structure and classification of viruses.
d. Introduction to laboratory techniques.

2. **The viral replication cycle:**

a. Replication strategies for DNA and RNA genome viruses.
b. Viral receptors, attachment.

c. Entry of enveloped and non-enveloped viruses.
d. Uncoating and disassembly.
e. Structural, Nonstructural viral proteins.
f. Viral genome replication.
g. Assembly and maturation of virions.
3. **Pathogenesis – viral entry, spread and host response.**
a. Routes of entry and transmission.
b. Tissue tropism, evasion of host response.
c. Latency, Persistence, transformation.
d. Acute and persistent infections.
e. Transformation, viral oncogenes.
f. Endogenous viruses.

4. Virus evolution and emerging/re-emerging viral infections

a. Variation and viral polymerases.

b. Natural selection, drift vs shift.

c. Recombination and reassortment.

d. Virus-host co-evolution.

e. Emergence and re-emergence.

5. Transmission

a. Transmission strategies.

b. Incubation and generation time.

c. Epidemic and endemic viruses, herd immunity.

d. Detection and Surveillance, eradication and control.

e. Viral vectors and gene therapy.

6. Detection and prevention:

a. Eradication of viral diseases.

b. Laboratory methods for detecting and classifying.

c. Techniques for developing viral vaccines.

d. Antiviral therapies.

7. Virus family case studies.

a. DsDNA viruses – adenoviruses, herpesviruses, poxviruses.

b. SsDNAviruses,Circoviruses and parvoviruses.

c. DsRNA viruses,reoviruses. Positive sense

d. ssRNA viruses, Picornaviruses, caliciviruses, flaviviruses, coronaviruses.

e. Negative sense ssRNAvirusesorthomyxoviruses, paramyxoviruses, rhabdoviruses.

f. ssRNA viruses with Reverse Transcriptase – retroviruses.

g. DsDNA viruses with Reverse Transcriptase – hepadnaviruses.

Recommended Books:

1. Christopher Burrell Colin Howard Frederick Murphy. 2016. Fenner and White's Medical Virology, 5th Edition. Imprint: Academic Press.University of Texas Medical Branch, Galveston, TX, USA.
2. Dorothy H. Crawford. 2011. Viruses: A Very Short Introduction.Publisher Oxford University Press.
3. James H. Jorgensen, Michael A. Pfaller. 2015. Manual of Clinical Microbiology.11th Edition Publisher American Society for Microbiology. Washington DC, United States.

ZOO-770	**Mericulture Technology**	3.0

THEORY:

1. Mariculture

a. Histroy

b. Introduction to mariculture technology

c. A survey of mariculture in the world

2. Mariculture technology

a. Technology on artificial breeding of abalone

b. Techniques of larval rearing and farming in the white shrimp (Litopenaeusvannamei)

c. Living food organism and their cultivation

d. Practical culture techniques of Scylla

e. Breeding and rearing of grouper

f. Oyster farming techniques

g. Grey mullet culture techniques

3**. Marine algae culture**

a. History

b. Techniques

4. **Aquatic weeds**

a. Production techniques for aquatic feeds;

b. Artificial breeding and culture technique of ovate pompano

5. **Marine biodiversity**

a. Marine biodiversity protection and sustainable development of mariculture industry

b. Disease occurrence and control strategy of mariculture organisms;

c. Monitoring and management of water quality in aquaculture

Practical:

1. Aquaculture techniques of white shrimp (*Litopenaeusvannamei*)
2. Culture techniques of Scylla;
3. Breeding of abalone grouper; Oyster Grey mullet, ovate pompano
4. Production techniques for aquatic feeds; monitoring and management of water quality in aquaculture

Recommended Books/Readings:

1. Bensam, P. 1999. Development of Marine fisheries science in India Daya publishing House-Delhi.

2. Fish Catching Methods of the World IV Edition. 2005. O. Gabriel,K. Lange, E. Dahm& T. Wendt, Blackwell Publications

3. Fish Products and Processing, 2007. W. Horner & R. Robles, Blackwell Publications

4. Sustainable Fishery Systems, 2001. Anthony T. Charles, Blackwell Publications 378

ZOO-771	**Molecular Evolution**	3.0

Course Outline (contents):

1. An overview of the molecular genetic tools used to investigate ecological and evolutionary processes in natural populations.

2. Usefulness of some concepts of ecology, evolution, and genetics.

3. Evolutionary forces; vital force theory for living organisms.

4. Nucleotide sequence, gene structure, genetic code, and mutations. Dynamics of genes in populations.

5. Allele frequencies. Natural selection. Random genetic drift. Effective population size. Polymorphism and divergence.

6. Linkage disequilibrium. Sequence alignment. Evolutionary change of nucleotide sequences. Multiple substitution problem and the inference of the number of evolutionary events.

