SHAHEED BENAZIR BHUTTO UNIVERSITY
SHERINGAL, DIR UPPER (KP)



COMPLETE WORKING PAPER

BS ZOOLOGY

DEPARTMENT OF BASIC AND APPLIEDZOOLOGY

SHAHEED BENAZIR BHUTTO UNIVERSITY

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SCHEME OF STUDIES (Semester wise break up) and course content FOR BS DEGREE IN ZOOLOGY

Semester 1			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-311	Diversity of Invertebrates	3(2-1)
Interdisciplinary	BOT-314	Diversity of Plants	3(2-1)
General Education	QRZ-311	Quantitative Reasoning-I (Exploring Quantitative Skills)	3(3-0)
Interdisciplinary	CHEM-311	Basic Chemistry	3(2-1)
General Education	ENG- 311	Functional English	3(3-0)
General Education	BCS-313	Applications of Information & Communication Technologies (ICT)	3(2-1)
General Education	ISL-314	Fehm-e-Quran-I	1(1-0)
Total Credits			19

Semester 2			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-321	Cell Biology	3(2-1)
Major	ZOO-322	Diversity of Chordates	3(2-1)
Interdisciplinary	BOT-434	Plant Physiology and Ecology	3(2-1)
General Education	QRZ-321	Quantitative Reasoning-II (Tools for quantitative reasoning)	3(3-0)
General Education	ENG- 321	Expository writing	3(3-0)
General Education	ISL-327	Seerat-e-Mustafa (PBUH)	2(2-0)
General Education	ISL-325	Fehm-e-Quran-II	1(1-0)
Total Credits			18

Semester 3			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-431	Animal Behavior	3(3-0)
Major	ZOO-432	Animal Ecology	3(2-1)
Major	ZOO-433	Animal Form & Function – I (Comparative Anatomy)	3(2-1)
General Education	CHEM-434	Environmental Chemistry	3(2-1)
General Education	ISL-326	Islamic Studies	2(2-0)
General Education	PS-435	Pakistan Studies	2(2-0)
General Education	LLB-431	Human Rights and Citizenship	2(2-0)
Total Credits			18

Semester 4			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-441	Evolution	3(3-0)
Major	ZOO-442	Animal Form & Function – II (Comparative Physiology)	3(2-1)
Major	ZOO-443	Entomology	3(2-1)
Major	ZOO-444	Developmental Biology	3(2-1)
General Education	MGT-443	Entrepreneurship	2(2-0)
General Education	PS-425	Civics & Community Engagement	2(2-0)
General Education	PS-322	Ideology & Constitution of Pakistan	2(2-0)
Total Credits			18

Semester 5			
Course Category	**Course**	**Course Title**	**Credits**

	Code		
Major	ZOO-551	Zoogeography and Paleontology	3(2-1)
Major	ZOO-552	Marine Biology	3(3-0)
Major	ZOO-553	Principles of Systematic Zoology	3(2-1)
Interdisciplinary	ZOO-554	Principles of Biochemistry	3(2-1)
Interdisciplinary	ZOO-555	Principles of Genetics	3(2-1)
Major	ZOO-556	Economic Zoology	3(3-0)
Total Credits			18

Semester 6			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-561	Fisheries & Aquaculture	3(2-1)
Major	ZOO-562	Research Methodologies & Bioethics	3(2-1)
Interdisciplinary	ZOO-563	Molecular Biology	3(2-1)
Interdisciplinary	BST-562	Biostatistics	3(2-1)
Interdisciplinary	ZOO-565	Microbiology & Immunology	3(2-1)
Total Credits			15

Semester 7			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-671	Wildlife Conservation & Management	3(2-1)
Major	ZOO-672	Protozoology and Protozoic Diseases	3(2-1)
Major	ZOO-673	Insect systematics and Taxonomy	3(2-1)
Major	ZOO-674	Ichthyology	3(2-1)
Interdisciplinary	CB-675	Computational Biology	3(2-1)

Internship		Internship	3
Total Credits			18

Semester 8			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-681	Fish Farm and Hatchery Management	3(2-1)
Major	ZOO-682	Helminthology	3(2-1)
Major	ZOO-683	Taxidermy	3(2-1)
Major	ZOO-684	Vector Biology and Public Health	3(2-1)
Capstone	CAP-685	Capstone	3
Total Credits			15

Grand Total: 19+18+18+18+18+15+18+15= 139

DETAIL OF STUDIES FOR BS ZOOLOGY

Semester 1			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-311	Diversity of Invertebrates	3(2-1)
Interdisciplinary	BOT-314	Diversity of Plants	3(2-1)
General Education	QRZ-311	Quantitative Reasoning-I (Exploring Quantitative Skills)	3(3-0)
Interdisciplinary	CHEM-311	Basic Chemistry	3(2-1)
General Education	ENG- 311	Functional English	3(3-0)
General Education	BCS-313	Applications of Information & Communication Technologies (ICT)	3(2-1)
General Education	ISL-314	Fehm-e-Quran-I	1(1-0)
Total Credits			19

Detail of the Courses:

Major	ZOO-311	Diversity of Invertebrates	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

1. Identify and describe the diversity of invertebrate phyla.
2. Analyze structural and functional adaptations of invertebrates.
3. Evaluate the ecological significance and evolutionary history of invertebrates.

Course Contents

1. **Introduction**
   a. Scope and importance of invertebrate zoology
   b. Criteria for classification of invertebrates
   c. Overview of evolutionary trends in body plans
2. **Protozoa**
   a. General features and classification
   b. Structural organization and locomotion
   c. Modes of nutrition and reproduction
   d. Ecological and medical significance
3. **Porifera and Cnidaria**
   a. Porifera: Body organization, canal systems, skeleton, reproduction, ecological roles
   b. Cnidaria: Tissue grade organization, polymorphism, life cycle, corals and reefs
4. **Platyhelminthes and Nematoda**
   a. Platyhelminthes: General characteristics, adaptations to parasitism, life cycles of common parasites (e.g., liver fluke, tapeworms)
   b. Nematoda: Body plan, free-living and parasitic forms, human and agricultural importance
5. **Annelida**
   a. Segmentation and coelom
   b. Locomotion, nervous system, reproduction
   c. Ecological significance (earthworms, leeches, polychaetes)
6. **Mollusca**
   a. Body plan and diversity of classes (Gastropoda, Bivalvia, Cephalopoda)
   b. Feeding, locomotion, reproduction
   c. Adaptations and economic importance
7. **Arthropoda**
   a. General features, segmentation, exoskeleton and molting
   b. Major groups: Crustacea, Insecta, Arachnida, Myriapoda
   c. Insect morphology and metamorphosis
   d. Ecological and economic importance (pollinators, vectors, pests)
8. **Echinodermata**
   a. General features
   b. Ambulacral system
   c. Reproduction and development in echinoderms

Practical:

1. Museum study of representative Phyla, Permanent slide preparation
2. Study of Euglena, Amoeba, Entamoeba, Plasmodium, Trypanosoma
3. Paramecium as representative of animal-like protists. (Prepared slides).
4. Paramecium as representative of animal-like protists. (Prepared slides).
5. Study of sponges and their various body forms.
6. Study of principal representative classes of Phylum Cnidaria.
7. Study of principal representative classes of Phylum Platyhelminthes.
8. Study of principal representative classes of Phylum Mollusca
9. Study of principal representative classes of Phylum Annelida
10. Brief notes on medical/economic importance of the following:
11. Plasmodium, Entamoeba histolitica, Leishmania, Liverfluke, Tapeworm, Earthworm, Silkworm, Citrus butterfly

Books recommended:

1. Bernd Schierwater & Rob DeSalle 2021 Invertebrate Zoology: A Tree of Life Approach
2. Stephen A Miller and John P. Harley 2016 Zoology McGraw Hill
3. Jan A. Pechenik 2015 Biology of the Invertebrates, 7th Edition
4. Invertebrate Zoology: A Laboratory Manual by Alan R. Holyoak 2013
5. A Manual of Practical Zoology: Invertebrates (P. S. Verma) 2010
6. Invertebrate Zoology by P. S. Verma — popular in South Asia
7. Modern Textbook of Zoology – Invertebrates by R. L. Kotpal — recent editions

Interdisciplinary	BOT-314	Diversity of Plants	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

1. Students will learn about the diversity of plants.
2. To learn about the different structure 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
    a. i.Riccia
    b. ii.Anthoceros
    c. iii. Funaria
7. Pteridophytes

a. Fossils and fossilization
b. Psilopsida (Psilotum)
c. iii.Lycopsida (Selaginella)
d. iv.Sphenopsida (Equisetum)
e. v.Pteropsida (Marsilea)

8. Gymnosperms
   a. Cycas
   b. Pinus
   c. Ephedra

Practicals:

1. Culturing, maintenance, preservation and staining of microorganisms. Study of morphology and reproductive structures of the types mentioned in theory.
2. Identification of various types mentioned from prepared slides and fresh collections.

Books recommended:

1. Lee, R. E. 1999. Phycology. Cambridge University Press, UK1. Prescott, L. M., Harley, J. P. and Klein, A. D. 2004. Microbiology, 3rd Ed. WM.C. Brown Publishers.
2. Alexopoulos, C. J., Mims, C. W. and Blackwell, M. 1996. IntroductoryMycology. 4th Ed. John Wiley and Sons Publishers.
3. Agrios, G. N. 2004. Plant pathology. 8th Ed. Academic Press London.
4. Vashishta, B. R. 1991. Botany for degree students (all volumes). S. Chand andCompany. Ltd. New Delhi.
5. Andrew, H. N. 1961. Studies in Paleobotany. John Willey and Sons.
6. Ingrouille , M. 1992. Diversity and Evolution of Land Plants. Chapman & Hall.
7. Mauseth, J. D. 2003. Botany: An Introduction to Plant Biology 3rd Ed., Jonesand Bartlett Pub. UK
8. Marti. J. Ingrouille & Plant: Diversity and Evolution. 2006 CUP
9. Taylor, T. N. & Taylor, E. D. 2000. Biology and Evolution of Fossil Plants.Prentice Hall. N. Y.
10. Hussain, F. 2012. A Text Book of Botany and Biodiversity. Pak Book Empire.

General Education	QRZ-311	Quantitative Reasoning-I (Exploring Quantitative Skills)	3(3-0)

Course Learning Outcomes (CLOs)

By the end of this course, students shall have:

1. Fundamental numerical literacy to enable them work with numbers, understand their meaning and present data accurately;
2. Understanding of fundamental mathematical and statistical concepts;
3. Basic ability to interpret data presented in various formats including but not limited to tables, graphs, charts, and equations etc.

Course Contents

1. **Numerical Literacy**

a. Number system and basic arithmetic operations;
b. Units and their conversions, dimensions, area, perimeter and volume; Rates, ratios, proportions and percentages
c. Types and sources of data
d. Measurement scales
e. Tabular and graphical presentation of data
f. Quantitative reasoning exercises using number knowledge

2. **Fundamental Mathematical Concepts**

a. Basics of geometry (lines, angles, circles, polygons etc.)
b. Sets and their operations
c. Relations, functions, and their graphs
d. Exponents, factoring and simplifying algebraic expressions
e. Algebraic and graphical solutions of linear and quadratic equations and inequalities
f. Quantitative reasoning exercises using fundamental mathematical concepts.

3. **Fundamental Statistical Concepts**

a. Population and sample
b. Measures of central tendency, dispersion and data interpretation
c. Rules of counting (multiplicative, permutation and combination)
d. Basic probability theory
e. Introduction to random variables and their probability distributions
f. Quantitative reasoning exercises using fundamental statistical concepts.

Suggested Instructional/ Reading Material

1. I "Quantitative Reasoning: Tools for Today's Informed Citizen" by Bernard L. Madison, Lynn and Arthur Steen.
2. Quantitative Reasoning for the Information Age" by Bernard L. Madison and David M. Bressoud.
3. "Fundamentals of Mathematics" by Wade Ellis.
4. "Quantitative Reasoning: Thinking in Numbers" by Eric Zaslow.
5. "Thinking Clearly with Data: A Guide to Quantitative Reasoning and Analysis" by Ethan Bueno de Mesquita and Anthony Fowler.
6. "Using and Understanding Mathematics: A Quantitative Reasoning Approach" by Bennett, J.O. , Briggs, W. L. , & Badalamenti, A.
7. "Discrete Mathematics and its Applications" by Kenneth H. Rosen.
8. "Statistics for Technology: A Course in Applied Statistics" by Chatfield, C."Statistics': Unlocking the Power of Data" by Robin H. Lock, Patti Frazer Lock, Kari Lock Morgan, and Eric F. Lock.

Interdisciplinary	CHEM-311	Basic Chemistry	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

1. Understand the fundamental concepts of inorganic and organic chemistry.
2. Apply principles of stoichiometry, chemical reactions, and thermodynamics to solve

basic chemistry problems.

3. Explain the properties of gases, liquids, and solids, and their behavior in various chemical systems.

Course Contents:

Introduction to inorganic chemistry, Periodic Table, Bonding, classification of bond, physical and chemical bonds, ionic bond, covalent bond, coordinate covalent bond, Bonding theories (VSEPR, VBT, MOT), acid and bases, different theories of acids and bases, strength of acids and bases. Introduction to physical chemistry, Gases ideal & non-ideal gases, Laws of gases, Solution chemistry, Thermodynamics. Introduction to Organic chemistry, alkyl group, homologous series, functional group, Classification of organic compounds, Chemistry of functional groups of organic compounds like alkane, alkene, alkynes, benzene & benzene derivatives, alcohols, aldehydes & ketones, carboxylic acid.

Practical work

Lab safety & ethics, solvent extraction, determination of melting point, chromatography, (paper chromatography, thin layer chromatography, column chromatography), Preparation of standard solution, titration, determination of viscosity, refractive index.

Recommended books

1. Shriver, D. F., Atkins, P. W., Langford, C. H., *Inorganic Chemistry*, 2nd ed., Oxford University Press, (1994).
2. Cotton, F. A. and Wilkinson, G., *Advanced Inorganic Chemistry*, 6th ed., John-Wiley & Sons, New York, (2007).
3. Brown, W. and Poon, T., *Introduction to Organic Chemistry*, 3rd ed., John-Wiley & Sons, Inc., (2005).
4. John, E. M. *Organic Chemistry*, 8th ed., Brooks/Cole Publishing Co, USA, (2012).
5. Robert, T. M. and Robert, N. B., *Organic Chemistry*, 6th ed., Prentice Hall, New Jersey, (1992).
6. Younus, M., *A Textbook of Organic Chemistry*, Ilmi Kitab Khana, Urdu Bazar, Lahore, Pakistan, (2006).
7. McQuarrie, D. A. and Simon, J. D., Physical Chemistry – A Molecular Approach,1st ed., University Science Books,(1997).
8. Atkins,P. and Paula,J.D., Atkin's Physical Chemistry, 9th ed., Oxford University Press, (2010).
9. Shoemaker, D., Experiments in Physical Chemistry, 8th ed., McGraw Hill Publishing Company Limited, (2003).
10. Silbey, R., Alberty, R. and Bawendi, M., Physical Chemistry, 4th ed., (2005).
11. Glasstone, S., *Textbook of Physical Chemistry*, Macmillan London (1960).

