



DEPARTMENT OF BASIC AND APPLIED ZOOLOGY
SHAHEED BENAZIR BHUTTO UNIVERSITY SHERINGAL
DIR UPPER, KPK, PAKISTAN

REVISED CURRICULUM FOR BS (4-YEAR) IN ZOOLOGY DEGREE AS PER HEC UNDERGRADUATE POLICY 2023

PROGRAM OFFERING APPROVED:

- **BS (SINGLE MAJOR) & ASSOCIATE DEGREE**
- 4 years (8 Semesters) for BS (4 Years) and Associate Degree (2 Years) duration with each semester of 16-18 weeks
- Each semester having 15-18 Credit Hours,
- Number of courses per semester: 5-6
- Total credit hours required for BS (4-Years) in Zoology are 120-144 while in associate degree are 72-81 Cr. Hours.

Break up approved:

Course Category (As per New Policy)	Required Credit Hours	Number of Courses	Credit Hours
General Education	30	12	30
Allied	12	04	12
Major	Minimum 72	27	85
Field Experience/Internship	03	-	03
Capstone Project	03	-	03
Total		45	133

SCHEME OF STUDIES (Overall + Semester wise break up) FOR BS DEGREE IN ZOOLOGY

BS FIRST YEAR - SEMESTER-I			
Course Category	Course Code	Course Title	Credits
General Edu.	ENG- 311	Functional English	03
General Edu.	ISL-312	Islamic Studies / Ethics (only for Non-Muslims)	02
General Edu.	QRZ-311	Quantitative Reasoning-I (Exploring Quantitative Skills)	03
Allied	BOT-314	Botany-I (Diversity of Plants)	3(2+1)
Allied	CHEM-151	Inorganic Chemistry	3(2+1)
Major	ZOO-316	Animal Diversity-I (Invertebrates)	4(3+1)
Total Credits			18

BS FIRST YEAR - SEMESTER-II			
Course Category	Course Code	Course Title	Credits
General Edu.	ENG - 321	Expository writing	03
General Edu.	PS-322	Ideology and Constitution of Pakistan	02
General Edu.	QRZ-321	Quantitative Reasoning-II (Tools for quantitative reasoning)	03
Allied	CHEM-161	Organic Chemistry	3(2+1)
Major	ZOO-325	Cell Biology	3(2+1)
Major	ZOO-326	Animal Diversity-II (Chordates)	4(3+1)
Total Credits			18

BS SECOND YEAR - SEMESTER III			
Course Category	Course Code	Course Title	Credits
General Edu.	CHEM-	Natural Sciences (Environmental Chemistry)	3(2+1)
General Edu.	PS-425	Civics and Community Engagement	02
General Edu.	ISL-311	Arts (Islamic History)	02
Allied	BOT-434	Botany-II (Plant Physiology and ecology)	3(2+1)
Major	ZOO- 435	Animal Behavior	4(3+1)
Major	ZOO-436	Animal Form and Function-I	4(3+1)
Total Credits			18

BS SECOND YEAR - SEMESTER-IV			
Course Category	Course Code	Course Title	Credits
General Edu.	BCS-323	ICT	3(2+1)
General Edu.	MGT-443	Entrepreneurship	02
General Edu.	LLB 441	Human Rights	02
Major	ZOO- 444	Biological Techniques	4(2+2)
Major	ZOO- 445	Biochemistry-I	3(2+1)
Major	ZOO- 446	Animal Form & Function-II	4(3+1)
Total Credits			18

*The affiliated colleges may offer “Introduction to Sociology” in lieu of the course “Human Rights”.

BS THIRD YEAR - SEMESTER-V			
Course Category	Course Code	Course Title	Credits
Major	ZOO- 551	Economic Zoology	3(2+1)
Major	ZOO-552	Biochemistry-II	3(2+1)
Major	ZOO-553	Physiology	4(3+1)
Major	ZOO-554	Ecology	3(2+1)
Major	ZOO-555	Evolution	2(2+0)
Major	ZOO-556	Principles of Systematics	3(2+1)
Total Credits			18

BS THIRD YEAR - SEMESTER-VI			
Course Category	Course Code	Course Title	Credits
Major	ZOO-561	Research Methodology	2(2+0)
Major	BST-562	Biostatistics	3(2+1)
Major	ZOO-563	Developmental Biology	4(3+1)
Major	ZOO-564	Genetics	4(3+1)
Major	ZOO-565	Zoogeography and Palaeontology	3(2+1)
Total Credits			16

BS FOURTH YEAR - SEMESTER-VII			
Course Category	Course Code	Course Title	Credits
Major	ZOO-671	Wildlife	3(1+2)
Major	ZOO-672	Molecular Biology	3(2+1)
Major	ZOO-673	Field Experience/Research Work	3
Major	Optional*	Elective-I	3(2+1)
Major	Optional*	Elective - II	3(2+1)
Total Credits			15

BS FOURTH YEAR - SEMESTER-VIII			
Course Category	Course Code	Course Title	Credits
Major	ZOO-681	Capstone Project/Thesis	3
Major	Optional*	Elective-III	3(2+1)
Major	Optional*	Elective-IV	3(2+1)
Major	Optional*	Elective-V	3(2+1)
Major	Optional*	Elective-VI	3(2+1)
Total Credits			15

***The courses will be selected from list of special/elective courses.**

Note:

Courses included in the General Education Category are designed by the respective departments including their course codes, credit hours and titles (reflected in the scheme of studies). Any change (if approved by respective departments) in the codes of general category courses will be updated accordingly.

SCHEME OF STUDIES (SEMESTER WISE BREAK UP) AND COURSE CONTENT FOR BS (4 YEARS) AND ASSOCIATE DEGREE IN ZOOLOGY

Year I Semester-I			
Course Category	Course Code	Course Title	Credits
General Edu.	ENG- 311	Functional English	03
General Edu.	ISL-312	Islamic Studies / Ethics (only for Non-Muslims)	02
General Edu.	QRZ -311	Quantitative Reasoning-I (Exploring Quantitative Skills)	03
Allied	BOT-314	Botany-I (Diversity of Plants)	3(2+1)
Allied	CHEM-151	Inorganic Chemistry	3(2+1)
Major	ZOO-316	Animal Diversity-I (Invertebrates)	4(3+1)
Total Credits			18

General Edu.	ENG - 311	Functional English	03
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Course Outline:

Basics of Grammar: Parts of speech and use of articles, Sentence structure, Active and passive voice, Practice in unified sentence, Analysis of phrase, clause and sentence structure, Transitive and intransitive verb, Punctuation and spelling Comprehension: Answers to questions on a giventext

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

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

Translation skills: Urdu to English

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

Presentation skills: Introduction to presentations and deliberations

Note: Extensive reading is required for vocabulary building

Reference Materials

1. Thomson, A.J., Martinet, A.V. Practical English Grammar and Exercises Latest Ed. Oxford University Press
2. Boutin, M-C., Brinand, S., Grellet, F. Writing. Intermediate and Supplementary Skills. Oxford Fourth Impression Latest Edi.
3. Tomlinson, B., Ellis, R. Latest Edition. Reading. Upper Intermediate. Oxford SupplementarySkills. Third impression

General Edu.	ISL -312	Islamic Studies	02
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Course Contents

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

Study of Selected Text of Holy Quran: Verses of Surah Al-Baqra Related to Faith (Verse No-284-286), Verses of Surah Al-Hujrat Related to Adab AlNabi (Verse No-1-18), Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11), Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77), Verses of Surah Al-Inam Related to Ihkam(Verse No-152-154)

Study of Selected Text of Holy Quran: Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.), Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment, Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)

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

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

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

Selected Study from Text of Hadith

Introduction to Islamic Law & Jurisprudence: Basic Concepts of Islamic Law & Jurisprudence; History & Importance of Islamic Law & Jurisprudence; Sources of Islamic Law & Jurisprudence; Nature of Differences in Islamic Law; Islam and Sectarianism

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

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

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

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

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

General Edu.	ISL-312	Ethics (Only for Non-Muslims)	02
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Ethics (for Non-Muslims only)

Course Outlines

Defining Ethics; and its relation to Philosophy, Morality as Compared with other Normative Subjects, Characteristics of Moral Principle, The Purposes of Morality, Cultural Relativism, Cultural Relativism as a theory of Morality, Judging a Cultural Practice to be Undesirable, Ethical Subjectivism, The First Stage: Emotivism, Emotivism, Reason and Moral Facts, The Presumed Connection between Morality and Religion, The Natural Law Theory, The Utilitarian Approach: a Revolution in Ethics:, Mill's Utilitarianism: a modified version, Implications of Utilitarianism, Is Happiness the Only Thing That Matters? Are Consequences All That Matters?, Defense of Utilitarianism, Kant and the Categorical Imperative, Absolute Rules and the Duty Not to Lie, Kant and the Respect for Person, Retribution and Utility in the Theory of Punishment, The Ethics of Virtue and the Ethics of Right Action, Some Advantages of Virtue Ethics, Business Ethics, The Nature of Business Ethics, The Ethics of Advertising and Green Issues in Business, Environmental Ethics, Arguments for and against the Use and Exploitation of the Natural Environment, Bioethics---Ethical Issues in Medicine, Confidentiality, Guilt and Innocence in Treating Patients, Euthanasia, Ethics and Behavior Control, Genetics

Recommended Books

1. Rachels, J., & Rachels, S. (2012). The Elements of Moral Philosophy 7e. McGraw Hill. ISBN: 0-07-247690-7
2. Loue, S. (2007). Textbook of research ethics: Theory and practice. Springer Science & Business Media.
3. Hendin, J. (1999). The Right Thing to Do. Feminist Press at CUNY.
4. Pojman, L. P., & Fieser, J. (2016). Cengage advantage ethics: Discovering right and wrong. Cengage Learning.
5. Vaughn, L. (2015). Doing ethics: Moral reasoning and contemporary issues. WW Norton & Company

General Edu.	QRZ -311	Quantitative reasoning-I (Exploring Quantitative Skills)	03
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WEEKLY BREAKDOWN

MODULE-I Exploring Importance of Quantitative Reasoning Skills (1 WEEK):

1. What is quantitative reasoning?
2. Overview of Contributions of Mathematicians especially Muslim scholars.
3. Different types of Standard numbers and their role in practical life scenarios.

MODULE-II Problem Solving Techniques (2.5 WEEKS):

1. Understanding relationship between parts and whole
2. Practical life scenarios involving units and rate
3. Unit Analysis as a problem-solving tool.

MODULE-III Number and the Universe (2.5 WEEKS)

1. Understanding our World through numbers.
2. Dealing with very big and small numbers & their applications.
3. Understanding uncertainty and its applications.

MODULE- IV Financial Issues (3 WEEKS)

1. Money management (profit, loss, discount, taxation, and other scenarios involving percentage)
2. Money management in practical life scenarios like investments and federal budget, simple and compound interest, Saving plans, and economy.

MODULE-V Exploring Expressions (2 WEEKS)

1. Practical scenarios involving expressions.
2. Equating two expressions in one variable & using it to solve practical problems.

MODULE-VI Exploring Beauty in Architecture and Landscape (2 WEEKS)

1. Introduce geometrical objects through architecture and landscape.
2. Dealing with social and economic issues involving geometrical objects.

MODULE-VII Venn Diagrams (1 WEEK)

Venn diagrams and their applications.

TEACHER MANUAL

[Quantitative Reasoning Courses\Quantitative Reasoning Teacher Manual - Sept 2021 - HEC.pdf](#)

RECOMMENDED RESOURCES:

1. Using and understanding mathematics, 6th edition by Jeffrey Bennet and William Briggs, published by Pearson USA.
2. Mathematical thinking and reasoning 2008 by Aufmann, Lockwood, Nation & Clegg published by Houghton Mifflin Company USA.
3. Precalculus by Robert Blitzer, 5th edition published by Pearson USA.
4. Precalculus Graphical, Numerical, Algebraic 8th edition by Franklin D. Demana, Bert K. Waits, Gregory D. Foley & Daniel Kennedy published by Addison Wesley USA.
5. Precalculus Mathematics for Calculus, 6th edition by James Stewart, Lothar Redlin and Saleem Watson published by Brooks/Cole Cengage Learning USA.
6. GRE Math Review https://www.ets.org/s/gre/pdf/gre_math_review.pdf
7. OpenAlgebra.com A free math study guide with notes and YouTube video tutorials

Allied	BOT-314	Botany – I (Diversity of Plants)	3(2+1)
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Specific Objectives of course: To introduce the students to the diversity of plants and their structures and significance.

Course Contents

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

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

Practicals:

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

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

Allied	CHEM-151	Inorganic Chemistry	3(2+1)
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Course Objectives:

Students will acquire knowledge about the key introductory concepts of chemical bonding, acid base chemistry, and properties of p-block elements as well as using this knowledge for qualitative and quantitative analysis of inorganic compounds during laboratory work.