7. Rates and patterns of nucleotide substitution. Probability of fixation of a new neutral mutation. Rate of neutral substitution.

8. Gene trees and species trees. Methods of reconstruction. Branch length estimation. Molecular clocks. Over-dispersed clocks.Testing the neutral mutation hypothesis.

9. Positive selection and Genome evolution I. Evolution of gene duplications. Paralogy and orthology.

Text and Reference Books:

1. Wagner, G.P. 2014. Homology, Genes and Evolutionary Innovation. Princeton Univ. Press, New Jersey, USA.

2. Roderic, D.M., E.C. Holmes. 2000. Molecular Evolution: Phylogenetic approach: Blackwell Sci. Publ., Inc., USA.
3. Bromham, L., 2016. Molecular Evolution and Phylogenetics. Oxford Univ. Press, England.
4. Wiley, E.O., B.S. Lieberman. 2011. Wiley-Blackwell, New Jersey, USA.
5. Yang, Z. 2014. Molecular Evolution. Oxford Univ. Press, Clairent Street, England.

ZOO-772	**Molecular Immunology**	3.0

Course Outline:
Course Outline:
1. Immunology,
2. Immunobiology,
3. Immunophysiology,
4. Immunopathology,
5. Immunity,
6. Natural and acquired immunity,
7. Active and passive immunity,
8. Antigens and elicitation of immune response,
9. Molecular basis of cell mediated and humoral immunity,
10. Immunoglobulins,
11. Synthesis of antibodies and theories of antibody synthesis,
12. Antigenecity,
13. Interaction of antigens and antibodies,
14. Factors affecting immune response ,
15. Nature of antigens,
16. Genetic constitution of individuals and route of administration.
17. Detection and application of antigen –antibody reactions in vivo and in vitro.
18. Monoclonal antibodies,
19. Major histocompatibility complex and conservation of antigen binding site.
20. Cellular basis of immune response.
21. Specific response of individual lymphocytes to antigenic stimulation.
22. Histological features of immune response.
23. Hypersensitivity, anaphylactic,
24. antibody dependent cytotoxicity,
25. immune complex mediated,
26. delayed type hypersensitivity and stimulatory hypersensitivity.
27. Histological feature of allergic reactions and changes in immune respose at molecular level,
28. Immunological tolerance and autoimmunity ,
29. Immuno potentiation and immunosupression.
30. Transplantation Immunology,

31. Tumor immunology.
32. Immunity against infectious diseases.
33. Immuno deficiency diseases,
34. Immunization.
35. Immunization procedures ,
36. vaccines and their development.

Text and Reference Books:

1. Bain, B., Bates, I., Laffan, M. and Lewis, M., 2012: Decie and Lewis Practical Hematology. 11th Ed. Churchill livingstone
2. Montanaro, A., 2015: Primary immunodeficiency Disorders. 1st Ed. Elesvier
3. O'Hehir, R.E., Holgate, S. T. and Sheikh, A., 2016: Middleton's Allergy Essentails. 2nd Ed. Elesvier
4. Park,K., 2002: Park's text book of Preventive and Social medicine. 2nd ed. MIS Barnarsid, India.
5. Richard, A. Goldsby, Thomas and Barbra,A. Kuby., 2007: IMMUNOLOGY. 6th edition. W.H Freeman and company Newyark

Additional Reading:

1. Abbas, L., and Pober, W., 1994: Cellular and molecular immunology. 2nd edition. B Saunders company London.
2. Roitt,I., 1990: Essential immunology. Black well Scientific Publication. 2nd ed. Oxford, UK.
3. Stities, D.P., Stobo, J.D., Fundnberg, H.H and Well, J.V., 1990: Basic and clinical Immunology. . Lange Medical Publication, USA.

ZOO-773	**Principles of Aquaculture**	3.0

Course Outlines:

1. Basis of aquaculture (scope and definitions, cultural and socio-economic basis, biological and technological basis, role in fishery management).
2. History of aquaculture and its present state.
3. Origin and growth of aquaculture.
4. National planning of aquaculture development; national priorities and aquaculture development, national resources, technology and human resources, legal and environmental factors.
5. Selection of sites for aquaculture; general considerations, land based farms, open water farms.
6. Water quantity and quality.
7. Sources of pollution and user conflicts.
8. Selection of species for aquaculture.
9. Biological characteristics.
10. Economic and market considerations.
11. Introduction to exotic species, common aquaculture species.
12. Design and construction of aquafarms.

