DEPARTMENT OF ZOOLOGY

APPROVAL

CURRICULUM BS (4YEARS) PROGRAM

SESSION 2019 and Onwards

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SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR
DEPARTMENT OF ZOOLOGY

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SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

BS (4 YEARS) ZOOLOGYPROGRAM

INTRODUCTION

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

Eligibility Criteria

Eligibility Criteria for BS:

F.Sc. Pre medical/ A level (withBiology and Chemistry)

Objectives and Outcomes

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

Career Opportunities

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

Positions in various government and non governmental organizations, teaching and research, administration and management, aquaculture, fisheries, forestry, agriculture, biological control program, integrated pest management, lab diagonostics, poultry, plant protection, wildlife, livestock and other areas.

Pedagogy (Teaching - Learning Methodologies)

1. The courses will be delivered through lectures, seminars, practicals, discussions and field trips.

2. Teaching learning material will include text-books, reference books journals/periodicals, handouts and internet.
3. Using audio/ visual aids i.e., slides/ overhead transparencies / multimedia.

Assessment and Evaluation

Internal evaluation (left to the individual universities)

Mid term test

Seminars and Assignments

Final Examination

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR
DEPARTMENT OF ZOOLOGY
BS ZOOLOGY (4YEARS) COURSES WITH COURSE CODES

COURSES OFFERED TO OTHER DEPARTMENTS				
Sr. No.	**Department /Program/Semester**	**Course Title**	**Credits**	**Course Codes**
Course-I	Education (B.Ed) 1st	General Science	3	ZOL-301
Course-II	Microbiology 1st	Biodiversity of Animal Life	2+1	ZOL-302
Course-III	Chemistry 4th	Essentials of Biology	3	ZOL-401
Course-IV	Education(B.Ed) 5th	Fundamentals of Cell Biology	3	ZOL-501
Course-V	Education(B.Ed) 6th	Fundamentals of Zoology	3	ZOL-502
Course-VI	Education(B.Ed) 7th	Essentials of Zoology	3	ZOL-601

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DEPARTMENT OF ZOOLOGY
BS ZOOLOGY (4YEARS) COURSES WITH COURSE CODES

COMPULSORY COURSES (9)			
Course Category	**Course Title**	**Credits**	**Course Codes**
Compulsory-I	English-I	3	ENG-301
Compulsory-II	Islamic Studies	2	ISL-301
Compulsory-III	Basic Calculus	3	MTH-307
Compulsory-IV	English-II	3	ENG-302
Compulsory-V	Pakistan Studies	2	PST-323
Compulsory-VI	Introduction to Information and Communication Technologies	1+2	CSC-301
Compulsory-VII	English-III	3	ENG-410
Compulsory-VIII	Cell Biology	2+1	ZOL-411
Compulsory-IX	Biostatistics	2+1	STAT-401

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DEPARTMENT OF ZOOLOGY
BS ZOOLOGY (4YEARS) COURSES WITH COURSE CODES

GENERAL COURSES (8)			
Course category	**Course title**	**Credits**	**Course Codes**
General-I	Plant Diversity	2+1	BOT-301
General-II	Fundamental Inorganic Chemistry	3+1	CHM-301
General-III	Plant Physiology	2+1	BOT-302
General-IV	Fundamental Organic Chemistry	3+1	CHM-401
General-V	Systematic Botany and Cytogenetics	2+1	BOT-401
General-VI	Environmental Chemistry	3+1	CHM-402
General-VII	Sociology	2	SCO-
General-VIII	Understanding Psychology	3	PSY-301

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DEPARTMENT OF ZOOLOGY
BS ZOOLOGY (4YEARS) COURSES WITH COURSE CODES

FOUNDATION COURSES (10)			
Course category	**Courses title**	**Credits**	**Course Codes**
Foundation-I	Diversity of Invertebrates	3+1	ZOL-311
Foundation-II	Diversity of Chordates	3+1	ZOL-321
Foundation-III	Principles of Biochemistry	2+1	BCHM-
Foundation-IV	Fundamentals of Microbiology and Immunology	2+1	MB-421
Foundation-V	Anatomy and Physiology of Invertebrates	2+1	ZOL-421
Foundation-VI	Principles of Biotechnology	2+1	ZOL-422
Foundation-VII	Anatomy and Physiology of chordates	3+1	ZOL-511
Foundation-VIII	Economic Zoology	2+1	ZOL-512
Foundation IX	Evolutionary Biology	3	ZOL-514
Foundation-X	Principles of Animal Systematics	2+1	ZOL-521

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DEPARTMENT OF ZOOLOGY
BS ZOOLOGY (4YEARS) COURSES WITH COURSE CODES

MAJOR COURSES(13)			
Course category	**Courses title**	**Credits**	**Course Codes**
Major-I	Fundamentals of Bioinformatics	2+1	BI-409
Major-II	Molecular Biology	2+1	ZOL-513
Major-III	Animal Behavior	3	ZOL-515
Major-IV	Research Planning and Report Writing	3	ZOL-522
Major-V	Animal Ecology	2+1	ZOL-523
Major-VI	Principles of Genetics	2+1	ZOL-524
Major-VII	WildlifeConservation and Management	2+1	ZOL-525
Major-VIII	Zoogeography and Paleontology	2+1	ZOL-611
MAJOR-IX	Biological Techniques	1+2	ZOL-612
Major-X	Animal Reproductive Biology	2+1	ZOL-613
Major-XI	Developmental Biology	2+1	ZOL-621
Major-XII	Endocrinology	2+1	ZOL-622
Major-XIII	Internship/ Thesis	3/6	ZOL-690 ZOL-699

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR
DEPARTMENT OF ZOOLOGY
SCHEME OF STUDY BS (4YEARS) PROGRAM SESSION (2019 AND ONWARDS)

Year-1

SEMESTER–I

Course Title	Theory	Practical	Credit hours	Course codes
English-I	3	0	3	ENG-301
Islamic Studies	2	0	2	ISL-301
Basic Calculus	3	0	3	MTH-307
Plant Diversity	2	1	3	BOT-301
Understanding Psychology	3	0	3	PSY-301
Diversity of Invertebrates	3	1	4	ZOL-311
Total Credits			**18**	

SEMESTER–II

Course Title	Theory	Practical	Credit hours	Course codes
English-II	3	0	3	ENG-302
Pakistan Studies	2	0	2	PST-323
Introduction to Information and Communication Technologies	2	1	3	CSC-301
Plant Physiology	2	1	3	BOT-302
Fundamental Inorganic Chemistry	3	1	4	CHM-301
Diversity of Chordates	3	1	4	ZOL-321
Total Credits			**19**	

Year-II

SEMESTER–III

Course Title	Theory	Practical	Credit hours	Course codes
English-III	3	0	3	ENG-410
Cell Biology	2	1	3	ZOL-411
Systematic Botany andCytogenetics	2	1	3	BOT-401
Fundamental Organic Chemistry	3	1	4	CHM-401
Sociology	2	0	2	SCO-
Principles of Biochemistry	2	1	3	BCHM-

Total Credits			**18**	

SEMESTER–IV

Course Title	**Theory**	**Practical**	**Credit hours**	**Course Codes**
Biostatistics	2	1	3	STAT-401
Environmental Chemistry	3	1	4	CHM-402
Fundamentals of Microbiology and Immunology	2	1	3	MB-421
Anatomy and Physiology of Invertebrates	2	1	3	ZOL-421
Principles of Biotechnology	2	1	3	ZOL-422
Fundamentals of Bioinformatics	2	1	3	BI-409
Total Credits			**19**	

YEAR-III

SEMESTER–V

Course Title	**Theory**	**Practical**	**Credit hours**	**Course Codes**
Anatomy and Physiology of Chordates	3	1	4	ZOL-511
Economic Zoology	2	1	3	ZOL-512
Molecular Biology	2	1	3	ZOL-513
Evolutionary Biology	3	0	3	ZOL-514
Animal Behavior	3	0	3	ZOL-515
Total Credits			**16**	

SEMESTER–VI

Course Title	**Theory**	**Practical**	**Credit hours**	**Course Codes**
Biological Techniques	2	1	3	ZOL-521
Research Planning and Report Writing	3	0	3	ZOL-522
Animal Ecology	2	1	3	ZOL-523
Principles of Genetics	2	1	3	ZOL-524
Wildlife Conservation and Management	2	1	3	ZOL-525
Total Credits			**15**	

YEAR-IV

SEMESTER–VII

Course Title	Theory	Prcatical	Credit hours	Course codes
Zoogeography and Paleontology	2	1	3	ZOL-631
Principles of Animal Systematics	2	1	3	ZOL-632
Animal Reproductive Biology	2	1	3	ZOL-633
Entomology	2	1	3	ZOL-634
Optional Course-I	2	1	3	ZOL-
Optional course-II/ Thesis	2/0	1/3	3	ZOL-/ ZOL-699
Total Credits			**18**	

SEMESTER–VIII

Course Title	Theory	Practical	Credit hours	Course Codes
Endocrinology	2	1	3	ZOL-641
Developmental Biology	2	1	3	ZOL-642
Optional Course-III	2	1	3	ZOL-
Optional Course-IV	2	1	3	ZOL-
Thesis/Internship	0	3	3	ZOL-699/ ZOL-690
Total Credits			**15**	

18+ 19+18+19+16+15+18+15=138

BS ZOOLOGY (4 YEAR PROGRAM) SESSION 2019 AND ONWARDS

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

Compulsory Requirements (the student has no choice)		General Courses to be chosen from other departments		Discipline Specific Foundation Courses		Major courses including research project/ Internship		Elective Courses within the major	
9 courses		7-8 courses		9-10 courses		11-13 courses		4 courses	
Subject	**Cr. hr**	**Subject**	**Cr. Hr**	**Subject**	**Cr. hr**	**Subject**	**Cr. Hr**	**Subject**	**Cr. hr**
i. English-I: Functional English	3(3+0)	i. Botany-I	3(2+1)	i. Animal Diversity-I (Invertebrates)	4(3+1)	i. Animal Behavior	3(3+0)	Special PaperA2/Elective I*****	3(2+1)
ii. Islamic Studies / Ethics	2(2+0)	ii. Chemistry-I	3(2+1)	ii. Animal Diversity-II (Chordates)	4(3+1)	ii. Biological Techniques	3(1+2)	Special PaperB2/ Elective –II *****	3(2+1)
iii. Mathematics-I	3(3+0)	ii. Botany-II	3(2+1)	ii. Cell Biology	3(2+1)	iii. Molecular Biology	3(2+1)	Elective – III*****	3(2+1)
iv. English-II: Communication Skills	3(3+0)	iv. Chemistry-II	3(2+1)	v. Animal Form & Function–I	4(3+1)	iv. Physiology	4(3+1)	Elective – IV*****	3(2+1)
v. Pakistan Studies									
vi. English-III: Technical writing and presentation skills	2(2+0)	v. Botany-III	3(2+1)	v. Animal Form & Function-II	4(3+1)	v. Ecology	3(2+1)		
vii.	3(3+0)	vi. Chemistry-III	3(2+1)	vi. Economic Zoology	3(2+1)	vi. Developmental Biology	4(3+1)		
iii. Introduction to Computer	3(1+2)	vii. Social Sciences/Univ. Option**	2(2+0)	ii. Biochemistry-I	3(2+1)	vii. Genetics	4(3+1)		
ix. English-IV / Univ. Option*	3(3+0)	ii. Psychology/ Geography/ Etc**.	2(2+0)	ii. Biochemistry-II	3(2+1)	iii. Wildlife	3(2+1)		
x. Biostatistics/Univ option	3(2+1)			x. Evolution	2(2+0)	ix. Zoogeography & Paleontology	3(2+1)		
				x. Principles of Systematics	3(2+1)	x. Research Methodology	2(2+0)		
						xi. Bioinformatics	3(1+2)		
						ii. Special Paper A1***/ Thesis(Univ. Option)****	3(2+1)/(0+3)		
						iii. Special Paper B1/ Thesis(Univ. Option)****	3(2+1)/(0+3)		
	25		**22**		**33**		**41**		**12**

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

** Sociology, social work, principles of management, Ethical and moral values in society

*** Aquacultue, Fisheries and fish farming,Mariculture, Apiculture, Taxidermy, Sericulture, Parasitology,Molecular biology, Entomology, Pest Control,Ornithology, Ostrich farming, Quail farming,Immunology, Vaccine production,Environmental Sciences, Endocrinology, etc. (universities may offer any other special paper depending upon the availability of the expertise)

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

***** All elective subjects should be selected to support the opted special paper/thesis. Special paper students will take 2 elective papers as special papers and 2 as electiveand those opting for research will take 2 courses as elective.

Complete List of Optional Courses offered by Department of Zoology

S. No.	Course Title	Course Codes	Theory	Practical	Credit Hours
1.	Comparative Animal Physiology	ZOL- 664	2	1	3
2.	Comparative Endocrinology	ZOL-665	2	1	3
3.	Host Parasite Relationship in Animals	ZOL-666	2	1	3
4.	Clinical Bacteriology	ZOL-667	2	1	3
5.	Medical Virology	ZOL-668	2	1	3
6.	Faunal Biodiversity of Pakistan	ZOL-669	2	1	3
7.	Helminthology and Protozoology	ZOL-670	2	1	3
8.	Fish Nutrition and Health	ZOL-671	2	1	3
9.	Human Genetics	ZOL-672	2	1	3
10.	Epidemiology of Animal Parasites	ZOL-673	2	1	3
11.	Wildlife of Pakistan	ZOL-674	2	1	3
12.	Quantitative Zoology	ZOL-675	2	1	3
13.	Behavioral Ecology	ZOL-676	2	1	3
14.	Ornithology	ZOL-677	2	1	3
15.	Mammology	ZOL-678	2	1	3
16.	Aquaculture and Fisheries	ZOL-679	2	1	3
17.	Biotechnology in Aquaculture	ZOL-680	2	1	3
18.	Limnology	ZOL-681	2	1	3
19.	Wildlife Ecology	ZOL-682	2	1	3
20.	Wildlife techniques and data analysis	ZOL-683	2	1	3
21.	Vector Biology	ZOL-684	2	1	3
22.	Population Genetics	ZOL-685	2	1	3
23.	Bioremediation	ZOL-686	2	1	3
24.	Biology and control of vertebrate pests	ZOL-687	2	1	3

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DEPARTMENT OF ZOOLOGY
CURRICULUM BS (4YEARS) PROGRAM SESSION (2019 AND ONWARDS)

SEMESTER–I

Course Title	Theory	Practical	Credit hours	Course codes
English-I	3	0	3	ENG-301
Islamic Studies	2	0	2	ISL-301
Basic Calculus	3	0	3	MTH-307
Plant Diversity	2	1	3	BOT-301
Understanding Psychology	3	0	3	PSY-301
Diversity of Invertebrates	3	1	4	ZOL-311
Total Credits			**18**	

ENGLISH-I (ENG-301)

Contact Hours:
Theory = 48
Practicals = 0
Total = 48

Credit Hours
Theory = 3.0
Practical = 0.0
Total = 3.0

Course Objectives:

The main focus of this course is to introduce students to the basic concepts of English grammar and to develop their understanding of English language and effective listening and oral communication skills. Objectives of the course are:

- Enabling the students to identify grammatical structures/ errors and use correct tenses, spellings, punctuation, and mechanics required for formal and informal communication
- Enabling students to comprehend language through various listening strategies
- Preparing students to use presentation skills for effective communication through a variety of classroom activities within specific (given) contexts.

Course Contents

- Tenses
- Parts of speech
- Sentence structures
- Phrase and Clause (Dependent and Independent Clause)
- Voices of Verb (Active and Passive)
- Punctuation
- Word Formation
- Idioms and Proverbs
- Listening and Speaking Skills

(Listening practice+ presentation skills
interview techniques
extempore/prepared unprepared talks)

Note: Extensive reading is required for vocabulary building

Recommended Readings

An Introduction to the Pronunciation of English by A.C Gimson
London: Edward Hrnold, 1971

English II: a Contemporary Approach by Robdert W Boyton. New York:
Haydon,1987

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 1.Third edition.Oxford University Press. 1997. ISBN 0194313492
2. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2.Third edition.Oxford University Press. 1997. ISBN 0194313506
3. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet.Oxford Supplementary Skills.Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.
4. Upper Intermediate. Brain Tomlinson and Rod Ellis.Oxford Supplementary Skills.Third Impression 1992.ISBN 0 19 453402 2.

ISLAMIC STUDIES (ISL-301)

Contact Hours:	**Credit Hours**
Theory = 32	Theory = 2.0
Practicals = 0	Practical = 0.0
Total = 32	**Total = 2.0**

Objectives:

This course is aimed at:

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

Detail of Courses

Introduction to Quranic Studies

1) Basic Concepts of Quran
2) History of Quran
3) Uloom-ul -Quran

Study of Selected Text of Holly Quran

1) Verses of Surah Al-Baqra Related to Faith(Verse No-284-286)
2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
3) Verses of Surah Al-Mumanoon Related to Characteristics of faith (Verse No-1-11)
4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
5) Verses of Surah Al-Inam Related to Ihkam(Verse No-152-154)

Study of Sellected Text of Holly Quran

1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57, 58)

2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
3) Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)

Seerat of Holy Prophet (S.A.W) I
1) Life of Muhammad Bin Abdullah (Before Prophet Hood)
2) Life of Holy Prophet (S.A.W) in Makkah
3) Important Lessons Derived from the life of Holy Prophet in Makkah

Seerat of Holy Prophet (S.A.W) II
1) Life of Holy Prophet (S.A.W) in Madina
2) Important Events of Life Holy Prophet in Madina
3) Important Lessons Derived from the life of Holy Prophet in Madina

Introduction To Sunnah
1) Basic Concepts of Hadith
2) History of Hadith
3) Kinds of Hadith
4) Uloom-ul-Hadith
5) Sunnah& Hadith
6) Legal Position of Sunnah

Selected Study from Text of Hadith

Introduction To Islamic Law & Jurisprudence
1) Basic Concepts of Islamic Law & Jurisprudence
2) History & Importance of Islamic Law & Jurisprudence
3) Sources of Islamic Law & Jurisprudence
4) Nature of Differences in Islamic Law
5) Islam and Sectarianism

Islamic Culture & Civilization
1) Basic Concepts of Islamic Culture & Civilization
2) Historical Development of Islamic Culture & Civilization
3) Characteristics of Islamic Culture & Civilization
4) Islamic Culture & Civilization and Contemporary Issues

Islam & Science
1) Basic Concepts of Islam & Science
2) Contributions of Muslims in the Development of Science
3) Quran & Science

Islamic Economic System
1) Basic Concepts of Islamic Economic System
2) Means of Distribution of wealth in Islamic Economics
3) Islamic Concept of Riba
4) Islamic Ways of Trade & Commerce

Political System of Islam
1) Basic Concepts of Islamic Political System

2) Islamic Concept of Sovereignty
3) Basic Institutions of Govt. in Islam

Islamic History
1) Period of Khlaft-E-Rashida
2) Period of Ummayyads
3) Period of Abbasids

Social System of Islam
1) Basic Concepts Of Social System Of Islam
2) Elements Of Family
3) Ethical Values Of Islam

Recommended Books:

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

BASIC CALCULUS (MTH-307)

Contact Hours:	**Credit Hours**
Theory = 48	Theory = 3.0
Practicals = 0	Practical = 0.0
Total = 48	**Total = 3.0**

Credit Hours: 3

OBJECTIVES

This is the first course of the basic sequence, Calculus I-III, serving as theFoundation of advanced subjects in all areas of mathematics. The sequence,equally, emphasizes basic concepts and skills needed for mathematicalManipulation. Calculus I & II focus on the study of functions of a singleVariable

Course Detail

- Limits and continuity.
- Derivative of a function and its applications.
- Mean value theorem (Taylor's theorem and the infinite Taylor series with applications) and curve sketching; anti-derivative and integral.
- Definite integral and applications.
- The fundamental theorem of Calculus.