Course Contents:

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

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

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

Practicals:

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

Recommended Books:

1. Inorganic chemistry, principles of structure and Reactivity 4th Ed. By J.E Huheey, E.A. Keiter and R.L Keiter, Harper international.
2. Basic inorganic chemistry by F.A Cotton and G.Willinson, Advanced chemistry 5th Ed. F.A cotton john wiley and sonsn New York.
3. Housecroft.C. Sharpe. A.G. Inorganic Chemistry (2nd Edition).2004. PrenticeHall
4. House.J.E. Inorganic Chemistry.2008. Academic Press

Major	ZOO-316	Animal Diversity-I (Invertebrates)	4(3+1)
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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 Systems; 4. To provide the description of mode of Reproduction and Development 5. To provide the information of their economic and ecological importance

Course Contents:

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

1. INTRODUCTION

a. Classification of Organisms:

2. ANIMAL-LIKE PROTISTS: THE PROTOZOA

a. Characteristics. b. Classification up to class c. Symbiotic Life-styles. d. Locomotion in protozoa, e. Nutrition and Reproduction; f. Economic importance of protozoa. g. Parasitism in protozoa, h. Protozoa and human diseases

3. MULTICELLULAR AND TISSUE LEVELS OF ORGANIZATION

Phylum Porifera

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

Phylum Cnidaria (Coelenterate)

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

Phylum Ctenophore;

a. Characteristics, body organization

4. THE TRIPLOBLASTIC ORGANIZATION

PHYLUM PLATYHELMINTHES (ACOELOMATE)

a. Characteristics. b. Classification up to class, c. The Free-Living Flatworms and the Tapeworms, parasitic adaptations in platyhelminths

5. PHYLUM ASCHELMINTHS (PSEUDOCOELOMATE)

a. General Characteristics, b. Classification up to class, c. Helminths and human diseases,

COELOMATIC ORGANIZATION

6. PHYLUM ANNELIDA

a. General Characteristics, b. Metamerism and Tagmatization, c. Classification up to Class. d. Locomotion, Feeding and the Digestive system, Gas Exchange and Circulation, e. Nervous and Sensory Functions, Excretion, f. Reproduction; Regeneration,

7. PHYLUM MOLLUSCA

a. General Characteristics, b. Classification up to class. c. Shell, Feeding, Digestion, Gas Exchange, Locomotion, d. Reproduction and Development, e. Economic importance

8. PHYLUM ARTHROPODA

a. General Characteristics, b. Classification up to class. c. Biological success; d. Insects mouth parts, e. Economic importance of insects, f. Reproduction: Development, Metamorphosis; g. Economic importance of crustaceans.

9. PHYLUM ECHINODERMS

a. General Characteristics, b. Classification up to class. c. Reproduction; Regeneration, Larval forms.

Practical:

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

1. Study of Euglena, Amoeba, Entameba, Plasmodium, Trypanosome, Paramecium as representative of animal like Protists.

2. Study of prepared slides of sponges, spicules of sponges, and their various body forms. Study of representatives of classes of Phylum Porifera.

3. Study of principal representatives of classes of Phylum Coelenterate.

4. Study of principal representatives of classes of Phylum Platyhelminthes.
5. Study of representatives of phylum Rotifer, Phylum Nematode.
6. Study of principal representatives of classes of Phylum Mollusca.
7. Study of principal representatives of classes of Phylum Annelida.
8. Study of principal representatives of classes of groups of Phylum Arthropoda
9. Study of representatives of classes of phylum Echinodermta.
10. Preparation of permanent mount of Leucosolenia, Obelia, Hydra, Proglottid of Tapeworm, Parapodia of Nereis and Daphnia. Drawing and labeling.
11. Preparation of permanent slide of mouthpart of insects (after dissection). Drawing and labeling.
12. How to make grade-wise series for preparation of temporary and permanent slides.
13. Field study tour to Insectary, Insect museum, Invertebrates aquaria etc

Recommended Principal Reference Book:

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

BOOKS FOR PRACTICAL

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

Year 1 Semester-II			
Course Category	Course Code	Course Title	Credits
General Edu.	ENG - 321	Expository writing	03
General Edu.	PS -322	Ideology and Constitution of Pakistan	02
General Edu.	QRZ -321	Quantitative reasoning-II (Tools for quantitative reasoning)	03
Allied	CHEM-161	Organic Chemistry	3(2+1)
Major	ZOO-325	Cell Biology	3(2+1)
Major	ZOO-326	Animal Diversity-II (Chordates)	4(3+1)
Total Credits			18

General Edu.	ENG - 321	Expository writing	03
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1. COURSE

CONTENTS Unit

1: Self Reflection

- Introduction to the basics of the writing process
- Introduction to the steps of essay writing
- Students practice prewriting activities like brainstorming, listing, clustering and free writing
- Students practice outlining of the essay

Unit 2: Personalized Learning

- Students reflect on their learning process
- Group discussion about learning styles based on the reading material provided to students
- Introduction to personalized learning
- Students practice goal setting
- And create a learning plan
- Introduction to the structure and significance of oral presentations
- Class discussion about content selection and slide preparation for oral presentations
- Peer review through a gallery walk

Unit 3: Critical Reading Skills

- Introduce authentic reading (DAWN newspaper and non-specialist academic books/texts)
- Conduct classroom reading activities (using strategies skimming, scanning, SQW3R, previewing, annotating, detailed reading and note-taking) using standard tests (TOEFL and IELTS) Assign books/articles/reports for their individual home assignments.
- Share model review reports and annotated bibliographies

Unit 4: Community Engagement

- Showing short documentaries to students on global environmental issues
- Student-led brainstorming on local versus global issues
- Teacher-led introduction to the unit assignment (using assignment sheet)
- Readings (or other input sources - video, social media) from local news on possible community issues, letters to editor and op-eds
- Identify research problems
- Begin drafting research questions based on the problems identified
- Facilitating students on developing research questions in groups
- Draft interview or survey questions for community research (in English or L1)
- In-class role-plays of interviews with community members
- Engaging students in critical reading and reflection on the issues found in different communities
- In-class work on understanding interview information, how to present interview or survey information
- Refining the research questions, designing a detailed research plan in groups, dividing the tasks and deciding the timeline for the completion of the project
- Exposure to interview questions and interviewing techniques to develop an in-depth understanding of the issues

- Continued group work on report outline
- In-class lecture and group work on analyzing information
- Discussion based on translating the data from the source language to the target language (English)
- Sharing the experience of field work in class orally
- Teacher feedback on outline of report (globally to entire class and individually to groups as needed)
- Revisions to oral report in groups Engaging students in individual structured reflective writing based on their experience of working on the project
- Sharing their reflective writing to learn about each other's points of view
- Think-pair-share the findings (group similar issues)
- Individual writing of reflection on the community engagement project and their role in the group
- Brainstorm using creativity for dissemination - cartoons, advertisements for university magazine or beyond, creating posts for FB
- Summarizing/ converting the report to a letter to the editor to highlight the problems explored and their possible solutions (homework - connecting activity for week 11 - Unit 5)

Unit 5: Letter to the Editor

- Teacher-directed instruction on genres (types) of writing focusing on letter-writing
- Model-practice-reflect: Introduce types of letters comparing the use of formal and informal vocabulary and phrases in each type
- Introduce the format and purpose of the letter-to-editor explaining with the help of an actual letter from a local newspaper
- Group reading of sample letters-to-editor selecting ones that deal with issues familiar to the students
- Invite a guest lecturer (local newspaper editor or faculty from journalism) to talk about what issues are currently raised in letters-to-editors and what are editors' criteria to accept letters for publication
- Work in groups to continue reviewing letter samples, analyzing the structure of letters
- Each group identifies an issue they want to write about and give a brief oral presentation to the class
- Submit the first draft of letters (to the teacher and peer-review group)
- In-class peer review of drafts using a checklist focusing on content and structure DUE:
- First draft of letter (to teacher and peer review group)
- Groups revise first draft of letter
- Differentiate among revision, proofreading and evaluation (as sub stages of finalizing documents)
- Discuss critically the draft-letter and implement the 'revision' phase of writing Reading of (DAWN) newspaper and sharing important letters (to editors) on local issues
- Groups revise second draft of letter Explicit instruction (paragraph structure, syntax, diction, grammar, and mechanics)
- Classroom discussion/debrief of activity Discuss critically and finalize the draft-letter as the last phase of writing

Teacher Manual & Suggested Reading

[Expository Writing Course Outline - Sept 2021 - HEC.pdf](#) [Detailed Courses - Expository Writing - Sept 2021 - HEC.pdf](#)

[Expository Writing Teachers Manual - Sept 2021 - HEC.pdf](#)

General Edu.	PS -322	Ideology and Constitution of Pakistan	02
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I. CREATION OF PAKISTAN

a) Ideology: Conservative and liberal perspectives

- i) Significance before and after independence
- ii) Quaid-e-Azam's vision about Pakistan

b) POLITICAL DYNAMICS

- i) Democracy and authoritarianism
- 1. **Political Culture:** Parties and pressure groups
- iii) **National integration:** Resources and distribution
- iv) Governance and civil rights

II. ECONOMY

- i) Agro-industrial growth
- ii) Irrigation projects
- iii) Economic development and poverty alleviation
- iv) Foreign aid and economic stability
- v) Characteristics of developing countries

III. FOREIGN POLICY

Determination of foreign policy, national interests, post-cold war environments of Pakistan: new world, order and nuclear non-proliferation

IV. ENVIRONMENT; definition and dimensions, management and natural resources
environmental pollutions: industrial; agricultural; land; water; air and space environmental protection

V. POPULATION: Characteristics: Rural; urban; gender; age groups; and population growth, economic indicators: employment; education health and poverty, migration

VI. SOCIETY: Definitions, characteristics: multilingual, multi-ethnic and parochial, social stratification and social mobility, social problems

VII. CULTURE: Definitions, social organization; kinships; family; clan and tribe, material and non-material cultures, cultural institutions

Books Recommended

1. Shahid Javed Burki, State and Society in Pakistan, The Macmillan Press Ltd. 1980 (Reprint, 1997)
2. Wayne Wilcox The Emergencies of Bangladesh, Washington American Enterprise Institute of Public Policy Research 1972
3. Safdar Mehmood Pakistan Kayyum Tooda Idara-Saqafat-e-Islamia, Club Road Lahore
4. Tahir Amin National Movement of Pakistan Institute of Policy studies Islamabad.
5. Lawrence Ziring, Enigma of Political Development, Wm Dawson and son Ltd. Cannon House Falkstone. Kent England 1980
6. Waseem Ahmad Pakistan under Marshal Law, Lahore 2002

General Edu.	QRZ -321	Quantitative reasoning-II (Tools for quantitative reasoning)	03
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WEEKLY BREAKDOWN

MODULE-1 Exploring Graphical Information

1. Investigating relationships between variables.
2. Exploring tools to find relationship between variables, Resources, and population growth: dealing with economic, environmental, and social issues.

MODULE-2 Building blocks of a plane

1. Graphical and analytical approaches to solve a problem.
2. Applications of graphical & analytical approaches to solve social & economic problems.

MODULE-3 Exploring inequalities

1. Understanding inequalities around us
2. Dealing with practical problems involving inequalities in different disciplines

MODULE-4 Comparing quantities

1. Golden ratio in sculptures
2. Comparison of statements and their use in social and economic problems,
3. Sequence

MODULE-5 Thinking Logically

1. Survival in the modern World,
2. Propositions and truth values,
3. Categorical proposition, and its applications

MODULE-6 Understanding Data

1. Methods to explore and summarize data, drawing graphs and identifying misleading graphs,
2. Methods to discuss the basic characteristics of any datasets, like finding a most representative value in a data, and methods to measure the amount of spread of a data,
3. Methods to measure degree of relationship among variables, finally this module includes methods to Count the odds.

TEACHER MANUAL

[Quantitative Reasoning Courses\Quantitative Reasoning Teacher Manual - Sept 2021 - HEC.pdf](#)

RECOMMENDED RESOURCES

1. Using and understanding mathematics, 6th edition by Jeffrey Bennet and William Briggs, published by Pearson USA.
2. Mathematical thinking and reasoning 2008 by Aufmann, Lockwood, Nation & Clegg published by Houghton Mifflin company USA.
3. Pre-calculus by Robert Blitzer 5th edition published by Pearson USA.
4. Pre-calculus Graphical, Numerical, Algebraic 8th edition by Franklin D. Demana, Bert K. Waits, Gregory D. Foley & Daniel Kennedy published by Addison Wesley USA.
5. Pre-calculus Mathematics for Calculus, 6th edition by James Stewart, Lothar Redlin and Saleem

Allied	CHEM-161	Organic Chemistry	3(2+1)
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Course Objectives:

Students will acquire knowledge about basic concepts of organic chemistry, chemistry of hydrocarbons and functional groups and the mechanism of organic reactions. Such information will be useful for qualitative analysis and synthesis of organic compounds.

Basic Concepts of Organic Chemistry:

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

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

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

Practicals:

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

Books recommended:

1. Organic chemistry for B. Sc by M. Younas
2. Organic chemistry by B. S. Bhal
3. Clayden.J, Greeves N, Warren.S and Wothers.P.Organic Chemistry.2008. Oxford University Press
Klein.D.R.Organic Chemistry as a Second Language.2009. Wiley

Major	ZOO-325	Cell Biology	3(2+1)
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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: 29 1. ACQUIRE the basic concepts of cell biology. 2. UNDERSTAND the metabolic processes of cells in terms of cellular organelles, membranes, and biological molecules. 3. ABILITY to understand the role of macromolecules regulating cellular processes. 4. FORMULATE the critical thinking skills and knowledge on cell.

Course Outline:

1. Introduction cell structure and function

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

2. Cell membranes

- a. Structural models
- b. Chemical composition and function

3. Cell Organelles (structure and function)

- a. Endoplasmic reticulum
- b. Golgi Bodies
- c. Mitochondria
- d. Lysosomes

e. Peroxisomes

f. Ribosome

4. Nucleus

a. Structure and function

b. Nuclear membrane

c. Chromatin

5. Cytoskeleton

a. Structure and types

b. Function of cytoskeleton

6. Cellular transport

a. Diffusion and osmosis

b. Facilitated and active transport

c. Endocytosis and exocytosis

7. Cellular reproduction

a. Cell cycle

b. Mitosis

c. Meiosis

Practical:

1. Microscopy

2. Staining techniques (Gram staining)

3. Identification of cell organelles (prepared slides)

4. Preparation of temporary whole mount.

5. Preparation of permanent whole mount.

6. Squash preparation of onion root tip for mitotic stages.

7. Study of mitotic and meiotic stages (prepared slides)

Books Recommended:

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

2. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey C. Martin. 2016. Molecular Cell Biology. W. H. Freeman Publishers, Scientific American Inc.

3. Geoffrey M.C., Robert E.H. 2007. The cell: A Molecular Approach, Sinauer Associates, INC.

4. Karp, J. 2005. Cell and Molecular Biology, Concepts and Experiments, Jhon Wiley and Sons, INC.

5. De Robertis, E. D. P. 2017. Cell and Molecular Biology, 8th edition, Lea & Febiger, New York.

Major	ZOO-326	Animal Diversity-II (Chordates)	4(3+1)
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Course Objectives:

The objectives of the course are: - 1. To enable students to understand the Taxonomic characteristics of protochordates and chordates. 2. To impart knowledge about the phylogenetic relationships of protochordates and various classes of chordates. 3. To develop critical thinking about phylogeny of chordates with respect to their physiological adaptations, behavior and ecology.