13. Inland and coastal farms, tank and raceways, cage culture, pens and enclosures, design and construction of hatcheries.
14. Farm management; nutrition and feeds, reproduction and genetic selection, health and diseases, control of weeds, pests and predators.
15. Harvesting and post-harvest technology.
16. Marketing of aquaculture products.
17. Aquaculture practices; carps, trout and salmon culture, catfish culture, tilapias culture, shrimp and prawn culture, other finfish culture;
18. Integration of aquaculture with crop and livestock, aquaponics, hydroponics.
19. Environmental and other impacts of aquaculture.

Practical:

1. Pond water analysis (Physical, Chemical and Biological);
2. Pond design and components
3. Calculation of pond/tank area and volume
4. Hatchery components
5. soil and water sampling; fish feed ingredients and preparation of artificial feed; feed formulation, calculation of food quotient/Feed Conversion Ratio, Calculation of Specific growth rate (SGR); and feeding ratios
6. Identification of zooplanktons and phytoplanktons
7. Preparation of feasibility reports of modern fish farms
8. Identification of important fish diseases; artificial fish breeding; injection; striping and fertilization.
9. Visit of aquafarms and fish hatcheries to study aquaculture effluents and polluted sites.

Recommended Books:

1. Stickney R.R. 2016. Aquaculture an introductory text, CABI.
2. Fitzsimmons, K., R.S.N. Janjua and M. Ashraf, 2015. *Aquaculture Handbook – Fish Farming and Nutrition in Pakistan.*
3. Stickney, R. R. 2009. Aquaculture an introductory text. CABI Publising, USA.
4. Sharma, O. P. 2009. Handbook of Fisheries and Aquaculture. Agrotech Publishing Academy, Udaipur, New Delhi, India.
5. Parker, R. O. 2004. Aquaculture Science 4th Ed. Delmar Learning, London, UK.
6. John, S. L. and Paul C. S. 2003. AQUACULTURE. Farming Aquatic Animals and Plants. Blackwell Publishing, Oxford, UK.
7. NIIR 2003. Hand Book on Fisheries & Aquaculture Technology. Asia Pacific Business Press Inc., Delhi.
8. Huet, M. and Timmermans, J. (2002). Text book of Fish Culture. Blackwell Science Ltd. UK.
9. Shammi, Q.J. and Bhatnagar, S. 2002. Applied Fisheries, Agro bios, India.
10. Ali, S.S. 1999. Fresh Water Fisher Biology. Naseem Book Depot, Hyderabad.

11. Pillay, T.V.R. 2002. Aquaculture: Principles and Practices. Blackwell Science Limited. UK.

ZOO-774	**Recombinant DNA Technology**	3.0

Course Outline:

1. **SALIENT FEATURES OF CLONING VECTORS**

a. Types of cloning vectors

b. Plasmids, cosmids, ssDNA Phages, Yeast cloning vectors

c. Animal viruses, Ti plasmids and Cauliflower Mosaic Virus.

2. **PLASMID BIOLOGY**

a Structural and functional organization of plasmids

b. Plasmid replication

c. Stringent and relaxed plasmids

d. Incompatibility of plasmid maintenance

3. **BIOLOGY OF BACTERIOPHAGE LAMBDA**

a. Lambda phage as a natural *in vivo* vector

b. *In vitro* construction of lambda vector

c. Classes of vectors and their use

4. **ENZYMES IN GENETIC ENGINEERING**

a. DNA polymerase, polynucleotide kinase, T4 DNA ligase

b. Nick translation system

c. Terminal deoxynucleotidy1 transferase, Reverse transcriptase Restriction endonucleases Type I & II.

5. **ISOLATION OF GENOMIC AND NUCLEAR DNA**

a. DNA digestion and restriction fragment analysis

b. Sequencing by chemical, enzymatic and big-bye terminator methods

6. **CLONING AND SUBCLONING STRATEGY**

a. Construction of recombinant DNA and preparation of competent cell transformation

b. Transfection, recombinant selection and screening; Genomic DNA library; cDNA synthesis strategies–Linkers–Adapter homopolymer tailing

c. Genomic and cDNA libraries in plasmids and phages. PCR product cloning (TA cloning). Cloning strategies in yeast (*Saccharomyces cervisiae*) and bacteria (*E. coli* and *B. subtilis*).