General Education	ENG- 311	Functional English	3(3-0)

Course Learning Outcomes

By the end of the course, students will be able to:

1. Apply enhanced English communication skills through effective use of word

choices, grammar and sentence structure.
2. Comprehend a variety of literary/non-literary written and spoken texts in English.
3. Effectively express information, ideas and opinions in written and spoken English.
4. Recognize inter-cultural variations in the use of English language and to effectively adapt their communication style and content based on diverse cultural and social contexts.

Course Contents

1. **Foundations of Functional English**

a. Vocabulary Building (contextual usage, synonyms, antonyms, and idiomatic expressions).
b. Communicative grammar (subject-verb agreement, verb tenses, fragments, run ons, modifiers, articles, word classes, etc.)
c. Word formation (affixation, compounding, clipping, back formation etc.).
d. Sentence structure (simple, compound, complex and compound complex)
e. Sound production and pronunciation.

2. **Comprehension and Analysis**

a. Understanding purpose, audience and context
b. Contextual interpretations (tones, biases, stereotypes, assumptions, inferences, etc.)
c. Reading strategies (skimming, scanning, SQ4R, critical reading etc.)
d. Active listening (overcoming listening barriers, focused listening, etc.)

3. **Effective Communication**

a. Principles of communication (clarity, coherence, conciseness, courteousness, correctness, etc.)
b. Structuring documents (introduction, body, conclusion, formatting)
c. Inclusively in communication (gender-neutral language, stereotypes, cross-cultural communication etc.)
d. Public Speaking (overcoming stage fright, voice modulation and body language)
e. Presentation skills (organization content, visual aids and engaging the audience)
f. Informal communication (small talk, networking and conversational skills)
g. Professional writing (business e-mails, memos, reports, formal letters, etc.)

Suggested Practical Activities (Optional)

- As part of the overall learning requirements, students will also be exposed to relevant simulations, role-plays, and real-life scenarios and will be required to apply skills acquired throughout the course in the form of the final project.

Suggested Instructional/Reading Materials

1. Understanding and using English Grammar by Betty Schrampfer Azar
2. English in Use by Raymond Murphy
3. The Blue Book of Grammar and Punctuation by Jane Straus
4. English for Specific Purposes: A Learning Centered Approach by Tom Hutchinsin and Alan Waters
5. Cambridge English for Job-hunting by Calm Downes
6. Practical English Use by Micheal Swan
7. Reading Literature and Writing Argument by Missay James and Alan P Merickel

8. Improving Reading: Strategies, Resources, and Common Core Connections by Jerry Jones and Susan Lenski
9. Comprehension: A Paradigm for Cognition by Walter Kintsch
10. Communication Skills for Business Professionals by J.P. Verma and Meenakshi Raman

General Education	BCS-313	Applications of Information & Communication Technologies (ICT)	3(2-1)

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

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

2. Proficiency in Using Productivity Software

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

3. Electronic Communication Skills

a. Email, using a common email program (example: MS Outlook, Gmail, Apple Mail)
b. Compose, Send, Reply, Forward messages

c. Add attachments to a message
d. Retrieve attachments from an email message
e. Copy, paste and print message content
f. Organize email folders
g. Understand what an electronic discussion list is and how to sign up and leave one (example:Listserv, Listproc)

4. Internet Skills

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

5. Moving Files

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

Recommended Books

1. Bruce J. McLaren, Understanding and Using the Internet, West Publishing Company, 610 OppermanDrive, P. 0. Box 64526, St. Paul, MN 55164.
2. Computer Applications for Business, 2nd Edition, DDC Publishing, 275 Madison Avenue, NewYork,
3. Nita Hewitt Rutkosky, Microsoft Office Professional, Paradigm Publishing Company, 875 MontrealWay, St Paul, MN 55102.42
4. Robert D. Shepherd, Introduction to Computers and Technology, Paradigm Publishing Inc., 875Montreal Way, St. Paul, MN 55102.
5. Shelly Cashman Waggoner, Discovering Computers 98, International Thomson PublishingCompany, One Main Street, Cambridge, MA 02142.
6. V. Wayne Klemin and Ken Harsha, Microcomputers, A Practical Approach to SoftwareApplications, McGraw-Hill Book Company, New York, NY 10016.

General Education	ISL-314	Fehm-e-Quran-I	1(1-0)

Understanding of Holy Quran – I

Course Title: Understanding of Holy Quran – I

Course Code: ISL-314

Course Book: Muallim ul Quran (Volume 1, 2 & 3) by Dr Ubaid ur Rahman

Credit Hours: 1 (0-1)
Contact Hours: 3 per week **Weeks:** 15-16
(45-48 hours)

Course Learning Outcomes:

By the end of this course, students will be able to:

1. Develop the ability to understand basic words of the Quran, phrases and sentences that do not contain verbs (unit 1 to 5 of Muallim ul Quran Book) and then sentences having present tense (first half of unit 6 of Muallim ul Quran Book).
2. Acquire a strong foundation for understanding long verses of the Quran with clarity.
3. Comprehend Quranic vocabulary, particles (operative & non operative particles) , compounds (Adjective & Possessive compound), pronouns (singular & plural) and types of plural through hundreds of Quranic sentences.
4. Recognize and understand different styles of Quranic sentences, including nominal sentence, emphatic sentence, double emphatic sentence, negative sentence, interrogative sentence, oath –based sentences.
5. Strengthen understanding of fundamental Quranic linguistic styles, expressions and idioms.
6. Understand at least 30 to 40 % of each page of the holy Quran.

Provision of material, content and books:

- **Paper book**: All volumes are available in printed book form.
- **Tutorial videos:** Teaching video of each lesson available on YouTube.
- **Confirmation Videos:** A complete series of confirmation videos of all lessons is available in which the student can confirm his answers.
- **A flipbook:** A flipbook edition is also accessible.
- **Helping material:** Helping material for the teachers like quizzes, question papers and images is available on website.

Course Outline:

Weeks	Lectures (1.5 hrs)	Units	Lessons	Assignments/Home Task	Linguistic Rules
1.	1.	1	1-6	Writing the meaning of Quranic words Lesson 1-8	Proper Noun Masculine & Feminine
	2.	1	9-14	Writing the meaning of Quranic words 9-14	Two kinds of plural Concept of (و) "And" Common Noun

2.	1.	1	15-17	Writing the meaning of Quranic words, phrases & translation of Sentences 15-17	Demonstrative Noun (This & That for Masculine (هذا- هذه) Demonstrative Noun (This & That for Feminine) (ذلك- تلك)
	2.	1	18-19 & Revisio n (Unit 1)	Writing the meaning of Quranic words , phrases & translation of Sentences 17-19 Quiz	Laam for emphasis (لام التأكيد) Superlative Degree like أكبر Revision of all Quranic Sentences
3.	1.	Unit 2	1-3	Writing the meaning of Quranic words, phrases & translation of Sentences 1-3	Emphatic Particle إن Preposition "For" (اللام) Preposition (في)
	2.	2	4-6	Writing the meaning of Quranic words, phrases & translation of Sentences 4-6	Preposition (على- من- إلى)
4.	1.	2	7- 9	Writing the meaning of Quranic words & translation of Sentences 7-9	Preposition (الباء) Absolute Negation Particle Exceptive Particle (لا النافية (إلا) (ما النافية)(للجنس
	2.	2	10-13 & Revisio n (Unit 2)	Writing the meaning of Quranic words, phrases & translation of Sentences 10-13 Quiz	Subordinating Conjunction(أن), Was (كان), Vocative Particle(حرف النداء)

5.	1.	Unit 3	1-2	Writing the meaning of Quranic phrases 1-2	Quranic Adjective Compounds (صفة وموصوف)
	2.	3	3-5	Writing the meaning of Quranic phrases & translation of sentences 3-5	Quranic Possessive Construction (مضاف ومضاف إليه)

6.	1.	3	6 -7	Writing the meaning of Quranic phrase translation of sentences 6-7	Quranic Possessive Construction (مضاف ومضاف إليه)
	2.	3	8-10 & Revisio n (Unit 3)	Writing the meaning of Quranic phrase & translation of sentences 8-10 Quiz	Active Participle (اسم الفاعل), Passive Participle (اسم المفعول), Dual (مثنى)
7.	1.	Unit 4	1-2	Writing the meaning of Quranic phrase & translation of sentences 1-2	Personal Pronoun He(هو المنفصل) Possessive Pronoun His ـه المتصل)
	2.	4	3-4	Writing the meaning of Quranic phrase & translation of sentences 3 -4	Possessive Pronoun with prepositions like في بيته Pronoun "His" with prepositions like له، منه، فيه
8.	1.	4	5-8	Writing the meaning of Quranic sentences 5-8	Personal Pronoun You(أنت المنفصل) Possessive Pronoun Your ك المتصل) Possessive Pronoun with prepositions like في بيتك Pronoun "your" with prepositions like لك، منك، فيك
	2.	Mid Term			

9.	1.	4	9-12	Writing the meaning of Quranic phrases & sentences 9-12	Personal Pronoun She(هي المنفصل) Possessive Pronoun Her ها المتصل) Possessive Pronoun with prepositions like في بيتها Pronoun "Her" with prepositions like لها،

	2.	4	13-16	Writing the meaning of Quranic phrases & sentences 13-16	Personal Pronoun I (أنا المنفصل) Possessive Pronoun Her ي المتصل) Possessive Pronoun with prepositions like Pronoun "My" في بيتي with prepositions like لي
10.	1	4	17 & Revisio n Unit 4	Revision of all Quranic sentences of Unit 4 Quiz	Adverb (حال)
	2.	Unit 5	1-2	Writing the meaning of Quranic phrases & sentences 1-2	Masculine Plural جمع المذكر السالم و جمع المذكر السالم المسبوق بحرف الجر
11.	1.	5	3-4	Writing the meaning of Quranic phrases & sentences 3-4	Possessive Construction with Plurals جمع المذكر السالم المسبوق بالإضافة
	2.	5	5-6	Writing the meaning of Quranic phrases, sentences & verses 5-6	Personal Pronoun They (هم المنفصل) Possessive Pronoun Their هم المتصل)
12.	1.	5	7-8	Writing the meaning of Quranic phrases, sentences & verses 7-8	Possessive Pronoun with prepositions like Pronoun "Their" في بيتهم with prepositions like لهم
	2.	5	9-11	Writing the meaning of Quranic phrases, sentences & verses 9-11	Personal Pronoun You (أنتم المنفصل) Possessive Pronoun Your كم المتصل) Possessive Pronoun with prepositions

					في بيتكم like
13.	1.	5	12-14	Writing the meaning of Quranic phrases & sentences & verses 12-14	Pronoun "Your" with prepositions like لكم Personal Pronoun We (نحن المنفصل) Possessive Pronoun Our نا المتصل)
	2.	5	15-16	Writing the meaning of Quranic sentences & verses 15-16	Possessive Pronoun with prepositions في بيتنا like Pronoun "Our" with prepositions like لنا
14.	1.	5	17-18	Writing the meaning of Quranic sentences & Verses 17-18	Demonstrative Pronoun These, Those (أولئك -هؤلاء)
	2.	5	19-23	Writing the meaning of Quranic sentences & Verses 19-23	ما / إلا، إن / إلا، إنما، ليس، ما ،) (أ/أم، أن، بل، كأن (ألا، أليس، اليوم، يومئذ، سبحان، مابينهما، قل، إذن، بئس، نعم، كلا، ما أدراك، حسب، أعلم ب، مصير، مرجع، دينا(تمييز)
15.	1.	5	Revision Unit 5	Quiz	
	2.	5	1-3 (till Page 16)	Writing the meaning of Quranic Verbs &Translation of Quranic Sentences & Verses (1-3)	Introduction of Present Tense(فعل مضارع) & Verbal Sentence (جملة فعلية) Present Tense الفعل المضارع صيغة المفرد يعلم
16.	1.	6	3 (From Page 17) & 4 -5	Translation of Quranic Sentences & Verses 3-5	Present Tense الفعل المضارع صيغة المفرد يعلم
	2.	6	6	Translation of Quranic Sentences & Verses	Present Tense الفعل المضارع صيغة الجمع يعلمون

Semester 2			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-321	Cell Biology	3(2-1)
Major	ZOO-322	Diversity of Chordates	3(2-1)
Interdisciplinary	BOT-434	Plant Physiology and Ecology	3(2-1)
General Education	QRZ-321	Quantitative Reasoning-II (Tools for quantitative reasoning)	3(3-0)
General Education	ENG- 321	Expository writing	3(3-0)
General Education	ISL-327	Seerat-e-Mustafa (PBUH)	2(2-0)
General Education	ISL-325	Fehm-e-Quran-II	1(1-0)
Total Credits			18

Major	ZOO-321	Cell Biology	3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Understand the structure, function, and molecular organization of animal cells.
2. Explain the mechanisms of cell division and cellular signaling.
3. Analyze cellular transport and communication processes.