Inverse functions (Chapters 1-6 of the text

Recommended Books:

1. Anton H, *Calculus: A New Horizon* (6th edition), 1999. John Wiley,New York.
2. Stewart J, *Calculus* (3rd edition), 1995, Brooks/Cole (suggested text)
3. Thomas G. B, Finney A. R., *Calculus* (10th edition), 2002. Addison-Wesley, Reading, Ma, U.S.A.
4. Anton, H., 1999. *Calculus: A New Horizon*, 6th Edition, John Wiley,New York.
5. Stewart J, 1995. *Calculus* ,3rd Edition, Brooks/Cole
6. Thomas, G. B. and Finney, A. R, 2002. *Calculus* 10th Edition, Addison-Wesley, Reading, Ma, U.S.A.

PLANT DIVERSITY (BOT-301)

Contact Hours:	**Credit Hours**
Theory = 32	Theory = 2.0
Practicals = 32	Practical = 1.0
Total = 64	**Total = 3.0**

COURSE OBJECTIVES:

The course aims to:

- Provide in-depth knowledge of diversity of plants
- To study general characters, classification, reproduction and affinities

COURSE LEARNING OUTCOMES:

On completion of this course, the students should be able to:

- **IDENTIFY** the diversity of plant
- **KNOW** the primary characteristics of plants
- **UNDERSTAND** reproduction and life cycle of plants

Theory and Practical

Algae: General structure, occurance, reproduction and classification

Fungi: General structure, occurance, reproduction and classification, life cycle, economic importance with emphasis on industrial and medicinal significance. Methods of control of pathogenic forms (smut and rust).

Lichens: General account, structure and life history of Physcia

Bryophyta (Atracheophyta): General account, reproduction, classification, affinities and ecological importance with special reference to the life cycle of Anthoceros and Funaria.

Pteridophyta:

Psilopsida: General account, structure and life history of Psilotum and its affinities.

Lycopsida: General account, structure and life history of Selaginella and its affinities.

Sphenopsida: General account, structure and life history of equisetum.

Pteropsida: Filicinae (Ferns), general account, life history of Adiantum and Marsilea.

Gymnosperms: General account with reference to structure and life history of Cycas, Pinus and Ephedra and their affinities

Angiosperms: Life cycle of a typical angiosperm.

UNDERSTANDING PSYCHOLOGY (PSY-301)

Contact hour's **Credit hours: 3**

Theory =48Theory =3
Practical =0Practical =0
Total = 48 total =3

Course Objectives

- To describe psychology with major areas in the field,
- To identify the parameters of this discipline. Distinguish between the major perspectives on human thought and behavior.
- To gain insight into human behavior and into one's own personality or personal relationships. Explore the ways that psychological theories are used to describe, understand, predict, and control or modify behavior.

Intended Learning Outcomes

Students will have the basic knowledge of Psychology, human behavior, methods used in testing of human behavior.

Course Outline

1. **Introduction to Psychology:**

a. Definition and brief history of Psychology.

2. **Biological Basis of Behavior**

a. Neuron: Structure and Functions
b. Central Nervous System and Peripheral Nervous System

3. **Sensation, Perception and Attention**

a. Sensation
i. Characteristics and Major Functions of Different Sensations
b. Perception
i. Definition of Perception
ii. Factors affecting Perception: Subjective, Objective
c. Attention
i. Factors: Subjective and Objective
ii. Span of Attention
iii. Fluctuation of Attention
iv. Distraction of Attention
5. Motives
a. Definition of motives
b. (Biogenic) Motives:
c. Sociogenic Motives

6. **Emotions**

a. Definition

b. Theories of Emotion : James Lange Theory; Canon-Brad Theory, Schechter-Singer Theory

7. Learning

a. Definition of Learning

b. Types of Learning: Classical and Operant Conditioning,

c. Definition and Types of Reinforcement

8. Memory

a. Definition

b. Sensory memory, short term memory, long term memory

c. Forgetting and theories of forgetting: decay theory, interference theory, motivational forgetting theory

9. Thinking

a. Definition

b. Problem Solving: strategies and obstacles

Recommended Books:

1. Atkinson R. C., & Smith E. E. (2000). *Introduction to psychology* (13th ed.). Harcourt Brace College Publishers.
2. Fernald, L. D., & Fernald, P. S. (2005). *Introduction to psychology*. USA: WMC Brown Publishers.
3. Glassman, W. E. (2000). *Approaches to psychology*. Open University Press. Hayes, N. (2000). *Foundation of psychology* (3rd ed.). Thomson Learning. Lahey, B. B. (2004). *Psychology: An introduction* (8th ed.). McGraw-Hill Companies, Inc.
4. Leahey, T. H. (1992). *A history of psychology: Main currents in psychological thought*. New Jersey: Prentice-Hall International, Inc.
5. Myers, D. G. (1992). *Psychology*. (3rd ed.). New York: Wadsworth Publishers.
6. Ormord, J. E. (1995). *Educational psychology*: *Developing learners*. Prentice- Hall, Inc

DIVERSITY OF INVERTEBRATES(ZOL-311)

Contact Hours:	**Credit Hours:**
Theory =48	Theory = 3.0
Practical = 32	Practical = 1.0
Total = 80	Total = 4.0

COURSE OBJECTIVES:

1. To provide the knowledge of evolutionary/phylogenetic relationship (from simple to the complex organisms).
2. To impart the basic taxonomic characteristics and classification of all the invertebrate phyla.
3. To provide understanding of body organization, Feeding and Digestive system; Other Organ System;
4. To provide the description of mode of Reproduction and Development
5. To provide the information of their economic and ecological importance

COURSE LEARNING OUTCOMES:

This course will be based on following outcomes:

1. Acquire the basic concepts of invertebrates with explanation of evolutionary origin and diversification.
2. Understand invertebrate organismal concepts in laboratory and field.
3. Demonstrate major evolutionary innovations for invertebrates with functional importance.
4. Understand how reproduction and development occured and able to breed animal in the laboratory/field
5. Analyze economic and ecological importance of 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:
   b. Evolutionary Relationships and Tree Diagrams: Patterns of organization.
2. **ANIMAL-LIKE PROTISTS: THE PROTOZOA**
   a. Evolutionary perspective; Life within a single plasma Membrane;
   b. Symbiotic Life-styles.
   c. Protozoon Taxonomy; (up to Phyla, subphyla and super Classes, wherever applicable).
   d. Pseudopodia and Amoeboid Locomotion; Cilia and other pellicular structure;
   e. Nutrition; Genetic Control and Reproduction; Symbiotic ciliates;
   f. Further Phylogenetic Consideration.
3. **MULTICELLULAR AND TISSUE LEVELS OF ORGANIZATION**
   a. Evolutionary Prespective:
   b. Origins of Multicellularity; Animal Origins.

   Phylum Porifera
   a. Characteristics and classification. Cell Types, Body Wall, and Skeletons;
   b. Water Current and Body Forms;
   c. Maintenance Functions, Reproduction.

   Phylum Cnidaria (Coelenterate)
   a. Characteristics and classification. The body Wall and Nematocysts: Alteration of Generations;
   b. Maintenance Functions; Reproduction and
   c. Classification up to Class.

   Phylum Ctenophore;
   a. Characteristics, body organization
4. **THE TRIPLOBLASTIC AND WITH ACOELOMATE BODY PLAN PHYLUM PLATYHELMINTHES**
   a. Evolutionary Perspective; Classification up to class;
   b. The Free-Living Flatworms and the Tapeworms, adaptive modification for parasitic life style

   Phylum Numerate; Characteristics, body organization
   Phylum Gastrotrich; Characteristics, body organization
5. **PSEUDOCOELOMATE BODY PLAN**

PHYLUM ASCHELMINTHS

a. Evolutionary perspective; General Characteristics; Classification up to order with External Features;
b. Feeding and Digestive system; Other Organ System; Reproduction and Development including Phylum**Rotifera,** Phylum**Nematoda** and Phylum **Kinorhyncha**.
c. Some Important Nematode Parasites of Humans;

6. **PHYLUM MOLLUSCA**

a. Evolutionary perspective; Relationship to other animals; Origin of the Coelom;
b. Molluscan Characteristics, Classification up to class. The Characteristics of Shell and Associated Structures,
c. Feeding, Digestion, Gas Exchange, Locomotion,
d. Reproduction and Development, Other maintenance Functions and Diversity in Gastropods, Bivalves and Cephalopods:

7. **PHYLUM ANNELIDA**

a. The Metameric Body Form; Evolutionary perspective; Relationship to other animals,
b. Metamerism and Tag-matization, Classification up to Class. External Structure and Locomotion,
c. Feeding and the Digestive system, Gas Exchange and Circulation,
d. Nervous and Sensory Functions, Excretion,
e. Regeneration, Reproduction and Development, in Polychaeta, Oligochaeta and Hirudinea, Further Phylogenetic Consideration.

8. **PHYLUM ARTHROPODA:**

a. Evolutionary Perspective: Classification and Relationship to other Animals;
b. Metamerism and Tagmatization;
c. The Exoskeleton; Metamorphosis;
d. Classification up to Class; Further Phylogenetic Consideration.

9.**The Hexapods and Myriapods:**

a. Evolutionary Perspective: Classification up to class. External Structure and Locomotion,
b. Nutrition and the Digestive system, Gas Exchange, Circulation and Temperature Regulation,
c. Nervous and Sensory Functions, Excretion, Chemical Regulation,
d. Reproduction and Development in Hexapoda,
e. Insects Behavior, Insect and Human;

10. **PHYLUMECHINODERMS**

a. Evolutionary Perspective: Relationship to other Animals; Echinoderm Characteristics; Classification up to class.
b. Maintenance Functions, Regeneration,
c. Reproduction, and Development in Asteroida, Ophiuroidea, Echinoidea, Holothuridea and Crinoidea;

SOME LESSER-KNOWN INVERTEBRATES;

a. The Lophophorates, Entoprocts, Cycliophores, and Cheatognaths.

PRACTICAL:

Note: Classification of each member of each phylum upto 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, Endameba, 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 Sixth Edition, Menlo Park, California; Benjamin Cummings Publishing Company, Inc.

BOOKS FOR PRACTICAL

1. Miller, S.A., 2002. GENERAL ZOOLOGY LABORATORY MANUAL. 5th Edition (International), Singapore : McGraw Hill.

2. Hickman, C.P. and Kats, H.L., 2000. Laboratory Studies in integrated principal of zoology. Singapore : McGraw Hill.

SEMESTER–II

Course Title	Theory	Practical	Credit hours	Course codes
English-II	3	0	3	ENG-302
Pakistan Studies	2	0	2	PST-323
Introduction to Information and Communication Technologies	2	1	3	CSC-301
Plant Physiology	2	1	3	BOT-302
Fundmental inorganic Chemistry	3	1	4	CHM-301
Diversity of Chordates	3	1	4	ZOL-321

Total Credits			**18**	

English – II (ENG-302)

Contact Hours:
Theory = 48
Practicals = 0
Total = 48

Credit Hours
Theory = 3.0
Practical = 0.0
Total = 3.0

Course Objectives:

Main focus of this courseis the development of effective communication strategies, oral presentation, and written correspondence within the formal and informal context.

The objectives of this course are:

- Enabling the students to recognize the components and barriers of oral and written communication
- Developing students' skills to apply their knowledge of grammar and usage for formal and informal communicative purposes.
- Enhancing students' language skills to be used in diversified context and audience.

Course Contents

1. Components of Communication
   - Context
   - Sender-Encoder
   - Message
   - Medium
   - Receiver-Decoder
   - Feedback
2. Communication Skills (7 C's of Communication)
3. Barriers of Communication & Measures to avoid these (Practice with sentences & paragraphs)
4. Paragraph Writing (Thesis Statement, Topic Sentence and Supporting Sentences)
5. Letters (Formal and informal)
6. Comprehension Skills (Reading and Understanding within the context)
   Reading strategies (skimming, scanning, speedy)
7. Précis Writing (Rules & Practice)

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

English II: a Contemporary Approach by Robdert W Boyton. New York: Haydon,1987

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.

1. Writing. Intermediate by Marie-ChrisitineBoutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
2. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).

Course Name: Pakistan Studies (Compulsory)	**Course Code: PST-323**
Course Structure: Lectures: 2	**Credit Hours:** 2
Prerequisites: None	

Introduction/Objectives

- Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
- Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.
- To make students understand the dynamics of population characteristics; Relationship between man, environment and resources. To highlight the importance of demographic data in planning and decision-making

Course Outline

1) **Historical Perspective**

aPeople and Land

i. Indus Civilization

ii. Muslim advent

iii. Location and geo-physical features.

b. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah.

c. Factors leading to Muslim separatism

2) **Government and Politics in Pakistan**

a) Adoption of 1935 Act and Independence Act 1947 as Interim Constitution of Pakistan
b) Objective Resolution
c) Salient Features of the constitutions of ;
Constitution of 1956

Constitution of 1962

Constitution of 1973

3) **Pakistan in the 21st Century;**

a. Economic institutions and issues

b. Foreign policy of Pakistan and challenges

4**) Population Dynamics in Pakistan.**

Introduction ,Population characteristics: Physical, Social and Economic

Population dynamics: Patterns of fecundity and fertility, morbidity and mortality Population growth and change through pyramids,Population policies, current population situation, family planning and Islam
Text Books: 1) Burki, Shahid Javed. *State & Society in Pakistan*, The Macmillan Press Ltd 1980. 2) Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000. 3) S.M. Burke and Lawrence Ziring. Pakistan"s Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993. 4) Mehmood, Safdar. *Pakistan Political Roots & Development.* Lahore, 1994. 5) Wilcox, Wayne. *The Emergence of Banglades.*, Washington: American Enterprise, Institute of Public Policy Research, 1972. 6) Mehmood, Safdar. *Pakistan KayyunToota*, Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd. 7) Amin, Tahir. *Ethno - National Movement in Pakistan*, Islamabad: Institute of Policy Studies, Islamabad. 8) Ziring, Lawrence. *Enigma of Political Development.* Kent England: WmDawson& sons Ltd, 1980. 9) Zahid, Ansar. *History & Culture of Sindh.* Karachi: Royal Book Company, 1980. 10) Afzal, M. Rafique. *Political Parties in Pakistan*, Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998. 11) Sayeed, Khalid Bin. *The Political System of Pakistan.* Boston: Houghton Mifflin, 1967. 12) Aziz, K. K. *Party, Politics in Pakistan*, Islamabad: National Commission on Historical and Cultural Research, 1976. 13) Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987. 14) Haq, Noor ul. *Making of Pakistan: The Military Perspective.* Islamabad: National Commission on Historical and Cultural Research, 1993.

INTRODUCTION TO INFORMATION &COMMUNICATION TECHNOLOGIES

(CSC-301)

Contact Hours:	**Credit Hours:**
Theory = 32	Theory =2.0
Practical = 32	Practical = 1.0
Total = 64	Total = 3.0

Introduction/Objectives

The course focuses on introducing computing environment, general application software, basic computing hardware, operating systems, desktop publishing, internet, software applications and tools and computer usage concept.

COURSE OUTLINE:

Introduction to computer and Uses of computer in different disciplines.History of computer.Generations of computer.First Generation.Second generation.Third generation.Fourth generation. Fifth generation Computer Hardware: Introduction to hardware, Parts of computer and their functions (CPU,monitor,keyboard,mouse etc).computer types and classification. Types of .computer (digital and analogue).classification.Minicomputer.Micro computer.Mainframe computer. Super computerOperating System: Introduction. Windows 98/2000.Computer software .Introduction to software.Types of software.System software and application software.Internet Access.Internet Access.Different databases on Internet.Word Processing.Introduction.MS-Word.MS-Word Applications. Spread Sheets. Introduction.MS-Excel. MS-Excel Applications

PRACTICAL:

Other Software related Practical

Text Books:

1. Introduction to computer science, P.K Sinha.
2. Computer science- An Overview, Glenn Books.

A text book of computer B.com part-I

PLANT PHYSIOLOGY (BOT-302)

Contact Hours:	**Credit Hours**
Theory = 32	Theory = 2.0
Practicals = 32	Practical = 1.0
Total = 64	**Total = 3.0**

Objectives:

The course aims to:

- Provide in-depth knowledge of physiology of plants
- To study transport, respiration, photosynthesis, mineral metabolism in plants

Course outcomes:

On completion of this course, the students should be able to:

- **UNDERSTAND** physiological systems of plants
- **STUDY** growthand movements in plants
- **KNOW** the chemical reactions going on in the plants

Theory and Practical

1. Types and properties of solutions, electrolytes and non electrolytes
2. S.I Units for expressing concentration of solutions, acids, bases and salts, pH definition of buffers and their role in biological systems
3. Colloidal systems: their nature, properties and biological significance.

4. Diffusion, imbibitions, osmosis and osmotic components (osmotic potential, pressure potential, water potential, matric potential). Absorption and translocation of water, transpiration, factors affecting transpiration, stomatal physiology
5. Mineral uptake, soil and sources of minerals, passive and active transport, essential mineral elements, their role and deficiency symptoms emphasis on Calcium, Sodium, Potassium and Phosphorus.
6. Enzymes: Definition, nature properties and classification
7. Photosynthesis: measurement, factors affecting photosynthesis, concept of limiting factors, absorption and action spectra, mechanism of photosynthesis and dark fixation of CO_2 C_3 C_4 and CAM plants, product of photosynthesis.
8. Respiration: Definition and mechanism of respiration, glycolysis, anaerobic respiration, Kreb's cycle, electron transport system and oxidative phosphorylation, respiratory substances and respiratory quotients.
9. Nitrogen metabolism: Biological nitrogen fixation
10. Growth: Definition, role of auxins, gibberllins and cytokinins in controlling growth, introduction to plant tissue culture
11. Photoperiodism: Definitoin, historical background, short day long day and day neutral plants, Night interruption experiments, hormonal concept in photoperiodism, role of phytochromes
12. Dormancy: Definition and causes of dormancy, methods of breaking dormancy
13. Vernalization: Annual and biennial forms, hormonal concept and phasic development theory.
14. Plant movements: Tropic movements, phototropism, gravitropism and their mechanisms. Nastic movements.

FUNDMENTAL INORGANIC CHEMISTRY (CHM-301)

Contact Hours:		**Credit Hours:**
Theory = 32		Theory =3.0
Practical = 32		Practical = 1.0
Total = 64	Total = 4.0	

The Periodic Law and Periodicity: Development of Periodic Table; Classification of elements based on *s, p, d* and *f* orbitals, group trends and periodic properties in *s, p, d* and *f* block elements, i.e., atomic radii, ionic radii, ionization potential, electron affinities, electronagetivities and redox potential.

Principles of Chemical Bonding: Types of chemical bonding; Lewis structures and prediction of shapes using VSEPR model, the localized bond approach: VB theory, hybridization and resonance; the delocalized approach to bonding: molecular orbital theory as applied to diatomic and polyatomic molecules, three center bonds, bonding theory of metals and intermetallic compounds; conductors, insulators and semiconductors; bonding in electron deficient compounds; hydrogen bonding.

Acids and Bases: Concepts of acids and bases including SHAB concept, 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.