7. **SELECTION OF rDNA CLONES AND THEIR EXPRESSION PRODUCTS**

a. Direct and indirect methods. Drug resistance, gene inactivation

b. DNA hybridization, colony hybridization and *in-situ* hybridization (Southern, Northern and Dot blots and immunological techniques, Western blotting).

8. **GENE MODIFICATION & APPLICATION OF RECOMBINANT DNA TECHNOLOGY**

a. Mutagenesis-Deletion mutagenesis, Oligonucleotide derived mutagenesis, Site directed mutagenesis

b. Applications of rDNA technology in Diagnostics; Pathogenesis

c. Genetic diversity; Therapeutic proteins-vaccines.

d. Molecular probes (Production, labelling and uses)

Text and Reference Books:

1. Brown, T. A., 2016. Gene Cloning and DNA Analysis: An Introduction; 7th Edition, John Wiley and Sons Ltd., Chicester, UK.

2. Glick, B. R., Pasternak, J. J. and Cheryl L. Patten, C. L. 2009. Molecular Biotechnology: Principles and Applications of Recombinant DNA; 4th Edition, ASM Press, Washington, USA.

3. Green, M. R. and Sambrook, J. 2012. Molecular Cloning: A Laboratory Manual; 4th Edition, Cold Spring Harbor Laboratory Press, New York, USA.

4. Howe, H. 2007. Gene Cloning and Manipulation, Cambridge University Press, New York, USA.

5. Jeremy W. Dale, J. W., Malcolm von Schantz, M. V. and Plant, N. 2011. From Genes to Genomes: Concepts and Applications of DNA Technology; 3rd Edition, John Wiley and Sons Ltd., Chicester, UK.

6. Nicholl, D. S. T. 2008. An Introduction to Genetic Engineering; 3rd Edition. Cambridge University Press, Singapore.

7. Old, R. W. and Primrose, S. B. 2009. Principles of Gene Manipulation, an Introduction to Genetic Engineering, 5th Edition, Blackwell Scientific Publications, USA.

8. Primrose, S. B. and Twyman, R. M. 2015. Principles of Gene Manipulation and Genomics; 8th Edition, Wiley-Blackwell, Oxford, UK.

9. Watson, J. D., Meyers, R. M., Caudy, A. A. and Witkowski, J. A. 2007. Recombinant DNA: Genes and Genomes A Short Course; 3rd Edition, Cold Spring Harbor Laboratory Press, New York, USA.

10. Watson, R. R. and Preedy, V. R. 2016. Genetically modified organisms in food: Production, safety, regulation and public health. Amsterdam: Elsevier Science

ZOO-775	**Reproductive Physiology**	3.0

Course Outline:

1. **Introduction: Overview of physiology of reproduction**

a. Reproductive strategies

b. comparative aspects

2. **Anatomy of the male reproductive system**

3. **Anatomy of the female reproductive system**

4. **Functional histology of male and female reproductive system**

5. **Neuroendocrine control of reproduction**

a. Pituitary and hypothalamus

b. Pineal gland

c. Adrenal gland

6. **Physiology of ovarian function**

a. Folliculogenesis

b. Oocyte maturation

c. Endocrinology
d. Ovulation
7. **Physiology of testicular function**
a. Organization
b. Endocrinology
c. Regulation
d. Immunology
8. **Physiology of sperm maturation and fertilization**
a. Spermatogenesis and spermiation
b. Epididymal function
c. Functions of accessory sex glands
d. Capacitation and acrosome reaction
e. Fertilization
9. **Physiology of gestation and early embryonic development**
a. Development in oviduct
b. Implantation and placentation
c. Maintenance of pregnancy
10. **Reproductive cycles**
a. Pre- and neonatal development
b. Puberty,
c. Estrous cycle
d. Breeding seasons
11. **Aging**
a. Physiology of menopause
b. Senescence in male

Practical:
1. Demonstration of male reproductive system in vertebrates.
2. Demonstration of female reproductive system in vertebrates.
3. Morphological studies of sperm in the buffalo/cattle.
4. Morphological studies of ova (buffalo/cattle/goat/sheep).
5. Histological studies of ovaries & oviduct
6. Histological studies of uterus at different phases of cycle
7. Histological studies of cervix and vagina
8. Histological studies of testes and epididymis
9. Radioimmuno assays of different hormones.

Text and Reference Books:
1. Essential Reproduction by M. H. Johnson. 8th edition (2018). Published by Wiley-Blackwell, USA.