Course Contents:

1. **Introduction to Cell Biology**

a. Overview of cell theory and historical perspectives
b. Prokaryotic vs. eukaryotic cells
c. Comparative structure of plant and animal cells
d. Comparison of prokaryotic and eukaryotic cells

2. **Cell Structure and Molecular Organization**

a. Detailed structure and function of cell membranes
b. Structural models of the membrane
c. Composition and roles of macromolecules (proteins, lipids, carbohydrates, nucleic acids)
d. Cytoplasm and cytoskeleton organization

3. **Organelles and Their Functions**

a. Nucleus: nuclear envelope, chromatin, nucleolus
b. Endoplasmic reticulum (rough and smooth)
c. Golgi apparatus
d. Mitochondria and energy metabolism
e. Lysosomes and peroxisomes
e. Ribosomes, centrioles, cilia, and flagella

4. Cellular Transport Mechanisms

a. Passive transport: diffusion, osmosis
b. Facilitated diffusion
c. Active transport and ATPase pumps
d. Endocytosis and exocytosis

5. Cell Division

a. Cell cycle phases and regulation
b. Mitosis and cytokinesis: processes and significance
c. Meiosis: stages and role in sexual reproduction

6. Cellular Signaling and Communication

a. Types of cellular signals (chemical, mechanical)
b. Signal transduction pathways
c. Receptors and second messengers
d. Cell communication in multicellular organisms

Practical

1. Microscopic study of animal cells and tissues
2. Observation of mitosis in onion root tips or animal cells
3. Demonstration of diffusion and osmosis
4. Experiments on cellular transport mechanisms
5. Case studies on cell signaling

Books Recommended

1. Molecular Biology of the Cell" by Alberts et al.
2. Cell Biology" by Thomas D. Pollard
3. Cell and Molecular Biology" by P.S. Verma and V.K. Agarwal

Major	ZOO-322	Diversity of Chordates	3(2-1)

Course Learning Outcomes

By the end of this course, the students will be able to:

1. Identify and classify major groups within the phylum Chordata.
2. Explain the evolutionary relationships and adaptations of chordates.
3. Analyze the ecological roles and physiological characteristics of different chordates

Course Outline:

1. Protochordates

a. Evolution of Chordates, classification of Protochordates.
b. Brief morphology, anatomy and life history of Hemichordates, Urochordates and Cephalochordates

2. Euchordates

2.1.Fishes (Pisces):

a. Brief introduction to Ostracoderm, Cyclostomata and Placoderm
b. Vertebrate Success in Water.
c. Classification of Chondrichthyes and Osteichthyes
d. Introduction and Morphology and anatomy of Chondrichthyes (Scoliodon) and Osteichthyes (Trout or Carp fish).

2.2.Tetrapoda:

Amphibians:

a. The first terrestrial vertebrates.
b. Characteristics and classification of amphibians, characteristics of order Caudata, Gymnophiona, and Anura.
c. Introduction, Morphology, anatomy, reproduction and metamorphosis in toads.

Reptiles:

a. The First Amniotes and cladistic interpretation of the amniotic lineage.
b. General characteristics and classification of reptiles.
c. Characteristics of order Testudines, Rhynchocephalia, Squamata, and Crocodylia
d. Comparative morphology and anatomy of chelonia, squamata, Rhynchocephalia and crocodilian.

Birds:

a. Characteristics and classification of Aves up to orders, origin of flight, flight adaptation and endothermy.
b. Phylogenetic relationships, Archaeopteryx
c. Introduction, Morphology, anatomy and reproduction of pigeon.
d. Migration and navigation.

Mammals:

a. Characteristics, classification up to order, dentition, endothermy, hair and viviparity.
b. Introduction, Morphology, anatomy and reproduction in rabbit.

practical:

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

Text and Reference Books:

1. Campbell, N.A. Biology. 9th Ed. 2011. Menlo Park, California Benjamin/Cummings Publishing Company, Inc.
2. Miller, S.A. and Harley, J.B. 2010. Zoology, 8th Edition (International) Singapore: McGraw Hill.
3. Miller, S.A. 2002. General Zoology Laboratory Manual. 5th Ed. (International), Singapore: McGraw Hill.
4. Hickman, C.P., Roberts, L.S. and Larson, A. Integrated Principles of Zoology, 14th Edition (International), 2009. Singapore: McGraw-Hill.
5. Pechenik, J.A. Biology of Invertebrates, 4th Edition (International), 2000. Singapore: McGraw Hill.

Interdisciplinary	BOT-434	Plant Physiology and Ecology	3(2-1)

Course Learning Outcomes (CLOs)

After completing this course, students will be able to:

1. Explain the fundamental physiological processes in plants (such as photosynthesis, respiration, water relations, mineral nutrition, and growth regulation) and relate them to plant structure and function.
2. Analyze ecological principles, including ecosystem organization, energy flow, biogeochemical cycles, population interactions, and plant–environment relationships.

3. Apply ecological and physiological concepts to interpret real-world environmental issues, evaluate plant adaptations, and understand the role of plants in ecosystem stability and biodiversity conservation.

Course Contents

1. **Plant Physiology**

a. Water relations (water potential, osmotic potential, pressure potential, matric potential). Absorption and translocation of water. Stomatal regulation.
b. Mineral nutrition: Soil as a source of minerals. Passive and active transport of nutrients. Essential mineral elements, role and deficiency symptoms of macronutrients.
c. 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.`
d. Respiration: Definition and respiratory substrates. chanism-Glycolysis, Krebs cycle. Electron transport and oxidative phosphorylation. Anaerobic respiration. Energy balance in aerobic and anaerobic respiration, Respiratory quotients.

2. Ecology

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

Practicals:

1. *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.

2. **Ecology**

1. Determination of physical and chemical characteristics of soil.
2. Measurements of various population variables

3. Measurement of vegetation by Quadrat and line intercept methods.
4. Field trips to ecologically diverse habitats.
5. 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.
8. **Journals / Periodicals:**
9. Plant Physiology, Journal of Ecology

General Education	QRZ-321	Quantitative Reasoning-II (Tools for quantitative reasoning)	3(3-0)

Course Learning Outcomes (CLOs)

By the end of this course, students shall have:

1. Understanding of logic and logical reasoning;
2. Understanding of basic quantitative modeling and analyses;
3. Logical reasoning skills and abilities to apply them to solve quantitative problems and evaluate arguments;
4. Ability to critically evaluate quantitative information to make evidence based decisions through appropriate computational tools.

Course Contents

1. **Logic, Logical and Critical Reasoning**

a. Introduction and importance of logic;
b. Inductive, deductive and abductive approaches of reasoning;
c. Propositions, arguments (valid; invalid), logical connectives, truth tables and propositional equivalences;
d. Logical fallacies;
e. Venn Diagrams;
f. Predicates and quantifiers;
g. Quantitative reasoning exercises using logical reasoning concepts and techniques.

2. **Mathematical Modeling and Analyses**
    a. Introduction to deterministic models;
    b. Use of linear functions for modeling in real-world situations;
    c. Modeling with the system of linear equations and their solutions;
    d. Elementary introduction to derivatives in mathematical modeling;
    e. Linear and exponential growth and decay models;
    f. Quantitative reasoning exercises using mathematical modeling.
3. **Statistical Modeling and Analyses**

a. Introduction to probabilistic models;
b. Bivariate analysis, scatter plots;
c. Simple linear regression model and correlation analysis;
d. Basics of estimation and confidence interval;
e. Testing of hypothesis (z-test; t-test);
f. Statistical inference in decision making;
g. Quantitative reasoning exercises using statistical modeling.

SUGGESTED INSTRUCTIONAL/READING MATERIALS

1. "Using and Understanding Mathematics: A Quantitative Reasoning Approach" by Bennett, J. O., Briggs, W. L., & Badalamenti, A.
2. "Discrete Mathematics and its Applications" by Kenneth H. Rosen.
3. "Discrete Mathematics with Applications" by Susanna S. Epp.
4. "Applied Mathematics for Business, Economics and Social Sciences" by Frank S Budnick.
5. "Elementary Statistics: A Step by Step Approach" by Allan Bluman.
6. "Introductory Statistics" by Prem S. Mann.
7. "Applied Statistical Modeling" by Salvatore Babones.
8. "Barrons SAT" by Sharvon Weiner Green, M.A and Ira K.Wolf.

General Education	ENG- 321	Expository writing	3(3-0)

Course Learning Outcomes

By the end of the course students will be able to:

1. Understand the essentials of writing process integrating pre-writing, drafting, editing and proof reading to produce well-structured essays.
2. Demonstrate mastery of diverse expository type to address different purposes and audiences.
3. Uphold ethical practices to maintain originality in expository writing.

Course Contents

1. **Introduction to Expository Writing**

a. Understanding Expository Writing (definition, types, purpose, and applications)
b. Characteristics of effective expository writing (clarity, coherence and organization)
c. Introduction to paragraph writing

2. **The Writing Process**

a. Pre-writing techniques (brainstorming, free-writing, mind-mapping, listing, questioning and outlining etc.)
b. Drafting (three stage process of drafting techniques)
c. Revising and editing (ensuring correct grammar, clarity, coherence, conciseness etc.)
d. Proof reading (fine-tuning of the draft)
e. Peer review and feedback (providing and receiving technique)

3. **Essay Organization and Structure**

a. Introduction and hook (engaging the readers and introducing the topic)
b. Thesis statement (crafting a clear and focused central idea)
c. Body paragraphs (topic sentences, supporting evidence and transitional devices)
d. Conclusion (type of concluding paragraphs and leaving an impact)
e. Ensuring cohesion and coherence (creating seamless connections between paragraphs)

4. **Different Types of Expository Writing**

a. Description
b. Illustration
c. Classification
d. Cause and effect (exploring causal relationship and outcomes)
e. Process analysis (explaining step-by-step procedures)
f. Comparative analysis (analyzing similarities and differences)

5. **Writing for Specific Purposes and Audiences**

a. Different types of purposes (to inform, to analyze, to persuade, to entertain etc.)
b. Writing for academic audiences (formality, objectivity, and academic conventions)
c. Writing for public audiences (engaging, informative and persuasive language)
d. Different tones and styles for specific purposes and audiences

6. **Ethical Considerations**

a. Ensuring original writing (finding credible sources, evaluating information etc.)
b. Proper citation referencing (APA, MLA, or other citation styles)
c. Integrating quotes and evidences (quoting, paraphrasing and summarizing)
d. Avoiding plagiarism (ethical considerations and best practices) Suggested Practical Activities (Optional)

As part of the overall learning requirements, students will be required to build a portfolio having a variety of expository texts and present the same at the end of the course

showcasing proficiency in expository writing.

Suggested Instructional/Reading Materials

1. The St. Martin' Guide to Writing by Rise B. Axelrod and Charles R. Cooper
2. They Say /I Say: The Moves that Matter in Academic Writing by Gerald Graff and Cathy Birkenstein
3. Writing Analytically by David Rosenwasser and Jill Stephen
4. Style: Lessons in Clarity and Grace by Joseph M. Williams and Joseph Bizup
5. The Elements of Style by Willaim Strunk Jr. and E.B. White
6. Good Reason with Contemporary Arguments by Lister Faigly and Jack Selzer
7. Writing to Learn: How to Write - and Think – Clearly About Any Subject at All by William Zensser
8. The Norton Field Guide to Writing by Richard Bullock, Maureen Daly Goggin and Francine Weinberg
9. The Art of Styling Sentences by Ann Longknife and K.D. Sullivan
10. Writing Today by Richard Johnson-Sheehan and Charles Paine

General Education	ISL-327	Seerat-e-Mustafa (PBUH)	2(2-0)

`Title	**Description**
Semester	2
Nature of Course	General Education
C.Hrs.	2 (2-0)
Total Teaching weeks	16
Code	ISL 327
Marks	50
Objectives of the Course اغراض و مقاصد	1۔طلبہ کو سیرۃ النبیﷺ کے تعارف ، مآخذ و اہمیت سے متعارف کرانا 2۔ طلبہ کو حیاتِ طیبہ کے مکی اور مدنی دور کی مستند وجامع احوال سے روشناس کرانا 3۔ طلبہ کو آپﷺ کی سماجی، معاشی، تعلیمی اورعلمی زندگی سے آگاہ کرنا 4۔ طلبہ میں عصر حاضر کے مسائل کو سیرۃ النبیﷺ کی روشنی میں حل کرنے کا رجحان پیدا کرنا

نمبر شمار	**عنوانات (ہفتہ وار)**	**تفصیلات**

.1	سیرۃ النبیﷺ کا تعارف	1۔سیرت کا لغوی اور اصطلاحی مفہوم، سیرت کی ضرورت واہمیت2۔ سیرت کا آغاز وارتقاء
.2	سیرت النبی ﷺ کے مأخذ	1۔ قرآن وحدیث 2۔ کتبِ سیرت کا تعارف
.3	نبی کریمﷺ کی حیاتِ طیبہ (مکی زندگی)	1۔ قبل از بعثت کے واقعات 2۔ ابتدائے بعثت تا ہجرت مدینہ کے واقعات
.4	نبی کریمﷺ کی حیاتِ طیبہ (مدنی زندگی)	1۔ ہجرت نبویﷺ تا غزوہ احزاب کے واقعات 2۔ صلح حدیبیہ تا وصال نبیﷺ کے واقعات
.5	نبی کریمﷺ کے حقوق وخصائص	1۔ نبی کریمﷺ کے حقوق 2۔ نبی کریمﷺ کے خصائص (کاملیت، تاریخیت، جامعیت، عملیت)
.6	رسول اللہﷺ بحیثیت انسانِ کامل	1۔ رسول اللہﷺ بحیثیت شہری، والد، شوہر، معلّم اور آپﷺ کے طریقہ ہائے تدریس 2۔ رسول اللہﷺ بحیثیت تاجر، منصف اور سپہ سالار وفاتح
.7	نبی کریمﷺ کے اخلاقِ حسنہ اور ان کے اثرات	1۔نبی کریمﷺ کے اخلاقِ حسنہ کے انفرادی اثرات 2۔ نبی کریمﷺ کے اخلاقِ حسنہ کے اجتماعی اثرات
.8	سیرۃ النبیﷺ اوردعوتِ اسلام	1۔ سیرۃ النبیﷺ اور انفرادی دعوت 2۔سیرۃ النبیﷺ اور اجتماعی دعوت
.9	سیرۃ النبیﷺ اور خواتین	1۔ خواتین کے حقوق 2۔ خواتین کا سماجی وثقافتی مقام ومرتبہ سیرتِ نبوی ﷺ کی روشنی میں
10	سیرۃ النبیﷺ اورورواداری	1۔غیر مسلموں کے ساتھ رواداری 2۔ مسلمانوں کے ساتھ رواداری
11	سیرۃ النبیﷺ اورمعیشت	1۔مختلف نظام ہائے معیشت کا تعارف 2۔ اسلامی معیشت
12	سیرۃ النبیﷺ اوررفاہِ عامہ	1۔ رفاہِ عامہ سے متعلق تعلیمات سیرت 2۔ رفاہِ عامہ کی عملی صورتیں
13	سیرۃ النبیﷺ اورتعلیم وتربیت	1۔اولاد کی تعلیم وتربیت 2۔ دیگر متعلقین کی تعلیم وتربیت
14	سیرۃ النبیﷺ اوراسلامی ریاست	1۔اسلامی ریاست کا تعارف وتنظیمی ڈھانچہ 2۔حکمران اور رعایا کے حقوق وفرائض
15	نبی کریمﷺ کی داخلہ اور خارجہ پالیسی	1۔ نبی کریمﷺ کی داخلہ پالیسی 2۔ نبی کریمﷺ کی خارجہ پالیسی
16	رسول اللہﷺ بحیثیت خاتم النبیین	1۔ختم نبوت کا تعارف، ضرورت واہمیت 2۔عقیدہ ختم نبوت: قرآن، حدیث اور اجماع کی روشنی میں

نصابی کتب

نمبر	نام مصنف	نام کتاب
1	سید سلیمان ندویؒ	خطبات مدراس
2	سید سلیمان ندویؒ	رحمتِ عالم
3	ڈاکٹر عبدالروؤف ظفر	اسوہ کامل

حوا لہ جات کتب

نمبر	نام مصنف	نام کتاب
1	ابن ہشام	سیرت ابن ہشام
2	علامہ شبلی نعمانیؒ/ سید سلیمان ندویؒ	سیرۃ النبیﷺ
3	مولاناحکیم عبدالرؤوف داناپوریؒ	اصح السیر
4	مولانا محمد ادریس کاندھلویؒ	سیرت المصطفیٰ
5	پیر کرم شاہ الازہریؒ	ضیاء النبیﷺ
6	مولانا مودودیؒ	سیرت سرورِ عالم
7	ڈاکٹر محمد حمید اللہؒ	سیرت النبی ﷺ
7	صفی الرحمٰن مبارک پوری	الرحیق المختوم

General Education	ISL-325	Fehm-e-Quran-II	1(1-0)

Understanding of Holy Quran – II

Course Title: Understanding of Holy Quran – II
Course Code: ISl-325
Course Book: Muallim ul Quran (Volume 3, 4 & 5) by Dr Ubaid ur Rahman
Credit Hours: 1 (0-1) **Contact Hours:** 3 per week **Weeks:** 15-16 (45-48 hours)

Course Learning Outcomes:

By the end of this course, students will be able to:

1. Directly comprehend hundreds of Quranic sentences & verses.
2. Understand at least 80 to 85 % of each page of the holy Quran.
3. Understand common verses across different Quranic topics.
4. Achieve proficiency in the basic and advance linguistic aspects of the Arabic language.
5. Understand the difference between Quranic verbs in various forms, such as present, past and imperative.