Chemistry of p-block Elements: Chemistry and structure of *p*-block elements; main emphasis on the chemistry and structure of noble gases and their compounds, chemistry and structure of interhalogens, pseudohalogens and polyhalides.

Recommended Books

1. Cotton, F. A., Wilkinson, G. and Gaus, P. L., "*Basic Inorganic Chemistry*", 3rd Ed., Wiley, New York, 1995.
2. Huheey, J. E., Keiter, E. A. and Keiter, R. L., "*Inorganic Chemistry: Principles of Structure and Reactivity*", 4th Ed., Harper and Row, New York, 2001.
3. Clyde Day, M. & Selbin, J., "*Theoretical Inorganic Chemistry*", 2nd Ed., Van Nustrand Reinhold, 1969.
4. Lee, J.D., "*Concise Inorganic Chemistry*", Chapman and Hall, 5th Ed.,1996.
5. Shriver, D. F., Atkins, P. W. and Langford, C. H., "*Inorganic Chemistry*", OxfordUniversity Press, 2nd Ed., 1994.
6. Bassette, J., Denney, G. H. and Mendham, J., "*Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis*" English Language Book Society, 4th Ed., 1981.

Laboratory

Ethics and Safety Measures: Awareness about the toxic nature of chemicals and their handling, cleaning of glassware, safe laboratory operations.

2. **Qualitative Analysis:** Analysis of four ions (two anions and two cations) from mixture of salts.
3. **Quantitative Analysis:**
   i) Volumetric Analysis: Practical exercises will be based on Redox, Iodometric and Iodimetric, Precipitation and Complexometric Reactions.

   ii) Gravimetric Analysis: Estimation of Ni^{2+}, Ba^{2+}. Determine percent of P and P_2O_5 in a sample of ammonium phosphomolybdate.

Recommended Book

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

DIVERSITY OF CHORDATES(ZOL-321)

Contact Hours:	**Credit Hours:**
Theory = 48	Theory = **3.0**
Practical = 32	Practical= 1
Total = 80	Total = **4.0**

Course Objectives

The objectives of the course are:-

1. To enable them to understand the Taxonomic characteristics of protochordates and chordates.
2. To impart knowledge about the phylogenetic relationships of protochodates and various classes of chordates.
3. To develop critical thinking about phlogeny of chordates with respect to their physiological adaptations, behavior and ecology.

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

1. **ACQUIRE** the basic knowledge of Taxonomic characteristics of chordates.
2. **UNDERSTAND** the phylogenetic relations and diversity of Pisces, amphibians, reptiles and mammals.
3. **ANALYZE** the process of micro evolution within chordates .
4. **DEMONSTRATE** individually Phylogentic relationships of chordates and their diversity.

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.
d. Phylogenetic relationships.

2. **Fishes**:

   a. Vertebrate Success in Water.
   b. Phylogenetic relationships of Pisces.
   c. Classification of Chondrichthyes, Osteichthyes, Dipnoi and Holocephalli
   d. 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 (*Cyprinuscarpio*and*Wallagoattu*).

3. **Amphibians**:

   a. The first terrestrial vertebrates. Characteristics of amphibians
   b. Phylogenetic relationships.
   c. Classification of amphibians and characteristics of order Caudata, Gymnophiona, and Anura.
   d. Structure and locomotoryadaptations,nutrition and the digestive system, circulation, gas exchange, temperatureregulation, 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 OrderTestudines 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 andsensory functions, excretion and osmoregulation, reproduction and development ofhelonia, squamata, Rhynchocephalia and crocodilian.

d. further phylogenetic considerations.

5. Birds:

a. Classification,Feathers, flight and endothermy.

b. Phylogenetic relationships; ancientbirds 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. Migrationand navigation.

6. Mammals:

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

b. Diversity of mammals.

c. Adaptations in external structure and locomotion, nutrition andthe digestive system, circulation, gas exchange, and temperature regulation,nervous and sensory functions, excretion and osmoregulation, behavior,reproduction and development.

PRACTICALS:

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

<u>Text and Reference books:</u>

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 Principlesof Zoology, 14th Edition (International), 2009. Singapore: McGraw Hill.
5. Pechenik, J.A. Biology of Invertebrates, 4th Edition (International), 2000. Singapore: McGraw Hill.

Year–II

SEMESTER–III

Course Title	Theory	Practical	Credit hours	Course codes
English-III	3	0	3	ENG-410
Cell Biology	2	1	3	ZOL-411
Systematic Botany andCytogenetics	2	1	3	BOT-401
Fundmental organic Chemistry	3	1	4	CHM-401
Sociology	2	0	2	SCO-
Principles of Biochemistry	2	1	3	BCHM-
Total Credits			**18**	

ENGLISH-III (ENG – 410)

Contact Hours:
Theory = 48
Practicals = 0
Total = 48

Credit Hours
Theory = 3.0
Practical = 0.0
Total = 3.0

This course builds on English- II

Course Objectives

This course aims to develop the formal writing skills of the students. The main objectives are:

- Acquainting students' with various writing strategies
- Enabling the students to make official (formal) correspondence
- Developing students' skills of report writing

Course Contents:

- Essay Writing:
    a. Essay Structure, Developing a Thesis, Outlining, Transitioning, Revising the Draft, Conclusion
    b. Kinds: Argumentative, Discursive, Analytical, Descriptive, Expository, Persuasive
- Revising Paragraphs
- Resume Writing
- Letters (Various formats)
    a. Business Letter
    b. Cover Letter

c. Personal Statements

- Memorandum
  a. Parts of a memo
  b. Format
- Report writing:
  a. Purpose of writing a Report
  b. Structure of a Report
  c. Major components of a Report

Note: A report (following the proper format) will be practiced as assignment upon instructor's discretion.

CELL BIOLOGY (ZOL-411)

Contact Hours:	**Credit Hours:**
Theory = 32	Theory = 2.0
Practical =32	Practical =1.0
Total = 64	Total = 3.0

COURSE OBJECTIVES:

The objectives of the course are:

1.To explain the basic concepts of cell biology.
2.To understand cellular structure, composition of the organelles, cell growth and cellular division.
3.To explain how macromolecules and organelles govern the dynamic organization, function of living cells.

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

- **ACQUIRE**the basic concepts of cell biology**.**
- **UNDERSTAND** the metabolic processes of cells in terms of cellular organelles, membranes, and biological molecules.
- **ABILITY** to understand the role of macromolecules regulating cellular processes.
- **FORMULATE** the critical thinking skills and knowledge on cell.

COURSE OUTLINE:

1. **Introductioncell 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:

- Microscopy
- staining techniques (Gram staining)
- Identification of cell organelles (prepared slides)
- Preparation of temporary whole mount.
- Preparation of permanent whole mount.
- Squash preparation of onion root tip for mitotic stages.
- 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, HiddePloegh, 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.
Zoology 10th ed miller 2016
6. Cytology: cell biology and molecular biology verma 2016
7. Biodiversity conservation environmental pollution and ecology pandey 2015
8. Cell biology genetics molecular biology kar 2018
9. Cell biology, genetics, molecular biology, evolution and ecology multicolour edition verma 2018

SYSTEMATIC BOTANY AND CYTOGENETICS (BOT-401)

Contact Hours:	**Credit Hours:**
Theory = 32	Theory = 2.0
Practical =32	Practical =1.0
Total = 64	Total = 3.0

Course Objectives :

The objectives of the course are:-

- Provide in-depth knowledge of systematics of plants
- To study classification system in plants
- To study cell division and laws of genetics in plants

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

1. **ACQUIRE** the basic knowledge of rules of classification
2. **UNDERSTAND** the basis of heredity and chromosome shape

Theory and Practical

1. Classification of Plants: Aims of classification, criteria for classification, units of classification
2. Systems of classification: Artificial system,Natural system, Phylogenetic system and Modern system.
3. Engler and Prantll's system of classification, Merits and Demerits of Engler and Prantll's system of classification,
4. Nomenclature: Common names, Scientific names, Rules of nomenclature.
5. **Dicot families:**
   - Aslepiadaceae: Distribution, vegetative characters, Floral characters, Floral formula, Important genera, Economic impportance
   - Cruciferae: Distribution, vegetative characters, Floral characters, Floral formula, Important genera, Economic impportance
   - Cucurbitaceae: Distribution, vegetative characters, Floral characters, Floral formula, Important genera, Economic impportance
   - Compositae (Asteraceae): Distribution, vegetative characters, Floral characters, Floral formula, Important genera, Economic impportance
   - Euphorbicaceae: Distribution, vegetative characters, Floral characters, Floral formula, Important genera, Economic impportance
   - Labiatae (Lamiaceae): Distribution, vegetative characters, Floral characters, Floral formula, Important genera, Economic impportance
   - Leguminosae: Distribution, vegetative characters, Floral characters, Floral formula, Important genera, Economic impportance
   - Malvaceae: Distribution, vegetative characters, Floral characters, Floral formula, Important genera, Economic impportance

- Ranunculaceae: Distribution, vegetative characters, Floral characters, Floral formula, Important genera, Economic impportance
- Rosaceae: Distribution, vegetative characters, Floral characters, Floral formula, Important genera, Economic impportance
- Solanaceae: Distribution, vegetative characters, Floral characters, Floral formula, Important genera, Economic impportance
- Umbelliferae (Apiaceae): Distribution, vegetative characters, Floral characters, Floral formula, Important genera, Economic impportance

6. **Monocot Families:**
   - Canaceae: Distribution, vegetative characters, Floral characters, Floral formula, Important genera, Economic impportance
   - Graminae (Poaceae): Distribution, vegetative characters, Floral characters, Floral formula, Important genera, Economic impportance
   - Liliaceae: Distribution, vegetative characters, Floral characters, Floral formula, Important genera, Economic impportance
   - Palmaceae: Distribution, vegetative characters, Floral characters, Floral formula, Important genera, Economic importance
7. **Cytogenetics**
   - Physical Basis of Heredity: The nucleus, nuclear membrane, nucleolus.
   - The chromosomes: shapes and types of chromosomes, Structure of SAT chromosome, Heterochromatin and Euchromatin, Karyotype
   - Chemical composition of chromosomes, histone and non histone proteins, Ultrastructure of chromosome
   - The cell division: Cell cycle, Mitosis, events of mitosis, Meiosis, events of meiosis, Significance of meiosis, comparison of meiosis and mitosis
   - Linkage and crossing over: single crossovers and multiple crossovers, interference and coincidence, linkage groups, linkage maps, three point mapping, detecting linkage through testcrosses.
   - Chromosomal Abberations: Variation in chromosome number and arrangement, Aneuploidy: euploidy, Monosomy. Trisomy, Tetrasomy. Euploidy: Monoploidy and Haploidy, polyploidy, autopolyploidy and allopolyploidy, Gene redundancy.
   - variation in chromosome structure and arrangement: Deficiencies or deletions, duplications, Inversions and Translocations
   - Genetics: Introduction, brief history and scope.
   - Mendelian Genetics: Mendals laws of inheritance
   - Structure and Function of nucleic acids, Watson and Crick model of DNA, DNA replication, Chemical nature and structure of RNA, Types of RNA. Protein synthesis.
   - Sex linked inheritance: Sex determination, Sexlinkage, Sex limited traits, Sex influenced traits

FUNDAMENTAL ORGANIC CHEMISTRY (CHM-401)

Contact Hours:	**Credit Hours**
Theory = 48	Theory = 3.0
Practicals = 32	Practical = 1.0
Total = 48	**Total = 4.0**

Introduction to Organic Chemistry: Organic chemistry–the chemistry of carbon compounds; the nature of organic chemistry– a historical perspective.Localized and delocalized chemical bonding, concept of hybridization and shapes of organic molecules; resonance; aromaticity; tautomerism; hyperconjugation; hydrogen bonding.

Classes and Nomenclature of Organic Compounds: Classification of organic compounds; development of systematic nomenclature of organic compounds; IUPAC nomenclature of hydrocarbons and heteroatom functional groups including polycyclic system and compounds containing more than one functional groups.

Functional Group Chemistry: A brief introduction to the chemistry of hydrocarbons, alkyl halides, alcohols, phenols, ethers, aldehydes, ketones, amines, and carboxylic acids and their derivatives.

Applications of Chemistry: Use of organic compounds in industries, like medicinal, pharmaceutical, cosmetics, paints and pigments, polymers etc.

Pre-requisite: CHM-301

Recommended Books

1. L.G. Wade, *Organic Chemistry*, 8thEd., Pearsons, 2012.
2. T.W. Graham Solomons and Graig B. Fryhle, *Organic Chemistry*, 10thEd., John Wiley & Sons, 2011.
3. J.G. Smith, *Organic Chemistry*, 3rdEd., McGraw-Hill Companies, 2012.
4. Brown and Foote, *Organic Chemistry*, 6thEd., Pearsons Publishers, 2011.
5. Stanley H. Pine, *Organic Chemistry*, 5thEd., McGraw-Hill, 2007.
6. D. Hellwinkel, *Systematic Nomenclature of Organic Chemistry*, Springer Verlag, 2001.

Practicals:

1. Qualitative organic analysis: Systematic identification of organic compounds (monofunctional and simple bifunctional) and preparation of their derivatives.
2. Preparation of the following compounds: Suphanilic acid, dibenzyl acetone, methyl orange, dinitrobenzene from benzene, isolation of caffine.
3. Estimation of phenol (bromide-bromate method) and aniline (bromide-bromate and acetylation methods).
4. Equivalent weight of an acid (neutralization).
5. Identification of organic functional groups by I.R. spectroscopy.

Recommended Books

1. K.N. Williamson and K.M. Masters, *Macroscale and Microscale Organic Experiments*, published by Cengage learning, 2011.
2. J.J. Li, C. Limberakis and D.A. Pflum, *Modern Organic Synthesis in Laboratory*, OxfordUniversity Press, 2007.
3. J. Leonard, B. Lygo and G. Procter Nelson, *Advanced Practical Organic Chemistry*, Thomes Ltd. UK, 2001.

PRINCIPLES OF BIOCHEMISTRY(BCHM-)

Contact Hours:
Theory = 32
Practicals = 32
Total = 48

Credit Hours
Theory = 2.0
Practical = 1.0
Total = 3.0

SEMESTER–IV

Course Title	Theory	Practical	Credit hours	Course Codes
Biostatistics	2	1	3	STAT-401
Environmental Chemistry	3	1	4	CHM-402
Fundamentals of Microbiology and Immunology	2	1	3	MB-421
Anatomy and Physiology of Invertebrates	2	1	3	ZOL-421
Principles of Biotechnology	2	1	3	ZOL-422
Fundamentals of Bioinformatics	2	1	3	BI-409
Total Credits			**19**	

BIOSTATISTICS (STAT-401)

Contact Hours:
Theory = 32
Practicals = 32
Total = 64

Credit Hours
Theory = 2.0
Practical = 1.0
Total = 3.0

Course Objectives:
To provide knowledge of importance of and its application in Biological Sciences. Understanding of use of statistical techniques to summarize and analyze Biological data.

Learning Outcomes:
Upon successful completion of this course the students will be able to:
- Understand the applications of statistical tools in biological science.
- Demonstrate an understanding of the central concepts of statistical theory in Biological Sciences.
- Apply appropriate statistical techniques to Biological data and analyze and communicate the results of statistical analysis effectively.

Course Contents:
Introduction to Biostatistics, scope. Types of data, variables; Categorical, numerical and censored data. Descriptive Statistics; Measure of central tendency; mean, median, mode. Measure of dispersion; Variance and standard deviation. Simple linear regression; model fitting. Correlation; correlation co-efficient, co-efficient of determination. Logistic regression. Logit transformations and their analysis, p values and its importance and role. Hypothesis testing.

ENVIRONMENTAL CHEMISTRY (CHM-402)

Contact Hours:	**Credit Hours:**
Theory = 48	Theory =3.0
Practical = 16	Practical = 1.0
Total = 64	Total = 4.0

Atmospheric Chemistry: The air around us, atmospheric temperature and pressure profile, Temperature inversion and photochemical smog, particulate matter in the atmosphere, Industrial pollutants, radioactivity, atmospheric aerosols, Acid rain –major sources, mechanism, control measures and effects on buildings and vegetation, Global warming – major green house gases, mechanism, control measures and global impact, The stratospheric ozone – the ozone hole, CFCs, ozone protection, biological consequences of ozone depletion.

Water Pollution and Water Treatment: Sources of water pollution-industrial sources and agricultural sources, heavy metals contamination of water, Eutrophification, 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.

Soil 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.

Energy Production and Environment: Liquid and gaseous fuel, hydrogen economy.

Recommended Books

1. Collin Baird, *Environmental Chemistry*, W. H. Freeman and Company, New York, 1995.
2. John W. Moore and Elizabeth A. Moore, *Environmental Chemistry*, Academic Press Inc., New York, 1976.
3. Peter O. Neill, *Environmental Chemistry*, Chapman and Hall, London, 1993.
4. Derek M. Elsom, *Atmospheric Pollution, Blackwell Publishers*, Oxford, 1992.
5. Geoffrey Lean and Don Hinrichsen, *Atlas of the Environment*, Helicon Publishing Ltd., Oxford, 1992.
6. Anil Kumar De, *Environmental Chemistry*, Wiley Eastern Ltd. New Delhi, 1989.
7. Staneley E. Manahan, *Environmental Chemistry*, Brooks, California.

Practicals:

1. Safety Rules and Regulations, Techniques in solution preparation.
2. The pH and Buffer Capacity of Environmental Waters.
3. Inorganic and Organic Profiles of Soil and Sediment Cores.
4. Alkalinity of Water Samples.
5. Conductivity of Various Water Samples
6. Metals Determination in water samples by Electrogravimetry.
7. Determination of Chloride Ion in Natural Waters.
8. Determination of the Temporary and Permanent Hardness of Waters by Complexometric and Precipitation Titration respectively.
9. Determining Iron and Manganese in Natural Waters and Sediments.

10. Determination of the DO, BOD and Chemical Oxygen Demand of Natural Water and Waste water Using Standard Method.
11. Introduction to Air Sampling: Particulates in Urban Air.
12. Determination of the Concentration of Carbon Dioxide in the Atmosphere.

Recommended Books

1. E. R. Weiner,*Applications of Environmental Chemistry: A Practical Guide for Environmental Professionals*, CRC Press, (2010).
2. P. D. Vowles, and D. W. Connell,*Experiments in Environmental Chemistry A Laboratory Manual Book*, Elsevier, Vol 4, (2013).
3. R. Gopalan , A. Anand&R. W. Sugumar, *A Laboratory Manual for Environmental Chemistry*, IK International Pvt Ltd., (2010).
4. W. F. Bleam,*Soil and Environmental Chemistry*, Academic Press, 2nd ed., (2016).

FUNDAMENTALS OF MICROBIOLOGY AND IMMUNOLOGY(MB-421)

Contact Hours:	**Credit Hours**
Theory = 32	Theory = 2.0
Practicals = 32	Practical = 1.0
Total = 64	**Total = 3.0**

Course contents

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

Basic concepts and principles of immune system, organs constituting the immune system, their location in the human body and basic architecture, principles and techniques of seriology. The immunnocompetent cells; their origin, surface makers, populations and subpopulations, immuniological characterization and function. Anibody induction and production: antigen and antibody metabolism, cells involved in cellular sequence of events, kinetics of antibody synthesis, Antibody diversity. The role of T-cells and immunoglobulins in the immune response. Immunologic memory

Laboratory Work Outline

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

7. Differential leukocyte count
8. Blood grouping
9. Agglutination tests and precipitation tests
10. ELISA test
11. Allergy reaction tests

Books Recommended:

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

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

1. Geo f. brooks, Stephen A. Morse, Janet Butel, Janet S. Butel (2001). Jawetz, Melnick and Adelberg's Medical Microbiology McGraw-Hill Companies.
2. Kuby, J. (1996). Immunology Immunology 2nd Ed. W.H. Freeman & Co. USA.