Course Outline:

1. Protochordates

a. Classification of protochordates.

b. Structure, anatomy and organ systems of Acorn worms, Urochordates and Cephalochordates

c. Reproduction; life histories and metamorphosis of protochordates.

2. Fishes:

a. Vertebrate Success in Water.

b. Classification of Chondrichthyes, Osteichthyes, Dipnoi and Holocephalli

c. Locomotory adaptations, nutrition and the digestive system, circulation, gas exchange, nervous and sensory functions, excretion and osmoregulation, reproduction and development of Chondrichthyes (Scoliodon) and Osteichthyes (Cyprinus carpio and Wallago attu).

3. Amphibians:

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

4. Reptiles:

- a. The First Amniotes and cladistic interpretation of the amniotic lineage. General characteristics of reptiles.
- b. Characteristics of Order Testudines or Chelonia, Rhynchocephalia, Squamata, and Crocodilia
- c. Adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange and temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction and development of chelonia, squamata, Rhynchocephalia and crocodilian.

5. Birds:

- a. Classification, Feathers, flight and endothermy.
- b. Phylogenetic relationships; ancient birds and the evolution of flight.
- c. Diversity of modern birds.
- d. Adaptation in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and regulation, nervous and sensory systems, excretion and osmoregulation, reproduction and development.
- e. Migration and navigation.

6. Mammals:

- a. Classification, Specialized teeth, endothermy, hair and viviparity.
- b. Diversity of mammals.
- c. Adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, behavior, reproduction and development.

Practicals:

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

Text and Reference Books:

1. Campbell, N.A. Biology. Latest Edition. Menlo Park, California Benjamin/Cummings Publishing Company, Inc.
2. Miller, S.A. and Harley, J.B.. Zoology, Latest Edition (International) Singapore: McGraw Hill.
3. Miller, S.A. 2002. General Zoology Laboratory Manual. 5th Ed. (International), Singapore: McGraw Hill.
4. Hickman, C.P., Roberts, L.S. and Larson, A. Integrated Principles of Zoology, 14th Edition (International), 2009. Singapore: McGraw-Hill.
5. Pechenik, J.A. Biology of Invertebrates, 4th Edition (International), 2000. Singapore: McGraw Hill.

Year 2 Semester 3 rd			
Course Category	Course Code	Course Title	Credits
General Edu.	CHEM-434	Natural Sciences (Environmental Chemistry)	3(2+1)
General Edu.	PS-425	Civics and Community Engagement	02
General Edu.	ISL-311	Arts (Islamic History)	02
Allied	BOT-434	Botany-II (Plant Physiology and ecology)	4(3+1)
Major	ZOO- 435	Animal Behavior	03
Major	ZOO-436	Animal Form and Function-I	4(3+1)
Total Credits			18

General Edu.	CHEM-434	Natural Sciences (Environmental Chemistry)	3(2+1)
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Course Objectives: Students will be able to acquire knowledge and develop understanding about the fundamental principles of environmental chemistry and different types of pollutions. Such information will be useful in studying and solving pollution related issues and experiments in the laboratory.

Course Contents:

Atmospheric Pollution: The atmosphere, composition, temperature and pressure profile, role of free radicals in the atmosphere, temperature inversion and photochemical smog, particulate matter in the atmosphere, Industrial pollutants, atmospheric aerosols, acid-rain major sources, mechanism, control measures and effects on buildings and vegetation, global warming, major greenhouse gases, mechanism, control measures and global impact, the stratospheric ozone–the 17 ozone hole, CFCs, ozone protection, biological consequences of ozone depletion.

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

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

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

Recommended Books:

1. Baird, C. and Cann, M., Environmental Chemistry, 5 th ed., W. H. Freeman & Company, (2012).
2. Dara, S. S. and Mihsra, D. D., A Text Book of Environmental Chemistry and Pollution Control, 9 th ed., S. Chand & Co. Ltd., (2004).
3. Singhi, R. and Singh, V., Green Chemistry for Environmental Remediation, John-Wiley & Sons, Inc., (2011).
4. Holloway, A. M. and Wayne, R. P., Atmospheric Chemistry, 1 st ed., Royal Society of Chemistry, (2010).
5. Vaclavikova, M., Vitale, K., Gallios, G. P. and Ivanicova, L. Water Treatment Technologies for Removal of High Toxicity Pollutants, Springerlink, UK, (2010).

General Edu.	PS-425	Civics and Community Engagement	02
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Contents

1. Introduction to citizenship education and Community Engagement
2. Identity, Culture, and Social Harmony
3. Multi-cultural society and inter-cultural dialogue
4. Active Citizen: Locally Active, Globally Connected
5. Human rights, constitutionalism and citizens' responsibilities
6. Social issues in Pakistan
7. Social Action Project
8. Assignment (Formative/Summative)

Recommended Books

1. John J. Macionis, Linda Marie Gerber, Sociology (New York: Pearson Education, 2010)
2. Community Development, Social Action and Social Planning by Alan Twelvetrees 12 May 2017
3. The Constitution of the Islamic Republic of Pakistan (Pakistan: The National Assembly of Pakistan, 2012), also available online at the official website of National Assembly of Pakistan: http://na.gov.pk/uploads/documents/13333523681_951.pdf (Accessed on April 25, 2017)

Suggested Books

1. Anne Karin Larsen, Participation in Community Work: International Perspectives (Vishanthie Sewpaul, Grete Oline Hole, 2013)
2. British Council, Active Citizen's Social Action Projects Guide (Scotland: British Council, 2017)

General Edu.		ISL-311	Arts (Islamic History)	02
Objectives of the Course		ISLAMIC HISTORTY <ol style="list-style-type: none"> 1. To educate the students about the Islamic History. 2. To enable the students to find the solutions of current problems of Ummah in the light of glorious period of Muslim Rulers 3. To enable the students to plan for the future in the light of golden period of Muslim Rulers. 		
S.No	Topic	Description		
1.	Basics of History	<ol style="list-style-type: none"> 1. Definition, Types, Sources and Importance of History 2. Introduction to Prominent Muslim Historians and Their Books. (Ibn Ishaq, Ibn Hisham, Tabari, Ibn Kasir, Ibn Khaldoon) 		
2.	Geographical, Socio-Economic and Religious conditions of Pre-Islamic World	<ol style="list-style-type: none"> 3. Geographical, Socio-Economic and Religious conditions of Pre-Islamic Room and Faris 4. Geographical, Socio-Economic and Religious conditions of Pre-Islamic Arabia, especially of Hijaz 		
3.	The Prophet Hazrat Muhammad (S.A.W)	<ol style="list-style-type: none"> 1. Life in Makkah Mukarramah 2. Life in Makkah Mukarramah 		
4.	The Prophet Hazrat Muhammad (S.A.W)	<ol style="list-style-type: none"> 1. Life in Madinah Munawwarah 2. Life in Madinah Munawwarah 		

5.	The Prophet Hazrat Muhammad (S.A.W)	1. Life in Madinah Munawwarah 2. Life in Madinah Munawwarah
6.	The Pious Caliphs (R.A) Hazrat Abu Bakr Siddiq (R.A) (632-634 AD)	1. Introduction , Major Challenges 2. Religious, Military and Political achievements.
7.	The Pious Caliphs (R.A) Hazrat Umar Farooq (R.A) (634-644 AD)	1. Introduction , Major Challenges 2. Religious, Military and Political achievements.
8.	The Pious Caliphs (R.A) Hazrat Usman Ghani (R.A) (644-656 AD)	1. Introduction , Major Challenges 2. Religious, Military and Political achievements.
9.	The Pious Caliphs (R.A) Hazrat Ali (R.A) (656-661 AD)	1. Introduction , Major Challenges 2. Religious, Military and Political achievements.
10.	The Umayyad's (661-750AD)	1. Introduction (Rise) of Umayyad's , 2. Major Challenges
11.	The Umayyad's (661-750AD)	1. Achievements(Cultural, Military and Political) 2. Causes of Fall
12.	The Abbasid's (750-1258 AD)	1. Introduction (Rise) of Abbasid's , 2. Major Challenges
13.	The Abbasid's(750-1258 AD)	1. Achievements(Cultural, Military and Political) 2. Causes of Fall
14.	Muslim Rule in Spain	1. Introduction (Rise) of Muslims in Spain , 2. Achievements & Causes of Fall
15.	Different Islamic States	1. Brief Introduction of Khelafat Osmania 2. Brief Introduction of Mughal Empire

Text Books

S#	BOOK NAME	AUTHOR
.1	Muhammad Arabi	Muhammad Inyatullah Subhani
.2	Al Raheeq Al Makhtoom	Safi Ur Rahman Mubarak Pori
.3	البدایہ و لنہایہ	علامہ ابن کثیر
.4	تاریخ ابن خلدون	عبدالرحمان بن محمد ابن خلدون
.5	تاریخ امت مسلمہ	مولانا اسماعیل ریحان
.6	History Of Islam	Akber Shah Najeebabadi
.7	A study of Islamic History	Prof. K. Ali
.8	سلطنت عثمانیہ	ڈاکٹر علی محمد الصلابی
.9	The Lost Islamic History	Firas Alkhateeb
.10	جامع تاریخ ہند	محمد حبیب، خلیق احمد نظامی
.11	مختصر التاريخ الاسلامی	محمد عبدالله عودہ

Allied	BOT-434	Botany-II (Plant Physiology and Ecology)	3(2+1)
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Specific Objectives of course:

To understand: 1. various systems of classification, identification and nomenclature of Angiosperms, 2- Structures and functions of tissues and organs at embryonic level

Course Contents

a) Plant Physiology

1. Water relations (water potential, osmotic potential, pressure potential, matric potential). Absorption and translocation of water. Stomatal regulation.
 2. Mineral nutrition: Soil as a source of minerals. Passive and active transport of nutrients. Essential mineral elements, role and deficiency symptoms of macronutrients.
 3. Photosynthesis: Introduction, Oxygenic and non-oxygenic photosynthesis Mechanism: light reactions (electron transport and photophosphorylation) and dark reactions (Calvin cycle). Differences between C3 and C4 plants. Factors affecting this process, Products of photosynthesis.
- b) Respiration: Definition and respiratory substrates. Mechanism-Glycolysis, Krebs cycle. Electron transport and oxidative phosphorylation. Anaerobic respiration. Energy balance in aerobic and anaerobic respiration, Respiratory quotients.**

c) Ecology

1. Introduction, aims and applications of ecology.
2. Soil: Physical and Chemical properties of soil (soil formation, texture. pH, EC, organism and organic matter etc) and their relationships to plants.
3. Light and Temperature. Quality of light, diurnal and seasonal variations. Ecophysiological responses.
4. Water: Field capacity and soil water holding capacity. Characteristics of xerophytes and hydrophytes. Effect of precipitation on distribution of plants.
5. Wind: Wind as an ecological factor and its importance.
6. Population Ecology: Introduction. A brief description of seed dispersal and seed bank.
7. Community Ecology
 - i. Ecological characteristics of plant community
 - ii. Methods of sampling vegetation (Quadrat and line intercept)
 - iii. Major vegetation types of the local area.
8. Ecosystem Ecology
 - i. Definition, types and components of ecosystem.
 - ii. Food chain and Food web.
9. Applied Ecology: Causes, effects and control of water logging and salinity with respect to Pakistan

Lab Outline:

a) Plant Physiology

1. Preparation of solutions of specific normality of acids/bases, salts, sugars, molal and molar solutions and their standardization.
2. Determination of uptake of water by swelling seeds when placed in sodium chloride solution of different concentrations.
3. Measurement of leaf water potential by the dye method.
4. Determination of the temperature at which beet root cells lose their permeability.
5. Determination of the effects of environmental factors on the rate of transpiration of a leafy shoot by means of a porometer/cobalt chloride paper method.

b) Ecology

- Determination of physical and chemical characteristics of soil.
- Measurements of various population variables
- Measurement of vegetation by Quadrat and line intercept methods.
- Field trips to ecologically diverse habitats.

- Measurements of wind velocity.

Recommended Books:

1. Ihsan, I. Latest Edi.. Plant Physiology, Biochemical Processes in Plants, UGC Press.
2. Witham and Devlin. Latest Edi. Exercises in Plant Physiology, AWS Publishers, Boston.
3. Taiz, L. and Zeiger, E. Latest Edi.. Plant Physiology. 4th. Ed. Sinauers Publ. Co. Inc. Calif.
4. Salisbury F. B. and Ross C. B. 1992. Plant Physiology. 5th Edition. Wadsworth Publishing Co. Belmont CA.
5. Hopkins, W. B. Latest Edi.. Introduction to Plant Physiology. 2nd Ed. John Wiley and Sons. New York
6. Schultz, J. C. Latest Edi. Plant Ecology. Springer-Verlag, Berlin.
7. Ricklefs, R. E. Latest Edi. Ecology. W. H. Freeman and Co., UK.

Journals / Periodicals:

Plant Physiology, Journal of Ecology

Major	ZOO-435	Animal Behavior	04 (3+1)
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Course Objectives:

The objectives of the course are: 1. To impart knowledge about animal responses to external stimuli 2. To emphasize on different behavioral mechanisms (classical and recent concepts). 3. To explain development of behavior with suitable examples of animals. 4. To understand role of genetic and neuro-physiology in behavioral 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 behavioral rhythms in diurnal and nocturnal periodicities. 4. PREDICT and anticipate variety of animal actions (costs and benefits) as assessed by innate and learned Behaviour; displays. 5. INTEGRATE the animal behavior as balanced mechanism to develop animal personality.