6. Develop the ability to understand long verses of the holy Quran independently and then comprehend their interpretation.

Provision of material, content and books:

- **Paper book**: All volumes are available in printed book form.
- **Tutorial videos:** Teaching video of each lesson available on YouTube.
- **Confirmation Videos:** A complete series of confirmation videos of all lessons is available in which the student can confirm his answers.
- **A flipbook:** A flipbook edition is also accessible.
- **Helping material:** Helping material for the teachers like quizzes, question papers and images is available on website.

Course Outline:

Weeks	Lectures	Units	Lessons	Assignments/Home Task	
1.	1.	6	6	Understanding & Translation of Verses	Present Tense صيغة جمع مذكر غائب مثل يعبدون
	2.	6	7-8	Understanding & Translation of Verses	Present Tense صيغة جمع مذكر غائب مثل يعبدون
2.	1.	6	9-10	Understanding & Translation of Verses	Present Tense صيغة مفرد مذكر مخاطب (تعبد) وجمع مذكر مخاطب (تعبدون)
	2.	6	11-12	Understanding & Translation of Verses	Present Tense صيغة جمع مذكر مخاطب (تعبدون)
					صيغة المتكلم (أعبد)
3.	1.	6	13	Understanding & Translation of Verses	Present Tense صيغة جمع المتكلم (نعبد)
	2.	6	14-15	Understanding & Translation of Verses	Negative Imperative صيغة المفرد وصيغة الجمع , لا تعبدْ، لا تعبدوا
4.	1.	6	16-17	Understanding & Translation of Verses	Conditional Sentences & masdar moawal (مصدر موؤل)
	2.	6	18-19	Understanding & Translation of Verses	Laam uttaleel (لام التعليل) & Laam ul jhood(لام الجحود)
5.	1.	6	20-21	Understanding & Translation of Verses	Present with object pronouns & Passive Voice
	2.	6	Revision (Unit 6)	Quiz	
6.	1.	Unit 7	1 (sec 1-3)	Understanding & Translation of Verses	Past Tense صيغة المفرد الغائب

	2.	6	1 (Sec 4-5)	Understanding & Translation of Verses	Past Tense صيغة المفرد للغائب
7.	1.	6	1 (Sec 5-6)	Understanding & Translation of Verses	Past Tense صيغة المفرد للغائب
	2.	6	1 (Sec 7-9)	Understanding & Translation of Verses	Past Tense صيغة المفرد للغائب
8.	1.	7	Revision	Understanding & Translation of Verses QUIZ	Past Tense صيغة المفرد للغائب
	2.	MID TERM			
9.	1.	7	2 (sec 1-2)	Understanding & Translation of Verses	Past Tense صيغة الجمع للغائب عبدوا
	2.	7	2 (sec 3)	Understanding & Translation of Verses	Past Tense صيغة الجمع للغائب عبدوا
10.	1.	7	2 (sec 4-5)	Understanding & Translation of Verses	Past Tense صيغة الجمع للغائب عبدوا
	2.	7	2 (sec 6-7)	Understanding & Translation of Verses	Past Tense صيغة الجمع للغائب عبدوا
11.	1.	7	3 (sec 1-2)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمتكلم عبدنا

	2.	7	3 (sec 2-3)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمتكلم عبدنا
12.	1.	7	3 (sec 3-4)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمتكلم عبدنا
	2.	7	3 (sec 4-5)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمتكلم عبدنا
13.	1.	7	4 (sec 1-2-3)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمخاطب عبدتم
	2.	7	4 (sec 4-5)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمخاطب عبدتم
14.	1.	7	5-6	Understanding & Translation of Verses Quiz	Past Tense صيغة المتكلم والمخاطب عبد ت ، عبد ْ ت
	2.	7	7	Understanding & Translation of Verses	Past Tense صيغة المؤنث للغائب عب ْدتْ
15.	1.	7	8	Understanding & Translation of Verses	Passive Voice (Past Tense) فعل مجهول للمفرد
	2.	7	9	Understanding & Translation of Verses	Passive Voice (Past Tense) فعل مجهول الجمع
16.	1.	8	1-4	Understanding & Translation of Verses	Imperative Verb for singular فعل الأمر للمفرد
	2.	7	5-8	Understanding & Translation of Verses	Imperative Verb for plural فعل الأمر للجمع

Semester 3			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-431	Animal Behavior	3(3-0)
Major	ZOO-432	Animal Ecology	3(2-1)
Major	ZOO-433	Animal Form & Function – I (Comparative Anatomy)	3(2-1)
General Education	CHEM-434	Environmental Chemistry	3(2-1)
General Education	ISL-326	Islamic Studies	2(2-0)
General Education	PS-435	Pakistan Studies	2(2-0)
General Education	LLB-431	Human Rights and Citizenship	2(2-0)
Total Credits			18

Major	ZOO-431	Animal Behavior	3(3-0)

Course Learning Outcomes (CLOs):

By the end of this course, students will be able to:

1. Explain the fundamental principles and mechanisms of animal behavior
2. Analyze the influence of genetics, environment, and learning on animal behavior.
3. Evaluate the ecological and evolutionary significance of different behavioral patterns

Course contents:

1. **Introduction to Animal Behavior:**
   a. Overview and definition of animal behavior
   b. Historical perspectives and significance of studying behavior
   c. Major types of behavior
2. **Causes of Behavior:**
   a. Proximate causes and ultimate causes of Behavior
3. **Development of behavior:**
   a. Role of neural and physiological mechanisms in behavioral development
   b. Influence of external (environmental) and internal (hormonal/genetic) stimuli
   c. Gene-environment interactions in shaping behavior
4. **Animal Responses to Stimuli:**
   a. Physiological basis of behavioral adaptation under changing environments; hormonal control of stress, aggression, and reproductive behaviors
5. **Innate and Imprinting Behaviors:**
   a. Definition and examples of innate behavior
   b. Innate releasing mechanisms (IRMs) and fixed action patterns (FAPs)
   c. Imprinting and its ecological importance
6. **Learned Behavior:**
   a. Types of learn behavior and ecological significance
   b. Mechanisms of learning (habituation, conditioning, trial-and-error, insight learning)

c. Cost-benefit ratio in behavior
d. Quick learners and slow learners

7. Territoriality and Defense:

a. Concept and ecological role of territoriality
b. Factors influencing territory size and defense
c. Defensive behaviors and adaptive strategies (threat displays, mimicry, escape responses).

8. Circadian Rhythms and Bio-rhythmicity:

a. Concept and mechanisms of biological clocks
b. Circadian rhythms and adaptive significance
c. Diurnal, nocturnal, and seasonal periodicities

9. Altruism and Parental Sacrifice:

a. Altruistic behaviors and their evolutionary explanations
b. Kin selection and inclusive fitness
c. Parental investment and sacrifice to enhance offspring survival.

10. Social Organization in Animals:

a. Social organization and group living-advantages and disadvantages
b. Aggression, appeasement, cooperation, and selfish behaviors
c. Social structures in insects (ants, bees, termites) and mammals (primates, canids, elephants).

11. Communication in Animals:

a. Forms of animal communication: visual, auditory (bioacoustics), electrical, chemical, and tactile
b. Importance of chemical signals (pheromones) in animal behavior and ecosystem interactions

Text and Reference Books:

1. Dngatkin, L. A. 2012. Principles of Animal Behavior.W.W. Nortan and Co.New York.
2. Nordell, S.E. and Valone, T.J. 2017. Animal Behavior. Concepts, Methods, and Applications. Second edition. iSBn978-0-19-027674-4
3. Alcock, J. (2019). Animal Behavior: An Evolutionary Approach (11th ed.). Sinauer Associates.
4. Tinbergen, N., & Tinbergen, E. (2020). The Study of Instinct. Oxford University Press.
5. Shettleworth, S. J. (2010). Cognition, Evolution, and Behavior (2nd ed.). Oxford University Press.
6. Bradbury, J. W., & Vehrencamp, S. L. (2011). Principles of Animal Communication (2nd ed.). Sinauer Associates.
7. Foster, S. A., & Endler, J. A. (2019). An Introduction to Behavioral Ecology (5th ed.). Wiley-Blackwell.
8. Dukas, R. (2019). Evolutionary Behavioral Ecology. Oxford University Press.

Major	ZOO-432	Animal Ecology	3(2-1)

Course Learning Outcomes (CLOs):

By the end of this course, students will be able to:

1. Understand the interactions between animals and their environments.

2. Analyze population dynamics and community structure within ecosystems.
3. Evaluate the impact of environmental changes on animal populations and biodiversity.

Course Outline:

1. **Introduction**
a. Ecology and basic terminologies
b. Basic concepts of and types of Ecology
2. **Energy**
a. Types of energy, Laws of thermodynamics, primary and secondary productivity
b. Trophic levels and energy variation with increasing trophic levels, energy flow, food chains and food webs.
3. **Biogeochemical cycle**
a. Nitrogen, Phosphorus, Sulphur, Water, Carbon and Oxygen.
4. **Limiting factors**
a. Basic Concepts, Temperature, Soil, Water and Humidity, Light and Fire.
5. **Global ecosystems**
a. Atmosphere, Hydrosphere, Lithosphere and Ecosphere.
b. An introduction to ecosystem
c. Major ecosystem of the world; Forest, Grassland, Desert, Tundra ecosystems, Marine, Estuarine, Freshwater and Wetlands
6. **Population ecology**
a. Basic population characters
b. Growth and Growth Curves
c. Population Dynamics and Regulations.
7. **Community ecology**
a. Basic concepts, Community Analysis, Ecotones, Inter-population Interactions
8. **Pollution**
a. Definition, Types, Water, Air, Land and Noise, Sources and Management.
9. **Radiation ecology**:
a. Global Environmental Changes (ozone depletion, acid rain, greenhouse effect and global warming, Koyota protocol, Radioactivity leakage, Environmental laws).
b. Desertification, Deforestation, exotic, native and invasive species

Practical:

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

Text and Reference Books:

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

Major	ZOO-433	Animal Form & Function – I (Comparative Anatomy)	3(2-1)

Course Learning Outcomes:

By the end of this course, the students will be able to:

1. Describe the anatomical structures of various animal groups.
2. Compare the functional adaptations of organ systems across different taxa.
3. Evaluate the evolutionary significance of anatomical variations for adaptations

Course Contents:

1. **Protection, Support, and Movement:**

a. Protection: the integumentary system of invertebrates and vertebrates;
b. Movement and support: the skeletal system of invertebrates and vertebrates;
c. Movement: non-muscular movement; an introduction to animal muscles; the muscular system of invertebrates and vertebrates

2. **Communication I:**

a. Nerves: Neurons: structure and function.

3. **Communication II:**

a. Senses: Sensory reception: baroreceptors, chemoreceptors, georeceptors, hygroreceptors, phonoreceptors, photoreceptors, proprioceptors, tactile receptors, and thermoreceptors of invertebrates
b. Lateral line system and electrical sensing, lateral-line system and mechanoreception, hearing and equilibrium in air and water, skin sensors of mechanical stimuli, sonar, smell, taste and vision in vertebrates.

4. **Communication III:**

a. The Endocrine System and Chemical Messengers: Chemical messengers: hormones chemistry; and their feedback systems; mechanisms of hormone action
b. Hormones with principal function each of porifera, cnidarians, platyhelminthes, nemerteans, nematodes, molluscs, annelids, arthropods, and echinoderms invertebrates; an overview of the vertebrate endocrine system; endocrine systems of vertebrates, endocrine systems of birds and mammals

5. **Circulation and Immunity:**

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

nonspecific defenses, the immune response

Practicals:

1. Study of insect chitin, fish scale, amphibian skin, reptilian scales, feathers and mammalian skin.
2. Study and notes of skeleton of Labeo (Labeo rohita), Frog (Hoplobatrachus tigerinus), Varanus (Varanus bengalensis), fowl (Gallus gallus domesticus) and rabbit (Oryctolagus cuniculus).
3. Note: *Exercises of notes on the adaptations of skeletons to their function must be done.*
4. Earthworm or leech; cockroach, freshwater mussel, Channa or Catlacatla or Labeo or any other local fish, frog, pigeon and rat or mouse and rabbits dissections as per availability.
5. Study of heart, principal arteries and veins in a representative vertebrate (dissection of representative fish/mammals).

Books Recommended:

1. Pechenik, J.A. 2013. Biology of Invertebrates, 4th Ed. (International), Singapore: McGraw-Hill.
2. Hickman, C.P., Roberts, L.S., Larson, A. 2004. Integrated Principles of Zoology, 11th Ed. (International), Singapore: McGraw-Hill.
3. Miller, S.A. and Harley, J.B. 2016. Zoology, 10th 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.