Benjamini, E. Immunology. (2001).

ANATOMY AND PHYSIOLOGY OF INVERTEBRATES(ZOL-421)

Contact Hours:	**Credit Hours**
Theory = 32	Theory = 2.0
Practicals = 32	Practical = 1.0
Total = 64	**Total = 3.0**

Course Objectives:

The Objectives of the courses are:

1. To teach about animals' diversity adapted in different strategies' for performance of their similar functions through modifications in body parts in past and present times.
2. To impart understanding of diverse strategic structural adaptations in each of the functions of integumentary, skeletal, muscular, nervous and sensory, endocrine, circulatory and respiratorysystemsfor effective survival in their specific conditions.
3. To understand the organ systems, their specialization and coordination with each other and constantly changing internal and external environment, inside and outside the animal's body.
4. To embrace the phenomena in basic structure of each system that determines its particular function.

Course Learning Outcomes:

1. **Acquire**the concept that for the performance of a function for example exchange of respiratory gases the different forms are adapted in t environments e.g. gills in aquatic and lungs in terrestrial environment.
2. **Understand**that diverse forms adapted to perform the same functions are because of the different past and present conditions.
3. **Solve**of emergence of diversity of forms for the performance of similar function.

4. **Analyze**the requirements of diverse forms for the performance of similar function in their past and present needs.
5. **Evaluate**the adaptations in forms for its efficiency in managing the function in differing situations in the past and present times.
6. **Demonstrate**that a form is successfully adapted to perform a function adequately and successfully.

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 (*Labeorohita)*, Frog (*Hoplobatrachustigerinus*), Varanus (*Varanusbengalensis)*, fowl*(Gallus gallusdomesticus)*andrabbit (*Oryctolaguscuniculus)*.
   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.
5. 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 Principlesof 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.NewYork: McGraw Hill.
6. Hickman, C.P., Kats, H.L. 2000. Laboratory Studies in IntegratedPrinciples of Zoology. Singapore: McGraw Hill.

PRINCIPLES OF BIOTECHNOLOGY (ZOL-422)

Contact Hours:	**Credit Hours**
Theory = 32	Theory = 2.0
Practicals = 32	Practical = 1.0
Total = 64	**Total = 3.0**

Course Objectives:
To acquaint students of zoology with the basic concepts and significance of biotechnology.

Course outcomes:
Upon successful completion of the course, the students should be able to:

- **COMPREHEND**about the introduction and history of biotechnology
- **UNDERSTANDING** of core molecular genetics concepts including molecular biology, genetics, cell biology, physiology, and evolution
- **KNOW** about basic of rDNA technology, concept and principle and application of genetic engineering, transgenic animals, cryopreservation, apoptosis, and animal cloning.

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:

DNA Extraction from different sources
Quantification of DNA using gel electrophoresis and spectrophotometer
Amplification of DNA using PCR
PCR product measurement using gel electrophoresis
Gender typing of human and animal samples using PCR
Restriction fragment length polymorphism of samples
Species identification of different animal samples using PCR and RFLP

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

FUNDAMENTALS OF BIOINFORMATICS (BI-409)

Credit Hours:
Theory=2
Practical=1
Total=3

Credit Hours:
Theory=2
Practical=1 Total=3

Course Objective:

The course is designed to introduce the most important and basic concepts, methods, and tools used in Bioinformatics. This course will introduce basic biological database sources, principles and methods for sequence and genome analysis. The overall aims are

a. To help the students to reach rapidly the frontier of bioinformatics and be able to use the bioinformatics biological Databases.

b. To convey the importance of bioinformatics for viewing the biomedical information.

c. To provide hands-on experience using Biological Databases searching, retrieving, critically evaluating results and interpreting their biological significance.

Course Outline:

Introduction,Goals,Scope,Applications,Limitations.Databases,Types of Databases, Biological Databases, Sequence Storage, Information retrieval and analysis, Sequence Alignment, Similarity and homology, Types of alignments, local and global alignment,. Methods of Alignment, pairwise and multiple sequence alignments, Significance of Sequence Alignment, Algorithm, Sequence Alignment Methods, Relationship of multiple sequence alignment to phylogenetic analysis, DNA sequence Analysis, Protein Sequence Analysis. Motif Search, Molecular phylogenetic, Phylogenetic Basis, Phylogenetic Tree construction methods and Programs. Molecular Modeling and Drug Designing and Discovery.

Lab Outline:

Accessing NBCI databases, sequence databases, Genbank, EMBL, SWISS-PROT Accessing structure database PDB, SCOP and CATH, Expasy server, using online alignment tools for pair wise and multiple sequence alignment, using BLAST and FASTA, phylogenetic analysis. Molecular Modeling and Drug Designing

Recommended Books:

1. Arthur M. Lesk, Introduction to Bioinformatics.4th Edition (2008).Oxford University Press.
2. Ignacimuthu SJ. Basic Bioinformatics, 2nd Edition (2005) Narosa Publishing House.
3. S.C.Rastogi, N.Mendiratta,P.Rastogi,Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery. 3rd Edition (2009). PHI Learning Pvt. Ltd.
4. David Mount, Bioinformatics: Sequence and Genome analysis.2nd Edition (2004). Cold Spring Harbour Laboratories.
5.Jin Xiong, Essential Bioinformatics,(2006), Cambridge University Press

YEAR-III

SEMESTER–V

Course Title	Theory	Practical	Credit hours	Course Codes
Anatomy and Physiology of Chordates	3	1	4	ZOL-511
Economic Zoology	2	1	3	ZOL-512
Molecular Biology	2	1	3	ZOL-513
Evolutionary Biology	3	0	3	ZOL-514
Animal Behavior	3	0	3	ZOL-515
Total Credits			**16**	

ANATOMY AND PHYSIOLOGY OF CHORDATES(ZOL-511)

Contact Hours:
Theory = 48
Practical = 32
Total = 80

Credit Hours:
Theory = 3.0
Practical = 1.0
Total = 4.0

Course Objectives:

The Objectives of the courses are:

1. To teach about animals' diversity adapted in different strategies' for performance of their similar functions through modifications in body parts in past and present times.
2. To impart understanding of diverse strategic structural adaptations in each of the functional systems of nutrition, excretion, osmoregulation and reproduction and development for effective survival in their specific conditions.
3. To understand the organ systems, their specialization and coordination with each other and constantly changing internal and external environment, inside and outside the animal's body.
4. To embrace the phenomena in basic structure of each system that determines its particular function.

Course learning outcomes:

Upon successful completion of the course, the student will be able to:

1. **Acquire** the concept that for the performance of a function for example exchange of respiratory gases the different forms are adapted in t environments e.g. gills in aquatic and lungs in terrestrial environment.
2. **Understand** that diverse forms adapted to perform the same functions are because of the different past and present conditions.
3. **Solve** of emergence of diversity of forms for the performance of similar function.
4. **Analyze** the requirements of diverse forms for the performance of similar function in their past and present needs.
5. **Evaluate** the adaptations in forms for its efficiency in managing the function in differing situations in the past and present times.
6. **Demonstrate** that a form is successfully adapted to perform a function adequately and successfully.

Course Outline:

1. Nutrition and Digestion:

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

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

c. Themammalian digestive system: gastrointestinal motility and its control

d. Oralcavity, pharynx and esophagus, stomach, small intestine: main site ofdigestion; large intestine; role of the pancreas in digestion; and role of theliver and gallbladder in digestion.

2. Temperature and Body Fluid Regulation:

a. Homeostasis and TemperatureRegulation; The Impact of Temperature on Animal Life; Heat Gains andLosses; Some Solutions to Temperature Fluctuations; TemperatureRegulation in Invertebrates, Fishes, Amphibians, Reptiles, Birds andMammals; Heat Production in Birds and Mammals

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

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

3. Reproduction:

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

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

c. The humanmale reproductive system: spermatogenesis, transport and hormonalcontrol, reproductive function;

d. The human female reproductive system:folliculogenesis, transport and hormonal control, reproductive function;hormonal regulation in gestation; prenatal development and birth: theplacenta; milk production and lactation.

Practicals:

1. Study of excretory system in an invertebrate and a vertebraterepresentative (Model).
2. Study of dissection system in invertebrate and a vertebrate representative (Dissection).
3. Dissection and study of male and female reproductive system in vertebraes 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 Principlesof 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 IntegratedPrinciples of Zoology. Singapore: McGraw Hill.

ECONOMIC ZOOLOGY (ZOL- 512)

Contact Hours:	**Credit Hours:**
Theory =32	Theory = 2.0
Practical = 32	Practical = 1.0
Total = 64	Total = 3.0

Course Objectives:

The objectives of the course are:

1. To educate scholars about the relationship of commerce with domestic animals, their products, by-products and associated farming practices
2. To teach the importance of human and domestic animal diseases and their vital relation to the economy
3. To provide knowledge about internal and external parasites and their effects on domestic animals and their farming practices
4. To familiarize with the value of studying various general practices, principles and techniques in farming and rearing of animals in sericulture (silk worms), apiculture (honey bees), aquaculture (fisheries, pearl culture, prawns and oysters), poultry (domestic fowl and ostriches) and cattle husbandry
5. To study the economics and principles of stored grained pests, pesticides and integrated pest management

Course learning outcomes:

Upon successful completion of the course, the student will be able to:

1. **Acquire**basic knowledge of Commerce and Economics in relation to Zoology
2. **Understand** the Economic relationship of Animals with Humans
3. **Solve** problems related to animal husbandry and pest management by applying theoretical knowledge with practical efficacy
4. **Analyze**and enhance Animal husbandry techniques by using different Entrepreneurship skills
5. **Evaluate** problems using practical knowledge in Zoology
6. **Demonstrate** the Economy based interactions of Man and Animals

Course outline:

1. Basic concepts in Economic Zoology.
2. Parasitic protozoans and human disease. Economic importance of protozoa.
3. Vectors of human and domestic animals.
4. Ecto- and Endo-parasites of fish, poultry, cattle and Man (Crustacea, Helminthes and Arachnida).
5. Pests of pulse crops. Pests of oil seed crops. Stored grain pests. Pests of cotton. Pests of vegetables. Pests of fruits. Pests of tea.
6. Apiculture, and Sericulture, Lac insect culture and Pearl culture
7. Aquaculture and Fisheries (Edible Fresh water, Pond and Marine fish, Prawns, Pearl oysters). Economic importance of fishes.
8. 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

a. and report writing. Identification of important species of Fish and their natural animal.

6. Visit to any bird farm and write a report on their observations.

Books Recommended:

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. 1sted: 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.

MOLECULAR BIOLOGY (ZOL-513)

Contact Hours: **Credit Hours:**

Theory = 32	Theory =2.0
Practical = 32	Practical = 1.0
Total = 64	Total = 3.0

Course Objectives:

The objectives of the course are:

1. To understand the principles of bioenergetics;
2. To know the dietary requirements of man and animals;
3. To provide knowledge of metabolism of dietary and endogenous carbohydrate, lipid, and protein;
4. To impart the knowledge of principles and major mechanisms of metabolic control and molecular signalling by hormones;

Course learning outcomes:

Upon successful completion of the course, the student will be able to:

1. Demonstrate knowledge and understanding of the principles that govern the structures of macromolecules and their participation in molecular recognition;
2. Demonstrate knowledge and understanding of the principles and basic mechanisms of metabolic control and molecular signalling;
3. Use basic laboratory skills and apparatus to obtain reproducible data from biochemical experiments;
4. Implement experimental protocols, and adapt them to plan and carry out simple investigations;
5. Analyse, interpret, and participate in reporting to their peers on the results of their laboratory experiments;
6. Build on their knowledge and understanding in tackling more advanced and specialised courses, and more widely to pursue independent, self-directed and critical learning.

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.

Practicals:

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
2. McGraw-Hill Book Company, London.
3. Wilson, K and Walker, J., 1994. Practical Biochemistry: Principles and Techniques, 4th Edition, Cambridge University Press.
4. Alexander, R.R. and Griffiths, J.M. 1993. Basic biochemical methods. Wiley – Liss,New York.

5. Sawhney, S. K. and Singh, R., 2006. Introductory Practical Biochemistry, 2nd Edition,Narosa Publishing House.
6. Oser, B. L., (Latest Edition). Hawk's Physiological Chemistry, McGraw Hill Book Company.
7. David L. Nelson, and Michael M. Cox, 2005. Lehninger Principles of Biochemistry 4th Edition, Macmillan Worth Publishers, New York.
8. LubertStryer, 1995. Biochemistry, 4th Edition, W.H. Freeman & Company, New York.
9. Murray, R. K., Granner, D. K., Mayer, P. A. and Rodwells, V. W., 2000. Harper's Biochemistry, McGraw Hill Bok Company, New York.
10. Elliott, W. H. and Elliot, D. C., 2002. Biochemistry and Molecular Biology, Oxford Medical Publications, Oxford University Press.
11. Voet, D., Voet, J. G. and Pratt, C. W., 1999. Biochemistry, John Wiley & Sons.
12. Zubay, G. 1993. Biochemistry, Wm. C. Brown Publishers, Oxford.

EVOLUTIONARY BIOLOGY(ZOL-514)

Contact Hours:Credit Hours:

Theory = 48	Theory= 3.0
Practical= 0	Practical = 0.0
Total =48	Total = 3.0

Course Objectives:

The objectives of the course are:

1. To provide detailed account based on origin of life
2. To develop some basic concepts and ideas for causing evolutionary changes.
3. To determine the significance of systematics in relation to their nomenclature.

Course learning outcomes:

Upon successful completion of the course, the student will be able to:
:

1. To **acquire** basic knowledge for the factors and theories related to the origin of life.
2. To **understand** the vital concepts proposed by various scientists for the appearance of life on earth.
3. To **solve** the critical issues for the discrepancies based on origin of life.
4. To **analyze** certain issues regarding the animal phyla, classes, orders till sub-species levels.

Course Contents:

1. Theories of Evolution: theories to explain diversity of life– modern synthetic theory, factors initiating elementary evolutionary changes (micro-evolution) and change of gene frequencies.
2. Mutation pressure, selection pressure, immigration and crossbreeding, genetic drift.

3. Role of isolation in evolution: factors of large evolutionary changes (macroevolution). Conceptsofallometry, orthogenesis, adaptive radiation.
4. Modern concept of Natural Selection: levels of selection, selection patterns, some examples of Natural Selection.
5. 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.

Books Recommended:

1. Strickberger. M.W. 2012.Evolution. Jones& Barrett Publishers.GowerStreet, 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, New York
4. Wiley, E. O. and Lieberman, B. S. 2011. Phylogenetics: Theory and Practical Practice ofPhylogenetic systematics.2nd Ed. Wiley-Blackwell.
5. Mayer, E. Principles of Systematic Zoology. 1994. McGraw Hill, New York.
6. Zoology 10th Ed by Miller 2016
7. Evolution 2nd Ed by Bergstrom 2016

ANIMAL BEHAVIOR(ZOL-515)

Contact Hours:Credit Hours:

Theory = 48 Theory = 3.0

Practical = 0 Practical = 0

Total =48 Total =3.0

Course Objectives:

The objectives of the course are:

4. To impart knowledge about animal responses to external stimuli
5. To emphasize on different behavioural mechanisms (classical and recent concepts).
6. To explain development of behavior with suitable examples of animals.
7. To understand role of genetic and neuro-physiology in behavioural development.

Course learning outcomes:

Upon successful completion of the course, the student will be able to:

1. Outline the baseline information and knowledge for animal behavior.
2. Associate the likely role of external and internal stimuli on various animals during the day, season and year.
3. Relate daily behavioural rhythms in diurnal and nocturnal periodicities.

4. Predict and anticipate variety of animal actions (costs and benefits) as assessed by innate and learned behavioura; displays.
5. Integrate the animal behavior as balanced mechanism to develop animal personality.

Course Contents:

1. **Introduction**
a. **Behaviour** and its types
b. **Proximate** and **ultimate** causes of behavour.
2. **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.
3. **Hormones** and behavior in animals.
4. **Innate behavior and innate releasing mechanisms**; built in programmed performance by offspring to that of parents. Innate behavior of three spined stickle back fish.
5. **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.
6. **Circadian rhythms** and concept of **bio-rhythmicity** in animals. Maintenance of internal biological clock to perform various diurnal and nocturnal periodicities.
7. **Costs and benefit ratios** in behavior; successful foragers and winners of predator-prey relationships. Altruism and parental sacrifice to nurture the young.
8. **Competition for resources**; survival of the most suitable individuals; evolutionary arms races in behavior.
9. **Social organization** in animals and concept of group living; benefits and losses. Aggression, appeasement and selfish individuals. Social organization in insects and mammals.
10. **Communication in animals**: Visual, Bioacoustic, electrical, chemical and tactile.
11. Various types of **chemical signals in animals'** behavior and their importance in ecosystems.

Books Recommended:

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.9thEdition.Sinauer Publishers
3. Scott, G. 2009. Essential Animal Behavior. Wiley publishers
4. Scott, G. 2005.Essential Animal Behavior. Blackwell Pub. New York.
8. Goodenough, J., McGuire, B., Wallace, R.A. 2001.Perspective on Animal Behavior. John Wiley & Sons, New York.
9. A Textbook of Animal Behaviour-GUNDEVIA 2016

SEMESTER–VI

Course Title	Theory	Practical	Credit hours	Course Codes
Biological Techniques	2	1	3	ZOL-521

Research Planning and Report Writing	3	0	3	ZOL-522
Animal Ecology	2	1	3	ZOL-523
Principles of Genetics	2	1	3	ZOL-524
Wildlife Conservation and Management	2	1	3	ZOL-525
Total Credits			**15**	

BIOLOGICAL TECHNIQUES (ZOL-521)

Contact Hours:
Theory = 32
Practical = 32
Total = 64

Credit Hours:
Theory =2
Practical = 1
Total = 3

Objectives of the Courses:
The course aims to teach the students about:

a.Principles of light microscopy. Magnification, Resolution, Contrast.Types of microscopy, Phase Contrast Dark Field Interference microscope, Electron microscope.
b.Preparation of stock solutions of various strengths.
c. Sampling soil organisms, Invertebrates, Aquatic animals, Mammals, Estimation of population size, Preservation of dry and wet specimens.

Course learning outcomes:
At the end of course:

1. Students are able to know the Principles of light microscopy. Magnification, Resolution, Contrast. Types of microscopy, Phase Contrast Dark Field Interference microscope, Electron microscope.
2. Students are able to know the Preparation of stock solutions of various strengths.
3. Students are able to know the Sampling of soil organisms, Invertebrates, Aquatic animals, Mammals, Estimation of population size, Preservation of dry and wet specimens.

Course Outline:
(Theory and Practical)
Microscopy: Principles of light microscopy. Magnification, Resolution, Contrast. Types of microscopy, Phase Contrast Dark field Interference microscope, Electron microscope.

Micrometery and Morphometry: Use of stage and ocular micrometer.Calibration of ocular micrometer.Size measurement (length, width, diameter).

Specimen preparation for optical microscopy.

Standard system for weight, length and volume. Preparation of stock solutions of various strengths.

Microtomy: Fixation, embedding, Section cutting (transverse, longitudinal section, mounting and staining. Sections in paraffin and cryosections.

Extraction techniques: Centrifugation, Ultra centrifugation, cell fractionation, filtration, Distillation, Use of Soxhalet and Rotary evaporator for extraction.