Course Outline (Contents)

1. Introduction

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

Practicals

1. Locomotory behavior of small animals, earthworm, garden snails etc.
2. Ear pinna reflex responses in domestic cats

3. Preparation of skinner box or maze for study of mouse or rat behavior
4. Mother-pup bond in mice and rats
5. Infant killing behavior
6. Pecking behavior of chickens
7. Hiding behavior of chicks
8. Observation of birds' nests and study of parental behavior
9. Altruistic behavior in monkeys

TEXT AND REFERENCE BOOKS:

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

Major	ZOO-436	Animal Form and Function-I	4(3+1)
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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 respiratory systems 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:

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. 36 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, hygrometers, 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, nemertean, nematodes, molluscs, annelids, arthropods, and echinoderms invertebrates; an overview of the vertebrate endocrine system; endocrine systems of vertebrates, endocrine systems of birds and mammals

5. Circulation and Immunity:

- a. Internal transport and circulatory systems in invertebrates
- b. Characteristics of invertebrate coelomic fluid, hemolymph, and blood cells
- c. transport systems in vertebrates; characteristics of vertebrate blood, blood cells and vessels; the hearts and circulatory systems of bony fishes, amphibians, reptiles, birds and mammals; the human heart: blood pressure and the lymphatic system; immunity: nonspecific defenses, the immune response

Practicals:

1. Study of insect chitin, fish scale, amphibian skin, reptilian scales, feathers and mammalian skin.
2. Study and notes of skeleton of Labeo (*Labeo rohita*), Frog (*Hoplobatrachus tigerinus*), Varanus (*Varanus bengalensis*), fowl (*Gallus gallus domesticus*) and rabbit (*Oryctolagus cuniculus*).

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

3. Earthworm or leech; cockroach, freshwater mussel, Channa or Catlacatla or Labeo or any other local fish, frog, pigeon and rat or mouse and rabbits dissections as per availability.
4. Study of heart, principal arteries and veins in a representative vertebrate (dissection of representative fish/mammals).

Books Recommended:

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

Year 2 Semester-IV			
Course Category	Course Code	Course Title	Credits
General Edu.	BSC-323	ICT	3(2+1)
General Edu.	MGT-443	Entrepreneurship	02
General Edu.	LLB-441	Human Rights law	02
Major	ZOO- 444	Biological Techniques	4(2+2)
Major	ZOO- 445	Biochemistry-I	3(2+1)
Major	ZOO- 446	Animal Form & Function-II	4(3+1)
Total Credits			18

General Edu.	BSC-323	ICT	3(2+1)
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Course Contents

Basic Definitions & Concepts, Hardware: Computer Systems & Components. Storage Devices, Number Systems, Software: Operating Systems, Programming and Application Software, Introduction to Programming, Databases and Information Systems, Networks, Data Communication, The Internet, Browsers and Search Engines, The Internet: Email, Collaborative Computing and Social Networking, The Internet: E-Commerce, IT Security and other issues, IT Project.

1. Basic Knowledge of Computers

- Understand basic computer hardware components and terminology
- Understand the concepts and basic functions of a common computer operating system
- Start up, log on, and shut down a computer system properly
- Use a mouse pointing device and keyboard
- Use Help and know how to troubleshoot routine problems
- Identify and use icons (folders, files, applications, and shortcuts/aliases)
- Minimize, maximize and move windows
- Identify common types of file extensions (e.g. doc, docx, pdf, html, jpg, gif, xls,ppt, pptx, rtf, txt,exe)
- Check how much space is left on a drive or other storage device
- Backup files
- Download and install software on a hard disk
- Understand and manage the file structure of a computer
- Check for and install operating system updates

2. Proficiency in Using Productivity Software

- Create documents of various types and save in a desired location
- Retrieve an existing document from the saved location
- Select, copy, and paste text in a document or desired location
- Print a document
- Name, rename, copy and delete files
- Understand and know how to use the following types of software programs:
- Word processing (example: MS Word, Google Doc, Writer)
- Presentation (example: PowerPoint, Impress)
- Spreadsheet (example: Excel, Calc)
- PDF reader (example: Acrobat Reader, Preview)
- Compression software (example: WinZip, StuffIt, 7-Zip)

3. Electronic Communication

Skills

- Email, using a common email program (example: MS Outlook, Gmail, Apple Mail)
- Compose, Send, Reply, Forward messages
- Add attachments to a message
- Retrieve attachments from an email message
- Copy, paste and print message content

- Organize email folders
- Understand what an electronic discussion list is and how to sign up and leave one (example: Listserv, Listproc)

4. Internet Skills

- Set up an Internet connection and connect to the Internet
- Have a working knowledge of the World Wide Web and its functions, including basic sitenavigation, searching, and installing and upgrading a Web browser
- Use a browser effectively, including bookmarks, history, toolbar, forward and back buttons
- Use search engines and directories to find information on the Web
- Download files and images from a Web page
- Understand and effectively navigate the hyperlink structure of the Web
- Understand how keep your information safe while using the Internet

5. Moving Files

- Transfer files by uploading or downloading
- View and change folder/document security settings
- Copy files from hard disk to storage devices and vice versa

Recommended Readings

- Bruce J. McLaren, Understanding and Using the Internet, West Publishing Company, 610 Opperman Drive, P. O. Box 64526, St. Paul, MN 55164.
- Computer Applications for Business, 2nd Edition, DDC Publishing, 275 Madison Avenue, New York, New York,
- Nita Hewitt Rutkosky, Microsoft Office Professional, Paradigm Publishing Company, 875 Montreal Way, St Paul, MN 55102.42
- Robert D. Shepherd, Introduction to Computers and Technology, Paradigm Publishing Inc., 875 Montreal Way, St. Paul, MN 55102.
- Shelly Cashman Waggoner, Discovering Computers 98, International Thomson Publishing Company, One Main Street, Cambridge, MA 02142.
- V. Wayne Klemin and Ken Harsha, Microcomputers, A Practical Approach to Software Applications, McGraw-Hill Book Company, New York, NY 10016.

General. Edu	MGT-443	Entrepreneurship	02
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Course Description: This course is designed for the students to understand that Starting & operating a new business which involves considerable risk & an effort to overcome the inertia against something new. In creating and growing a new venture, the entrepreneur assumes the responsibility and risks for its development & survival and enjoys the corresponding rewards. In the end the students will be able to develop business plans to start and initiate their own ventures.

Chapter-01: Introduction: Entrepreneurship and the Entrepreneurial Mind-Set Entrepreneurial Intentions and Corporate Entrepreneurship Entrepreneurial Strategy: Generating and Exploiting New Entries

Chapter-02: From Idea to Opportunity, Creativity and the Business Idea, Identifying and Analyzing Domestic and International Opportunities, Intellectual Property and Other Legal Issues for the Entrepreneur

Chapter-03: From the Opportunity to the Business Plan, The Business Plan: (Creating and Starting the Venture), The Marketing Plan, The Organizational Plan, The Financial Plan

Chapter-04: From the Business Plan to Funding the Venture Sources of Capital, Informal Risk Capital, Venture Capital, and Going Public Strategies for Growth and Managing the Implication of Growth Accessing Resources for Growth from External Sources. Succession Planning and Strategies for Harvesting and Ending the Venture

Suggested Readings:

Entrepreneurship by Robert d Hisrich 10th edition McGra Hill publications Entrepreneurship by Donald F. Kuratko and Richard M Hodgetts

General Edu.	LLB-441	HUMAN RIGHTS LAW	02
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Course Objectives

The Purpose of this course is to acquaint the students of LL.B with the basics of Human Rights as to what are the International Documents that regulate Human Rights at the International forum and as to what is the National Human Rights regime and as to what is the enforcement mechanism for the Human Rights at the National as well as International Forum. Human rights law is a distinct and fast developing area of law. The course is designed to impart knowledge about meaning, scope and importance of human rights. The focus of the course would be on the course will also examine major human rights issues in Pakistan and the region.

Course Contents

- International Bill of Human Rights, Enforcement mechanism under the UN Charter based Organs. Enforcement mechanism under the treaty based Organs. National Human Rights Law as contained in the Constitution and its enforcement mechanisms. National Commission for Human Rights Act 2012.

Topics

- History and development of Human Rights. Philosophy of Human Rights. National Human Rights Regime. Enforcement Mechanism Art 199 and 184(3). UDHR 1948, ICCPR, ICESCR, ECHR, IACHR, ACHPR, Women Rights, Refugees law, IHL

Recommended Readings:

1. Bhansali, S.R. Basu's Human Rights in Constitutional Law. New Delhi: Lexis Nexis, 2008.
2. Brownlie, Sir Ian & Goodwin Guys. Brownlie's Documents on Human Rights, (6th edn) Oxford: Oxford University Press, 2010.
3. Fenwick, Helen. Civil Liberties. London: Cavendish, 1994.
4. Judgments on Human Rights and Public Interest Litigation by Supreme Court of Pakistan. Lahore: PLD, 1999.
5. Smith, Rhona K. M. Texts and Materials on International Human Rights, (2nd edn) Oxon: Rutledge, 2010.

Useful Websites:

1. <http://www.un.org/rights/index.html> (UN Human Rights)
2. <http://www1.umn.edu/humanrts/> (University of Minnesota HRs Library)

Major	ZOO- 444	Biological Techniques	4(2+2)
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Course Objectives:

The objectives of the course are:- 1. To be able to clearly state the role of the immune system and a foundation in immunological processes 2. To provide students with knowledge on how the immune system works building on their previous knowledge from biochemistry, genetics, cell biology and microbiology 3. The students will be able to describe immunological response and how it is triggered and regulated.

Course Learning Outcomes:

Upon successful completion of the course, the student will be able to: 1. Explore the basic knowledge of immune system 2. Describe the concepts of how the immune system works. 3. Interpret the problems using immunological techniques for diagnosis of immune disorders. 4. Identify the problems using immunological diagnostic tools. 5. Detect the problems using the same techniques for other disorders. 6. DEMONSTRATE individually the ELISA and other Assays/Test

Course Contents:

1. Microscopy:

- a. Principles of light microscopy. Magnification, Resolution,
- b. Types of microscopy (Bright field, Dark field, Phase Contrast)
- c. Confocal Microscopy
- d. Electron microscope: Scanning electron microscope and Transmission electron microscope (SEM and TEM).

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

- a. Different Measurement systems (length; surface; weight, volume, temperature), Calculations and related conversions
- b. Concentrations- percent volume; ppt; ppm - molarity, normality, molality
- c. Preparation of stock solutions of various strengths
- d. Use of stage and ocular micrometers
- e. Calibration of ocular micrometer and measurement of size animal and plant cell and nuclei

3. Specimen preparation for optical microscopy:

- a. Introduction to Microtomy and its types
- b. Tissue Fixation, dehydration, clearing, embedding, Section cutting (transverse, longitudinal section)
- c. Tissue mounting (dry mount, wet mount)
- d. Staining: Hematoxylin and Eosin staining

4. Separation and purification techniques:

- a. Cell fractionation
- b. Centrifugation and its types
- c. Filtration and its types,

5. Chromatography:

- a. Chromatography: Principle, applications, types,
- b. Paper chromatography and thin layer chromatography
- c. Column chromatography
- d. High pressure liquid chromatography.
- e. Electrophoresis: Principle, applications and types (Agarose and PAGE).

6. Spectrophotometry:

- a. Principle, applications, types
- b. Visible/UV spectrophotometry

7. Basic principles of Sampling and Preservation:

- a. Sampling from soil, water, air, plants and animals
- b. Preservation of dry and wet specimens.
- c. Preservation techniques. Lyophilization, preservation in ethanol, formalin etc.

8. DNA sequencing

- a. Polymerase chain reaction (PCR), principle and application
- b. DNA sequencing (Sanger and Maxam Gilbert).

Practicals:

1. Preparation of slides (dry mount and wet mount)
2. Observation of wet mounts of human cheek cells employing bright and dark field microscopy
3. Measurement of cell size: bacterial and eukaryotic Cell
4. Recording of microscopic observations with the help of camera lucida
5. Liquid handling: proper use of pipettes and micropipettes
6. Hematoxylin and Eosin staining
7. Gram's staining,
8. Handling of centrifuge machines
9. Paper Chromatography
10. Thin layer chromatography of amino acids
11. Spectrophotometric estimation of glucose
12. Collection and Preservation of representative animals of various phyla

Books Recommended:

6. Dean, J. R. 1999. Extraction Methods for Environmental Analysis. John Wiley and Sons Ltd. UK.
7. Cheesbrough, M.1998. District Laboratory Practice in Tropical Countries. Part I. Cambridge University Press, UK.
8. Cheesbrough, M. 1998. District Laboratory Practice in Tropical Countries. Part II. Cambridge University Press, UK.
9. Curoso, M. 1997.Environmental Sampling and Analysis: Lab Manual. CRC Press LLC. USA.
10. Curoso, M. 1997. Environmental Sampling and Analysis: ForTechnician. CRC Press LLC. USA.
11. Slingsby, D., Cock, C.1986. Practical ecology. McMillan Education Ltd. London.
12. Gallagher, S.R. and Wiley E.A. 2008. Current protocols essential laboratory Techniques. John Wiley & Sons Inc, USA.

Major	ZOO- 445	Biochemistry-I	3(2+1)
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Course Objectives:

1. To provide knowledge about macro molecule of eukaryotic cells and organelles, including membrane structure and dynamics;
2. To provide in-depth knowledge about the polymerized organic compounds of life.
3. To provide knowledge of the principles of bioenergetics and enzyme catalysis
4. To provide knowledge of the chemical nature of biological macromolecules, their three dimensional construction, and the principles of molecular recognition;

Course Learning Outcome

By the end of the course, students should be able to: 1. Demonstrate knowledge and understanding of the molecules of living cells; 2. Demonstrate knowledge and understanding of the principles that govern the structures of macromolecules and their participation in molecular recognition; 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. Analyze, interpret, and participate in reporting to their peers on the results of their laboratory experiments; 6. Participate in and report orally on team work investigations of problem-based assignments;

Course Contents

1. Introduction to Macromolecules

- Structure, types and role of various building blocks their respective macromolecules.
- Carbohydrates: Introduction; Classification Stereoisomerism in carbohydrate, Structure, types and role of monosaccharides, oligosaccharides and polysaccharides; Glycosaminoglycans and glycoconjugates;
- Carbohydrates as an information carrier molecule.