General Education	CHEM-434	Environmental Chemistry	3(2-1)

Course Learning Outcomes:

By the end of this course, the students will be able to:

1. To acquire knowledge and develop understanding about the fundamental principles of environmental chemistry.
2. To learn about different types of pollutions.
3. To solve pollution related issues and experiments in the laboratory.

Course Contents:

1. 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 theozone hole, CFCs, ozone protection, biological consequences of ozone depletion.

2. 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.

3. 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.

4. Green Chemistry:

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

Practicals:

Water quality criteria: temperature, PH, TDS, Conductivity, hardness of water, detection of coliform bacteria, detection of various salts. BOD, COD. Any other practical depending on the availability of resources in the lab.

Recommended Books:

1. Baird, C. and Cann, M., Environmental Chemistry, 5th ed., W. H. Freeman & Company, (2012). 40
3. Dara, S. S. and Mihsra, D. D., A Text Book of Environmental Chemistry and Pollution Control, 9th ed., S. Chand & Co. Ltd., (2004).
4. Singhi, R. and Singh, V., Green Chemistry for Environmental Remediation, John-Willey & Sons, Inc., (2011).
5. Holloway, A. M. and Wayne, R. P., Atmospheric Chemistry, 1st ed., Royal Society of Chemistry, (2010).
6. Vaclavikova, M., Vitale, K., Gallios, G. P. and Ivanicova, L. Water Treatment
5. Technologies for Removal of High Toxicity Pollutants, Springerlink, UK, (2010).
7. Manahan, S. E., Environmental Chemistry, 9th ed., CRC press, Taylor & Francis group, USA, (2009).
8. Girard, J. E., Principles of Environmental Chemistry, 2nd ed., Jones and Bartlett
6. publishers, (2010).
9. Harrison, R. M., Monks, P., Farmer, J. G., Graham, M. C., Mora, S. J., Pulford, I. and
7. Hulsal, C., Principles of Environmental Chemistry, 1st ed., Royal Society of Chemistry, (2007).
10. Matalack, A., Introduction to Green Chemistry, 2nd ed., CRC press, Taylor & Francis group, USA, (2010).
11. Wright, J., Environmental Chemistry, Routledge, (2003).
12. O‟Neill, P., Environmental Chemistry, 3rd ed., Blackie Academic & Professional, (1998).

General Education	ISL-326	Islamic Studies	2(2-0)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Understand the basic information about Islamic Studies
2. Recognize the understanding of Islamic Civilization
3. Realize the skill to know issues related to faith and religious life.

Course contents

1. Introduction to Quranic Studies

a. History of Quran
b. Uloom-ul -Quran
c. Basic Concepts of Quran

2. Study of Selected Text of Holly Quran

a. Verses of Surah Al-Baqra Related to Faith (Verse No-284-286)
b. Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
c. Verses of Surah Al-Mumanoon Related to Characteristics of Faithful (Verse No-1-11)
d. Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
e. Verses of Surah Al-Inam Related to Ihkam (Verse No-152-154)

3. Study of Selected Text of Holly Quran

a. Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.)
b. Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
c. Verses of Surah Al-Saf Related to Tafakar, Tadabar (Verse No-1,14)

4. Seerat of Holy Prophet (S.A.W)-I

a. Life of Muhammad Bin Abdullah (Before Prophet Hood)
b. Life of Holy Prophet (S.A.W) in Makkah
c. Important Lessons Derived from the life of Holy Prophet in Makkah

5. Seerat of Holy Prophet (S.A.W)-II

a. Life of Holy Prophet (S.A.W) in Madina
b. Important Events of Life Holy Prophet in Madina
c. Important Lessons Derived from the life of Holy Prophet in Madina

6. Introduction to Sunnah

a. Basic Concepts of Hadith
b. History of Hadith
c. Kinds of Hadith
d. Uloom –ul-Hadith
e. Sunnah& Hadith
f. Legal Position of Sunnah

7. Selected Study from Text of Hadith

a. Introduction to Islamic Law & Jurisprudence
b. Basic Concepts of Islamic Law & Jurisprudence
c. History & Importance of Islamic Law & Jurisprudence
d. Sources of Islamic Law &Jurisprudence
e. Nature of Differences in Islamic Law
f. Islam and Sectarianism

8. Islamic Culture & Civilization

a. Basic Concepts of Islamic Culture & Civilization
b. Historical Development of Islamic Culture & Civilization
c. Characteristics of Islamic Culture & Civilization, and Contemporary Issues.

9. Islam & Science

a. Basic Concepts of Islam & Science

b. Contributions of Muslims in the Development of Science
c. Quran & Science

10. 1o. Islamic Economic System

a. Basic Concepts of Islamic Economic System
b. Means of Distribution of wealth in Islamic Economics
c. Islamic Concept of Riba
d. Islamic Ways of Trade & Commerce

11. Political System of Islam

a. Basic Concepts of Islamic Political System
b. Islamic Concept of Sovereignty
c. Basic Institutions of Govt. in Islam

12. Islamic History

a. Period of Khlaft-E-Rashida
b. Period of Ummayyads
c. Period of Abbasids

13. Social System of Islam

a. Basic Concepts of Social System of Islam
b. Elements of Family
c. Ethical Values of Islam

Suggested Reading Materials

1. Ahmed, A. S., & Sonn, T. (Eds.). (2010). The SAGE handbook of Islamic studies. Sage.
2. Loop, J. (2013). Johann Heinrich Hottinger: Arabic and Islamic studies in the seventeenth century. Oxford-Warburg Studies.
3. Denny, F. (2015). An introduction to Islam. Routledge.
4. Brown, D. W. (2017). A new introduction to Islam. John Wiley & Sons.
5. Ali, K. (2024). The Woman Question in Islamic Studies. Princeton University Press.
6. Mir Waliullah, "Muslim Jurisprudence and the Quranic Law of Crimes" Islamic Book Service (1982).
7. Tibi, B. (2024). Islamism and the Political Order. In Handbook of Political Islam in Europe: Activities, Means, and Strategies from Salafists to the Muslim Brotherhood and Beyond. Cham: Springer International Publishing.

General Education	PS-435	Pakistan Studies	2(2-0)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Have enhanced knowledge of the geographical, historical, and political aspects of Pakistan.
2. Understand the society and culture of Pakistan.
3. Understand and explain the socio-economic developments in Pakistan.
4. Explore contemporary issues and challenges and their implications for P a k i s t a n .

Course Contents:

1. Introduction to Pakistan:

a. Geographical location and significance.

b. Historical background: Ancient civilizations in the region.
c. Factors leading to the creation of Pakistan.

2. Political History of Pakistan

a. Formative phase: Military interventions and democratic transitions.

3. Geography of Pakistan:

a. Physiographic: Mountains, plains, plateaus, deserts, valleys and coastal areas.
b. River systems: Indus River and its tributaries.
c. Climatic regions of Pakistan.

4. Society and Culture of Pakistan:

a. Socio-cultural diversity.
b. Languages and literature of Pakistan.

5. Economic Development of Pakistan:

a. Agricultural and industrial sectors of Pakistan.
b. Economic challenges of Pakistan.

6. Contemporary Issues:

a. Foreign Relations of Pakistan.
b. Security Challenges: Terrorism, extremism, and regional conflicts.
c. Environmental problems and sustainable development (SDGs).
d. Media and Social Change

Recommended Books

1. The struggle for Pakistan by Ishtiaq Husain Qureshi. 1965. University of Karachi.
2. Pakistan, the Formative Phase, 1557-1945" by Khalid B. Sayeed. 1965. OUP.
3. Hayat, S. (2020). Aspects of the Pakistan movement. M/s Roohani Art Press, Blue Area, Islamabad, Pakistan.
4. Constitutional and Political History of Pakistan" by Hamid Khan. 2020.OUP.
5. Trek to Pakistan" by Ahmad Saeed and Kh. Mansur Sarwar.2019. Peace Publication.
6. Pakistan: The Modern History" by Ian Talbot. 2001. South Asia Research.
7. Politics in Pakistan: The Nature and Direction of Change" by Khalid B. Sayeed. 1980. Praeger.
8. Papanek, G. F. (2024). Pakistan's development: Social goals and private incentives. Harvard University Press.
9. Candland, C. (2024). The Islamic Welfare State: Muslim Charity, Human Security, and Government Legitimacy in Pakistan. Cambridge University Press.
10. Rumi, R. (2018). Being Pakistani: Society, culture and the arts. Harper Collins.

General Education	LLB-431	Human Rights and Citizenship	2(2-0)

Course Learning Outcomes

By the end of this course, students will be able to:

1. To promote human values, in particular religious tolerance for others
2. To promote HR, in particular those of the minorities and ethnic groups
3. To develop a cross-cultural understanding, to recognize the value of difference
4. To relate human progress through a sense of diversity, good citizenship & tolerance for social harmony.

Course Contents

1. The Last address of the Holy Prophet (Peace be upon Him)
2. The United Nations Human Rights Charter.

The above may be studied for the understanding of the following:

1. What is Human Rights (HR)?
2. Evolution of the Concept of HR
3. Four Fundamentals in HR: freedom, equality, justice, and human dignity
4. Universal Declaration of HR
5. Three Key Principles in HR: inalienability, indivisibility and universality
6. Are HR Universal? (debate/ discussion etc.)
7. HR in South Asia: Issues
8. Rights of Women
9. Rights of Children (debate/ discussion on child labour, etc.)

Recommended Readings

1. Dean, B. Joldoshalieva, R. & Sayani, F. (2006). *Creating a Better World*. Karachi, Pakistan: Aga Khan University, Institute for Educational Development.
2. Ed. Williams, Isabel. (2008). *Teaching Human Rights through English Education*. Karachi: Oxford University Press.

Semester 4			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-441	Evolution	3(3-0)
Major	ZOO-442	Animal Form & Function – II (Comparative Physiology)	3(2-1)
Major	ZOO-443	Entomology	3(2-1)
Major	ZOO-444	Developmental Biology	3(2-1)
General Education	MGT-443	Entrepreneurship	2(2-0)
General Education	PS-425	Civics & Community Engagement	2(2-0)
General Education	PS-322	Ideology & Constitution of Pakistan	2(2-0)
Total Credits			18

Major	ZOO-441	Evolution	3(3-0)

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:

1. Introduction:

a. Definition and scope of evolution in Zoology
b. Evidence for evolution

2. Theories of Evolution:

a. Pre-Darwinian theories: Lamarckism
b. Darwin theory of natural selection
c. Neo-Darwinism and the Modern Synthesis - modern synthetic theory

3. Mechanism of evolution:

a. Factors initiating elementary evolutionary changes (micro-evolution) and change of gene frequencies.
b. Mutation pressure, selection pressure, immigration and crossbreeding, genetic drift.
c. Nonrandom mating and hardy Weinberg Principle of equilibrium

4. Role of isolation in evolution:

a. Factors of large evolutionary changes (macroevolution) concepts of allometry, orthogenesis, adaptive radiation.

5. Modern concept of Natural Selection:

a. Levels of selection, selection patterns, some examples of Natural Selection.
b. Impacts of Natural Selection leading to Convergence, Radiation, Regression and Extinction.
c. Batesian mimicry, Mullerian mimicry, sexual selection: Darwin's concept, Fisher's view, Zahavi's handicap theory and Recapitulation theory.

6. Molecular evolution and phylogenetic

Books Recommended

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

Major	ZOO-442	Animal Form & Function – II (Comparative Physiology)	3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Explain the comparative physiological processes in animals.
2. Compare physiological adaptations of animals in response to environment.
3. Analyze the role of homeostasis in maintaining functional stability in animals.

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.
e. STDs, Contraceptive methods

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. 2016. Zoology, 10th Ed. (International), Singapore: McGraw-Hill.
4. Campbell, N.A. 2002. Biology, 6th Ed. Menlo Park, California: Benjamin /Cummings Publishing Company, Inc.
5. Kent, G.C., Miller, S. 2001. Comparative Anatomy of Vertebrates. NewYork: McGraw-Hill.
6. Hickman, C.P., Kats, H.L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw-Hill
7. Guyton, A.C. & Hall, J.E. (2020). *Textbook of Medical Physiology*. Elsevier. (for supplementary reading)

Major	ZOO-443	Entomology	3(2-1)

Course Learning Outcomes

By the end of this course, the students will be able to:

1. Identify and classify major insect orders and families.
2. Analyze the ecological roles of insects and their interactions with other species.
3. Evaluate the ecological, economic, medicinal, and agricultural significance of insects

Course Outline:

1. **Brief introduction to Arthropods**
2. **Introduction to Entomology and its branches**
3. **Morphology of Insects**

a. Head, thorax, Abdomen, Antennae, Wings, Legs and other appendages
b. Exoskeleton and integument of insects.

4. **Anatomy and Physiology of Insects**

a. Mouth Parts and endoskeleton of head, Digestive, Respiratory, Circulatory, Excretory, Nervous, reproductive systems and Metamorphosis.

5. **Phylogeny and Classification of Insects up to order level**
6. **Insects are the most successful group and importance of insects**
7. **Introduction to Entomological industries:**

a. Apiculture
b. Sericulture
c. Lac-culture
d. Integrated pest management
e. Insect pests of major crops (cotton, wheat, rice, sugarcane) and store grains**,** Identification, Life histories, Mode of damage
f. Control of pests: Cultural control, biological control, Physical control, Mechanical control, Chemical control, Bio-technological control

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. Study of sericulture and apiculture facilities.
6. Museum visits

Text and Reference Books:

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

Major	ZOO-444	Developmental Biology	3(2-1)

Course Learning Outcomes

By the end of this course, the students will be able to:

1. Understand the cellular and molecular mechanisms underlying animal development.
2. Describe the stages of embryonic development and differentiation in major animal groups.
3. Evaluate the genetic regulation of developmental processes and teratology

Course Outline:

1. Introduction

a. Introduction to developmental biology
b. Origin of sexual reproduction

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

3.1. Oogenesis

a. Mechanism of oogenesis among various classes of vertebrates.
b. Hormonal control of oogenesis

4. Fertilization

a. External & Internal Fertilization
b. Species-specific recognition of sperm and egg (Gamete recognition)
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. Cleavage and blastulation in Sea urchin, fishes, amphibians, birds and mammals.

7. Gastrulation

a. Morphogenetic movements
b. Gastrulation in Fishes, amphibians, birds and mammals
c. Fate maps

8. Organogenesis

a. Neurulation in different classes of vertebrates

9. Placenta and extraembryonic membranes and Parturition

10. Twins and its types

11. Cell adhesion molecules.

a. Cell junctions, cell adhesion molecules and substrate adhesion molecules
b. Mechanism of teratogenesis

12. 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

Reference Books:

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

General Education	MGT-443	Entrepreneurship	2(2-0)

Course Learning Outcomes

By the end of this course, the students will be able to:

1. To educates the students about successful creation, operation and growth of innovative entrepreneurial ventures.
2. To recognize, create and shape opportunities, provide the leadership and build the team to create economic and social value.
3. Equips the students about various sources and methods of generating new viable business ideas. It also provides an insight into business plan development and its implementation.
4. Students will be able to develop a business plan to start and initiate their own ventures.