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

Spectrophotometery: Principle, applications, types, visible spectrum, UV spectrum, atomic absorption.

Basic principles of Sampling and Preservation: Sampling soil organisms, Invertebrates, Aquatic animals, Mammals, Estimation of population size, Preservation of dry and wet specimens.

Books Recommended:

1. Dean, J. R. Extraction Methods For Environmental Analysis. 1999. John Wiley And Sons Ltd. Uk.
2. Curos, M. Environmental Sampling And Analysis: Lab Manual. 1997. Crc Press Llc. Usa.
3. Curos, M. Environmental Sampling And Analysis: For Technician. 1997. Crc Press Llc. Usa.
4. Cheesbrough, M. District Laboratory Practice In Tropical Countries. Part I. 1998. University Press Cambridge, Uk.
5. Cheesbrough, M. District Laboratory Practice In Tropical Countries. Part Ii. 1998. University Press Cambridge, Uk. Slingsby, D. And Cock, C.

RESEARCH PLANNING AND REPORT WRITING(ZOL-522)

Contact Hours:		**Credit Hours:**
Theory =	48	Theory =3.0
Practical =	0	Practical = 0.0
Total =	48	Total = 3.0

Course Objectives:

The objectives of the course are:

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

Course learning outcomes:

Upon successful completion of the course, the student will be able to:

- **Understand** a general definition of research design.
- **Identify** the overall process of designing a research study from its inception to its report.
- Become **familiar** with ethical issues in educational research, including those issues that arise in using quantitative and qualitative research.
- **Know** the primary characteristics of quantitative research and qualitative research.
- **Identify** a research problem stated in a study.

- Become **familiar** with how to write a good introduction to an educational research study.
- To **distinguish** a purpose statement, a research question or hypothesis, and a research objective.

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.

Books Recommended:

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.

ANIMAL ECOLOGY(ZOL-523)

Contact Hours:	**Credit Hours:**
Theory = 32	Theory = **2.0**
Practical = 32	Practical = 1.0
Total = 64	Total = **3.0**

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Course Objectives:

The objectives of the course are:-

1. To enable the student to understand habitat and Ecology
2. To develop expertise in the students about the contemporary themes of Ecology and ecosystems
3. To understand global Environmental threats and their mittigation

Course Learning Outcomes:

Upon successful completion of the course, the student will be able to:

a. Understand and applythe basic concepts of Ecology
b. Acquiretheoretical knowledge for rehabilitation of destroyed ecosystems and habitats in the environment.
c. Solve the ecological Problems and their management through scientific approach

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

6. Basic population characters, Growth and Growth Curves, Population Dynamics and Regulations. **Community ecology**
7. Basic concepts, Community Analysis, Ecotones, Inter-population Interactions
8. **Applied Ecology**: resources and their ecological management;
9. Mineral, Agricultural Desalination, Weather Modification, Forest and Range Management, Landscape and Land use
10. **Pollution**:
11. Definition, Types, Water, Air, Land and Noise, Sources and Management.
12. **Radiation ecology**: Global Environmental Changes (ozone depletion, acid rain, greenhouse effect and global warming, Koyota protocol, Radioactivity leakage, Environmental laws).
13. **Exotic and Invasive Species**
    a. Desertification, Deforestation, exotic and invasive species

Practicals:

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

Books Recommended:

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

PRINCIPLES OF GENETICS(ZOL-524)

Contact Hours:	**Credit Hours:**
Theory = 32	Theory = **2.0**
Practical = 32	Practical = 1.0
Total = 64	Total = **3.0**

Course Objectives:

The objectives of the course are:

1. To understand the terms and basic concepts of genetics, providing a conceptual framework for future reference
2. To provide understanding about the continuity of the life from one generation to other generation is based on the mechanisms involving nucleus, chromosomes and genes etc.
3. To develop the concept that continuity not only transfers the traits of the parents but also imparts variations that render the generations sustainable in changing environment
4. To understand how traits are inherited and to use this understanding in analyses (to solve problems and complete pedigrees)
5. To understand probability concepts and use these concepts to solve problems (including basic statistical problems)
6. To understand how genetic problems may lead to disease or lethality
7. To understand the molecular basis of genetics (including such topics as replication, transcription, translation, and mutation)
8. To understand mechanism of repair and molecular genetic analysis
9. To understand the workings and importance of major genetics techniques such as PCR
10. To understand current issues regarding genetics (e.g., cloning, use of transgenic organisms)
11. To understand Mendelian and non-Mendelian pattern of inheritance in human
12. To understand the workings and uses of population genetics technique

Course learning outcomes:

Upon successful completion of the course, the student will be able to:

1. Able to define terms of genetics and apply concepts of modern transmission
2. Identify and describe the process and purposes of the cell cycle, meiosis, and mitosis, as well as predict the outcomes of these processes.
3. Solve transmission genetics problems, make accurate predictions about inheritance of genetic traits, and map the locations of genes.
4. Identify the parts, structure, and dimensions of DNA molecules, RNA molecules, and chromosomes, and be able to categorize DNA as well as describe how DNA is stored
5. Able to accurately draw the diagram and describe the processes of replication, transcription, translation, as well as predict the outcomes of these processes.
6. Describe what causes and consequences of DNA sequence changes and how cells prevent these changes, as well as make predictions about the causes and effects of changes in DNA.
7. Describe the processes of gene regulation and predict how a gene will be expressed under specific circumstances.
8. Learn and practice common genetics laboratory techniques.
9. Describe applications and techniques of modern genetic technology, as well as select the correct techniques to solve practical genetic problems
10. Carry out genetics laboratory and research techniques.
11. Identify the human traits and genetic diseases
12. Describe experimental results in written format both informally and in formal manuscript format
13. Able to solve problem related to population genetics

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 ErythroblastosisFoetalis.
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.

Practicals:

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

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
12. GENETICS-VERMA-2016

WILDLIFE CONSERVATION AND MANAGEMENT(ZOL-525)

Contact Hours:	**Credit Hours**
Theory = 32	Theory = 2.0
Practicals = 32	Practical = 1.0
Total = 64	Total =3.0

Course Objectives:

The objective of this course is

1. to enable the student to understand philosophy and significance of wildlife conservation
2. to understand the wildlife management rules and regulations in Pakistan
3. to understand how National and International agencies are involved in conservation and management of wildlife

Course Learning Outcomes:

Upon successful completion of this course, the student will be able to:

1. **Acquire**theoretical knowledge about the identification, distribution, status, conservation and management of amphibians, reptiles, birds and mammals of major importance in Pakistan
2. **Understand**the protected area system (Game Reserves, Wildlife Sanctuaries and National Parks)
3. **Solve** the threats to wildlife by applying the scientific principles and modern technologies (Sustainable development through local community participation).
4. **Analyse**,interpret and synthesize data and other information about the population of wildlife
5. **Evaluate** the conservation management by government department, National and International organisations
6. **Demonstrate**the ecological assessment and importance of wildlife to certain area.

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

Books Recommended:

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 University Press
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.

YEAR–IV

SEMESTER–VII

Course Title	Theory	Prcatical	Credit	Course

			hours	codes
Zoogeography and Paleontology	2	1	3	ZOL-631
Principles of Animal Systematics	2	1	3	ZOL-632
Animal Reproductive Biology	2	1	3	ZOL-633
Entomology	2	1	3	ZOL-634
Optional Course-I	2	1	3	ZOL-
Optional course-II/ Thesis	2/0	1/3	3	ZOL-/ ZOL-699
Total Credits			**18**	

ZOOGEOGRAPHY AND PALEONTOLOGY (ZOL-631)

Contact Hours:
Theory = 32
Practical = 32
Total = 64

Credit Hours:
Theory =2
Practical = 1
Total = 3

Objectives of the Courses:

The objectives of the course are: -

1. To provide information on the distribution of animals and their associations in the past and to rationalize their relationship in the present time.
2. To impart knowledge and concepts of evolution mainly on the basis of fossil record.
3. To give understanding those fossil records also provide information about the distribution of animals in the past eras.

Course learning outcomes:

Upon successful completion of the course, the student will be able to:

1. **Describe**the zoogeographical distribution of animals and processes involved in the fossilization of animals.
2. **Illustrate** the association of animals present to their past through fossils record.
3. **Develop** the understanding of speciation, dispersal isolation and extinction process through biogeography and fossils record.
4. **Illustrate**the ability to locate, characterize and differentiate various biomes and fossils of animals over time.
5. **Explain** the distribution of animals on the basis of fossils record.
6. **Develop**understanding regarding process of fossilization and its importance in evolutionary history of an animal and its distribution.

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. **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.

Practicals:

1.Study of fauna of various zoogeographical regions.
2.Study of mould, cast, pseudomorph, coprolite, petrified fossils of plants and animals.
3.Study of invertebrate fossils of coelenterates, trilobites, ammonite, brachiopods, molluscs and echinoderms.
4.Study of vertebrate fossils e.g. horse/elephant/camel/bovids.
5.Study and identification of Igneous, Sedimentary and Metamorphic rocks
6.Map work for identification of various zoogeographical regions of the World.

BooksRecomended:

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.

PRINCIPLES OF ANIMAL SYSTEMATICS(ZOL-632)

Contact Hours:	**Credit Hours:**
Theory = 32	Theory =2.0
Practical = 32	Practical = 1.0
Total = 64	Total = 3.0

Course Objectives:

The objectives of the course are:

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

Course learning outcomes:

Upon successful completion of the course, the student will be able to:

1. To **acquire** basic knowledge of taxonomy and systematics..
2. To **understand**similarities and differences between animals used for classification.
3. To **acquire** basic knowledge of classification of animals.
4. To **analyze** certain issues regarding the animal phyla, classes, orders till sub-species levels.

Course Contents:

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

Practicals:

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

Books Recommended:

1. Wiley, E. O. and Lieberman, B. S. 2011.Phylogenetics: Theory and practice of phylogenetic systematics. 2nd Ed. Wiley-Blackwell.
2. Hill, New York.
3. Mayer, E. and Asblock, P.D. Principles of Systematic Zoology. 1991. McGraw Hill, New York
4. Mayr, E. *Animal Species and Evolution*, 1985.Harvard University Press.
5. Heywood, V.H. *Taxonomy and Ecology*. 1975. Academic Press, London.
6. Whili, M.J.D. *Modes of Speciation*, 1978. W.H. Freeman and Co., San Francisco.

ANIMAL REPRODUCTIVE BIOLOGY(ZOL-633)

Contact Hours:		**Credit Hours:**
Theory =	32	Theory =2
Practical =	32	Practical =1
Total =	64	Total = 3

Course Objectives:

The objectives of this course are

1. Understand on the molecular and cellular mechanisms of physiological function as the basis of unity in diverse animals e.g. membrane excitability, exchange of respiratory gases, removal of nitrogenous wastes tissue, osmotic and organ physiological mechanisms underlying animal homeostasis and temperature effects.

2. Grasp the development of performing the function developed at molecular and cellular level in the complexity of the animals such as chemical & nervous integration, respiratory and excretory functions. 3. Know the strategy acquired to perform the functions in diverse environment such as in dry & aquatic and cold and hot at molecular and cellular level and regulations to achieve strategy by chemical and nervous regulation at organ levels.

4. Comprehend the concepts in homeostasis and integration in sustaining the life in constantly changing conditions.

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. An understanding of critical concepts, processes, and factual information in the performance of functions and changing conditions.

2. A knowledge of resources for finding the solution for strategies to sustain diverse forms of animal life kept and in wild in normal and abnormal conditions.

3. The ability to utilize knowledge of animal physiology in critical study and for making intelligent decisions in professional life.

Course Contents:

Introduction: Overview of biology of reproduction; reproductive strategies, comparative aspects. Anatomy of reproductive system: male reproductive system, female reproductive system; functional histology of male and female reproductive system: Neuoendocrine control of reproduction. Pituitary and hypothalamus. Physiology of testicular function. Organization; endocrinology, regulation; immunology. Physiology of sperm maturation and fertilization: Epididymal function, ejaculation, fertilization, capacitation. Reproductive cycles: pre- and neonatal development; puberty, estrous cycle, breeding seasons, aging. Physiology of overian function: folliculogenesis, egg maturation, ovulation, endocrinology, regulation. Transport of gametes: sperm and ovum, development in oviduct, implantation.

Practicals:

Demonstration of male and female reproductive system in vertebrates. Histological studies of ovaries, testes and different endocrine glands. Radioimmunoassays of different hormones.

Books Recommended:

1. Neischlag, E. and Behre, H.M. 1997. Andrology. (Eds.) Springer. NY. USA.
2. Knobil, E. and Neill, J.D. 1995. The Physiology of Reproduction. Raven Press. NY. USA.
3. DeGroot, L.J. 1995. endocrinology. Vol. III, Saunders Publishers. NY. USA.
4. Hafez, E.S.E. and Febiger, L. 1987. Reproduction in Farm Animals. John Wiley, NY. USA.
5. An Introduction To Embryology 5th Ed Balinsky 2015
6. Developmental Biology Sastry 2019.
7. Langman's Medical Embryology South Asian 14th Ed Sadler 2019

ENTOMOLOGY (ZOL-634)

Contact Hours:	**Credit Hours:**
Theory = 32	Theory =2
Practical = 32	Practical =1
Total = 64	Total = 3

Course Objectives:

The objectives of this course are

1. Understand classification of insect of different classes.
2. to understand norphology of insects
3 to understand insect significance
4 to understand its relationship with diseases

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. The objectives of this course are

1. Understand classification of insect of different classes.
2. to understand norphology of insects
3 to understand insect significance
4 to understand its relationship with diseases

Course Outline

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

Laboratory Work Outline

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

Books Recommended

1. Richards, O.W. and Davies, R.J., (1977). Imm's General Textbook of Entomology.
2. Ross, H.H., (1965). A Textbook of Entomology, John Wiley, N.Y.
3. Patton, R.L., (1963). Introductory Insect Physiology, W.B. Saunders, London.
4. Candy, D.J. and Kilby, B.A., (1975). Insect Biochemistry and Function, Chapman and Hall, London.
5. Price, P.W., (1984). Insect Ecology, John Wiley, N.Y.
6. Snodgrass, R.F. (1935). Principles of Insect Morphology, McGraw Hill, N.Y.
7. Chapman, R.G., (1985). The Insects: Structure and Function, Hodder and Stoughton, London.
8. Wigglesworth, V.B., (1974). The Principles of Insect Physiology, Chapman and Hall, London.

SEMESTER–VIII

Course Title	Theory	Practical	Credit hours	Course Codes
Endocrinology	2	1	3	ZOL-641
Developmental Biology	2	1	3	ZOL-642

Optional Course-III	2	1	3	ZOL-
Optional Course-IV	2	1	3	ZOL-
Thesis/Internship	0	3	3	ZOL-699/ ZOL-690
Total Credits			**15**	

ENDOCRINOLOGY (ZOL-641)

Contact Hours:
Theory = 32
Practical = 32
Total = 64

Credit Hours:
Theory =2
Practical =1
Total = 3

Objectives of the Courses

The objectives of the course are: -

- To introduce the field of Endocrinology and significance
- To impart knowledge about mechanism of hormone action.

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

1. **Understand** the fundamental anatomy endocrine glands in various mammalian species
2. **Acquire**knowledge about histology and physiology of the male and female hormone system
3. **Comprehend** the basic patterns and periodicity of processes controlled by hormones.
4. **Elaborate** the socio-economic problems related to hormone imbalance.

Course outline:

An overview of general concepts and principles of endocrinology: The endocrine system; Type of hormones; Endocrine andnervous system relationship; General principles in function, interaction,nature, synthesis, transport of hormones; General concept of feed back,biorhythms, pathology and assessment of endocrine function; Evolution ofendocrine system. Hypothalamus and pituitary: Hypothalamic hormones: Origin,chemistry and actions; hormones of anterior pituitary: Hypothalamic pituitaryregulation, General chemistry, Physiological action and metabolism ofprolactin-growth hormone family, glycoprotein hormone family,corticotiophins and other pro-opiomelanocortin peptides; posterior pituitary:Release, regulation and actions of vasopressin and oxytocin. Thyroid gland: Anatomy and histology; Formation andsecretion of thyroid hormones; Thyroid hormones in peripheral tissues,Regulation and factors affecting thyroid function.

Calcitrophic and Mineral Metabolism Hormones: Chemistry,physiological actions and metabolism of parathyroid hormone, metabolism of calcium and phosphate and magnesium; Parathyroid gland, Calcitonin and Cholecalciferol; Pancreatic Hormones and Regulatory Peptides of the Gut: Anatomy and histology for sources of the hormones; Chemistry,physiological roles and mechanism of action of insulin and glucagon;Physiological roles of gut peptides. Adrenal Medulla and Catecholamines:

Chromaffin cell andorganization; Structure of adrenal medulla; Biosynthesis, storage, releaseand metabolism; Adrenergic receptors. Adrenal Cortex: Steroid biochemistry; Physiological actions of corticoid hormones; Regulation and metabolism of glucocorticoids, mineralocorticoids and adrenal sex steroids. Hypothalamic-pituitary-adrenocortical axis, adrenal medulla and sympathetic nervous system together integrate responses to stress.Energetics of reproduction; functional anatomy, synthesis and regulation of gonadal steroids, secretory pattern of gonadal steroids at different stages of life; Male reproduction: Roles of androgen, biology and regulation of spermatogenesis, male puberty; Female reproduction: Roles of ovarian steroids, biology and regulation of oogenesis, female puberty, Steroid biochemistry and biosynthesis; Transport, metabolism and mechanism of action. Endocrinology of heart Heart, Kidney, pineal gland. Functional Diversity of Hormones in Vertebrates. Overview of Endocrine Mechanisms in Invertebrates. Neuroendocrinology; structural and functional abnormalities in endocrine glands, pharamacoendocrinology.

Laboratory Work Outline

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

Books Recommended

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

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

DEVELOPMENTAL BIOLOGY (ZOL-642)

Contact Hours:		**Credit Hours:**
Theory =	32	Theory =2
Practical =	32	Practical =1
Total =	62	Total = 3

Course Objectives:

The objectives of the course are:

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

Course learning outcomes:

Upon successful completion of the course, the student will be able to:

3. **Gain** familiarity with features that make an organism model for the learning of developmental biology *e.g.*, fertilization in sea urchin with mammalian like mechanisms.
4. **Apprehend** the contributions of the sperm and the egg to form zygote
5. **Elucidate** the problems associated with cell differentiation through fate mapping.
6. **Arrange and investigate** the classical and modern experiments into “find it”, “block it”, and “move it” categories
7. **Assess** the set of experiments that will establish whether a planned aspect is both necessary and ample to cause a developmental episode
8. **Demonstrate**the ability to label macromeres, mesomeres, and micromeres and know which cell types are derived from each of these cell layers in the early embryo (*e.g.*, primary and secondary mesenchyme, ectoderm, endoderm, and mesoderm).

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**
4. **Oogenesis**
   - a. Mechanism of oogenesis among various classes of vertebrates.
   - b. Vitellogenesis
   - **c.** Hormonal control of Vitellogenesis and oogenesis
5. **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
6. ***IN VITRO* Fertilization (IVF)**
   - *a.* History, Steps and advantages of IVF
   - *b.* Disadvantages and risk factors
7. **Cleavage &Blastulation**
   - a. Patterns of embryonic cleavage and blastulation among different vertebrate classes
   - b. Mechanism of cleavage**.**
8. **Gastrulation**
   - a. Fate maps
   - b. Gastrulation in amphibians, birds and mammals
9. **Early Vertebrate Development**
   - a. Neurulation, ectoderm, mesoderm and endoderm formation

10. **Placenta and extraembryonic membranes**

11. **Cellular Basis of Morphogenesis**
    - a. Differential cell affinity, cell adhesion molecules
    - b. Organogenesis
    - c. Mechanism of teratogenesis

12. **Aging and Regeneration in vertebrates**

Practicals:

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

Books Recommended:

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.