2. Amino acids, peptides & proteins:

- Types of amino acids & their classification;
- Uncommon amino acids; Acid/base behavior of amino acids.
- Titration curves in amino acids and their importance;
- Peptides & proteins;
- Biologically active peptides & polypeptides;
- Amino acid sequence in proteins & their importance; Conjugated proteins;

2.1. Purification Techniques for Proteins

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

2.2. Organization of proteins:

- Structural levels of proteins; Covalent structure of proteins;
- function of some structural & functional proteins; Hemoglobin, Cytochrome-c: Chymotrypsin, alpha Keratin and Collagen;
- Proteins, their examples and role;

3. Enzymes

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

4. Lipids:

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

4.1. Classification and important characteristics;

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

5. Nucleic acids

- Nucleic acids and their types; Structure and role of various Bases in nucleic acids,
- Nucleoside & Nucleotides;
- Structure of DNA and RNA molecules;
- Organization and Chemistry of Double helical structure of DNA with their details.

Practical:

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

Books Recommended:

1. Lehninger principle of biochemistry by David L.Nelson and Michael M.Cox , 7th latest edition,ISBN-10:1-4641-2611-9,ISBN-13:978-14641-2611-6
2. Berg, J. M.,Tymoczko,J. L., Lubert Stryer. 2010. Biochemistry. 7th Ed.
3. Lodish, H., Berk, A., Zipursky, S. L., Paul. M., Baltimore D, Darnell, J. 2012. Molecular Cell Biology.
4. Nelson, D. L., Cox, M. M. 2012. Lehninger Principles of Biochemistry. McMillan Worth Publishers, New York.
5. The Molecular Basis of Life. 3rd Edition, McGraw-Hill
6. Lodish, H., Berk, A., Zipursky, S. L., Paul.M., Baltimore D,Darnell, J. 2012. Molecular Cell Biology.
7. Molecular cell biology W.H Freeman by Lodish, Berk, Krieger, Scott, Bretscher,Ploegh and Matsudaira 8th edition/latest edition,ISBN:1464183392,ISBN-13:97814641183393

Text book for Practical:

1. Wilson, K and Walker, J., 1994. Practical Biochemistry: Principles and Techniques, 4th Ed., Cambridge University Press.
2. Sawhney, S.K and Singh, R., 2008. Introductory Practical Biochemistry, Narosa Publishing House, New Delhi, India.

Major	ZOO- 446	Animal Form & Function-II	4(3+1)
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Course Objectives:

The Objectives of the courses are: 45 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:

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. 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 of nutrients in heterotrophs; digestion
- b. Animal strategies for getting and using food, diversity in digestive structures of invertebrates.
- c. The mammalian digestive system: gastrointestinal motility and its control
- d. Oral cavity, pharynx and esophagus, stomach, small intestine: main site of digestion; large intestine; role of the pancreas in digestion; and role of the liver and gall bladder in digestion.

2. Temperature and Body Fluid Regulation:

- a. Homeostasis and Temperature Regulation; The Impact of Temperature on Animal Life; Heat Gains and Losses; Some Solutions to Temperature Fluctuations; Temperature Regulation in Invertebrates, Fishes, Amphibians, Reptiles, Birds and Mammals; Heat Production in Birds and Mammals
- b. Control of Water and Solutes (Osmoregulation and Excretion); Invertebrate and Vertebrate
- c. Excretory Systems; How Vertebrates Achieve Osmoregulation; Vertebrate Kidney Variations; Mechanism in Metanephric Kidney Functions. Reproduction and Development

3. Reproduction:

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

- b. Sexual reproduction in invertebrates; advantages and disadvantages of sexual reproduction; sexual reproduction in vertebrates; reproductive strategies; examples of reproduction among various vertebrate classes;
- c. The human male reproductive system: spermatogenesis, transport and hormonal control, reproductive function;
- d. The human female reproductive system: folliculogenesis, transport and hormonal control, reproductive function; hormonal regulation in gestation; prenatal development and birth: the placenta; milk production and lactation.

Practicals:

- 1. Study of excretory system in an invertebrate and a vertebrate representative (Model).
 - 2. Study of dissection system in invertebrate and a vertebrate representative (Dissection).
 - 3. Dissection and study of male and female reproductive system in vertebrates and invertebrates.
- Note: *Prepared slides and preserved specimen and/or projection slides and/or CD ROM computer projections may be used.*

Books Recommended

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

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

Major	ZOO- 551	Economic Zoology	3(2+1)
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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 75 (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:

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

Practical:

1. To study the prepared slides of various types of ecto- and endo-parasites.
2. To observe and study Museum specimens of vertebrate and invertebrate pests of important crops and stored grains in Pakistan.
3. To visit Honey Bee farm. Write a report on their observations.
4. Visit to Sericulture farm in a nearby locality and write report on their observations.

5. Study visit to fish Hatchery, Nursery ponds, Stocking ponds, Commercial fish breeding farms and report writing.
6. Identification of important species of Fish and their natural animal.
7. Visit to any bird farm and write a report on their observations.

Recommended Books

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

Major	ZOO-552	Biochemistry-II	3(2+1)
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Course Objectives:

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 signaling by hormones;

Course Learning Outcome By the end of the course, students should 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 signaling; 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. Analyze, interpret, and participate in reporting to their peers on the results of their laboratory experiments;

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. Phosphorylation 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

- Digestion, mobilization and transport of Fats; Biosynthesis of Triacylglycerol;
- Utilization of Triacylglycerol; Oxidation of Fatty acids; Activation of Fatty acids and their transportation to mitochondria;
- Beta (β)-Oxidation; Bioenergetics of β -oxidation; Omega (ω)-Oxidation pathway;
- Biosynthesis of Saturated Fatty acid, Supply of raw material for palmitic acid synthesis; Fatty acid synthetase (FAS) multienzyme complex;
- 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

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

5. Nitrogen metabolism

- Metabolic fate of amino acids; Catabolism of amino acids; Deamination and Transamination;
- Role of glutamate, glutamine and alanine in transport of ammonia in tissues;
- Nitrogen excretion and urea cycle; Regulation of urea cycle;
- Pathways of amino acid degradation showing entry points in Citric acid cycle; Decarboxylation of amino acids to biological amines.
- Biosynthesis of some amino acids; Incorporation of ammonia in glutamate and glutamine;
- Purine and Pyrimidine biosynthesis showing the sources of various atoms in both molecules.

Practical:

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

Books Recommended:

- Plummer, David T., 1990. An Introduction to Practical Biochemistry, 4th Edition McGraw-Hill Book Company, London.
- Wilson, K and Walker, J., 1994. Practical Biochemistry: Principles and Techniques, 4th Edition, Cambridge University Press.
- Alexander, R.R. and Griffiths, J.M. 1993. Basic biochemical methods. Wiley Liss, New York.
- Sawhney, S. K. and Singh, R., 2006. Introductory Practical Biochemistry, 2nd Edition, Narosa Publishing House.
- Oser, B. L., (Latest Edition). Hawk's Physiological Chemistry, McGraw Hill Book Company.
- David L. Nelson and Michael M. Cox, 2005. Lehninger Principles of Biochemistry 4th Edition, Macmillan Worth Publishers, New York.

Major	ZOO-553	Physiology	4(3+1)
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Course Learning Outcomes:

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

Course Outlines

Concept of Physiology

- Principles of Homeostasis and conformity

2. Principles of regulation and adaptation

Membrane Physiology:

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

Nerve and Muscle Physiology:

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

Endocrine Physiology:

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

Cardiovascular Physiology:

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

Respiratory Physiology:

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

Excretory Physiology:

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

Physiology of Nutrition:

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

Practicals:

Respiration and Circulation

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

Nerve and Muscle

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

Nervous System:

1. Study of brains in different animals in relation to complexity of functions.

2. Study of human brain model and different areas eliciting behaviours.

3. Videos study on 1 and 2 studies.

Hormones System:

1. Video studies on the effects of hormones in breeding season behaviours of various behaviours.

2. Study through clinics data on the insulin and glycemia in type1 and type 2 diabetic subjects.

Text/Reference Books:

1. **Principles of Animal Physiology Third Edition** Moyes, Christopher D.^Schulte, Patricia M. Publisher: Pearson; 3rd edition, 2015.

2. **Eckert Animal Physiology** Fifth Edition David Randall, Warren Burggren, Kathleen French W. H. Freeman; 2001.

3. **Animal Physiology: From Genes to Organisms** 2nd Edition Lauralee Sherwood, Hillar Klandorf, Paul Yancey Brooks Cole; 2012.

4. **Animal Physiology** 4th Edition Richard W. Hill, Gordon A. Wyse, Margaret Anderson Sinauer Associates, Oxford University Press, 2016.

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

Course Learning Outcomes:

Upon successful completion of the course, the student will be able to: 1. Understand and apply the basic concepts of Ecology 2. Acquire the critical knowledge for rehabilitation of destroyed ecosystems and habitats in the environment. 3. 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, Sulphur, Water, Carbon and nutrient.

3. Limiting factors

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

4. Global ecosystems:

a. Atmosphere, Hydrosphere, Lithosphere and Ecosphere.

b. An overview of Ecosystem with special reference to Ecological Niche, basic concepts and types

c. Major ecosystem of world, Forest, Grassland, Desert, Tundra and Agricultural ecosystems.

d. Marine, Estuarine, Freshwater and Wetlands

5. Population ecology

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

6. Community ecology

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

7. Applied Ecology: resources and their ecological management;

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

9. Pollution:

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

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

12. Exotic and Invasive Species

a. Desertification, Deforestation, exotic and invasive species

Practical:

1. Population Sampling Techniques (Quadrat, Line Transact, Point count, Focal Scan and Capture and Recapture Method).

2. Study of different Ecosystems (Fresh Water, Terrestrial, Marine /Mountain/ Desert).
3. Ecological Notes.
4. Measurements of physical Factors of different Ecosystems.
5. Adaptive features of animals in relation to food and environment.
6. Food chain studies through analysis of gut contents.
7. Analysis of polluted and fresh water for biotic and abiotic variations.
8. Field visits for study of selected terrestrial habitat and writing notes.
9. Experimental design and approaches in ecological research; writing a research project
10. Development of an ecological management plan of some selected area

Text and Reference Books:

1. Molles, M.C. 2005. Ecology: Concepts and Applications. 6th Ed., McGraw Hill, New York, USA.
2. Cox, C.B., Morre, D. Latest Edi. 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. Latest Edi. Ecology. Oxford Univ. Press, UK.
4. Chapman, J.L., Reiss, M.J. Latest Edi. Ecology: Principles and Applications. Cambridge Univ. Press, UK.
5. Odum, E. P. Latest Edi. Fundamentals of Ecology. . W.B. Saunders.Philadelphia.

Major	ZOO-555	Evolution	2(2+0)
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Course Objectives:

- 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: 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:

- Theories of Evolution: theories to explain diversity of life– modern synthetic theory, factors initiating elementary evolutionary changes (micro-evolution) and change of gene frequencies.
- Mutation pressure, selection pressure, immigration and crossbreeding, genetic drift. Role of isolation in evolution: factors of large evolutionary changes (macroevolution).concepts of allometry, orthogenesis, adaptive radiation.
- Modern concept of Natural Selection: levels of selection, selection patterns, some examples of Natural Selection.
- Impacts of Natural Selection leading to convergence, radiation, regression and extinction, Batesian mimicry, Mullerian mimicry, sexual selection: Darwin's concept, Fisher's view, Zahavi's handicap theory and recapitulation theory.
- Study of preserved invertebrate species and their classification to species levels.

Text and Reference Books:

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

Major	ZOO-556	Principles of Systematics	3(2+1)
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Course Objectives:

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

Course Contents:

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

Practicals:

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

Books Recommended:

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

Year III Semester-VI			
Course Category	Course Code	Course Title	Credits
Major	ZOO-561	Research Methodology	2(2+0)
Major	BST-562	Biostatistics	3(2+1)
Major	ZOO-563	Developmental Biology	4(3+1)
Major	ZOO-564	Gene tics	4(3+1)
Major	ZOO-565	Zoogeography and Paleontology	3(2+1)
Total Credits			16

Major	ZOO-561	Research Methodology	2(2+0)
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Course Objectives:

The course is aims to: 1. Develop research skills Provide understanding how to design scientific research, to collect data and its interpretation 2. Emphasize the importance of ethics in scientific research 3. Enable students to write a research proposal

Course Learning Outcomes:

On completion of this course, the students should be able to: 1. UNDERSTAND a general definition of research design. 2. IDENTIFY the overall process of designing a research study from its inception to its report. 3. Become FAMILIAR with ethical issues in educational research, including those issues that arise in using quantitative and qualitative research. 4. KNOW the primary characteristics of quantitative research and qualitative research. 5. IDENTIFY a research problem stated in a study. 6. Become FAMILIAR with how to write a good introduction to an educational research study. 7. 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,

9. Scientific Writing: a. Difference between thesis/report/synopsis/research proposal.

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

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

Text and Reference Books:

1. Creswell, J. W. (2013). Research Design Quantitative Qualitative and Mixed Methods Approaches. Sage.
2. Khan, J.A. (2008). Research Methodology. New Delhi: APH Publishing.
3. Kothari, C.R., & Gaurav, G. (2014). Research Methodology: Methods and Techniques. New Delhi: New Age International.
4. Kumar, R. (2011). Research Methodology: A Step By Step Guide for Beginners. Cornwall: SAGE Publications, Inc.
5. Walliman, N. (2005). Your Research Project, 2nd Edition, A step by step guide for the first-time researcher. New Delhi, Vistaar Publications

Major	BST-562	Biostatistics	3(2+1)
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Course Objectives:

1. To provide knowledge about the importance and use of statistics in life sciences. 2. To familiar students with the methods of data analysis pertaining to their research work and to assess the significance of their experimental designs.