Course Contents:

1. Nature & Importance of Entrepreneurship & Entrepreneur:

a. What is Entrepreneurship?
b. The Entrepreneur.
c. Small-business owners & Entrepreneurs:
d. Intrapreneurship.
e. Distinction between an Entrepreneur & a manager.
f. Types of Entrepreneurs:
g. Why Do People Become Entrepreneurs?
h. The Entrepreneurial Process.
i. Start-Ups and Types of Start-Up Firms.
j. Role of Entrepreneurship.
k. Personal Entrepreneurial Characteristics/ Characteristics of Successful Entrepreneurs

2. Recognizing Opportunities:

a. What is a business opportunity?

b. Difference between opportunities and ideas.
c. Approaches/ways to identify opportunities.
d. Opportunity Recognition.
e. Opportunity recognition and the opportunity assessment plan.

3. Creativity and Innovation:

a. The Nature of Creativity.
b. The Creative Process.
c. Creating the Right Setting for Creativity.
d. Innovation.
e. Difference between Creativity and Innovation.
f. Types of Innovation.
g. Sources of Innovation.
h. Principles of Innovation.
i. Sources of New Ideas.
j. Methods of Generating Ideas.
k. Product Planning and Development Process.

4. Feasibility Analysis:

a. Feasibility Analysis
b. Product/Service Feasibility Analysis.
c. Industry/Target Market Feasibility Analysis.
d. Organizational Feasibility Analysis.
e. Financial Feasibility Analysis.

5. Developing an Effective Business Model:

a. Business Models and Their Importance.
b. General Categories of Business Models.
c. The Barringer/Ireland Business Model Template.

6. Business plan development:

a. What is a Business Plan?
b. Who Should Write The Plan?
c. Who Reads The Plan? / Scope and Value of the Business Plan:
d. Elements of a Business Plan:
e. Benefits of a Business Plan:
f. Guidelines to Remember:

Recommended Textbooks

1. Bruce R. Barringer, R. Duane Ireland "Entrepreneurship: Successfully Launching New Ventures" (Pearson) 6th edition, global edition.
2. Robert D.Hisrich & Michael P.Peter "Entrepreneurship" (McGraw Hill) 10th Edition.
3. Donald F. Kuratko, Howard Frederick & Allan O'Connor, "Entrepreneurship: Theory/Process/Practice" (Cengage Learning) Latest Edition.
4. Bruce A.Kirchott "Entrepreneurship & Dynamic Capital"
5. Zafar Altaf (Croom Helm) "Entrepreneurship in the third world"
6. Robert J. Calvin "Entrepreneurial Management" (tata McGraw Hill Edition)

General Education	PS-425	Civics & Community Engagement	2(2-0)

As per the course contents taught in Pak-study Department.

General Education	PS-322	Ideology & Constitution of Pakistan	2(2-0)

Course Learning Outcomes:

By the end of this course students will be able to

1. Demonstrate enhance knowledge of the basis of the ideology of Pakistan with special reference to the contribution of the founding fathers of Pakistan.
2. Demonstrate fundamental knowledge about the constitution of Pakistan 1973 and its evolution with special reference to state structure.
3. Explain about the guiding principles on rights and responsibilities of Pakistan's citizens as enshrined in the constitution of Pakistan 1973.

Course Contents:

1. Introduction to the ideology of Pakistan:

a. Definition and significance of ideology.
b. Historical context of the creation of Pakistan (with emphasis on socio-political, religious and cultural dynamics of British India between 1857 till 1947.
c. Contributions of founding fathers of Pakistan in the freedom movement including but not limited to Allama Muhammad Iqbal, Muhammad Ali Jinnah, etc.
d. Contributions of women and students in the freedom movement for separate homeland for Muslims of British India.

2. Two-Nation Theory:

a. Evolution of the Two-Nation Theory (Urdu-Hindi controversy, partition of Bengal, Shimla Deputation 1906, Allama Iqbal's Presidential Address 1930, Congress Ministries 1937, Lahore Resolution 1940.
b. Role of communalism and religious differences.

3. Introduction to the constitution of Pakistan:

a. Definition and importance of a constitution.
b. Ideological factors that shaped the constitution of Pakistan (Objectives Resolution 1949).
c. Overview of constitutional developments in Pakistan.

4. Constitution and State Structure:

a. Structure of Government (Executive, Legislature and Judiciary).
b. Distribution of powers between federal and provincial governments.
c. 18th Amendment and its impact on federalism.

5. Fundamental Rights, Principles of Policy and Responsibilities:

a. Overview of fundamental rights guaranteed to citizens by the Constitution of Pakistan 1973 (Articles 8-28).
b. Overview of Principles of Policy (Articles 29-40).
c. Responsibilities of the Pakistan citizens (Article 5).

6. Constitutional Amendments:

a. Procedures for amending the Constitution.
b. Notable constitutional amendments and their implications.

Suggested Books:

1. The Idea of Pakistan. Stephen P. Cohen.2006.
2. Ideology of Pakistan. Javed Iqbal. 2005.
3. Hoodbhoy, P. (2023). Pakistan: Origins, Identity and Future. Routledge India.
4. Kamran, T. (2024). Chequered Past, Uncertain Future: The History of Pakistan. .
5.Zahoor, B., & Rumi, R. (Eds.). (2020). Rethinking Pakistan: A 21st century perspective.

Anthem Press.

6. “Pakistan: A New History. by Ian Talbot. 2012.
7. “The Constitution of Pakistan 1973” Original.
8. “Constitutional Development in Pakistan” by G.W.Choudhury. 1960
9. “Constitutional and Political Development of Pakistan” by Hamid Khan. 2020

Semester 5			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-551	Zoogeography and Paleontology	3(2-1)
Major	ZOO-552	Marine Biology	3(3-0)
Major	ZOO-553	Principles of Systematic Zoology	3(2-1)
Interdisciplinary	ZOO-554	Principles of Biochemistry	3(2-1)
Interdisciplinary	ZOO-555	Principles of Genetics	3(2-1)
Major	ZOO-556	Economic Zoology	3(3-0)
Total Credits			18

Major	ZOO-551	Zoogeography and Paleontology	3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Understand the geographical distribution of animals and its evolutionary significance.
2. Analyze the fossil record to understand the history (geological timescale) and evolution of animal life.
3. Evaluate the role of geological and climatic changes in shaping animal diversity.

Course Contents:

1. Introduction to Zoogeography

a. Definition and scope of zoogeography
b. Branches of zoogeography: descriptive, ecological, historical, faunistics
c. Types of animal distribution: cosmopolitan, endemic, disjunct, bipolar
d. Barriers and dispersal mechanisms influencing animal distribution
e. Zoogeographical regions of the world (Palaearctic, Nearctic, Oriental, Ethiopian, Australian, Neotropical)
f. Zoogeography of Pakistan

2. Paleogeography and Geological Framework

a. Theories of continental drift and plate tectonics
b. Paleogeographic changes and their biological implications
c. Earth's structure: lithosphere, atmosphere, hydrosphere, biosphere
d. Types of rocks: igneous, sedimentary, metamorphic

3. Introduction to Paleontology

a. Definition, scope, and importance of paleontology
b. Fossil types and fossilization processes
c. Uses of fossils in understanding biological and geological history
d. Nature of fossils: moulds, casts, petrified fossils, coprolites

4. Geological Time Scale & Evolutionary History

a. Geological time scale (Precambrian, Paleozoic, Mesozoic, Cenozoic)
b. Major fossil faunas of different eras
c. Evolutionary significance of fossil records in tracing animal history

5. Dating Techniques

a. Principles of dating fossils and rocks
b. Radiometric dating methods: Uranium-Lead, Radiocarbon dating

6. Impact of Geological and Climatic Changes

a. Effect of plate tectonics and continental drift on animal distribution
b. Climatic changes and their role in shaping animal diversity and extinction events
c. Correlations between climatic shifts and evolutionary trends

Practical

1. Identification and study of different animal fossils (invertebrate and vertebrate)
2. Study of different types of rocks and their identification
3. Map exercises to identify zoogeographical regions globally and in Pakistan
4. Analysis of fossil samples and understanding fossilization processes

Books Recommended

1. Beddard, F.E., "A Textbook of Zoogeography"
2. Hickman, C.P., "Laboratory Studies in Integrated Principles of Zoology"
3. Tiwari, S.K., "Fundamentals of World Zoogeography"

Major	ZOO-552	Marine Biology	3(3-0)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Understand ecological processes and physical factors influencing marine ecosystems and organisms.
2. Analyze biodiversity and adaptations of marine life across coral reefs, open oceans, and deep-sea environments.
3. Evaluate impacts of human activities, climate change, and pollution on marine ecosystems and propose conservation strategies.

Course Contents:

1. Introduction to Marine Biology

a. Definition and scope of marine biology
b. Importance of marine ecosystems
c. Physical factors influencing marine environments (temperature, salinity, light, pressure)
d. Oceanographic processes: tides, waves, currents

2. Marine Ecosystems

a. Classification of marine habitats: coastal, coral reefs, estuaries, open ocean, deep sea
b. Ecological processes in marine ecosystems: primary production, nutrient cycling
c. Food chains and food webs in marine environments
d. Marine ecological zonation

3. **Marine Biodiversity and Adaptations**

a. Diversity of marine organisms: plankton, nekton, benthos
b. Adaptations of marine organisms to different habitats
c. Coral reefs: structure, importance, and major coral reef organisms
d. Deep-sea adaptations: bioluminescence, pressure adaptations, thermal vents

4. **Human Impact on Marine Ecosystems**

a. Pollution: plastic pollution, oil spills, chemical contaminants
b. Overfishing and destructive fishing practices
c. Habitat destruction: coral bleaching, mangrove deforestation
d. Climate change effects: ocean acidification, sea level rise, temperature changes

5. **Conservation and Management**

a. Marine protected areas (MPAs) and their importance
b. Strategies for sustainable fishery management
c. Role of international agreements and policies in marine conservation
d. Community participation and awareness programs

Books Recommended

1. "Marine Biology" by Peter Castro and Michael E. Huber
2. "Introduction to Marine Biology" by George Karleskint
3. "Ecology of Marine Animals" by T.G. Spence Bate

Major	ZOO-553	Principles of Systematic Zoology	3(2-1)

Course Learning Outcomes

By the end of this course, the students will be able to:

1. Explain the principles and methods of animal classification.
2. Analyze the evolutionary relationships among animals using phylogenetic methods.
3. Apply systematic approaches to classify and identify animal taxa

Course Contents:

1. **Importance and applications of systematics**:

a. Introduction to taxonomy and systematics and its branches
b. Taxonomy in Animal science
c. Systematics as a profession and its future perspectives.

2. **History of taxonomy**:

a. History of taxonomy
b. Basic terminologies of systematics.

3. **Species concept**:

a. Typological species concepts.
b. Nominalist species concept
c. Biological species concept
d. Evolutionary species concept
e. Difficulties in the application of biological species concept
f. Types of species
g. Speciation and its types.

4. **Intrapopulational variations and the comparison of population samples**
5. **Theory and practice of biological classification**

6. **Taxonomic characters**:

a. Kinds and weightage, micro taxonomy, taxonomic categories: specific category, intraspecific category, higher categories.

7. **Taxonomic procedures**

a. Taxonomic collection, their preservation and identification

b. Taxonomic keys, different kinds of keys and their merits and demerits.

8. **Brief concept of cladistics** and related terminologies, phylogenetic. Theory and practice of cladistics and phylogenetic systematics.

9. **The rules of Zoological Nomenclature**:

a. Zoological nomenclature

b. 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.

c. Taxonomic Publications

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 Yorks
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.

Interdisciplinary	ZOO-554	Principles of Biochemistry	3(2-1)

Course Learning Outcomes (CLOs)

1. Explain the structure, properties, and functions of biomolecules in animals.
2. Analyze key metabolic pathways and describe their regulation and interconnections.
3. Evaluate the role of biochemical reactions in animal physiology and cellular processes.

Course Contents:

1. **Introduction & Chemical Foundations:**
2. **Importance of biochemistry in Zoology**;

a. Water, pH, and buffers

b. Chemical bonds

c. Thermodynamics and bioenergetics (ΔG, equilibrium).

3. **Biomolecules I – Carbohydrates & Lipids**:

a. Structure, classification, and functions of carbohydrates
b. Monosaccharides, polysaccharides
c. Lipids – types, properties, biological roles

4. Biomolecules II – Amino Acids & Proteins:

a. Amino acid structure and properties
b. Peptide bond
c. Levels of protein structure
d. Protein folding and denaturation
e. Functions of proteins.

5. Enzymes and Catalysis:

a. Nature of enzymes, enzyme kinetics (Michaelis–Menten), enzyme inhibition, allosteric regulation, cofactors, and coenzymes

6. Nucleotides & Nucleic Acids:

a. Structure of DNA and RNA
b. Types of RNA
c. Nucleotides as energy carriers (ATP, GTP).

7. Bioenergetics & Oxidation–Reduction Reactions:

a. Redox reactions, electron carriers, ATP generation, overview of oxidative phosphorylation.

8. Carbohydrate Metabolism:

a. Glycolysis, TCA cycle, oxidative phosphorylation
b. Gluconeogenesis, glycogen metabolism
c. Regulation and integration.

9. Lipid & Amino Acid Metabolism:

a. β-oxidation of fatty acids
b. Ketone bodies
c. Amino acid catabolism and urea cycle.

10. Integration & Regulation of Metabolism:

d. Metabolic control
e. Hormonal regulation
f. Tissue-specific metabolism in animals

11. Applied / Comparative Biochemistry:

a. Biochemical basis of muscle contraction, nerve function, detoxification, and animal adaptation to environments

12. Review & Case Studies:

a. Metabolic disorders, enzyme deficiencies, biochemical diseases in animals; Revision & discussion.