Ham, R. G., Veomett, M. J. 1980. Mechanism of Development. C. V. Mosby Co.

8. An introduction to embryology 5th ed balinsky 2015
9. Developmental biology sastry 2019
10. Langman's medical embryology south asian 14th ed sadler 2019

COURSES OFFERED TO OTHER DEPARTMENTS				
Course Category	**Department /Program/Semester**	**Course Title**	**Credits**	**Course Codes**
Course-I	Education (B.Ed) 1st	General Science	3(3+0)	ZOL-301
Course-II	Microbiology 1st	Biodiversity of Animal Life	3(2+1)	ZOL-302

Course-III	Chemistry 4th	Essentials of Biology	3(3+0)	ZOL-401
Course-IV	Education(B.Ed) 5th	Fundamentals of Cell Biology	3(3+0)	ZOL-501
Course-V	Education(B.Ed) 6th	Fundamentals of Zoology	3(3+0)	ZOL-502
Course-VI	Education(B.Ed) 7th	Essentials of Zoology	3(3+0)	ZOL-601

Course Name: GENERAL SCIENCE

Course Code: ZOL-301
Credit Hours: 3(3+0)

Contact Hours:
Theory =48
Practical = 0
Total = 48

Credit Hours:
Theory = 3.0

COURSE OBJECTIVES:

The objectives of the course are:

- The course covers core concepts in physical science, life science, and earth science.
- To study the interdependence of ecosystems and the organisms
- To study evolutionary forces to the diversity of ecosystems and of the species within them.

COURSE LEARNING OUTCOMES:

On completion of this course, the students should be able to:

- Identify the effects of human activities and naturally occurring changes on ecosystems and the consequences of those changes.
- Be able to describe a chemical reaction in the context of a rearrangement of atoms and also in the context of the formation of a new substance with new properties.
- Acquire the knowledge about relationships among force, mass, and motion of an object or system.

COURSE CONTENTS:

1. **Unit 1: Course Overview**
   Science in personal and social perspective: The nature of science and scientific investigation (observations, inferences) Teaching of science: reflect upon the way prospective teachers learned science and how they want to teach science when they graduate.

2. **Unit 2: Populations and Ecosystems**
   Basic needs of living things: Interdependencies of living things (symbiotic relationships) Ecosystems and Habitats: Population Growth –Survival and Extinction, Populations and Ecosystem
3. **Unit 3: Diversity and Adaptations**
   Diversity of living things: Systems of classification
   Adaptations for survival: Evolution and Diversity, Diversity and Adaptation
4. **Unit 4: Earth –The Blue Planet**
   Earth - an inhabitable planet: Weather and Seasons, Categorizing the world by continents, biomes, vegetation zones, climate zones, etc. Introduction to maps; reading and creating simple data charts, Constant changes on earth: Erosion / sedimentation, Earthquakes and Volcanoes
5. **Unit 5: Force and Motion**
   Relationship among force, mass, and motion of an object, Interaction of objects as it relates to force and linear, constant motion. Graphing of motion and basic calculations of speed and average speed, Non-linear motion and accelerated motion (Laws of motion), Graphing of non-linear and accelerated motion
6. **Unit 6: Properties and Matter**
   Physical properties of matter, including melting point, boiling point, hardness, density, and conductivity, Atoms, molecules, mixtures, elements, and compounds, Introduction to the periodic table, States of matter: solid, liquid, gas (examples of water), Introduction to models and their limitations in science teaching

Books Recommended:

1. Target Science - Physics by Stephen Pople
2. Target Science - Chemistry by Michael Clugston& Rosalind Fleming The Teaching of Science in Primary schools –Wynne Harlen
3. Inquiry –Thoughts, Views, and Strategies for the K-5 Classroom – National Science Foundation Ready, Set, Science! Putting Research to Work in K-8 Science Classrooms –National Research Council
4. Taking Science to School: Learning and Teaching Science in Grades K-8 –National Research Council.

BIODIVERSITY OF ANIMAL LIFE (ZOL-302)

Contact Hours:	**Credit Hours**
Theory = 32	Theory = 2.0
Practicals = 32	Practical = 1.0
Total = 64	Total = 3.0

COURSE OBJECTIVES:

The objectives of the course are:

6. To provide the knowledge of evolutionary/phylogenetic relationship (from simple to the complex organisms).
7. To impart the basic taxonomic characteristics and classification of all the invertebrate phyla.
8. To provide understanding of body organization, Feeding and Digestive system; Other Organ System.

COURSE LEARNING OUTCOMES:

On completion of this course, the students should be able to:

6. Acquire the basic concepts of invertebrates with explanation of evolutionary origin and diversification.
7. Understand invertebrate organismal concepts in laboratory and field.
8. Demonstrate major evolutionary innovations for invertebrates with functional importance.
9. Understand how reproduction and development occured and able to breed animal in the laboratory/field
10. Analyze economic and ecological importance of invertebrates.

COURSE CONTENTS:

1. Classification of animal kingdom, Definition of classification, Major division invertebrates and vertebrates; Classification of invertebrates
2. Phylum protozoa including general features, classification of Ameoba, Paramecium, Volvox and chlamydomonas
3. Phylum Porifera; some general features, classification including important species; Sycon, Spongilla, Euplectella, Spongia.
4. Phylum Coelentrates; some general features, Classification including important species; Hydra, Obelia, Physalia, Aurilaaurita, Metridium.
5. Phylum Platyhelminthes; some general features, classification including Planaria, Liver fluke and tapeworm.
6. Phylum Aschelminthes; some general features, classification upto orders. Classes; 1. Gastrotricha, 2. Rotifera, 3.Nematoda with examples.
7. Phylum Annelida; general features, classification: Class Polychaeta, Class Oligochaeta, Class Hirudinea.
8. Phylum Mollusca; general features, classification:
   classes; 1. Amphineura, 2.gastropoda,3. Pelecypoda,4.Scaphopoda, 5. Cephalopoda.
9. Phylum Arthropoda: some general features, classification: Class Crustaceans, Class Insecta, Class Chilopoda, Class Diplopoda, Class Arachnids with examples.
10. Phylum Echinodermata (General features; classification)

PRACTICALS:

1. Study of Ameoba, Paramecium, Volvox and chlamydomonas
2. 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.

BOOKS RECOMMENDED:

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.
2. Additional Readings:
3. Hickman, C.P., Roberts, L.C/, AND Larson, A., 2018. INTEGRATED PRINCIPLES OF ZOOLOGY, 15th Edition (International), Singapore: McGRAW Hill.
4. Hickman, C.P., Roberts, L.C/, AND Larson, A., 2007. INTEGRATED PRINCIPLES OF ZOOLOGy, 12th& 13th Edition (International). Singapore: McGraw Hill.
5. Pechenik, J.A., 2015. BIOLOGY OF INVERTEBRATES, 7th Edition, (International), Singapore: McGraw Hill.
6. Kent, G. C. and Miller, S., 2001. COMPARATIVE ANATOMY OF VERTEBRATES New York: McGraw Hill.
7. Campbell, N.A., 2002; BIOLOGY Sixth Edition, Menlo Park, California; Benjamin Cummings Publishing Company, Inc.
8. BOOKS FOR PRACTICAL
9. Miller, S.A., 2002. GENERAL ZOOLOGY LABORATORY MANUAL. 5th Edition (International), Singapore : McGraw Hill.
10. Hickman, C.P. and Kats, H.L., 2000. Laboratory Studies in integrated principal of zoology. Singapore : McGraw Hill.

ESSENTIALS OF BIOLOGY(ZOL-401)

Contact Hours:	**Credit Hours:**
Theory =48	Theory = 3.0
Practical = 0	Practical = 0
Total = 48	Total= **3**

COURSE OBJECTIVES:

The objectives of the course are:

- To explain the basic concepts of cell biology
- To understand cellular structure, composition of the organelles, cell growth and cellular division.

- To explain how macromolecules and organelles govern the dynamic organization, function of living cells.

COURSE LEARNING OUTCOMES:

On completion of this course, the students should be able to:

- **ACQUIRE the basic knowledge of** levels of organization in life
- **UNDERSTAND** the metabolic processes of cells in terms of cellular organelles, membranes, and biological molecules.
- **ABILITY** to understand the role of macromolecules regulating cellular processes.

COURSE CONTENTS:

1. **Biology and its major fields of specialization**
2. **The Cell:** Emergency and Implication of Cell Theory, Organelles of cell
3. **Biological Molecules:** Protein, carbohydrates, lipids and nucleic acids i.e DNA and RNA, Mechanism of Enzymes action and factors affecting enzymatic activity
4. **Chromosomes and DNA:** Types and composition of chromosomes, Chemical nature of DNA and gene, DNA duplication, Transcription and translation (protein synthesis), Mutation
5. **Cell Cycle and Cell division:** Mitosis and Meiosis, Variation and Genetics, definition of Alleles, Gene pool, Law of segregation, Law of independent Assortment and sex Determination
6. **Bioenergetics:** Difference Between Photosynthesis and Respiration, Light and Dark Reactions Aerobic and anaerobic Respiration and glycolysis, Kreb's Cycle and Electron Transport Chain
7. **Biotechnology:** Gene cloning, Analyzing DNA (polymerase chain reaction) and biotechnology products, Gene therapy and gene culture
8. **Variety of life:** General Characteristics of: Kingdom Prokaryota, Kingdom Protista, kingdom Fungi, Kingdom Plantae, Kingdom Animalia
9. **The concept of Homeostasis:** Osmoregulation in plants and animals, Excretion in animals, Thermoregulation in animal, Growth and Development in plants and animals, Reproduction in plants and animals, Plant Movements and Plant Hormones, Coordination in Animals
10. **Evolution:** Evolution and its theories, Speciation
11. **Ecosystem and energy flow:** Major ecosystems, Biochemical cycles, Man and his environment, Renewable and non-renewable resources, Degradation and Depletion of resources, Global Warming and Conservation biology

RECOMMENDED BOOKS:

1. Biology: A course for O-Level. Lam Peng Kwan, Eric YK Lam. (2000). Pub. Federal Publishers.
2. Jane B. Reece (Author), Martha R. Taylor (Author), Eric J. Simon (Author), Jean I. Dickey. (2011). Campbell Biology: Concepts and Connections (7th Edition). Benjamin Cummings ISBN-13; 978-0321742582.

3. Ceice Starr, Christine Evers Lisa Starr. (2010). Biology; Concepts and Applications without Physiology 8th ISBN-10:0538729258; ISBN-13: 978-0538739252.

FUNDAMENTALS OF CELL BIOLOGY(ZOL-501)

Contact Hours:	**Credit Hours:**
Theory =48	Theory = 3
Practical = 0	Practical = 0
Total = 48	Total = 3

Objectives:

At the end of the students will be able to:

1. Identify the importance of Zoology.
2. Describe basic components of living organisms.
3. Explain cell and its organelles

Course outline:

Unit 1: Cell and its organelles

4.1: Composition
4.2: Structure
4.3: Function
Unit 5: Micoorganisms
a: Bacteria
b: Virus
c: Diseases

Unit 2: Organ and Organ systems

2.1: Structure
2.2: Function

Unit 3: Basic components of living organisms
3.1: Carbohydrates
3.2: Proteins
3.3: Lipids

Unit 4: Food and Nurtrition
4.1: Balance diet
4.2: Malnutrition

Unit 5: Cell Division

4.1. Mitosis
4.2. Meiosis
4.3. Chromosomal Abberration

Reference Books

- Biology Books Peshawar Text Book Board
- Integrated Principals of Zoology by Hickman
- Zoogeography and Paleontology by S.S Ali
- Ecology by Odum
- Evolution by Moodi
- Animal Behaviour by Prasad
- Genetics by Strickberger
- Economic Zoology by S.Chand and Prasad.

FUNDAMENTALS OF ZOOLOGY (ZOL-502)

Contact Hours:
Theory =48
Practical = 0
Total = 48 Total = 48

Credit Hours:
Theory = 3.0
Practical = 0

Objectives

At the end of the the students will be able to:

1. Differentiate between chordates and vertebrates
2. Describe organ and organ systems
3. Identify the relationship between living things and non living things

COURSE OUTLINES

Unit 1: Micorganisms

a. Bacteria
b. Virus
c. Diseases

Unit 2: Diversity of Life

2.1: Basic units of Classification

Unit 3: Invertebrates Phyla

3.1: Protozoa to Echinoderms

Unit 4 : Chordates and vertebrates

4.1: Pisces

4.2: Amphibians

4.3: Reptiles

4.4: Birds and Mammals

Unit 5: Genetics
5.1: Law of Mendel
5.2: Blood Groups
5.3: Linkage
5.4: Crossing Over
5.5: Cell division
5.6: Mutation
5.7: Chromosomal Abberration

Unit 6: Evolution
6.1: Natural Selectio
6.2: Lamarckism
6.3: Darwinism

Unit 7 Ecology
7.1: Ecosystem
7.2: Food Chain
7.3: Food Web
7.3: Population Ecology
7.5: Community Ecology
Unit 8: Adaptation

a. Aquatic
b. Aerial
c. Cursorial
d. Fossorial
e. Arboreal

Reference Books

- Biology Books Peshawar Text Book Board
- Integrated Principals of Zoology by Hickman
- Zoogeography and Paleontology by S.S Ali
- Ecology by Odum

- Evolution by Moodi
- Animal Behaviour by Prasad
- Genetics by Strickberger
- Economic Zoology by S.Chand and Prasad.

ESSENTIALS OF ZOOLOGY(ZOL-601)

Contact Hours:
Theory =48
Practical = 0
Total = 48

Credit Hours:
Theory = 3
Practical = 0
Total = 3

Objectives:
At the end of the the students will be able to:

1. Identify different stages of development
2. Describe animal behavior
3. Ezplain scope of Biotechnology

COURSE OUTLINE

Unit 1: Introduction to Zoology
1.1: Branches
1.2: Importance

Unit 2: Developmental Biology
2.1: Stages of Development
2.2: Regeneration

Unit 3: Animal Behaviour

3.1: Behaviour
3.2: Learning and its types
3.3: Social Organization
3.4: Migration

Unit 4: Zoogeography
4.1: Regions
4.2: Distribution of animals
4.3: Barriers

Unit 5: Economic Zoology
5.1: Culture
5.2: Zoonosis

5.3: Animal products

Unit 6: Biotechnology

6.1: Scope and Importance
6.2: concept of DNA and RNA
6.3: Gene
6.4: Protein Synthesis

Unit 7: Research Methoodology
7.1: Introduction
7.2: Processes
Reference Books

- Biology Books Peshawar Text Book Board
- Integrated Principals of Zoology by Hickman
- Zoogeography and Paleontology by S.S Ali
- Ecology by Odum
- Evolution by Moodi
- Animal Behaviour by Prasad
- Genetics by Strickberger
- Economic Zoology by S.Chand and Prasad.

Reference Books

- Biology Books Peshawar Text Book Board
- Integrated Principals of Zoology by Hickman
- Zoogeography and Paleontology by S.S Ali
- Ecology by Odum
- Evolution by Moodi
- Animal Behaviour by Prasad
- Genetics by Strickberger
- Economic Zoology by S.Chand and Prasad.

Complete List of Optional Courses offered by Department of Zoology

S. No.	Course Title	Course Codes	Theory	Practical	Credit Hours
1.	Comparative Animal Physiology	ZOL- 664	2	1	3
2.	Comparative Endocrinology	ZOL-665	2	1	3
3.	Host Parasite Relationship in Animals	ZOL-666	2	1	3
4.	Clinical Bacteriology	ZOL-667	2	1	3
5.	Medical Virology	ZOL-668	2	1	3
6.	Faunal Biodiversity of Pakistan	ZOL-669	2	1	3
7.	Helminthology and Protozoology	ZOL-670	2	1	3
8.	Fish Nutrition and Health	ZOL-671	2	1	3
9.	Human Genetics	ZOL-672	2	1	3
10.	Epidemiology of Animal Parasites	ZOL-673	2	1	3
11.	Wildlife of Pakistan	ZOL-674	2	1	3
12.	Quantitative Zoology	ZOL-675	2	1	3
13.	Behavioural Ecology	ZOL-676	2	1	3
14.	Ornithology	ZOL-677	2	1	3
15.	Mammology	ZOL-678	2	1	3
16.	Aquaculture and Fisheries	ZOL-679	2	1	3
17.	Biotechnology in Aquaculture	ZOL-680	2	1	3
18.	Limnology	ZOL-681	2	1	3
19.	Wildlife Ecology	ZOL-682	2	1	3
20.	Wildlife techniques and data analysis	ZOL-683	2	1	3
21.	Vector Biology	ZOL-684	2	1	3
22.	Population Genetics	ZOL-685	2	1	3
23.	Bioremediation	ZOL-686	2	1	3
24.	Biology and control of vertebrate pests	ZOL-687	2	1	3

DETAILS OF OPTIONAL COURSES OFFERED BY DEPARTMRNT OF ZOOLOGY BS SESSION 2019 AND ONWARD

COMPARATIVE ANIMAL PHYSIOLOGY	ZOL- 664	3(2+1)

Course Objectives:

The objectives of this course are

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

Course Outcomes:

Upon successful completion of this course, the students will be able to:

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

Course Contents:

Homeostasis, nutrition and physiology of digestion. Metabolism and basal metabolic rate. Bioluminescence. Bioelectricity, resting potential, action potential and its propagation, Netnst equation. Skeletal and smooth muscle, its properties, dynamic and molecular aspects of muscle contraction, all or none law kinds of contractions, twitch, tetanus, tonus. Respiration and adaptive mechanisms in aquatic, terrestrial environment and in the transition stage. Heart and vessels in fish, amphibian and mammalian levels. Excretion and osmosregulation: ammonia, urea, uric acid excretion, water conservation and counter current mechanism. Organizationof nervous system, neuron, reflex are, spinal and cranial pathways, autonomic outflow, sensory structures, morphological correlates of information processing, neurotransmitters.

Chemoreceptor adaptations at various levels. Endocrine glands, hormones (vertebrates and invertebrates). Reproductive strategies and morphological change form fish to mammals. Oviparity, viviparity and ovo-viviparity, Reversal of sex.

Practicals:

Study of temperature optima and pH on a selected digestive enzyme (amylase). Human blood counts. Measurement of haemoglobin and haematocrit. Measurement of blood pressure and effect of stress. Effect of vasoconstrictors and vasodilators on heart beat of frog. Measurement of osmolality. Experiments on absorption of glucose in intestine 9inverted sac technique). Effects of acetylcholine and epinephrine on intestinal movements. Determination of oxygen consumption in an aquatic animal. Determination of oxygen consumption in a terrestrial animal and effect of a factor. Cardiac cycle in a frog and effect of temperature. Effect of ions and drugs on cardiac activity in a frog. Extra systole in cardiac activity. Preparation of gastroenemius muscle in a frog and study of simple twitch, summation and tetany. Effect of temperature, acetylcholine and epinephrine on cardiac muscle activity. Examination of endocrine glands from fish to mammals. Study of physiological action of a hormone. Effect of ablation of a gland and replacement therapy. Study of rhythm in reproduction in a mammal. Movement of chemicals and ions across cell membrane (erythrocytes hemolysis techniques). Analysis of behaviour in selected animals, with the help of films shows/video, movies.