Course Outcomes:

Students who successfully complete this course will be able to: 1. DESCRIBE the roles biostatistics serves in zoology and biomedical research. 2. EXPLAIN general principles of study design and its implications for valid inference. 3. ASSESS data sources and data quality for selecting appropriate data for specific research questions. 4. TRANSLATE research objectives into clear, testable statistical hypotheses. 5. DESCRIBE basic principles and the practical importance of key concepts. 84 6. APPLY numerical, tabular, and graphical descriptive techniques commonly used to characterize and summarize data

Course Contents:

1. Introduction: a. Definition, branches of statistics, b. Scope and importance of statistics

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

3. Presentation of data: a. Descriptive statistics b. Tabulation of data c. Parts of table and construction of table.

d. Diagrams and graphs, pictogram, historigram, line chart, histogram, applications and uses of histogram e. Construction of histogram, comparison of data using histogram, f. Bar chart, multiple bar chart, pie chart, gantt chart, timeline, infograph, pedigree chart

4. Frequency distribution: a. Empirical FD, relative FD, Cumulative FD, class frequency, class limits, class boundaries, class mark, class interval, midpoints.

5. Measures of Central Tendency: a. Types of averages, arithmetic mean for grouped and ungrouped data, harmonic mean for grouped and ungrouped data, geometric mean for grouped and ungrouped data, median, quartiles, deciles, percentiles and mode. b. Advantages and disadvantages of arithmetic mean, harmonic mean, geometric mean, median and mode.

6. Measures of Dispersion: a. Range, grouped and ungrouped data, coefficient of range
b. Mean deviation of grouped and ungrouped data. Coefficient of mean deviation. c. Standard deviation and variance of grouped and ungrouped data, variance and standard deviation of population and sample data.

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

8. Tests of Significance: a. Hypothesis testing, b. Steps of hypothesis testing, c. Z-test, d. t-test, types, e. Chi-square, f. ANOVA, its uses and LSD, g. Correlation, h. Regression

Practicals / Tutorials:

1. Data collection, arrangement and frequency table

2. Data presentation in table, graphs (simple bar chart, multiple bar chart, component bar chart)

3. Construction of timeline, pedigree chart, organogram, Gantt chart, infogram

4. Calculating arithmetic mean, harmonic mean and geometric mean, median and mode from ungrouped and grouped data

5. Calculating mean deviation, standard deviation and variance from ungrouped and grouped data

6. Probability distribution, z-test, T-test, ANOVA, Correlation, Regression

Text and Reference Books:

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

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

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

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

Major	ZOO-563	Developmental Biology	4(3+1)
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Course Objectives:

The course aims to: 1. Provide information on transmission of traits from the parents in their gametes, the formation of zygote and its development 2. Impart detailed knowledge about cellular basis of morphogenesis, mechanisms of cellular differentiation and induction. 72 3. 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: 1. 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. 2. Apprehend the contributions of the sperm and the egg to form zygote 3. Elucidate the problems associated with cell differentiation through fate mapping. 4. Arrange and investigate the classical and modern experiments into “find it”, “block it”, and “move it” categories 5. Assess the set of experiments that will establish whether a planned aspect is both necessary and ample to cause a developmental episode 6. 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

1. Oogenesis: a. Mechanism of oogenesis among various classes of vertebrates. b. Vitellogenesis, c. Hormonal control of Vitellogenesis and oogenesis

4. Fertilization: a. External & Internal Fertilization, b. Species-specific recognition of sperm and egg, c. Fusion of male and female gametes, d. Polyspermy: slow and fast blocks to polyspermy, e. Activation of egg metabolism

5. IN VITRO Fertilization (IVF): a. History, Steps and advantages of IVF, b. Disadvantages and risk factors,

6. Cleavage & Blastulation: a. Patterns of embryonic cleavage and blastulation among different vertebrate classes, b. Mechanism of cleavage.

7. Gastrulation: a. Fate maps, b. Gastrulation in amphibians, birds and mammals

8. Early Vertebrate Development: a. Neurulation, ectoderm, mesoderm and endoderm formation

9. Placenta and extraembryonic membranes

10 Cellular Basis of Morphogenesis: a. Differential cell affinity, cell adhesion molecules

b. Organogenesis, c. Mechanism of teratogenesis

11. Aging and Regeneration in vertebrates

Practical:

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

Text and Reference Books:

1. Gilbert, S. F. 2013. Developmental Biology, Sinauer Associates, Sunderland, MA.

2. Klaus, K. 2001. Biological Development. 2nd Ed., McGraw-Hill.

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

4. Jamie. A. Davies. 2014. Life Unfolding: How the Human Body Creates Itself. Oxford University Press, USA

Major	ZOO-564	Genetics	4(3+1)
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Course Objectives:

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 Outcome

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.

Course Contents:

1. Introduction

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

2. Chromosomal Basis of Inheritance: a. Chromosomal theory of inheritance, b. Interaction of genes, Epistasis, Lethality and Pleiotropism.

3. Chromosomal Aberrations: a. Changes in chromosomal number, Euploidy, aneuploidy (Klinefelters syndrome, and Turners syndrome, Down syndrome and Edwards syndrome).

b. Structural changes, insertion, deletion (Cri du chat syndrome), duplication, c. Inversion and translocation

4. Pedigree Analysis: a. Normal human chromosome complement; Karyotyping. b. Sex-determination and Sex-linkage:

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

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

6. Molecular Genetics: a. Gene Concept (classical and modern), b. Genetics of Viruses and Bacteria, c. Transposons,d. Mutation and DNA repair e. Molecular Genetic Analysis,f. Regulation of Gene Expression in Prokaryotes,

g. Gene Regulation in Eukaryotes,h. Genetic basis of diseases, like cancer, i. Genetic control of animal development.

j. The genetic control of the Vertebrate Immune System,

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

8. Human Genetics; a. Single and Multifactorial Disorders:b. Autosomal anomalies, Pseudoautosomal genes,

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

9. Population Genetics:

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

Practical:

1. Drosophila culture techniques: preparation and maintenance of culture
2. Identification of male and female fruit fly and isolation of virgin females
3. Study of polytene chromosomes from the salivary glands of *Drosophila melanogaster*
4. Mutation induction in *Drosophila*
5. Human karyotyping from photographs prepared slides: paper cut out method
6. Preparation of human metaphase chromosomes from blood lymphocytes
7. Study of mitosis in plants by using onion root tip cells
8. Study of meiosis in the testes of male grasshopper
9. Extraction of genomic DNA from whole blood (lymphocytes)
10. Separation of heterogeneous population of bio-molecules through electrophoresis
11. Study of blood group polymorphisms in local population
12. Study of qualitative traits in humans: a survey of common physical heritable (monogenic) polymorphisms
13. Human Pedigree analysis problems (Determination of inheritance pattern of different human characters (Widows Peak, ear loop, etc), risk estimation and genetic counseling.
14. Study of quantitative traits in humans: finger prints as model of polygenic traits
15. Study of Barr bodies in human cell nucleus
16. Dermatoglyphics in normal and mentally retarded subjects
17. Probability problems. Tossing of coins. X²test
18. Study of transformed bacteria on the basis of antibiotic resistance
19. PCR

Books Recommended:

1. Snustad, D.P., Simmons, M.J. 2003. Principles of Genetics. 3rd Ed., John Wiley and Sons Ins. New York, USA.
2. Tamarin, R.H. 2001. Principles of Genetics. 7th Ed., WCB publishers USA.
3. Lewin, B. 2013. GENE-VIII. Oxford University Press. UK.
4. Strickberger, M.W. 2015. Genetics. McMillan, New York. USA.(9780024181206)
5. PRINCIPALS OF GENETICS Gardner E.J., Simmons M.J. and Snistad A.P. (Latest available Addition)

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

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 that fossil record also provides 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. Paleontology:**
The Planet Earth; a. History, age, shells of earth, b. atmosphere, hydrosphere, biosphere and lithosphere.
- 6. Rocks:** a. Types; Igneous rocks, sedimentary rocks and metamorphic rocks.
- 7. Fossil and Fossilization;** a. Fossil types and uses of fossils, nature of fossils. b. Fossilization , c. Invertebrates and Vertebrates Fossil, d. Biostratigraphy, e. Fossils of Pakistan, f. Paleontologically important areas of Pakistan.
- 8. Fossilization:** a. Geological time scale. b. Pre-Cambrian life. c. Post Cambrian life, d. Paleozoic life
e. Mesozoic life f. Cenozoic life.
- 9. Paleontological Techniques;** a. Excavation techniques b. Excavation tools and techniques c. Transportation and processing of fossils. d. Presentation of fossils, e. Pre requisites for paleontological excavation.
- 10. Geochronometry:** a. Uranium/Lead dating, b. radiocarbon dating, methods c. index fossils, d. evolutionary history of man, elephant, horse and camel, e. Paleoecology, Paleomagnetism.

Practical:

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

Text and Reference Books:

Zoogeography:

1. Beddard, F. E. 2008. A text book of zoogeography. Bibliobazar, LLC.
2. Tiwari, S.K. 2006. Fundamentals of world zoogeography. Wedams eBooks Ltd (India) Sarup & Sons. Delhi.

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.

Year –IV Semester-VII			
Course Category	Course Code	Course Title	Credits
Major	ZOO-671	Wildlife	3(2+1)
Major	ZOO-672	Molecular Biology	3(2+1)
Major	ZOO-673	Field Experience/Internship	3
Major	ZOO-674	Elective-I	3(2+1)
Major	ZOO-675	Elective-II	3(2+1)
Total Credits			15

Major	ZOO-671	Wildlife	3(2+1)
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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 organizations 6. DEMONSTRATE the ecological assessment and importance of wildlife to certain area.

Course Outline

1. Wildlife of Pakistan

- Introduction
- Important Definitions
- Identification
- Distribution
- Status
- 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

- Provincial Rules
- Federal Management of Wildlife (NCCW)

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

- National Organisations
- International Organisations

6. Protected Areas in Pakistan

- Sanctuaries
- Game Reserves
- National Parks

7. Ramsar convention

- Wetlands
- Ramsar Criteria
- Ramsar Sites

8. Threatened species of Pakistan.

- Vulnerable
- Endangered

c. Critically Endangered

Practicals:

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

Text and Reference Books:

1. Miller, A.S. and Harley, J.B., 1999 & 2002. Zoology, Latest Edition (International). Singapore: McGraw-Hill.
2. Ali. S.S. 2005 Wildlife of Pakistan.
3. Odum, E.P., 1994. Fundamentals of Ecology, W.B. Saunders.
4. Smith, R.L. 1980. Ecology and Field Biology, Harper and Row.
6. Roberts, T. J., 1991, 1992. The Birds of Pakistan, Vol. I and II. Oxford University Press
7. Roberts, T. J., 1997. The Mammals of Pakistan, Oxford University Press

Major	ZOO-672	Molecular Biology	3(2+1)
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Course Objectives:

1. To impart knowledge about chemical, physical and biological properties of nucleic acids.
2. To understand different molecular mechanisms and their regulation in prokaryotes and eukaryotes.

Course Learning Outcomes: Upon successful completion of the course, the student will be able to: 1. EXPLAIN how the structure and chemistry of nucleic acids relate to their functions, relative stability and interactions with proteins. 2. UNDERSTAND the regulation of proteins and nucleic acids interaction 3. COMPARE & CONTRAST mechanisms of DNA replication, transcription, translation, repair, recombination, gene regulation, RNA processing in prokaryotes and eukaryotes. 4. APPLY molecular knowledge to identify human genetic disorders and to understand underlying molecular mechanism

Course Outline:

- 1. Introduction;** a. Introduction to nucleic acids b. Chromosome structure, Chromatin, c. DNA forms, structures and packaging d. RNA types and structures
- 2. Replication;** a. DNA replication in prokaryotes, b. DNA replication in eukaryotes, c. Enzymology of replication d. DNA damage and repair,
- 3. Transcription;** a. Types of RNA polymerases in prokaryotes and eukaryotes, b. Synthesis of mRNA, rRNA and tRNA with special reference to enzymes involved , c. RNA processing d. Split genes, concept of ribozymes c. Genetic Code
- 4. Translation;** a. Role of Ribosomes, b. Mechanism of translation in prokaryotes and eukaryotes , c. Various factors, and posttranslational processing
- 5. Mutation;** a. Types of Mutations, b. Base-Analogue Mutagens, c. Chemical Mutagens
- 6. Gene expression and control;** a. Control of gene expression in Prokaryotes. b. Inducible and repressible operons. c. Control of gene expression in eukaryotes.

Practicals:

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

Text and Reference books:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D. 2017. Molecular Biology of the Cell. 6th Edition. Garland Publishing Inc., New York.
2. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey C. Martin. 2016. Molecular Cell Biology. W. H. Freeman Publishers, Scientific American Inc.
3. 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.

Year IV Semester-VIII			
Course Category	Course Code	Course Title	Credits
Major	ZOO-681	Capstone Project/Thesis	3
Major	ZOO-682	Elective-III	3(2+1)
Major	ZOO-683	Elective-IV	3(2+1)
Major	ZOO-684	Elective-V	3(2+1)
Major	ZOO-685	Elective-VI	3(2+1)
Total Credits			15

Major	ZOO-681	Capstone Project / Thesis	3
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LIST OF ELECTIVE COURSES

Courses	Credit Hours
Parasitology-I	2+1
Entomology-I	2+1
Parasitology -II	2+1
Entomology-II	2+1
Aquaculture	2+1
Bioinformatics	1+2
Endocrinology-I	2+1
Fish Health Management	2+1
Fish Feeding Management	2+1
Fish Physiology and Breeding	2+1
General and Comparative Endocrinology	2+1
Ichthyology	2+1
Immunology	2+1
Molecular Genetics	2+1
Reproductive Biology	2+1
Wildlife Parasitology	2+1

Parasitology I	3(2+1)
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Course Objectives: The objectives of the course are: - 1. Describe general principles and concepts of animal parasitology 2. Classify major animal parasites of animals and humans. 94 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 Learning Outcomes: Upon successful completion of the course, the student 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:

Protozoology

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

Pathology

The cell and cell injury and its relationship to disease. Acute and chronic inflammations, wound healing, disorders of growth, benign and malignant tumors in case of infections.