Practical / Laboratory Work:

1. Laboratory safety rules, use of pipettes, balances, and spectrophotometer
2. Preparation of buffers and determination of pH
3. Qualitative tests for carbohydrates, proteins, and lipids
4. Protein estimation by Biuret or Bradford method

5. Enzyme activity assay (e.g. catalase, amylase, or invertase)
6. Effect of pH and temperature on enzyme activity
7. Separation of amino acids/sugars by paper or thin-layer chromatography
8. Extraction and quantification of DNA
9. Demonstration: SDS–PAGE / Electrophoresis (optional)
10. Mini-project: Comparative enzyme activity in animal tissues

Recommended Books:

1. Nelson, D.L. & Cox, M.M. (2021). Lehninger Principles of Biochemistry, 8th Ed. W.H. Freeman.
2. Berg, J.M., Tymoczko, J.L., Gatto, G.J. (2024). Biochemistry, 10th Ed. Macmillan Learning.
3. Voet, D., Voet, J.G., Pratt, C.W. (2023). Fundamentals of Biochemistry, 6th Ed. Wiley.
4. Pratt, C.W. & Cornely, K. (2023). Essentials of Biochemistry, 5th Ed. Wiley.
5. Satyanarayana, U. & Chakrapani, U. (2019). Biochemistry, 4th Ed. Elsevier / Books and Allied.
6. Lippincott Illustrated Reviews: Biochemistry, 9th Ed. (2024). Wolters Kluwer.

Interdisciplinary	ZOO-555	Principles of Genetics	3(2-1)

Course learning Outcomes:

By the end of this course, the students will be able to:

1. Understand the principles of heredity and genetic variation in animals.
2. Analyze molecular mechanisms of mutations
3. Evaluate the role of genetics in evolution, breeding, and diseases.

Course Contents

1. Introduction to Genetics:

a. History and significance of genetics in zoology

2. Branches of genetics:

a. classical,
b. molecular,
c. population,
d. behavioral,
e. Model organisms in genetic research.

3. Mendelian Genetics:

a. Mendel’s experiments and laws of inheritance,
b. Monohybrid and dihybrid crosses,
c. Backcross and test cross,
d. Application of probability in genetics.

4. Extensions of Mendelian Genetics:

a. Incomplete dominance and codominance,
b. Multiple alleles,
c. Lethal alleles and gene interactions,
d. Polygenic inheritance and pleiotropy.

5. **Sex Determination and Sex-Linked Inheritance:**
a. Mechanisms of sex determination in animals,
b. X-linked,
c. Y-linked,
d. sex-influenced traits,
e. Examples from human and animal genetics,
f. Dosage compensation and Barr bodies.
6. **Chromosomal Structure and Aberrations:**
a. Structure of eukaryotic chromosomes
b. Karyotype and chromosome banding.
7. **Chromosomal mutations:**
a. deletion,
b. duplication,
c. inversion,
d. translocation,
e. Aneuploidy and polyploidy.
8. **Molecular Genetics:**
a. DNA and RNA structure and function,
b. DNA replication,
c. transcription,
d. translation,
e. Genetic code and its properties,
f. Gene regulation in eukaryotic cells (introduction).
9. **Mutations:**
a. types, causes, and effects.
10. **Population Genetics and Evolution:**
a. Gene pool and allele frequencies,
b. Hardy-Weinberg equilibrium and its assumptions.
11. **Factors influencing gene frequencies:**
a. mutation,
b. selection,
c. migration,
d. drift,
e. Role of genetics in animal evolution and adaptation.
12. **Genetics of Development and Behavior:**
a. Genetic regulation of animal development,
b. Heredity of behavioral traits, Introduction to epigenetics and environmental influence on gene expression.
13. **Applied Genetics in Zoology:**
a. Genetic basis of hereditary diseases in animals.
14. **Molecular tools in genetics:**
a. DNA extraction,
b. PCR,
c. gel electrophoresis.
15. **Genetic engineering:**
a. transgenic animals,
b. cloning (overview),
c. Conservation genetics and genetic biodiversity.

Practical

1. Mendelian genetics using simulations or Drosophila (if available)
2. Blood group determination and inheritance analysis
3. DNA extraction from animal tissue (or model plant source)
4. Gel electrophoresis (simulation or demonstration)
5. Pedigree analysis and genetic disorder case studies
6. Karyotyping and chromosome observation
7. Mitosis and meiosis under microscope

Recommended Textbooks

1. Snustad, D. P., & Simmons, M. J. (2021). *Principles of Genetics* (8th ed.). Wiley.
2. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A., & Killian, D. J. (2020). *Concepts of Genetics* (12th ed.). Pearson Education.
3. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2021). *Molecular Biology of the Gene* (8th ed.). Pearson.
4. Hartl, D. L., & Clark, A. G. (2020). *Principles of Population Genetics* (5th ed.). Sinauer Associates / Oxford University Press.
5. Lynch, M., & Walsh, B. (2019). *Genetics and Analysis of Quantitative Traits* (2nd ed.). Sinauer Associates.
6. Allendorf, F. W., Luikart, G., & Aitken, S. N. (2021). *Conservation and the Genetics of Populations* (3rd ed.). Wiley-Blackwell.
7. Glick, B. R., Patten, C. L., Delovitch, T. L., & Pasternak, J. J. (2020). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (5th ed.). ASM Press / Springer.
8. Miller, O. J., & Therman, E. (2018). *Human Chromosomes: Structure, Behavior, and Effects* (5th ed.). Springer.
9. Plomin, R., DeFries, J. C., Knopik, V. S., & Neiderhiser, J. M. (2023). *Behavioral Genetics* (8th ed.). Worth Publishers / Macmillan.
10. Hartwell, L. H., Goldberg, M. L., Fischer, J., Kaiser, C. A., & Hood, L. (2022). *Genetics: From Genes to Genomes* (7th ed.). McGraw-Hill Education.

Major	ZOO-556	Economic Zoology	3(3-0)

Course Learning Outcomes

After completing this course, students will be able to:

1. Explain the principles and scope of economic zoology and its contribution to Pakistan's economy.
2. Identify and describe parasitic protozoa, vectors, and economically significant ecto- and endo-parasites.
3. Classify and discuss major crop pests and their control strategies.
4. Explain and demonstrate basic knowledge of apiculture, sericulture, lac culture, pearl culture, aquaculture and bird farming systems practiced in Pakistan.

Course Outline (Theory)

1. Introduction to Economic Zoology:

a. Definition, scope, and importance;
b. relationship between zoology and economy;
c. role of animal resources in Pakistan's GDP (based on *Economic Survey of Pakistan*).

2. **Parasitic Protozoans and Human Diseases:**
a. *Entamoeba histolytica*, *Plasmodium spp.*, *Trypanosoma*;
b. economic significance of protozoa.
3. **Vectors of Humans and Domestic Animals:**
a. Insects and arachnids as vectors of diseases (mosquitoes, flies, lice, ticks);
b. vector control and prevention.
4. **Ecto- and Endo-Parasites of Fish, Poultry, Cattle, and Humans:**
a. Crustacean parasites (*Argulus*, *Lernaea*);
b. Helminthes (*Fasciola*, *Ascaris*, *Taenia*);
c. Arachnids (ticks, mites);
d. effects on health and production losses.
5. **Crop Pests of Economic Importance:**
a. Pests of pulse, oilseed, cotton, vegetable, fruit, and tea crops;
b. stored grain pests;
c. integrated pest management (IPM) approaches.
6. **Apiculture (Beekeeping):**
a. Species of honey bees;
b. structure of hive;
c. bee products (honey, wax, propolis);
d. diseases and management;
e. apiculture as a cottage industry in Pakistan.
7. **Sericulture (Silkworm Culture):**
a. Biology and life cycle of *Bombyx mori*;
b. silkworm rearing, cocoon formation, silk extraction, diseases, and control.
8. **Lac Insect and Pearl Culture:**
a. Biology, cultivation, and harvesting of lac insects;
b. uses of lac;
c. pearl oyster biology and artificial pearl culture.
9. **Aquaculture and Fisheries:**
a. Freshwater, pond, and marine fisheries;
b. edible fish and prawn culture;
c. major fish species of Pakistan;
d. fisheries production and economy based on *Economic Survey of Pakistan*.
10. **Bird Farming and Avian Industries:**
a. Economic importance of poultry, quail, turkey, ostrich, and pigeon farming;
b. management, feeding, and disease prevention.
11. **Wildlife Utilization and Ecotourism:**
a. Economic role of wildlife;
b. ecotourism and game farming;
c. sustainable wildlife management.

Practical

1. Study of prepared slides of various ecto- and endo-parasites of fish, poultry, cattle, and man.
2. Identification of protozoan parasites from prepared slides.
3. Observation of museum specimens of vertebrate and invertebrate pests of major crops and stored grains in Pakistan
4. Visit to a honey bee farm; study of hives, bees, and products; prepare a report.
5. Visit to a sericulture farm and report on rearing and silk production.

6. Field visit to fish hatchery, nursery ponds, or commercial fish farm; report writing.
7. Identification of economically important fish species and their natural enemies.
8. Visit to a bird farm (poultry, quail, or ostrich) and submission of observation report.
9. Discussion of *Economic Survey of Pakistan* (livestock, fisheries, and poultry sections) and data interpretation.

Recommended Books

1. Shukla, G.S. & Upadhyay, V.B. (2022). *Economic Zoology*. S. Chand & Company Ltd., New Delhi.
2. Kapoor, V.C. (2018). *Applied and Economic Zoology*. S. Chand Publishing, India.
3. Pandey, K. (2019). *Economic Zoology*. Rastogi Publications, India.
4. Nayar, K.K. (2016). *Economic Zoology*. Tata McGraw Hill Education.
5. Pillay, T.V.R. & Kutty, M.N. (2005). *Aquaculture: Principles and Practices.* Blackwell Publishing.
6. Rehman, H., & Qureshi, M.S. (2008). *Livestock and Poultry Production in Pakistan.* Higher Education Commission, Islamabad.
7. Government of Pakistan. (Latest Edition). *Economic Survey of Pakistan.* Finance Division, Islamabad.

Semester 6			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-561	Fisheries & Aquaculture	3(2-1)
Major	ZOO-562	Research Methodologies & Bioethics	3(2-1)
Interdisciplinary	ZOO-563	Molecular Biology	3(2-1)
Interdisciplinary	BST-562	Biostatistics	3(2-1)
Interdisciplinary	ZOO-565	Microbiology & Immunology	3(2-1)
Total Credits			15

Major	ZOO-561	Fisheries & Aquaculture	3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Explain the principles of fisheries management and aquaculture practices.
2. Analyze the ecological and economic importance of various aquatic species.
3. Evaluate sustainable practices in fisheries and the development of the aquaculture industry.

Course Outlines

1. Introduction to Fisheries and Aquaculture

a. Definition and scope of fisheries and aquaculture
b. History and development of aquaculture
c. Classification of fisheries: marine, freshwater, inland

2. Principles of Fisheries Management

a. Objectives and importance of fisheries management
b. Fishery resource assessment techniques
c. Population dynamics and sustainable yield concepts
d. Fisheries legislation and policies
e. Management tools: quotas, size limits, seasonal closures, gear restrictions

3. Aquaculture Practices

a. Types of aquaculture systems: extensive, semi-intensive, intensive
b. Fish hatchery and nursery management
c. Brood stock selection and reproductive biology
d. Induced breeding techniques
e. Feed formulation and feeding regimes
f. Disease management and biosecurity

4. Ecological and Economic Importance

a. Role of aquatic species in ecosystems and human economy
b. Commonly cultured species and their habitat requirements
c. Socio-economic aspects of fisheries and aquaculture

d. Impact of overfishing and habitat degradation

5. Sustainable Practices in Fisheries and Aquaculture

a. Sustainable fisheries management principles
b. Conservation of aquatic biodiversity
c. Integrated multi-trophic aquaculture (IMTA)
d. Environmental impact assessment (EIA) in aquaculture
e. Community-based and co-management approaches

Practical

1. Identification of economically important fish species
2. Brood stock management and induced breeding experiments
3. Feed formulation and nutritional analysis
4. Water quality analysis for aquaculture systems
5. Visit to fish hatcheries and aquaculture farms

Books Recommended

1. Stickney, R.R., "Aquaculture: An Introductory Text"
2. Pillay, T.V.R., "Aquaculture: Principles and Practices"
3. Tiews, K., "Fisheries Management

Major	ZOO-562	Research Methodologies & Bioethics	3(2-1)

Course Learning Outcomes (CLOs):

By the end of this course, the students will be able to:

1. Understand the ethical principles and guidelines governing biological research and experimentation
2. Analyze bioethical issues related to genetics, biotechnology, and animal welfare.
3. Apply ethical decision-making frameworks to address ethical dilemmas in scientific research and practice

Course Contents:

1. Introduction to Research:

a. Definition and scope of research in biological sciences,
b. Objectives and motivations for conducting research:

2. Research Methodology and Process:

a. Research methods vs. research methodology,
b. The scientific method in research,
c. Types of research,
d. General steps in the research process,
e. Problems and limitations of research in Pakistan:

3. Topic Selection and Literature Review:

a. Problem identification and criteria for topic selection,
b. Importance of literature review in research planning,
c. Sources of scientific literature (primary, secondary, databases, journals),
d. Referencing and citation styles (APA, MLA, etc.),
e. Plagiarism: types, consequences, and detection software:

4. **Aims and Objectives in Research:**
a. Formulating clear research questions, aims, and objectives,
b. Qualities of effective research objectives:
5. **Research Design**:
a. Parts of a research design,
b. Important features and concepts (validity, reliability, replication, control);
6. **Materials and Methods**:
a. Sampling techniques and requirements,
b. Data collection methods,
c. Scales of measurement (nominal, ordinal, interval, ratio),
d. Sources and types of error in research;
7. **Statistical Tools in Research**:
a. Data processing/analysis and presentation (Text, tables, graphs, figures),
b. Overview of descriptive vs. inferential statistics,
c. Common statistical tests: t-test, ANOVA, chi-square;
8. **Bioethics in Research**:
a. Animal and human subject ethics in biological research,
b. Informed consent, confidentiality, and privacy,
c. Bioethical issues in genetics,
d. biotechnology, cloning, GMOs, stem cells,
e. Animal right/welfare considerations in experimentation;
9. **Scientific Writing and Communication**:
a. Difference between synopsis/research proposal and thesis/report,
b. Parts of a synopsis/proposal and thesis;
10. **Budgeting and Funding in Research**:
a. Cost estimation and financial planning for research projects,
b. National and international funding sources (HEC, USAID, DoST, HED, PMRC, WWF, PSF, etc.)