Books Recommended:

1. Randall, D. Burggren, W. and French K. 1997. Eckert Animal physiology – Mechanisms and Adaptations. 4th edition. WH. Freeman, NY USA
2. Gordon, M.S., Bartholomew, G.A., General, A.D., Jorgenson, C.B. and White, F.N. 1992. Animal Physiology: Principles of Adaptations. MacMillan, NY.
3. Guyton, A.C. 1991. Textbook of Medical Physiology. W.B. Saunders Co., Philadelphia.
4. Turner, C.D. and Bagrara, J.T. 1976. General Endocrinology. W.B. Saunders Co., Philadelphia
5. Prosser, C.L. 1973. Comparative Animal Physiology. Saunder College, Philadelphia
6. Hoar, W.S. 1966. General and Comparative Physiology. Prentice Hall Inc., New Jersey.
7. Animal Physiology verma 2018
8. Animal Physiology and Biochemistry, revised edition agarwal 2018

COMPARATIVE ENDOCRINOLOGY	ZOL-665	3(2+1)

Course Objectives:

The objectives of this course are

1. To discuss the definition of hormone in terms of its general properties.
2. To differentiate among endocrine, paracrine and autocrine system.

3. To describe different classes and chemical structure of hormone.
4. To explain the roles of the endocrine system in maintain homeostasis, integrating growth and development, responding to environmental insult and promote successful reproduction.

Course Outcome:

Upon successful completion of this course, the students will be able to:

1. Explain the roles of the endocrine system in maintain homeostasis, integrating growth and development, responding to environmental insult and promote successful reproduction.
2. Discuss the definition of hormone in terms of its general properties.
3. Differentiate among endocrine, paracrine and autocrine system.
4. Describe different classes and chemical structure of hormone.
5. Identify the glands, organs, tissues and cell that synthesize and secrete hormones, hormone precursors and associated compounds.
6. Describe synthesis and mode of secretion of hormone.
7. Explain how the secretion of hormone is regulated, including the principles of negative and positive feedback mechanism.
8. Explain the importance of patterns of hormone secretion such as pulsatile, diurnal and cyclicle.

Course Contents:

Introduction to hormones & endocrine glands – hypothalamus, pituitary (master gland), thyroid, parathyroid, adrenal cortex and medulla, pancreas, ovary and testes – their morphology and hormones released – target organs and effect; positive and negative feedback mechanism; hypothalamus releasing factor, growth hormone, GnRH, gonadotrophins (LH, FSH, hCG), TSH, T_3 and T_4 oxytocin, prolactin, ADH, insulin, Glucagon, adrenocorticoids, synthesis of and biological action, regulation and effects of adrenalectomy; pregnancy hormones; regulation and action of androgens and ovarian hormones. Comparison of endocrine glands of vertebrates; the development of glands from pisces to mammalian; hypothalamus, pituitary, pineal, thyroid, pancrease and adrenal glands. Pheromones – their secretion and action.

Practicals:

Histological studies of endocrine glands of rats, chicken and uromastrix; RIA assays of various hormones (prolactin, thyroid hormones, growth hormone, FSH, LH); extraction of pituitary gland of rat and fish.

Books Recommended:

1. Neischalg, E. and Behre, HM. 1997. Andrology. Springer Publications. USA.
2. DeGroot, I.J. (Eds) 1995. Endocrinology (3 volumes). WB Saunders Publications, USA.
3. Nelson, RJ. 1995. An introduction to Behavioral Endocrinology. Sinauer Associates, NY USA.
4. Turner, CD and Bagnara, JT. 1976. General Endocrinology. WB Saunders Publications, USA.

HOST PARASITE RELATIONSHIP IN ANIMALS	ZOL-666	3(2+1)

Course Objectives:

The objectives of this course are

1. Describe general principles and concepts of animal parasitology
2. Classify major animal parasites of animals and humans.
3. Describe many of the disease conditions that animal parasite cause and to consider measures that may lead to control of these disease agents

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. Assess general principles and concepts of animal parasitology
2. Analyze many of the disease conditions that animal parasite cause and to consider measures that may lead to control of these disease agents

Course Contents:

Classification of parasites. Ectoparasites, endoparasite, temporary parasites, permanent parasites, facultative parasites, accidental parasites, wandering parasites (brief account and examples). Classification of hosts: Definitive, intermediate and paratenic hosts. Parasites of wild animals and birds. Role of wild animals and birds in dissemination of parasitic disease of domestic animals and man. Pathogenesis . Diagnosis and control of ecto and endo-parasites of wild animals and birds. Host susceptibility and specificity a. Various types of susceptibilities b. Host-parasite relationships c. Morphology and physiology of parasites d. Adaptations to parasitic mode of life e. Effects of parasitism on parasites. Effcets of parasites on hosts a. Influence of parasites on host populations. b. Pathological responses c. Immunoparasitology: immunity and immune responses of host. Diagnosis, prevention, control treatment a. Common drugs and anthelmintics b. Vector control methods. Animal association, adaptation to parasitism, protazoa, mollusca, arthropoda, acarina, insecta, nematode, acathocephala, trematoda, cestoda. Host specificity, action of parasite upon their host.

Practicals:

Culture, isolation and separation of parasitic larvae from soil and herbage material. Baerrmann technique for nematode larvae separation, McMaster technique for egg per gram counting, field herbage collection for carpological examination.

Recommended Books:

1. Anderson, R.C. 1992. Nematode Parasites of Vertebrate: Their Development and Transmission. CAB
2. International, USA.
3. Noble, E.R. and Noble G.A. 1982. Parasitology. Lea and Febiger, UK.
4. Bear, J.G. 1980. Ecology of Animal Parasites. Univ. of Illinois Press, Urbana, USA.

CLINICAL BACTERIOLOGY	ZOL-667	3(2+1)

Course Objectives:

The objectives of this course are

1. Describe general principles and concepts of Bacteriology
2. Classify major types of bacterias
3. Describe many of the disease conditions that are caused by pathogens

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. Assess general principles and concepts of clinical bacteriology
2. Analyze many of the disease conditions that are caused by bacterias.

Course Contents:

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

Practicals:

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

Books Recommended:

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

MEDICAL VIROLOGY	ZOL-668	3(2+1)

Course Objectives:

The objectives of this course are

1. To provide expertise in microbiology, with a particular focus on medical virology.
2. To achieve in-depth knowledge and understanding of medical virology.
3. Develop an understanding of the scientific basis of concepts, as well as practical skills in medical virology.

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. Understand differences between the lifecycles of major groups of viruses, in particular how different viruses exploit the molecular and cell biology of their hosts.
2. Understand the innate and adaptive defenses of mammals against viruses, and the strategies that viruses have evolved to evade these host defenses.
3. Understand strategies to prevent (vaccination) and to treat (antiviral therapy) viral infections.

Course Contents:

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

Practicals:

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

Books Recommended:

1. Topley and Wilson's Principles of Bacteriology, Virology, Mycology, Parasitology and Immunity (Vols. 1-6). 9th edition, 1998. Edward Arnold Publishers, UK.
2. Pelczar, Jr., MJ, Chan, ECS. And Kreig, NR. 1997. Microbiology: Concepts and Applications. International Edition. McGraw Hill Publishers, USA.

3. Cappuccino, JG and Sherman, N. 1996. Microbilolgy – a laboratory manual. Benjamin/Cummings Publishers, USA.
4. Joklik, WK., Willert, HP., Amos, DB. And Wilfert, CM, 1992. Zinsser Microbiology. Appleton and Lange, USA.
5. Baron, S. 1993. Medical Microbiology. Churchill Livingston, UK.

FAUNAL BIODIVERSITY OF PAKISTAN	ZOL-669	3(2+1)

Course Objectives:

The objectives of this course are

1. To enable the student to understand philosophy and significance of wildlife conservation
2. To understand the wildlife management rules and regulations in Pakistan
3. To understand how National and International agencies are involved in conservation and management of wildlife

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. ACQUIRE theoretical knowledge about the identification, distribution, status, conservation and management of amphibians, reptiles, birds and mammals of major importance in Pakistan
2. UNDERSTAND the protected area system (Game Reserves, Wildlife Sanctuaries and National Parks)
3. SOLVE the threats to wildlife by applying the scientific principles and modern technologies (Sustainable development through local community participation).
4. ANALYSE,interpret and synthesize data and other information about the population of wildlife

Course Contents:

Definition: genetics, species, ecosystem, principles of biological richness; paleohistory of Pakistan; present day faunal pattern and species advances of Pakistan. Zoogeography of Pakistan; species of south Asia; original species of Asian origin; species of African origin; bird migration from northern high mountains to Central Asian desert birds; of wetlands; other species including east-west migrants from south; freshwater fish zoo of Pakistan; faunal of eco-zone of Pakistan. Endemic species, species of managerial occurrence; hot spots of species; threatended and vulnerable species; habits and habitats Riparian zones; edge, snags, dead and down woods material; cliffs. Fallen and cover; marine biodiversity.

Practicals:

Methods and approaches data collection: mammals, birds, reptiles, amphibian, fish. Invertebrate data analysis: vertebrate, insects and other invertebrates; collection of ecological data; methods of estimating species richness; population studies and census of wildlife animal; method of estimating ecological rich areas and hot spots of species; methods of preparing faunal inventories.

Books Recommended:

1. Mirza, ZB. 1998. Illustrated handbook of animal biodiversity of Pakistan. Center of environmental research and conservation, Islamabad.
2. Dobson, A. 1998. Conservation and Biodiversity. Scientific American Library. NY. USA.
3. Daniel, JC. 1992. The book of Indian reptiles. Bombay Natural History Society, India
4. Roberts, T.J. 1992. The Birds of Pakistan. Vol-II. Oxford Univ. Press. UK.
5. Roberts, T.J. 1992. The Birds of Pakistan. Vol-I. Oxford Univ. Press. UK.
6. Bailey, J.A. 1986. Principles of Wildlife Management. John Wiley. USA.
7. Robinson, W.L. and Bolen, E.G. 1984. Wildlife Ecology and Management. MacMillan, Cambridge. UK.
8. Roberts, T.J. 1977. Mammals of Pakistan. Ernest Benon Ltd. London.
9. Ali, S. and Ripley, S.D. 1973. A handbook of birds of India and Pakistan. Oxford Univ. Press. London.

HELMINTHOLOGY AND PROTOZOOLOGY	ZOL-670	3(2+1)

Course Objectives:

The objectives of this course are

1. To impart knowledge on various protozoan parasites affecting human and animals.
2. To understand basic principles ofparasitic infection and the host immunological responses.
3. To familiarize students to differentiate among the common groups of protozoan parasites.
4. To improve their diagnostic assistance by explaining basic and advanced diagnostic techniques.

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. Attain the basic acquaintance of Protozoans and philosophy of hostparasite interface
2. Understandthe perception of parasitism and other animal associations; clarify the concept of damage; understand the basic features and characteristics of hosts
3. Elucidate the impediments related to the pathogenesis of the protozoan and effectively treating these infections.
4. Diagnose the protozoan infections by presentations of elementary and current techniques

Course Contents:

Parasitic Protozoa and its classification. Morphological features, Life cycles, host-parasite interactions, geographical distribution, reservoir hosts, methods of transmission and control, pathology, immunological aspects, diagnosis and treatment of the following protozoan parasites; a. Giardia species b. Trichomonas species c. Entamoeba species d. Naegleria species e. Trypanosoma species f. Leishmania species g. Plasmodium species h. Babesia species i. Anaplasma species 210 j. Cryptosporidium species k. Toxoplasma species l. Histomonas meleagridis 4. Parasitic Zoonosis and Risk Perception of Zoonotic infections in Pakistan. Host-parasite relationship and control of parasitic helminthes, with special reference to helminthes of

medical and veterinary importance. Host-parasite relationship and control of parasitic protozoa of medical and veterinary importance.

Practicals:

Collection, preservation/culture and preparation of slides of local helminthes and protozoa of medical and veterinary importance and their identification.

Books Recommended:

1. Topley and Wilson's Principle of Bacteriology, Virology, Mycology, Parasitology and immunity (Vol.1-6). 9th edition 1998. Edward Arnold Publishers, UK
2. Robert, LS. And Jonovy, JJr. 1996. Foundations Parasitology 5th edition. Wan Brown Publishers, Chicago, USA.
3. Smyth, JD. 1994. Introduction to animal Parasitology. 3rd edition. Cambridge University Press. UK.
4. Baron, S. 1993. Medical Microbiology. Churchill Livingston, UK.

FISH NUTRITION AND HEALTH	ZOL-671	3(2+1)

Course Objectives:

The objectives of this course are

1. To provide sufficient knowledge about all physiological phenomena in fishes.
2. To provides practical information to obtain better growth by following physiological aspects during extensive or semi-intensive culture.
3. To emphasize thoroughly in breeding of most cultivable freshwater fishes by manipulating reproductive and endocrinological aspects during natural season as well as off seasons.

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. Relatethe keyconcepts of fish physiology.
2. Describe the different systems and their coordination.
5. Judge the fish behavior and migration patterns.

Course Contents:

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

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

Practicals:

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

Books Recommended:

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

HUMAN GENETICS	ZOL-672	3(2+1)

Course Objectives:

The objectives of this course are

1. To understand the terms and basic concepts of genetics, providing a conceptual framework for future reference
2. To provide understanding about the continuity of the life from one generation to other generation is based on the mechanisms involving nucleus, chromosomes and genes etc.
3. To develop the concept that continuity not only transfers the traits of the parents but also imparts variations that render the generations sustainable in changing environment
4. To understand how traits are inherited and to use this understanding in analyses (to solve problems and complete pedigrees)
5. To understand probability concepts and use these concepts to solve problems (including basic statistical problems)

Course Outcome:

Upon successful completion of this course, the students will be able to:

1. Define terms of genetics and apply concepts of modern transmission
2. Identify and describe the process and purposes of the cell cycle, meiosis, and mitosis, as well as predict the outcomes of these processes.
3. Solve transmission genetics problems, make accurate predictions about inheritance of genetic traits, and map the locations of genes.
4. Identify the parts, structure, and dimensions of DNA molecules, RNA molecules, and chromosomes, and be able to categorize DNA as well as describe how DNA is stored
5. Able to accurately draw the diagram and describe the processes of replication, transcription, translation, as well as predict the outcomes of these processes.

Course Contents

Simples autosomal, sex-linked inheritance, lethal genes, chromosomal abnormalities, multiple alleles an blood groups, linkage an crossing over, variation in expression of genes, study of twins as a special method of genetic inference, congenital malformation and prenatal interaction,

genetic aspects of race and race mixture. Cancer as a genetic disorder; Gene therapy and its types; inherited immune deficiencies, eugenics; Human Genome Project – in – depth analysis.

Practicals:

Pedigree analysis, ability to taste PTC, human chromosomes (slides), study of inheritance of some human characteristics, hair color, eye color.

Books Recommended:

1. Lewis, R. 1997. Human Genetics – concepts and applications. WCB-McGraw Hill Publishers, USA.
2. Snustad, DP, Simmons, MJ and Jenkins JB. 1997. Principles of Genetics. John Wiley & Sons, Inc. New York
   USA.
3. tamarin RH. 1996. Principles of Genetics. 5th edition. WmC Brown Publishers USA.
4. Levitan, M. 1988. Textbook of Human Genetics. Oxford University Press. UK.

EPIDEMIOLOGY OF ANIMAL PARASITES	ZOL-673	3(2+1)

Course Objectives:

The objectives of this course are

1. Describe general principles and concepts of animal parasitology
2. Classify major animal parasites of animals and humans.
3. Describe many of the disease conditions that animal parasite cause and to consider measures that may lead to control of these disease agents

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. Assess general principles and concepts of animal parasitology
2. Analyze many of the disease conditions that animal parasite cause and to consider measures that may lead to control of these disease agents

Course Contents::

Animal association, adaptation to parasitism, protazoa, mollusca, arthropoda, acarina, insecta, nematode, acathocephala, trematoda, cestoda, stress. Effect of micro-environment on the parasite distribution in bost. Population an communities; ecological niche, ecological factors in parasite. Host complex, size relationships. Host age and parasite number, seasonal variations. Movements and hypobiosis: density of population; density dependence; parasite mix; food changes; microenvironments of host. Symobiotic cleaning. Host specificity, action of parasite upon their host.

Practicals:

1. Isolation and separation of parasitic larvae from fecal soil sample.
2. Preparation of temporary and permanent slides and identification of parasitic protozoan and local helminthes of medical and veterinary importance.

3. Methods of collection, preservation and transportation of parasitic material.
4. Identification of insects of medical and veterinary importance.

Books Recommended:

1. Anderson, R.C. 1992. Nematode Parasites of Vertebrate: Their Development and Transmission. CAB International, USA.
2. Noble, E.R. and Noble G.A. 1982. Parasitology. Lea and Febiger, UK.
3. Bear, J.G. 1980. Ecology of Animal Parasites. Univ. of Illinois Press, Urbana, USA.

Course Objectives:

The objectives of this course are

4. To familiarize the students about wildlife diversity of Pakistan
5. To demonstrate how National and International agencies are involved in management of wildlife

Course Outcomes:

Upon successful completion of this course, the students will be able to:

7. ACQUIRE theoretical knowledge about the identification, distribution, status of wildlife in Pakistan
8. ANALYSE,interpret and synthesize data and other information about the population of wildlife
9. DEMONSTRATE the ecological assessment and importance of wildlife to certain area.

Course Contents:

WILDLIFE OF PAKISTAN	**ZOL-674**	**3(2+1)**

Wildlife of Pakistan, Introduction, Important Definitions, Identification, Distribution, Status; Biodiversity and sustainability of wildlife; Conservation and Management of fishes, amphibians, reptiles, birds and mammals of major importance in Pakistan; Wildlife rules and regulations in Pakistan; National and International agencies involved in conservation and management of wildlife; Protected Areas in Pakistan, Sanctuaries, Game Reserves, National Parks; Ramsar convention, Wetlands, Ramsar Criteria, Ramsar Sites, Threatened species of Pakistan, Vulnerable, Endangered, Critically Endangered.

Practicals:

1. Visit to National Parks, Wildlife sanctuaries and game reserves.
2. Population studies of some reptiles, birds and small manuals.
3. Report on endangered species.
4. Demonstration of distribution of animal species of Pakistan (blank maps will be provided)

Books Recommended:

1. Ali S. & Ripley S. D., 1973. *A Handbook of Birds of India & Pakistan*, Oxford University Press, London.
2. Roberts, T. J., 1998. *The Birds of Pakistan*, Vol. I. Oxford.
3. Roberts, T. J., 1992. *The Birds of Pakistan*, (Vol. II), Oxford.
4. Roberts, T.J., 1977. *Mammals of Pakistan*. Ernest Benon Ltd, London,
5. Robinson, W.L. and Bolen, E.G., 1984. *Wildlife Ecology and Management*. McMillan, Cambridge.

QUANTITATIVE ZOOLOGY	ZOL-675	3(2+1)

Course Objectives:

The objectives of this course are:

1. **The course will provide knowledge about the importance and use of quantitative data in zoology.**
2. **To help the students to understand the methods to analyse data pertaining to their research work and to assess the significance of their experimental designs.**

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. TRANSLATE research objectives into clear, testable statistical hypotheses.
2. IDENTIFY appropriate statistical methods to be applied in each research setting.
3. APPLY numerical, tabular, and graphical descriptive techniques commonly used to characterize and summarize data.

Course Contents:

Introduction; aims and principles of Quantitative Zoology; Techniques used for obtaining quantitative information on morphological, anatomical, ecological and ethological varietiesof animal populations; comparison of faunal elements and contemporary approach to classification; handling and interpretation of numerical data, application of statistical techniques used in current zoological research.