2. Pathways to Pregnancy and Parturition by P. L. Senger. 3rd edition (2012). Published by Current Conceptions Incorporated USA.
3. Andrology by E. Nieschlag, H. M. Behre and S. Nieschlag**.** 3rd edition (2010). Published by Springer, USA.
4. Knobil & Neill's Physiology of Reproduction by *T. M. Plant and A. J. Zeleznik*. 4th edition (2014). Published by Springer, USA.

ZOO-776	**Research Methods in Entomology**	3.0

Course Outline:

1. **Introduction**

a. Techniques and apparatus employed in entomological research

b. Temporary and permanent mounts

2. **Microtomy**

a. use of ocular grid

b. micrometry

c. scientific photography

3. **Bio-assay techniques**

a. Atomic absorption spectrophotometer,

b. Gas chromatography,

c. High performanceliquid chromatography

d. UV-visual spectrophotometer

e. Amino acid analyzer

f. Electrophoresis

4. **Recombinant DNA techniques**

a. PCR

b. Ultra-centrifugation

5. **Microscopy**

a. Scanning electron microscopy

b. Transmission electron microscopy

6. **Computer software in entomology**

a. Methods of sampling

7. **Analysis of data**

a. Report writing

b. Lab/field experimental techniques.

Text and Reference Books:

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.

ZOO-777	**Sericulture**	3.0

Course Outline:

1. Introduction to Sericulture; what is Sericulture, Scope of Sericulture, Origin and history of Sericulture.
2. World output of Silk, other natural fibers- Present status of silk production. Importance of natural fiber vis-a-vis manmade fibre, Role of silk fiber amongst natural fibers. By-products of sericulture.
3. Introduction to mulberry silkworm *Bombyxmori;*.what is mulberry sericulture
4. Basic requirements for silkworm rearing House: Requirements for ideal rearing house – site selection- size of rearing house. Orientation – Model rearing house - B Model – advantages and disadvantages rearing houses.
5. Incubation of silkworm eggs, environmental conditions required for incubation – their influence in egg development – incubation method – low cost- incubation devices – earthen pot, double brick wall chamber –black boxing
6. Silkworm rearing techniques/methods and ecological requirements Brushing – methods – loose eggs and short eggs – capping and net Method – selection of Leaf brushing – advantages and disadvantages of different types o f brushing – cellular and mass brushing.
7. Mechanization in sericulture
8. Mounting, types of mountages, and cocoon quality parameters
9. Diseases of silkworm and their management
10. Economics of sericulture, concepts of benefit-cost ratio, marketing
11. Extension education in sericulture

Practical:

1. Sericulture maps.
2. Identification and study of sericulture products
3. Cocoon and silk yarn -different types,Pupae, Silk waste, Spun Yarn, Noil Yarn,Other by products.
4. Study of Morphology of silk worm : a Mouth parts of silkworm b External morphology of egg, larva, pupa and moth c Sex separation of larva, pupa and moth
5. Cocoon chararters of uni, bi and multivoltine races.
6. Identification of different non mulberry cocoons
7. Rearing Technology : Study of a model rearing house
8. Study visits to any Sericulture cottage industry and submit study report as well.

Text and Reference Books:

1. Eikichi Hiratsuka .2000.Silkworm breeding, Oxford and IBH publications, New Delhi.
2. Nobumasa Hojo .2000. Structure of the Silk yarn, Oxford and IBH publications, New Delhi. Devaiah M.C et al. 2001; Advances in Mulberry Sericulture. Dept. of Sericullture, UAS, Bangalore.

3. Yasuji Hamamura. 2001. Silkworm Rearing on artificial diet- Oxford & IBH Publishing Co.Pvt .Ltd. New Delhi & Calcutta.
4. S.Morohosi.2000. Development Physiology of Silkworms (Translated Japanese) Oxford & IBH Publishing Co.Pvt .Ltd. New Delhi , Calcutta.
5. Silk Dyeing and Finishing Handbook.2000.(Translated from Chinese) Compiled by Shanghai Silk Industry Corporation,China.Oxford & IBH Publishing Co.Pvt .Ltd. New Delhi & Calcutta.

ZOO-778	**Toxicology**	3.0

Course Outline

1. **Introduction to Principles of Toxicology**

a. The science of poison, early fundamental development

b. Types of toxicology, Common terms and Nomenclature

c. Applications of toxicology: Research, Regulatory toxicology, Forensic toxicology, Clinical toxicology

d. Classification of toxic agents according to use: Pesticides, food and industrial additives, Therapeutic drugs, Sources of toxins: Botanical, Environmental.