Practical

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

Books Recommended:

1. Dixon, M. E. Aid to Pathology. Latest Edition. Churchill Livingstone, Edinburgh London and New York.
2. Facust, E. C. and Russell, P. F. (Latest Edition). Craig and Faust's clinical Parasitology. Lea and Febiger, 8th edition London
3. Robbins, S. L. Basic Pathology. W. B. Latest Edition Saunders Co: London, Toronto.
4. Roberts, L.S. and Jonovy, J.Jr., (Latest Edition). Foundation of Parasitology. W. Brown Publishers, Chicasgo, USA.
5. Schmidt, G. D. and Robbert, T. S. (Latest Edition). Foundation of Parasitology. The C.V. Mosby Company, Saint Louise

Entomology-I	3(2+1)
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Course Objectives:

The objectives of the course are: - 1. To describe the reasons for evolutionary success of insects. 2. To establish the understanding about body structure of insects. 3. To familiarize the students about different physiological processes of insect. 4. To introduce concepts of insect ecology.

Course Learning Outcomes: Upon successful completion of the course, the student will be able to: 1. ACQUIRE the basic knowledge of the body structure of insects. 2. UNDERSTAND the role of structures in different life processes of insects. 3. CLASSIFY the insects at order level. 4. ASSOCIATE the insect structure, physiology and ecological interactions with their abundance and huge diversity. 5. DIFFERENTIATE the structural differences between different insects. 6. ANALYZE the impact of environmental factors on insect life.

Course Outline:

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

Classification of insect orders: General account of apterygota;

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

Subclass: Exopterygota; a. Order Dermaptera , b. Order Dictyoptera c. Order Embiidina

d. Order Neuroptera e. Order Strepsiptera f. Order Mantophasmatodea , g. Order Mecoptera , h. Order Orthoptera , i. Order Phasmatodea , j. Order Phthiraptera , k. Order Plecoptera l. Order Psocoptera m. Order Siphonaptera n. Order Zoraptera o. Order Megaloptera
 p. Order Raphidioptera q. Order Ephemeroptera r. Order Odonata

Endopterygota ; a. Order Megaloptera b. Order Hymenoptera c. Order Coleoptera d. Order Lepidoptera e. Order Trichoptera f. Order Siphonaptera g. Order Diptera h. Order Neuroptera i. Order Mecoptera j. Order Raphidioptera k. Order Strepsiptera

Knowledge of insect pests of

a. Rice b. Cotton c. Sugarcane d. Wheat

Brief account of different insect pest management strategies as:

a. Cultural Control b. Physical and Mechanical Control c. Host Plant Resistance d. Biological Control, e. Chemical Control f. Other approaches

Practical:

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

Practical:

1. Written (Long Questions, Short Questions, MCQs, identification etc) 40%
2. Collection of Insects 30%
3. Assignments 20%
4. Report Writing 10%

Text and Reference Books:

1. Atwal, A.S., 2015. Agricultural Pests of Southeast Asia and their Management. Kalyani Publishers, Ludhiana.
2. Ambrose, D.P., 2015. The Insects: Structure Functions and Biodiversity. Kalyani publishers, Ludhiana, India.
3. Chapman, R. F., 2013. The Insects-Structure and Function. 5th Edition. Cambridge University Press, New York.
4. Gullan, P. J. and Cranstan, P. S., 2014. The Insects: An Outline of Entomology. 4th edition. Wiley-Blackwell. A John Wiley & Sons, Ltd., Publication, UK.

Bioinformatics	3(1+2)
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Course Objectives

The course will provide: 1. An introduction to bioinformatics. 2. To develop awareness about fundamental bioinformatics databases. 3. Information on the tools used to compute solutions to those problems, and the theory upon which those tools are based.

Course Outcomes:

Upon successful completion of the course, the students should be able to: 1. GAIN an understanding of the basic concepts of Bioinformatics. 2. EXPLAIN the basics of bioinformatics and computational biology. 3. To USE bioinformatics search tools on the internet for mining data, pairwise and multiple sequence alignments and predict protein structures.

Course Contents:

1. Introduction:

- a. Introduction to Bioinformatics, Scope of bioinformatics, useful websites
- b. Aims of bioinformatics, disciplines related to bioinformatics, major tasks involved in bioinformatics analysis, bioinformatics tools
- c. Human genome project

2. Biological databases

- a. Data and types of data, data acquisition
- b. Major DNA databases around the world, NCBI, BOLD, DDBJ
- c. Major protein databases in the world, protein sequence databases, protein structure databases
- d. Specialized databases, genome and organism databases
- e. Non sequence databases, pubmed, pubmed health, OMIM

3. Genome mapping

Genetic and linkage mapping, physical mapping

4. Gene family:

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

5. Data Retrieval:

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

6. Primer Designing:

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

7. Sequence Alignment:

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

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

9. Multiple Sequence Alignment:

- a. Introduction, tools for MSA, uses and importance

10. Phylogenetic analysis:

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

Practicals / Tutorials:

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

Text and Reference Books:

1. Baxevanis, A.D., Ouellette, B.F.F. (2011) Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. John Wiley & sons, Inc.
2. Rastogi, S.C., Mendiratta, N., Rastogi, P. (2011) Bioinformatics Methods and Applications: Genomics, Proteomics and Drug Discovery. PHI publishing.
3. Pevsner, J. (2015) Bioinformatics and Functional Genomics. 3rd Edition. Willey-Blackwell
4. Lesk, A. (2014) Introduction to Bioinformatics. 4th Edition. Oxford University Press
5. Selzer, P., Marhofer, R. and Rohwer, A. (2008) Applied Bioinformatics: An Introduction. Springer publishing, Germany.
6. Primerose, S.B. (2004) Genomics: Applications in Human Biology. WilleyBlackwell
7. Westhead, D.R., Parish, J.H., Twyman, R.M. (2003) Instant Notes on Bioinformatics. Viva Books Private Limited.
8. Krane, D.E. and Raymer, M.L. (2002) Fundamental Concepts of Bioinformatics. Benjamin Cummings.
9. Gibas, C. and Jambeck, P. (2001) Developing Bioinformatics Computer Skills. O'Reilly publishers.

Websites

1. <http://www.ncbi.nlm.nih.gov>

2. <http://www.ebi.ac.uk>
3. <http://www.rcsb.org>
4. <http://www.ensemble.org>

Parasitology II	3(2+1)
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Course contents: Basic principles and concepts in Parasitology, Taxonomy, etiology, biology, epidemiology, pathology and pathogenesis, diagnosis, life cycle, control and treatment of **Digenetic Trematodes:** *Schistosoma mansoni*, *S.japonicum*, *S.haematobium*, *Fasciola hepatica*, *Fasciolopsis buski*, *Paragonimus westermani*, *Colonorchis sinensis*, *Heterophyes heterophyes*, **Monogenetic trematodes:** *Dactylogyru* *vastator*, *Gyrodactylus*, **Cestodes:** *Diphyllobothrium latum*, *Taenia saginata*, *T.solium*, *Echinococcus granulosus*, *Hymenolepis nana*, *Dipylidium caninum*, **Nematodes:** *Trichuris trichiura*, *Trichenella spiralis*, *Strongyloides stercoralis*, *Ancylostoma duodenale*, *Necator americanus*, *Ascaris lumbricoides*, *Toxocara canis*, *Enterobius vermicularis*, *Wuchereria bancrofti*, *Brugia malayi*, *Onchocerca volvulus*, *Loa loa* and *Dracunculus medinensis*.

Practicals

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

Books Recommended:

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

Entomology-II	3(2+1)
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Course Contents:

Applied Entomology:

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

Pest management

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

Books Recommended:

1. Atwal, A. S. (1984) Agricultural pests of India and South East Asia. Kalyani Publishers Delhi

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

Practical: Applied Entomology

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

Aquaculture	2+1
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Course Contents:

1. Introduction

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

2. Aquaculture (fin fish culture)

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

3. Shell fish culture

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

Practicals:

1. Collection and identification of various freshwater fish species
2. Visit and studying of fish pond Components.
3. Visit to fish hatchery and integrated fish farming.
4. Determination of Water quality parameters (Physical, chemical and biological)
5. Fish feed ingredients and formulation of fish feed
6. Artificial Fish breeding
7. Fish market visit
8. Visit to fish feed mill
9. Visit to head works/reservoirs etc.

Books Recommended:

1. Metha, V. 2009. Fisheries and Aquaculture Biotechnology. 2nd Ed. Campus Books International, New Delhi, India.
2. Sharma, O. P. 2009. Handbook of Fisheries and Aquaculture. Agrotech Publishing Academy, Udaipur, New Delhi, India.
3. Stickney, R. R. 2009. Aquaculture: An Introductory Text. CABI Publishing, London, UK.
4. Pandey, B. N., S. Deshpande and P. N. Pandey. 2007. Aquaculture. APH Publishing Corporation, New Delhi, India.
5. Parker, R. O. 2004. Aquaculture Science 4th Ed. Delmar Learning, London, UK.

6. Chakraborty, C. and A. K. Sadhu. 2001. Biology, Hatchery and Culture Technology of Tiger Prawn and Giant Freshwater Prawn. Dya Publishing House, New Delhi, India.
7. Gjedrem T. and Baranski M. 2009. Selective breeding in Aquaculture: An Introduction. Springer, USA
11. Shammi, Q.J. and Bhatnagar, S. 2002. Applied Fisheries, Agro bios, India.

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

- a. The endocrine system; Type of hormones; Endocrine and nervous system relationship;
- b. General principles in function, interaction, nature, synthesis, transport of hormones;
- c. General concept of feedback, biorhythms, pathology and assessment of endocrine function;
- d. Evolution of endocrine system. RIA, RIMA, ELISA, bioassay and receptor assay

2. Hypothalamus and pituitary:

- a. Hypothalamic hormones: Origin, chemistry and actions and mechanism of action;
- b. Anterior pituitary & hormones: Hypothalamic pituitary regulation,
- c. General chemistry, Physiological action, mechanism of action and metabolism of prolactin-growth hormone family,
- d. glycoprotein hormone family, corticotrophins and other pro-opiomelanocortin peptides;
- e. posterior pituitary: Release, regulation and actions of vasopressin and oxytocin.
- f. Causes and effect of over and under production of hypothalamic and pituitary hormones
- g. Hypothalamic, pituitary and thyroid, adrenocortical, gonadal and other axis.

3. Thyroid gland:

- a. Anatomy and histology of gland; Formation and secretion of thyroid hormones; Thyroid hormones in peripheral tissues, Function of thyroid hormone,
- b. Mechanism of action; regulation and factors affecting thyroid function.
- c. Causes and effect of Hypothyroidism and hyperthyroidism

4. Calcitropic and Mineral Metabolism Hormones:

- a. Chemistry, physiological actions, mechanism of action and
- b. metabolism of parathyroid hormone,
- c. Causes and effect of over and under production of hormone
- d. Calcitonin and calciferols; action and mechanism of action
- e. Homeostasis of calcium, phosphate and magnesium.

5. Pancreatic Hormones and Regulatory Peptides of the Gut:

- a. Anatomy and histology for sources of the hormones; Chemistry,
- b. Physiological roles and mechanism of action of insulin and glucagon;
- c. Physiological roles of gut peptides.
- d. Causes and effect of over and under secretion of pancreatic hormones
- e. Glucose homeostasis

6. Adrenal Medulla and Catecholamines:

- a. Chromaffin cell and organization; Structure of adrenal medulla;
- b. Biosynthesis, storage, release and metabolism;
- c. Adrenergic receptors and mechanism of action;
- d. Disorder of Adrenal medulla (pheochromocytoma)

7. Adrenal Cortex:

- a. Anatomy and Steroid biochemistry;
- b. Physiological actions of corticoid hormones and mechanism of action;
- c. Regulation and metabolism of glucocorticoids,
- d. Mineralocorticoids and adrenal sex steroids.
- e. Disorder of adrenal cortex hormones

8. Testes: Androgenic tissue:

- a. Anatomy, structure, chemistry, synthesis and transport of hormone,
- b. Metabolism, action and mechanism of action.
- c. Testicular disorder

9. Ovaries:

- a. Ovarian Anatomy, hormones: Steroid biochemistry and biosynthesis;
- b. Transport, metabolism, action and mechanism of action.
- c. Cyclic changes, menopause

d. Ovarian disorder

10. Endocrinology of Pregnancy:

a. Hormones in conception and implantation;

b. Hormonal actions and

c. Adaptation in pregnancy and parturition.

11. Fetus Endocrinology

a. Endocrinology of developing fetus

12. Endocrinology of Lactation:

a. Hormones in lactation.

13. Endocrinology of development of growth

a. Growth and Puberty

b. Disorders of growth and puberty

14. Endocrinology of

a Heart, Kidney,

b. Immune system:

c. Growth and pineal gland.

15. Functional diversity of vertebrate hormones

a. Functional diversity of hormones in different vertebrates

16. Overview of Endocrine Mechanisms in Invertebrates

a. Hormones of invertebrates

17. Geriatric Endocrinology

a. Endocrine and Associated Metabolism in aging: Specifically thyroid, glucose and calcium homeostasis

Practical:

1. Demonstration of endocrine glands and associated structures in dissections, transparencies, computer projections etc;

2. Histological and ultrastructure features of endocrine glands;

3. Experiments to demonstrate physiological roles of hormones of different endocrine glands;

4. Experiments to demonstrate regulation of hormones' releases.

5. Experiments to demonstrate functional diversity of hormones in different vertebrates.

6. Experiments on endocrine mechanism in vertebrates.

7. Experiment on recognition and response of receptors

8. Studies of disorders of pituitary by observing anatomical and histological features

9. Studies of thyroid status in deficient and excess hormone functions

10. Studies of type 1 and type 2 diabetes mellitus: Epidemiology of the types in population, studies of management of the type 2;

11. Model studies of Ovarian and Testicular disorders;

12. Model studies of obesity and anorexia;

13. Studies of hormonal status in puberty and aging

Text Books:

1. Greenspan, F.S. and Stewler, G.J., 2011. Basic and clinical endocrinology, 9th Edition. Prentice Hall International Inc., London.