Practicals:

Construction of phenograms / dendrograms; software programs in quantitative Zoology.

Books Recommended:

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.

BEHAVIORAL ECOLOGY	ZOL-676	3(2+1)

Course Objectives:

The objectives of this course are

1. To enable the student to understand not only behavior of animal but combination of behavior and ecology that contribute to reproductive success
2. To understand how animals struggle and survive.
3. To understand difference between survival values on function and those concerned with the casual mechanisms.

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. Acquire theoretical knowledge of animal behavior, natural selection and evolution.
2. Understand the struggle for survival, their ecological relationships
3. Solve the survival and breeding related problems which are result of anthropogenic activities.
4. Interpretation and synthesis of data and other information about animal behavior, competition and ecological relationships.

Course Contents:

9. Animal behavior and Ecology

a. Introduction
b. Gene and Behavior
c. Natural Selection and Behavior
d. Ecology and Evolution

10. 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

11. Competition for Resources in Individuals

a. Competition by Exploitation
b. Competition by Resource Defense

12. Merits and De-merits of living in Groups

13. Fighting Among Individuals
   a. Role of Resource Values and Fighting Ability
   b. Fighting for Dominance

14. Altruism
15. Kin Selection
16. Repository and Manipulation in Animals
17. Division of Labor and Specialized Helpers

Practicals:

4. Visit to Zoo/Aviary/Peasantry/Breading-center/Recreational Park/Aquarium to study the behavior of animals in different environmental conditions

Books Recommended:

1. Bonnett, R., H. Fordd., 1993 Behavioural ecology of fishes - Nature
2. Krebs. 1997 - Behavioural Ecology: An Evolutionary Approach by - Science
3. Krebs 1993 - An Introduction to Behavioural Ecology - Science

ORNITHOLOGY	ZOL-677	3(2+1)

Course Objectives:
The objectives of this course are

1. To impart knowledge to identify birds and understand their behavior and relationships in their natural habitat.
2. To provide vision to understand the factors that cause bird populations to change, and to assess certain bird habitats in relation to climate changes.

Course Outcomes:
Upon successful completion of this course, the students will be able to:

1. **ACQUIRE** the basic knowledge of the birds in the diversified habitats.
2. **UNDERSTAND** their behavior and their relationships to the natural habitats.
3. **ANALYZE** the likely impacts of changing climatic conditions on variety of birds in different ecosystems to sift in roosting, nesting and behavioural mechanisms.

Course Contents:
Introduction to ornithology; basic ecology and themes of study.
Classification and taxonomy of birds up to orders and species
Evolution of birds; evolution of bird flight, aerodynamics and aerial movements. Bird ancestry; development of feathers, types and their structure; plumage analysis.
Biology of fossil birds; study of the representative birds viz. *Archaeopteryx,Archaeornithes*and*Neoornithes*. Comparison with the present existing birds.
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.
Predator-Prey relationships, mobbing impacts; foraging and territoriality scuffles; predator avoidance.
Physiology of birds: types of food; mastication; digestion; metabolism, skeletal system; circulatory and nervous system. Role of kidneys in birds.
Bird conservation strategies; sanctuaries and importance of urban zoos in bird life.

Practicals:

1. Identification characteristics and taxonomy of birds to orders and families
2. Anatomy of bones, skull, girdles, spine, vertebrae, feathers, plumage
3. Study of gut contents of birds to understand feeding habits
4. Bird stuffing and preservation of eggs
5. Identification of bird species through feathers and egg shells
6. Beak and claw structures
7. Study of bird songs, recording bird songs, fundamental experimentation to understand bird songs in sensitive and sensorimotor phases
8. Study of flying mechanics through models

Books Recommended

1. Howell, S. N. G. (2010). Peterson Reference Guide to Molt in North American Birds (Peterson Reference Guides. Amazon Co.
2. 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.

MAMMOLOGY	**ZOL-678**	**3(2+1)**

Course Objectives:

The objectives of this course are

1. To impart knowledge to identify mammals and understand their behavior and relationships in their natural habitat.
2. To familiarize the students with economic importance of mammalian fauna of Pakistan.

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. **ACQUIRE** the basic knowledge of the distribution of mammals in the diversified habitats.
2. **UNDERSTAND** their behavior and their relationships to the natural habitats.
3. **ANALYZE** the scientific and economic importance of mammals

Course Contents:

Introduction to mammals; Characteristics, classification, distribution, ecology, reproduction and development, behavior and adaptive strategies of the Mammalia, the mammalian fauna of Pakistan and its scientific and economic importance, techniques of field study, method of collection, and preservation of mammals.

Practicals:

1. Study of common laboratory and zoo mammals
2. Identification and classification of local mammalian species
3. Study of locomotory adaptations
4. Flying mammals and study of bats
5. Collection and preservation of small mammals
6. Identification of mammals through paw patterns

Books Recommended

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

AQUACULTURE AND FISHERIES	ZOL-679	3(2+1)

Course Objectives:

The objectives of this course are

4. To familiarize students about different aquatic species, their rearing facilities and management by using basic techniques.
5. To impart knowledge about site selection and construction and management of fish farm.

Course Outcomes:

Upon successful completion of this course, the students will be able to:

5. Identify fish species on the basis of biological characteristics.
6. Recognize the problems of fish pond and solve them by using different strategies.
7. Acquire knowledge about diagnosis and control of diseases in commercially important fish species.

Course Contents:

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

Fin fish culture: Introduction and role of aquaculture, types of culture systems (Ponds, Raceways, cages, pen, raft and line culture).Site selection, design and construction of fish ponds.Pond problems; aquatic vegetation and their control, fish predators, water quality and management, fish disease and their control.

Types of fish feed, characteristics of artificial feed, methods of feeding, types and use of fertilizers.Artificial fish breeding techniques. Integrated aquaculture. Shell fish culture: Introduction of shrimp and prawn culture, crabs, lobsters and scallops culture etc.Mari-culture: Substrate system, sea water ponds. Aquaculture in fresh and brackish waters.

Practicals:

1. Collection and identification of local fishes (fin fish and shell fish).
2. Different field visits (Natural and Manmade Reservoirs and Fish Hatcheries) to acquire field knowledge about fish farming.
3. Visit and studying of fish pond Components.
4. Visit to fish hatchery and integrated fish farming.
5. Determination of Water quality parameters (Physical, chemical and biological)
6. Fish feed ingredients and formulation of fish feed
7. Artificial Fish breeding
8. Fish market visit
9. Visit to fish feed mill

Books Recommended

1. Pillay, T.V.R., 1999. Aquaculture: Principles and Practices. Fishing News Books, U.K.
2. Ali, S.S., 1993. An Introduction to Freshwater Fishery Biology. University Grants Commission, Islamabad.
3. Parker, R., 1994. Aquaculture Sciences. Delmar Publishers, Washington DC.
4. Bardach, I.E., 1977. Sustainable Aquaculture.
5. Mareel, H., 1971. Text Book of Fish Culture-Breeding and Cultivation of Fish.
6. Purdom, C.E., 1995. Genetics and Fish Breeding.
7. Schorperclaus, W., 1991. Fish Diseases. Oxonian Press Pvt. Ltd. New Delhi, India.

BIOTECHNOLOGY IN AQUACULTURE	**ZOL-680**	**3(2+1)**

Course Objectives:

The objectives of this course are:

1. To equip students with basic and advanced techniques used in fisheries & aquaculture research.
2. To aware students about the importance of biotechnology in the current era.

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. Identify and develop insight into the application of biotechnological advances in aquaculture.
2. Conceptualize the principal bases of biotechnology and emerging issues in aquaculture.
3. Demonstrate various techniques of molecular nature applied for aquaculture development.

Course Contents:

1. **Introduction**
   a) History of Biotechnology in Aquaculture
   b) Biotechnological approaches in Aquaculture

2. **Gynogenesis, Androgenesis and Cloned Populations**
   d. Induction of Gynogenesis and Androgenesis
   e. Performance of Gynogens and Androgens
   f. Reproduction
   g. Monosex Populations
   h. Cloned Populations.
3. **Biochemical and Molecular Markers**
   f. Isozymes and Enzymes.
   g. Restriction Fragment Length Polymorphism.
   h. Single Nucleotide Polymorphisms.
   i. Relative Costs of Different Markers
   j. Relative Effectiveness of Markers
4. **Gene-transfer Technique in Fish**
   Promoters
   Integration
   Transmission of Transgenes
   Transgene Expression of Growth-hormone and Reporter Genes
   Performance of Transgenic Fish
   Disease resistance
5. **Commercial Application ofFishBiotechnology**
   Polyploidy
   Sex Reversal and Breeding
   Genetic Engineering

6. **Combining GeneticEnhancement 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 fromGeneticBiotechnology**
   a. Theoretical Risks
   b. Environmental Risk Data on Transgenic Fish
   c. Common Goals of Aquaculture and Genetic Conservation

Practicals:

1. Study of chromosomes and DNA.
2. Isolation of DNA from fish.
3. Quantitative analyses of sex hormones.
4. Artificial fecundity and induced breeding of cultivable fish.

Books Recommended

1. Sinha, C.R.P. and Srivastava, 1991. Biotechnology and Aquaculture Engineering. Session Oxford and IBH Publishing Co. (Pvt.) Ltd., New Delhi.
2. Pimtani, M., 1992. Aquaculture Research Needs for 2000 AD. Oxford and IBH Publishing Co. (Pvt.) Ltd., New Delhi.
3. Gall, G.A. and Chen, H., 1994. Fish Bioenergetics. Chapman and Hall, London.
4. Schreck, C.B. and Moyle, P.B., 1990. Methods for fish Biology. American Fisheries Soc. Bethesda Maryland, USA.
5. Matty, A.J., 1985. Fish Endocrinology. Timber Press, USA.
6. Pakin, J. and Lensen, E.B. [eds], 1993. Fish Ecophysiology. Chapman and Hall, London.
7. Dunham, R.A., 2011. Aquaculture and Fisheries Biotechnology: Genetic approaches. CABI,UK.
8. Kumar, R., 2010. Biotechnology and Genetics in Fisheries and Aquaculture. Blackwell, USA.
9. Stickney, R.R., 2009. Aquaculture: An introductory Text. CABI Publishing, UK.

LIMNOLOGY	ZOL-681	3(2+1)

Course Objectives:

The objectives of this course are

1. To equip students with basic knowledge of limnology its origin and different types
2. To familiar students with the chemical and biological process occurring in the lakes to support aquatic life.
3. To familiar students with the importance and conservation management of lakes problems and management of fish farm

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. **Acquire**the basic knowledge ofphysico-chemical properties of lentic and lotic environment.
2. **Describe**thermal stratification, management and conservation of lakes.
3. **Illustrate** the basin morphometry and eutrophication of lakes.

Course Contents:

a) **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

b) **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

c) **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. Collection, preservation and study of fauna and flora of various water bodies
4. Field visit to different Lakes.

Books Recommended

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

WILDLIFE ECOLOGY	ZOL-682	3(2+1)

Course Objectives:

The objectives of this course are

1. To elaborate the interaction of wildlife and environment
2. To impart knowledge regarding distribution pattern of wildlife population

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. DEMONSTRATE the ecological assessment and importance of wildlife to certain area.
2. **UNDERSTAND** basic knowledge of freshwater and marinewater ecosystems , their relationship to the physical, chemical, and biological factors of environment

Course Contents:

Introduction to wildlife and their relationship with population. Concepts of wildlife conservation, sustainable development and ecosystem. Biomes: Forest, woodland, shrubland, grassland, desert, and marine biomes. Dispersal and distribution patterns. Effect of industrial and agricultural development and Urbanization on wildlife. Predation and its effect on population. Competition within species. Wildlife diseases and their biological control. Exotic wildlife. Endangered species causes and measures for the conservation. International conventions. Problems contributing to risk of extinction.

Practicals:

5. Visit to protected areas of Pakistan (Captive, Semi-captive and Wild Areas)
6. Ecological Indices
7. Animal Distribution Maps

Books Recommended

1. Smith, R.L. 1980. Ecology and Field Biology. Harper and Row.
2. Nebel, B.J. 1981. Environmental Science. Prentice Hall Inc.
3. Sheehun, *et. al*. 1984. Effects of Pollution on the Ecosystem. John Wiley, London.
4. Robinson, W.L. and Bolen, E.G. 1984. Wildlife Ecology and Management. McMillan, Cambridge.
5. Bailey, J.A.1986. Principles of Wildlife Management. John. Wiley, London.
6. Sexena, M.M. 1990. Applied Environmental Biology, Agro Botanical Publ. India
7. Ringer, P.G. 1991. Long Term Ecological Research. An International Perspective. John Wiley. London
8. Odum, E.P. 1994. Fundamentals of Ecology. W.B. Saunders.
9. Caughley, G. Sinclair, A.R.E. 1994. Wildlife Ecology and Management. Blackwell Science. Massachusetts. USA.

WILDLIFE TECHNIQUES AND DATA ANALYSIS	ZOL-683	3(2+1)

Course Objectives:

The objectives of this course are

1. To enable the student to understand values and objectives of wildlife conservation
2. To understand the wildlife management rules and regulations in Pakistan

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. Acquire basic information regarding data collection in wild animals
2. ANALYSE,interpret and synthesize data and other information about the population of wildlife

Course Contents:

Birds and mammals counting and estimate methods. Counting individual species, counting nesting and flocking birds. Territory mapping techniques. Description and measurements of habitat, habitat analysis and utilization. Capturing methods of animals. Home range measurement. Radio telemetry, density estimates and survival estimation by radio-tracking. Modern techniques for control of environmental pollution in wildlife areas. Processing and presenting data. Measuring average, variability, correlations and regression.

Practicals:

1. **Counting of nests and flock of birds in specific area.**
2. **Population Studies of some Reptiles, Birds and small Mammals.**
3. **Trapping and marking method**
4. **Report on Endangered species**

Books Recommended

1. Riney, T. 1982. Study and Management of Large Mammals. John Wiley and Sons. Brisbane.
2. Fowler, J. and Cohen, L. 1986. Statistics for Ornithologists. BTO, Tring, Herts.
3. Kenward, R.E. 1987. Wildlife radio-tagging. Equipment, Field Techniques and Data Analysis. Academic Press Limited. London.
4. White, G.C. and Garrott, R.A. 1990. Analysis of Wildlife Radio-tracking Data. Academic Press Limited. London.
5. Bibby, C.J. and Burgess, N.D. 1992. Bird Census Techniques. Academic Press Limited. London.
6. Caughley, G. Sinclair, A.R.E. 1994. Wildlife Ecology and Management. Blackwell Science. Massachusetts. USA.

VECTOR BIOLOGY	ZOL-684	3(2+1)

Course Objectives:

The objectives of this course are

1. To familiarize the students about vectors of medical and veterinary importance
2. To Know biology, morphology, pathogenesis and life cycle of vectors of medical and veterinary importance

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. Acquire basic information regarding parasites of mammals and birds
2. Understand life cycle of vectors and methods to control pests

Course Contents:

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 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.

Practicals:

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

Books Recommended:

1. Robert, LS, and Jonovy, Jr. 1996. Foundations Parasitology 5th edition. Wan Brown Publishers, Chicago. USA.

2. Urquhart, GM, Armour, J, Duncan, JL, Dunn, AN, Jennings, FW. 1995. Veterinary Parasitology. ELBS. USA.
3. Smyth, JD. 1994. Introduction to animal Parasitology. 3rd edition. Cabridge University Press. UK

POPULATION GENETICS	ZOL-685	Credit hrs:3(2+1)

Course objectives:

Course objectives are;

- To know about genetic basis of population
- To understand dynamic nature of population
- To give knowledge of environment role on genetics of a species

Course Outcomes:

The students will learn about;

- Population genetics
- Variation and causes of variation in population
- Role of environment on genetics of a species

Course content:

Hardy-Weinberg Equilibrium. Frequencies of gene and genotypes. Changes of gene frequency: migration, mutation, selection. Study of small populations: changes of gene frequency under simplified conditions, less simplified conditions, pedigreed population and in breeding; metric characters. Population means, average effects, breeding value, dominance deviation, interaction deviation. Genotypic and environmental variance. Genetic components of variance. Environmental variance. Genetic and statistical background of population genetics, genetic diversity in Mendelian population, random mating, assortative mating, inbreeding, coadaptation, the causes of evolution (random genetic drift, mutation, migration, natural selection, maintenance of genetic polymorphism), polygenic inheritance (artificial selection, heritability, analysis of genetic variation), population genetics and speciation.

Practicals:

1. Demonstration of Hardy-Weinberg Equilibrium in laboratory populations and natural populations.
2. Estimation of inbreeding factors.
3. Compartmentation of variance.

Books Recommended:

1. Falconer, D.S., 1989. Introduction to Quantitative Genetics, Longman, London.
2. Li. C.C. 2005: Population Genetics, University of Chicago Press.
3. Crow, J.F. and Kimura, 2000. An Introduction to Population Genetics Theory, Harper & Row , New York.

BIO/REMEDIATION	**ZOL-686**	**3(2+1)**

Course objectives:

The purpose of this course is to give knowledge of;

- Bioremediation technology that employs biological agents (microorganisms and plants) to treat hazardous contaminants in soil, and water; can lead to the permanent removal of contaminants from the environment; and may be inexpensive when compared to conventional techniques.

Course Outcomes:

Course learning outcomes are to:

1. Understand the nature and importance of bioremediation
2. Know the influence of site characteristics to bioremediation rates
3. Have knowledge of the impacts of contaminant to bioremediation process
4. Understand the use of bioremediation in real world applications

Course contents:

Current remediation practices, benefits of Bioremediation, The soil environment; Fate and transport of contaminants in soils and water bodies Chemical transformations, Microbial ecology and metabolism Biodegradation of common contaminant compounds In situ bioremediation strategies, Solid phase bioremediation, Slurry phase bioremediation and Vapour phase bioremediation, Advantages and disadvantages of bioremediation compared to nonbiological processes. Factors affecting choice of in situ or ex situ processes; bioavailability of pollutant. Biodegradation of specific contaminants (e.g. diesel fuel, polychlorinated biphenyls, dyestuffs, aromatic and polyaromatic hydrocarbons)

Practicals:

- Assessment of biodegradability
- biostimulation vs bioaugmentation
- mineralization vs. partial degradation
- factors affecting microbial activity (choice of electron acceptor, toxicity of pollutant, C/N/P ratio, co-substrates, soil humidity, pH and temperature)

Books Recommended:

1-Biodegradation and Bioremediation; 21june 2004

2-Applied Bioremediation and Phytoremediation A Singh O P Ward (Eds)

BIOLOGY AND CONTROL OF VERTEBRATE PESTS	**ZOL-687**	**3(2+1)**

Course Objectives:

- To impart the biology of vertebrate pests

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

Course Outcomes:

The students will learn about;

- The modern concepts of pests and their sustainable management
- The eco-friendly techniques used in vertebrate pest management

Course Contents:

Role of vertebrate pests as vectors of zoonotic diseases. Importance of vertebrate pest management. Biology and control of common vertebrate pests in agro-ecosystems of Pakistan. Types of crops inflicted with damage and economic losses by vertebrate pests. Impact of climatic changes on pest 97 efficiencies. Strategic pest management measures: Non-chemical and chemical measures. Pest resistance to chemicals. Estimation methods of damage on crops. Recommended and sustainable management measures in economically important crops for vertebrate pests. Induction of communicable and environmentally hazardous diseases by vertebrate pests and their management

Practicals:

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

Books Recommended:

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