2. **Effects of Chemicals**

a. Toxicological effects: General classification, Chemical allergies, Immediate versus delayed hypersensitivity, Local versus systemic effects, Mutagenic and carcinogenic effects, Biochemical properties

b. Exposure: Route: Oral administration, Intranasal administration, Inhalation, Dermal and Parenteral routes, Duration and frequency

c. Accumulation: According to physiological compartment, According to chemical structure, Chemical interactions, Dose-Response relationship, Criteria for measurement

3. **Toxicokinetics**

a. Relationship to pharmacokinetics: Applications to toxicology testing

b. Absorption: Ionic and non-ionic principles, Henderson- Hasselbach equation, Absorption in nasal and respiratory mucosa

c. Distribution: Fluid compartments, Plasma protein binding, Lipids, Liver and kidney, Blood-brain barrier

d. Biotransformation: Principles of detoxification, Biochemical pathways, Enzyme systems

e. Elimination: Urinary excretion, Fecal elimination, Pulmonary elimination, Mammary gland secretion, other secretion

4. **Descriptive Animal Toxicology**

a. Correlation with human exposure, Animal welfare and US animal welfare act

b. Chemicals: Selection of chemicals, Route of administration

c. Species differentiation: Selection of appropriate animal species, Methodologies

5. **Acute Toxicology**

a. Objectives of acute toxicology, LD50 and acute toxicology, Organization of studies

b. Range finding tests: Up-and-down procedure (UDP), Fixed dose procedure (FDP), Acute toxin class method (ATCM)

c. Classical LD50: Oral, Dermal and inhalation LD50, Other considerations with LD50 determinations, Applications of LD50.

Text and Reference Books:

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.

ZOO-779	**Vaccinology**	3.0

Course Outline:

1. **History of vaccines**

a. How vaccine originated

2. **Target ed proteins as Vaccine**

a. Viral proteins as potential targets for vaccine

3. **Types of Vaccine and Production**

a. Live versus attenuated vaccines

b. Role of multinational companies in vaccines production

c. DNA as vaccine

d. Peptide & Subunits vaccine

e. Adjuvants in vaccines

f. Population Genetic analysis: immunity to vaccine

g. Recombinant vaccine

4. Animal models of vaccine testing

5. Cost-effective approaches for production of new vaccines

6. Human testing and efficacy of vaccines: ethical issues

7. Recommendations of the Advisory Committee on Immunization Practices (ACIP)

8. Quadrivalent vaccine against human papillomavirus to prevent high-grade cervical lesions

9. Understanding the demand and supply of popular vaccine

10. Launching of vaccine and clinical trials

11. Anti-rabies immunoglobulin preparation based on F(ab')2 fragments

12. Effect of Panavir/Zanamivir on influenza A virus reproduction

13. Vaccine safety

Text and Reference Books:

1. Recombinant vectors in vaccine development by Fred Brown.

2. The Vaccine book by Barry R. Bloom.

3. Vaccine S by Plotkin_Orenstein.

4. Mass vaccine global aspect-progress and obstacles by Plotkin.

5. Pre-clinical and Clinical development of new vaccines by Fred Brown.

Journals Recommeded
1. VACCINE, JOURNAL OF ANTIMICROBIAL CHEMOTHERAPY
2. CLINICAL IMMUNOLOGY AND IMMUNOPATHOLOGY
3. MEDICAL MICROBIOLOGY AND IMMUNOLOGY

ZOO-780	**Wetlands Management**	3.0

Course Outline

1. **Wetlands of Pakistan**
a. Aquatic ecosystems
b. Introduction to Wetlands
c. Classification
d. Wetlands hydrology
e. Clarity on wetlands and Water Use
f. Wetlands and Water Quality
g. Wetlands and Environmental Flows
2. **Biogeochemistry**
3. **Wetlands and Climate change**
4. **Human Impacts and Management of wetlands**
5. **Values and valuation of wetlands**
a. Lakes and rivers
6. **Degradation of aquatic ecosystems**
7. **Wetlands and Nutrient Retention**
8. **Restoration of wetlands**
a. Passive restorations
b. Active Restoration
9. **The Ramsar strategic plans**
10. **Research on Sustainable Agriculture and Wetlands**

Practicals:

Preparation of a conservation project for wetlands
1. Wetlands without outlets
2. Wetlands with outlets
3. River and marsh lands
4. Coastal wetlands

Recommended Books:

1. Mitsch, W. J. and Gosselink, J. G. 2007. Wetlands 4th ed. John Wiley & Sons, Inc.
2. Greipsson, S. 2011, Restoration Ecology, Biology and Physics Department, Kennesaw State University, Kennesaw, Georgia
3. Parikh, J. and Dattye, H. (2003). Sustainable Management of Wetlands Biodiversity and beyond. Sage Publications New Delhi Thousand Oaks London. Pp.444.
4. Verhoeven, J. T. A., Beltman, B., Whigham, D. F., Roland Bobbink. (2006). Wetlands and Natural Resource Management. Verhoeven, J. T. A., Beltman, B., Whigham, D. F., Roland Bobbink (eds). Springer-Verlag Berlin Heidelberg

ZOO-781	**Wildlife Conservation and Management**	3.0

Course Outline:

1. **Wildlife of Pakistan**

a. Introduction
b. Important Definitions
c. Identification
d. Distribution
e. Status
f. Wildlife values
g. Conservation and Management (population estimate technology) of fishes, amphibians, reptiles, birds and mammals of major importance in Pakistan

2. **Objectives of wildlife conservation**
3. **Problems in wildlife conservation**
4. **Wildlife rules and regulations in Pakistan**

a. Principles of Reintroduction
b. IUCN categories of Wildlife
c. Zoo rules

5. **National and International agencies involved in conservation and management of wildlife**

a. National Organizations
b. International Organizations

6. **Protected Areas in Pakistan**

a. Sanctuaries
b. Game Reserves
c. National Parks

7. **Threatened species of Pakistan.**

a. Vulnerable
b. Endangered
c. Critically Endangered

8. **Modern Techniques for Control of Environmental Pollution in Wildlife Areas**
9. **Endangered Species Causes and Measures for the Conservation**
10. **International Conventions**

Practicals:

1. Visit to National Parks, Wildlife Sanctuaries, Game Reserves.

Recommended Books:

1. Mills, S. 2007. Conservation of Wild population. Blackwell Publishing & Co. London, UK.

2. Sinclair, A. R. E., Fryxell, J. M. and Caughley, G. 2006. Wildlife Ecology, Conservation and Management. Blackwell Publishing & Co., London, UK.

3. Sutherlands, W. J. 2000. The Conservation handbook, Blackwell Science.

4. Sexena, M.M., 1990. Applied Environmental Biology, Agro Botanical Publ. India.

5. Rigger. P.G. 1991. Long Term Ecological Research, an International Perspective. John Wiley.
6. Sheehun et. al. P. J. 1984. Effects of Pollution on the Ecosystem. John Wiley.

ZOO-782	**Wildlife of Pakistan**	3.0

Course Outline:

1. **Introduction**

a. An Introduction to Wildlife of Pakistan:
b. Existing Wildlife in Pakistan (Province)
c. Wildlife biology
d. Wildlife Population Ecology
e. National and International organizations involved in conservation and management of wildlife

2. **Wildlife Management**

a. Wildlife Management at Wetlands
b. Terrestrial Wildlife Management
c. Wildlife Damage Management
d. Captive Wildlife Management

3. **Wildlife Conservation**

a. Philosophy and significance of wildlife conservation.
b. Essentials of Wildlife Conservation and National Perspectives
c. Conservation of Amphibians and Reptiles
d. In-situ conservation and Ex-situ conservation

4. **Biodiversity of Pakistan:**

a. Biodiversity and sustainability of wildlife
b. Identification, distribution, status and endangered species
c. Mammals, Birds, Reptiles and Amphibians
d. Fresh water and Marine fish fauna of Pakistan, Insects and plants

5. **Wildlife Conservation**

a. Philosophy and significance of wildlife conservation.
b. Essentials of Wildlife Conservation and National Perspectives
c. Conservation of Amphibians and Reptiles
d. In-situ conservation and Ex-situ conservation

6. **Biodiversity of Pakistan:**

a. Biodiversity and sustainability of wildlife
b. Identification, distribution, status and endangered species
c. Mammals, Birds, Reptiles and Amphibians
d. Fresh water and Marine fish fauna of Pakistan, Insects and plants

7. **Protected Areas**

a. Protected Areas Systems, Zoo and Breeding Centers
b. Wildlife Sanctuaries, National Parks and Game Reserves
c. Wetlands and Ecological Zones

8. **Issues and challenges**

a. Threats to Wildlife

b. Species of Special Concern and Invasive species

c. Habitat destruction and fragmentation

d. Deforestation and urbanization

9. **Wildlife Rules and Regulations and importance**

a. Laws, Policy and social issues

b. Values and Economics of Wildlife

Practical:

1. Autopsy of animals, micro-histological studies and food/diet composition analysis,

2. Study of distribution description, biology, food, predators and status of wild animals of a zoo or Zoological park of Pakistan.