2. Bentley, P.J., 1998. Comparative Vertebrate Endocrinology. 3rd Ed. Cambridge University Press, Cambridge.

3. Sam A., Meeran K. Endocrinology and Diabetes. Lecture notes. Wiley-Blackwell (2009) (basic science and clinical context).

4. Laycock J, Meeran K. Integrative Endocrinology. Wiley-Blackwell (2013).

5. Rang H, Dale M and Ritter, J: Pharmacology, 4th ed., (1999). (relevant for drug information) 2nd Edition. The Oxford Textbook of Endocrinology and Diabetes DOI: 10.1093/med/ 9780199235292.003.0134

6. Yen & Jaffe's Reproductive Endocrinology: Physiology, Pathophysiology, and Clinical Management. Saunders – all editions are excellent (even the older editions)

7. Johnson MH. Essential Reproduction. 7th Ed. Wiley-Blackwell (2013) (relevant for some general background info on reproduction pitched for undergraduate students).

8. Chandra S. Negi, introduction to endocrinology

9. Charles Brook, Nicholas Marshall, essential endocrinology

10. Noris, vertebrate endocrinology

Additional Readings:

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

Fish Health Management	2+1
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Course Contents:

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

Practical:

1. Collection and studying of disease fish samples.
2. Fish dissection.
3. Water quality parameters.
4. Dis-infection methods.
5. Fish treatment methods, oral medication, injection, clinical work-up.
6. Fish biopsy techniques.
7. Fish diseases diagnosis.
8. Fish hematology.
9. Blood smears etc.

Books Recommended:

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

Fish Feeding Management	2+1
<p>Course Contents</p> <ol style="list-style-type: none"> Need of supplementary/ artificial feeding of fish. Scope of artificial feeding in fish. Metabolism of feed nutrients (Protein, Lipid, Carbohydrate) in fish. Feeding practices, Different types of feeders. Diet preparation and processing techniques. Estimation of apparent nutrient digestibility. FCR and FCE indices. Feed ration and frequency, judging fish feeding response. Food acquisition and patterns of estimation of food requirements. Feed processing and manufacturing: floating and sinking feed. Feed packaging, transportation and storage problems of feed stuff. <p>Practical:</p> <ol style="list-style-type: none"> Collection and identification of fish feed ingredients. Ration calculation for fish feeding based on body weight, body length etc. Proximate analysis of feed and feed ingredients i.e. moisture, dry matter, crude protein, crude lipid, carbohydrates and ash contents. Formulation of fish feed. Feeding methods; introduction and demonstration of demand and belt feeders. <p>Books Recommended</p> <ol style="list-style-type: none"> Fitzsimmons, K., R.S.N. Janjua and M. Ashraf, 2015. <i>Aquaculture Handbook—Fish Farming and Nutrition in Pakistan</i>. John Halver. 2013. <i>Fish Nutrition</i>, ELSEVIER. Tom Lovell. 2013. <i>Nutrition And Feeding of Fish</i>, Springer.Ojha, J.S. 2006. <i>Aquaculture Nutrition and Biochemistry</i>. GeetaSomaniAgrotech Publishing Academy, Udaipur, India. Lovell, T., 2012. <i>Nutrition and Feeding of Fish</i>. 2nd Ed. SpringerScience, USA Pillay T V R, M N Kutty. 2005. <i>Aquaculture: Principles and Practices</i>.Balckwell Publishing. UK. Reddy, M.S. and Sambasiva K.R.S. 1999. <i>A Textbook of Aquaculture</i>.Discovery Publishing House, N. Delhi. Pillay, T.V.R. 1999. <i>Aquaculture: Principals and Practices</i>. FishingNews Books, London. 	
Fish Physiology and Breeding	2+1

Course Objectives

The objectives of the 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.

Learning Outcomes.

Upon successful completion of the course, the student will be able to: 1. Relate the key concepts of fish physiology and breeding techniques. 2. Describe the different systems and their coordination. 3. Assess problems associated with natural and artificial breeding. 4. Determine the fish production with relation to induced breeding. 105 5. Judge the fish behavior and migration patterns.

Course Contents:

1. Fish nutrition

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

2. Transportation:

- Blood; Blood cells (Erythrocytes, leukocytes, Platelets and plasma);
- Circulation; Arterial system; Venous system; Capillaries;

c. Transport of food material.

3. Respiration:

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

4. Excretion:

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

5. Reproduction:

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

6. Breeding:

- a. Natural (seasonal); Artificial;
- b. Hormonal induced breeding;
- c. Temperature & photoperiod;
- d. control induced breeding.

7. Growth:

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

8. Fish health:

- a. Water quality;
- b. Hygiene of fish culture facilities;
- c. Hygiene of equipments used in fish culture.

9. Diseases and their control:

- a. Viral;
- b. Bacterial;
- c. Fungal;
- d. Parasitic;
- e. Protozoan;
- f. Helminths (trematodes, cestodes, nematodes, acanthocephalons); Crustaceans (cladocera);
- g. Annelids (leeches); Arthropods (water ticks, water flea, water mites).

10. Fish migration:

- a. To nursery ground;
- b. To maturation grounds;
- c. Freshwater to marine water;
- d. Marine water to freshwater.

11. Fish behaviour:

- a. Learning and memory;
- b. Light response for maturation;
- c. Courtship behaviour;
- d. Aquarium fish behavior

Practicals:

- 1. Study of gut contents,
- 2. Study of feeding modification and adaptation in fish,
- 3. Study of respiratory adaptation in fish, Study of blood cells and their counts in normal and diseased fish,
- 4. Study of water quality parameters (DO, NH₃, hardness, alkalinity, turbidity, transparency, temperature, salinity),
- 5. Study of various forms of swimbladder as hydrostatic organ,

6. Study fecundity of various fish species,
7. Study the effects of reproductive hormone (GnRH) on fish maturation,
8. Diagnosis of bacterial infection in infected fish,
9. Study of fish parasites,
10. Visit to various fish seed hatcheries during breeding seasons

Books Recommended

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

General and Comparative Endocrinology	2+1
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Course Contents:

a. An overview of general concepts and principles of endocrinology:

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

b. Hypothalamus and pituitary:

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

c. Thyroid gland:

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

d. Calcitropic and mineral metabolism hormones:

Chemistry, physiological actions and metabolism of parathyroid hormone, calcitonin and calciferols; Homeostasis of calcium, phosphate and magnesium.

e. Pancreatic hormones and regulatory peptides of the gut:

Anatomy and histology for sources of the hormones; Chemistry, physiological roles and mechanism of action of insulin and glucagon; Physiological roles of gut peptides.

f. Adrenal medulla and catecholamines:

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

g. Adrenal cortex:

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

h. Hypothalamic-Hypophysial-Gonadal axis in Reproduction:

Hormonal and neuronal factors and their interactions in ovarian, testicular and other reproductive targets functions.

i. Testes:

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

j. Ovaries:

Ovarian hormones: Steroid biochemistry and biosynthesis; Transport, metabolism and mechanism of action. The interactions in developments in estrous and menstrual cycles.

k. Endocrinology of pregnancy:

Hormones in conception and implantation; Hormonal actions and adaptation in pregnancy and parturition. The interactions in transitions from childhood to reproductive and post-reproductive states.

l. Endocrinology of lactation:

Hormones in lactation.

m. Endocrinology of heart, kidney, immune system: Growth and pineal gland.

n. Functional diversity of hormones in vertebrates.

o. Overview of endocrine mechanisms in invertebrates.

Study of hormones of invertebrates in concepts of growth, metamorphosis, reproduction and pheromones.

Title: Lab. General and Comparative Endocrinology

Demonstration of endocrine glands and associated structures in dissections, transparencies, computer projections etc. Histological and ultrastructure features of endocrine glands; Experiments to demonstrate physiological roles of hormones of different endocrine glands; Experiments to demonstrate regulation of hormones' releases. Experiments to demonstrate functional diversity of hormones in different vertebrates. Experiments on endocrine mechanism in vertebrates. Through flow chart to demonstrate the feedback mechanism of hormonal homeostasis.

Text Books:

1. Greenspan, F.S. and Stewler, G.J., 2011. Basic and clinical endocrinology, 9th Edition. Prentice Hall International Inc., London.
2. Bentley, P.J., 1998. Comparative Vertebrate Endocrinology. 3rd Ed. Cambridge University Press, Cambridge.
3. Sam A., Meeran K. Endocrinology and Diabetes. Lecture notes. Wiley-Blackwell (2009) (basic science and clinical context).
4. Laycock J, Meeran K. Integrative Endocrinology. Wiley-Blackwell (2013).
5. Rang H, Dale M and Ritter, J: Pharmacology, 4th ed., (1999). (relevant for drug information) 2nd Edition. The Oxford Textbook of Endocrinology and Diabetes DOI: 10.1093/med/ 9780199235292.003.0134
6. Yen & Jaffe's Reproductive Endocrinology: Physiology, Pathophysiology, and Clinical Management. Saunders – all editions are excellent (even the older editions)
7. Johnson MH. Essential Reproduction. 7th Ed. Wiley-Blackwell (2013) (relevant for some general background info on reproduction pitched for undergraduate students).
8. Chandra S. Negi, introduction to endocrinology
9. Charles Brook, Nicholas Marshall, essential endocrinology
10. Noris, vertebrate endocrinology

Additional Readings:

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

Ichthyology	2+1
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Course Contents:

1. Classification and distribution of freshwater fishes

- a. Systematic position of fish in animal kingdom
- b. Distribution of various commercial and noncommercial fishes of Pakistan

2. Morphology of fishes

- a. External features of fishes

3. Coordination of fishes

- a. Fish muscular system, locomotion and energetics of swimming.
- b. Physiology of respiration and air breathing among fishes.
- c. Cardiovascular system,
- d. blood and its circulation and hydromineral balance: Osmoregulation, ionic regulation, stress responses, freezing resistance and acid-base balance.
- e. Digestion and control of gastro-intestinal motility in fish. Physiology of gas bladder: Use of gas by the fish as a source of static lift.
- f. Gas in the gas bladder: Loss, retention and secretion of gas.
- g. Process of aestivation in fish.
- h. Control of kidney function in fish. Sensory system and communication in fish: Acoustico-lateralis system, sound reception and production.

Practical:

1. Collection and identification of some freshwater and marine water fishes.
2. Dissection of fishes for studying anatomical features (Reproductive, Digestive, Respiratory and circulatory systems).

Books Recommended:

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

Immunology	2+1
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Course Outline:

1. Introduction

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

2. Innate Immunity and Inflammation

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

3. Microbial Recognition and Responses in Innate Immunity

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

4. Antibodies

- a. Blymphocytes
- b. Antibody structure and function

5. Lymphocyte Development and Diversity

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

6. T Cell Activation by Antigens

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

7. T Cell-Dependent B Cell Responses

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

8. Helper T Cells

- a. Helper T cell functions

- b. The role of helper T cells in disease
- 9. Cytotoxic T Cells**
- a. Cytotoxic T cell functions
- b. Selection and expansion of cytotoxic T cells
- c. Therapies that target cytotoxic T cell functions
- 10. Failures of the Immune System**
- a. Immunodeficiency
- b. Autoimmune diseases
- c. Allergic diseases
- 11. Immunology-Based Therapy of Diseases**
- a. Transplantation and transfusion

Practical:

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

Text and Reference Books:

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

Molecular Genetics	2+1
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Course Outline:

- 1. Introduction**
- a. Genome organization of various organisms
- b. DNA and RNA viruses.
- c. Transposable Elements.
- 2. Gene Regulation**
- a. Gene regulation in Prokaryotes
- b. Gene regulation in Eukaryotes
- 3. Post Transcriptional Modifications**
- a. Capping and Poly A tail addition
- b. RNA splicing
- c. RNA editing.
- 4. DNA Damage**
- a. Single strand break
- b. Double strand break
- c. Oxidative damage
- d. Pyrimidine dimer formation
- 5. DNA Repair Mechanism**
- a. BER
- b. NER
- c. Photo reactivation
- 6. Study of Molecular Techniques**
- a. Southern blotting
- b. Western blotting
- c. Northern blotting

- d. RFLP
- e. RAPDS
- f. Microsatellite DNA

Practical:

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

Text and Reference Books:

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

Reproductive Biology	2+1
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Course Outline:

a. Introduction

a. Reproductive Biology Around Us – Overview

b. Anatomy of female reproductive system

c. Anatomy of male reproductive system

d. Reproductive Endocrinology

e. Pituitary and hypothalamus

6. Reproductive cycles

a. Puberty and seasonality of breeding

b. Estrous cycle and menstrual cycle

Disorders of sexual development

Folliculogenesis

Spermatogenesis

Fertilization and early embryonic development

Implantation and placentation

Parturition & Post-Partum recovery

Obesity & Reproduction

Regulation of Fertility in Humans

Reproductive Aging

Lactation

Addictions & Reproduction

Endocrinology of Stress in Reproduction

Course wrap up

Practical:

7. Demonstration of male reproductive organs in vertebrates.

8. Demonstration of female reproductive organs in vertebrates.

9. Histological studies of ovaries

10. Histological studies of testes

11. Histological studies of endocrine gland

Text and Reference Books:

1. Pathways to Pregnancy and Parturition by P. L. Senger. 3rd edition (2012). Published by Current Conceptions Incorporated USA.
2. Andrology by E. Nieschlag, H. M. Behre and S. Nieschlag. 3rd edition (2010). Published by Springer, USA.

3. Knobil & Neill's Physiology of Reproduction by *T. M. Plant and A. J. Zeleznik*. 4th edition (2014). Published by Springer, USA.
4. Endocrinology: Adult and Pediatric (Vol II) by J. L. Jameson and L. J. De Groot. 7th edition (2015). Published by Elsevier - Health Sciences Division.