3. Adaptive features of animals in relation to food and environment

4. Construction of food chain and food webs of wild animals.

Text and Reference Books:

1. Wildlife of Pakistan, 2002. Published by Punjab Wildlife Department, Lahore.

2. Miller, G.T. 2002. Living in the Environment: Principles, Connections and Solution. 12th Edition. Thomson Learning Inc., Australia.

3. Roberts, T.J., 1998. The Birds of Pakistan, Vol. II, Oxford.

4. Roberts, T.J., 1992. The Birds of Pakistan, Vol. II, Oxford.

5. Roberts, T.J., 1998. Mammals of Pakistan, Ernest Benon Ltd. London.

6. Robinson, W.L. and Bolen, E.G., 1984. Wildlife Ecology and Management, McMillan, Cambridge.

7. http://www.wildlifeofpakistan.com

ANNEXURE-F

Panel of Examiners

A list of panel of examiners was approved by the previous boards of studies and academic councils. Some new names are here by proposed /suggested for consideration by the 6th BOS.

1.	Dr. Hussain Ahmad	Assistant Professor, Department of Zoology, University of Buner
2.	Dr. Muzafar Shah	Assistant Professor, Department of Zoology, University of Swat Email: muzafar@uswat.edu.pk
3.	Dr. Gauhar Rehman	Assistant Professor, Department of Zoology, Abdul Wali Khan University, Mardan. Email: gauhar@awkum.edu.pk
4.	Dr. Abid Ali	Assistant Professor, Department of Zoology, Abdul Wali Khan University, Mardan. Email @awkum.edu.pk, +92-345-9181648
5.	Dr. Hina Jabeen	Assistant Professor, Department of Zoology, Woman University, Mardan. Email microbiology@wumardan.edu.pk
6.	Dr. Surrya Khanam	Assistant Professor, Department of Zoology, Woman University, Swabi.
7.	Dr. Romana Sarwar	Assistant Professor, Department of Zoology, Woman University, Swabi.
8.	Dr. Mehreen Riaz	Assistant Professor, Department of Zoology, Woman University, Swabi.
9.	Dr. Muhammad Faiz Khan	Assistant Professor, Department of Zoology, Hazara University, Mansehra.
10	Dr. Shabir Ahmad	Assistant Professor, Department of Zoology, Hazara University, Mansehra.
11	Dr. Sardar Azhar Mahmood	Assistant Professor, Department of Zoology, Hazara University, Mansehra.
12	Dr. Sadia Tabasum	Assistant Professor, Department of Zoology, Hazara

		University, Mansehra.
13.	Khalid Khan	Assistant Professor, Department of Zoology, Islamia College University, Peshawar.
14.	Dr. Muhammad Adnan	Assistant Professor, Department of Zoology, University of Peshawar. **Email:** muhammadadnan@uop.edu.pk
15.	Dr. Farrah Zaidi	Assistant Professor, Department of Zoology University of Peshawar. **Email:** zaidi_farrah@yahoo.com
16.	Dr. Abdur Rahim Khan	Assistant Professor, Department of Zoology University of Malakand. **Email:** Rahim.cemb@yahoo.com
17.	Dr. Adul Basit	Assistant Professor, Department of Zoology Bacha Khan University Charsadda.
18.	Dr. Abdul Aziz	Assistant Professor, Department of Zoology Khushal Khan Khattak University Karak.
19.	Dr. Rabea Ejaz	Assistant Professor, Department of Zoology, Shaheed Benazir Bhutto Woman University Peshawar
20.	Dr. Irum Maqsood	Assistant Professor, Department of Zoology Shaheed Benazir Bhutto Woman University Peshawar
21.	Dr. Asima Azam	Assistant Professor, Department of Zoology Shaheed Benazir Bhutto Woman University Peshawar
22.	*Dr.Mohammad Salim*	Assistant Professor, Department of Zoology, University of Haripur, Email: mohammadsalim@uoh.edu.pk Phone No: 0995-614164/0301-8920955
23.	*Dr.Sajida Noureen*	Assistant Professor, Department of Zoology, University of Haripur, Email: sajidanoureen@uoh.edu.pk
24.	*Mr.Muhammad Saad*	Assistant Professor, Department of Zoology,

		University of Haripur, Email: msaad@uoh.edu.pk Phone No: 0995-614164
25.	*Dr.Durr e Shahwar*	Assistant Professor, Department of Zoology, University of Haripur, Email: shahwar.awan@uoh.edu.p
26.	*Dr. Ruqia*	Assistant Professor, Department of Zoology GGC Mardan

ANNEXURE-G

Any other item (if any) with the permission of the chair