Practical:

1. **Orientation with Research Databases (**Google Scholar, PubMed, Web of Science, ScienceDirect, HEC Digital Library)**;**
2. **Searching for Scientific Papers (**Select a topic and search relevant research papers.
3. **Referencing & Citation Practice**: Introduction to reference managers (EndNote, Mendeley, Zotero); Practice APA style in-text citations and reference lists.
4. **Sampling & Data Collection Techniques**: (Designing simple sampling strategies (random, stratified, systematic, Practice with questionnaires, interviews, and observation sheets.
5. **Data Analysis Basics**: Hands-on practice in MS Excel/SPSS (mean, percentage, graphs, Running a simple t-test or chi-square with sample data.
6. **Scientific Writing Practice:** Research Proposal Development; Preparing tables, graphs, and figures correctly.
7. **Presentation of Research Proposal**: Each student/group presents a mini research proposal

Books recommended:

1. Paul Leedy, 2004, Practical Research: Planning and Design (8th Edition), Jeanne Ellis Ormrod

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

Interdisciplinary	ZOO-563	Molecular Biology	3(2-1)

Course Learning Outcomes (CLOs):

By the end of this course, the students will be able to:

1. Understand the molecular basis of gene structure, expression and regulation in animal cells.
2. Analyze the structure and function of nucleic acids and proteins.
3. Identify molecular techniques used to study biological processes

Course contents:

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
d. 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
d. Gene expression and control
e. Control of gene expression in Prokaryotes.

f. Inducible and repressible operons.
g. 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.

Interdisciplinary	BST-562	Biostatistics	3(2-1)

Course Learning 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,
d. Chi-square,
e. ANOVA, its uses and LSD,
f. Correlation,
g. 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.

Interdisciplinary	ZOO-565	Microbiology & Immunology	3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Explain the structure and function of microorganisms and their interactions with hosts.
2. Analyze immune system mechanisms in animals and their role in defense.
3. Evaluate the impact of microorganisms on animal health and disease.

Course Contents:

1. Introduction to Microbiology

a. Definition, history, and scope of microbiology
b. Classification of microorganisms: bacteria, viruses, fungi, protozoa, and algae
c. Structure and ultrastructure of bacterial, viral, and fungal cells
d. Microbial nutrition, growth, and reproduction

2. Microbial Interactions with Hosts

a. Symbiotic relationships: mutualism, commensalism, parasitism
b. Pathogenicity and virulence factors
c. Host-microbe interactions and infection mechanisms

3. Immune System Overview

a. Components of the immune system: organs, cells, molecules
b. Innate immunity: physical, chemical, cellular defenses
c. Adaptive immunity: humoral and cell-mediated responses

4. Immune Mechanisms

a. Antigens and antibodies: structure and function
b. Major Histocompatibility Complex (MHC)
c. Immune response to infection
d. Hypersensitivity, immunity disorders, and immunopathology

5. Microorganisms and Animal Health

a. Role of microbes in animal disease: bacterial, viral, fungal, and parasitic diseases
b. Diagnostic microbiology and disease prevention
c. Antibiotics, vaccines, and antimicrobial resistance
d. Microbial ecology and its role in animal health

Practical

1. Microscopic examination of bacteria, fungi, and protozoa
2. Culture techniques and staining methods (Gram stain, acid-fast stain)
3. Immunological assays: agglutination, ELISA, precipitation
4. Identification and analysis of microbial cultures
5. Case studies on infectious diseases in animals

Books Recommended

1. "Microbiology" by Prescott, Harley, and Klein
2. "Immunology" by Kuby
3. "Medical Microbiology and Immunology" by Warren Levinson

ZOOLOGY IN GENERAL

Semester 7			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-671	Wildlife Conservation & Management	3(2-1)
Major	ZOO-672	Protozoology and Protozoic Diseases	3(2-1)
Major	ZOO-673	Insect systematics and Taxonomy	3(2-1)
Major	ZOO-674	Ichthyology	3(2-1)
Interdisciplinary	CB-675	Computational Biology	3(2-1)
Internship		Internship	3
Total Credits			18

Major	ZOO-671	Wildlife Conservation & Management	3(2-1)

Course Learning Outcomes:

On the completion of the course, the students will:

1. Understand the diversity and distribution of wildlife in Pakistan.
2. Explore the roles and significance of protected areas in wildlife conservation.
3. Examine international conventions and agreements related to wildlife conservation.
4. Study the rules and regulations governing zoos and captive wildlife.
5. Identify and understand the threats to species and their habitats.
6. Investigate habitat ecology and the principles of wildlife conservation.
7. Develop skills in conservation planning and management.

Course Contents:

1. **Wildlife of Pakistan**
   a. Introduction
   b. Important Definitions
   c. Identification
   d. Distribution
   e. Status
   f. Conservation and Management of fishes, amphibians, reptiles, birds and mammals of major importance in Pakistan
2. **Philosophy and significance of wildlife conservation**
3. **Biodiversity and sustainability of wildlife.**
4. **Wildlife rules and regulations in Pakistan**
   a. Provincial Rules
   b. Federal Management of Wildlife (NCCW)
5. **National and International agencies involved in conservation and management of wildlife**
   a. National Organizations
   b. International Organizations

6. **Protected Areas in Pakistan**
a. Sanctuaries
b. Game Reserves
c. National Parks
7. **Ramsar convention**
a. Wetlands
b. Ramsar Criteria
c. Ramsar Sites
d. Threatened species of Pakistan.
e. Vulnerable
f. Endangered
g. Critically Endangered
8. **Introduction To Modern Techniques Used In Wildlife Conservation**
a. Radio telemetry
b. GIS
c. GPS
d. Remote camera
9. **Climate Change and Its Impact on Wildlife**
a. Definition
b. Factor affecting climate change
c. Impact of climate change on wildlife

Practicals

1. Visit to protected and conserved areas of Pakistan (Captive, Semi-captive and Wild Areas)
2. Visit to National Parks of Pakistan.
3. Ecological Indices
4. 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.
5. Roberts, T. J., 1991, 1992. The Birds of Pakistan, Vol. I1 and II. Oxford University Press
6. Roberts, T. J., 1997. The Mammals of Pakistan, Oxford University Press 8. Robinson, W.L. and Bolen, E.G., 1984. Wildlife Ecology and Management. McMillan

Major	ZOO-672	Protozoology and Protozoic Diseases	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

1. Explain the taxonomy, morphology, life cycles, and physiology of medically and economically important protozoa.
2. Analyze the epidemiology, pathogenesis, diagnosis, prevention, and control strategies of protozoan diseases affecting humans.

3. Demonstrate basic protozoological laboratory techniques (microscopy, staining, culture, slide preparation) and apply diagnostic approaches in identifying protozoa.

Course contents:

1. **Introduction & General Protozoology**

a. Scope and importance of Protozoology.
b. General morphology, locomotion, nutrition, and reproduction in protozoa.
c. Host–parasite relationships and protozoan transmission.

2. **Amoebae**

a. *Entamoeba histolytica* – morphology, life cycle, pathogenesis (amoebiasis).
b. Other amoebae of human importance (*Naegleria fowleri*, *Acanthamoeba*).
c. Laboratory diagnosis and treatment of amoebic infections.
d. Control and prevention strategies.

3. **Flagellates**

a. *Giardia lamblia* – giardiasis. *Trichomonas vaginalis* – trichomoniasis. *Trypanosoma* spp. – African sleeping sickness & Chagas disease. *Leishmania* spp. – cutaneous, mucocutaneous, and visceral leishmaniasis.
b. Control, vectors, and epidemiology of flagellate infections.

4. **Ciliates**

a. *Balantidium coli* – morphology, life cycle, pathogenesis, diagnosis.
b. Control and prevention of balantidiasis.

5. **Sporozoa & Apicomplexa**

a. *Plasmodium* spp. – malaria (life cycle, vector, pathogenesis).
b. Clinical features, diagnosis, treatment, and drug resistance in malaria.
c. *Toxoplasma gondii* – toxoplasmosis. *Cryptosporidium parvum* – cryptosporidiosis. *Cyclospora* and *Isospora* infections.
d. General epidemiology and control measures of apicomplexan diseases.

6. **Emerging & Opportunistic Protozoa**

a. Opportunistic protozoa in immunocompromised hosts (HIV/AIDS).
b. Zoonotic and waterborne protozoa of current public health concern.

7. **Applied & Public Health Aspects**

a. Laboratory and molecular diagnostic approaches in protozoology.
b. Control strategies: drugs, vaccines, vector management, sanitation.

Practicals

1. **Microscopy & Slide Preparation**

a. Wet mounts of protozoa (using cultures or preserved specimens).
b. Permanent stained slides (Giemsa, Trichrome).

2. **Identification**

a. Morphology of amoebae, flagellates, ciliates, and sporozoa under microscope.
b. Recognition of diagnostic stages (cysts, trophozoites, oocysts).

3. **Blood Protozoa**

a. Examination of *Plasmodium* stages in stained blood smears.
b. Identification of *Trypanosoma* in prepared slides.

4. Fecal Protozoa

a. Concentration techniques and microscopic detection of *Giardia, Entamoeba, Balantidium.*
b. Demonstrations / Virtual Labs
c. PCR / ELISA in diagnosis of malaria or leishmaniasis.
d. Culture techniques for *Leishmania* and *Trichomonas*.
e. Field / Case Studies
f. Visit to diagnostic labs or public health centers (if possible).
g. Epidemiological data analysis of protozoan diseases in the local area.

Recommended Books

1. Markell and Voge's Medical Parasitology – 10th Edition, 2021, by David T. John & William A. Petri.
2. Foundations of Parasitology – 10th Edition, 2021, by Gerald D. Schmidt & Larry Roberts.
3. Human Parasitology – 5th Edition, 2019, by Burton J. Bogitsh, Clint E. Carter & Thomas N. Oeltmann.
4. CDC & WHO Guidelines (open-access online) – especially for malaria, toxoplasmosis, and cryptosporidiosis.

Major	ZOO-673	Insect systematics and Taxonomy	3(2-1)

Course Learning Outcomes

By the end of the course, students will be able to:

1. Identify and classify insects up to family level.
2. Understand evolutionary relationships among major insect orders.
3. Use morphological and molecular data for systematic inference.
4. Prepare and maintain a basic insect reference collection.

Course Contents

1. Introduction to Insect Systematics

a. Scope and significance of insect systematics in biological sciences.
b. Historical development of insect classification.
c. Relationship between taxonomy, phylogeny, and evolution in insects.
d. Overview of traditional vs. modern (phylogenetic/molecular) systematics.

2. Morphological Basis of Classification

a. Taxonomically important external morphological characters: head, antennae, mouthparts, wings, legs, genitalia.
b. Types of wing venation and their systematic value.
c. Internal anatomical characters used in higher-level classification.
d. Role of larval and pupal characters in taxonomy.

3. Principles and Methods in Insect Classification

a. Hierarchical categories in insect taxonomy (species to order).
b. Concepts of species in insects (biological, morphological, phylogenetic, ecological).
c. Preparation and use of dichotomous keys.
d. Phylogenetic trees and cladograms — interpretation and construction.
e. Use of molecular tools (DNA barcoding, COI gene) in insect taxonomy.

4. **Classification and Diagnostic Features of Major Insect Orders**

a. Diagnostic characteristics, diversity, and phylogenetic relationships of major insect orders:
b. Apterygota (primitive wingless insects), Ephemeroptera, Odonata, Orthoptera, Hemiptera, Coleoptera, Lepidoptera, Diptera, Hymenoptera, etc.
c. Key families of economic or ecological importance.
d. Recent changes in higher classification based on molecular systematics.

Practical / Laboratory Work

1. Study of diagnostic morphological characters in major insect orders.
2. Collection and preservation of insect specimens from different habitats.
3. Preparation of dry and wet insect collections.
4. Identification of insects to family/order level using standard keys.
5. Construction of simple dichotomous keys for local fauna.
6. Taxonomic description and labeling of collected specimens.
7. Visit to entomological museum or insect reference collection (if available).

Recommended Books

1. Triplehorn, C. A., and Johnson, N. F. (2005). Borror and DeLong's Introduction to the Study of Insects.
2. Gullan, P. J., and Cranston, P. S. (2021). The Insects: An Outline of Entomology.
3. Ross, H. H. (1974). A Textbook of Entomology.
4. IMMs, A.D (1925) A general text book of Entomology (Volume I & II).

Major	ZOO-674	Ichthyology	3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Identify major fish groups and their distinguishing characteristics.
2. Explain fish anatomy, physiology, and adaptations to aquatic environments.
3. Analyze ecological roles and behaviors of fishes in aquatic ecosystems.
4. Evaluate fishery resources and conservation strategies.

Course Content

1. **Introduction to Ichthyology**

a. Definition, scope, and significance of ichthyology
b. Evolutionary history of fishes
c. Classification and taxonomy of fishes: major classes and orders

2. **Morphology and Anatomy of Fishes**

a. External morphology: body shapes, fins, scales, coloration
b. Internal anatomy: skeletal system, muscular system, digestive system, respiratory system, circulatory system, nervous system, reproductive system

3. **Fish Physiology**

a. Osmoregulation in freshwater and marine fishes
b. Respiratory adaptations
c. Sensory systems: vision, lateral line, electroreception
d. Locomotion and buoyancy

4. **Fish Ecology and Behavior**

a. Habitat types and distribution
b. Feeding habits and trophic interactions
c. Reproductive strategies and life cycles
d. Migration and schooling behavior

5. Fish Diversity and Systematics

a. Overview of major fish families with representative species
b. Identification techniques: keys and guides
c. Freshwater fishes of Pakistan: diversity and ecological significance

6. Fisheries and Conservation

a. Importance of fisheries and aquaculture
b. Fishery management principles
c. Threats to fish populations: overfishing, habitat destruction, pollution
d. Conservation strategies and sustainable practices

Practical

1. Identification of common freshwater and marine fish species
2. Examination of external and internal fish anatomy
3. Use of dichotomous keys for fish identification
4. Study of fish behavior and adaptation under controlled conditions
5. Water quality analysis in fish habitats

Recommended Textbooks

1. Fishes: An Introduction to Ichthyology by Peter B. Moyle & Joseph J. Cech Jr.
2. Ichthyology by Peter W. Scott & Mark C.Every
3. Inland Fisheries of Pakistan by M.A. Baig
4. Fish Morphology and Systematic by Rajendra Kumar

Interdisciplinary	CB-675	Computational Biology	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

1. Describe the scope and importance of computational biology.
2. Retrieve and interpret information from biological databases.
3. Perform basic sequence alignment and phylogenetic analysis using online tools.
4. Apply computational approaches to zoological and conservation problems.
5. Communicate results of computational analysis in scientific format.

Course Contents

1. Introduction

a. Definition, scope, and significance of "Computational Biology" in zoology
b. Relationship with bioinformatics, genomics, proteomics, systems biology

2. Biological Databases

a. Primary and secondary databases
b. NCBI, EMBL, UniProt, Swiss-Prot, ENSEMBLE, PDB, GeneBank
c. Data retrieval and annotation

3. Sequence Analysis

a. Introduction to primer designing

b. DNA, RNA, and protein sequences
c. Pairwise and multiple sequence alignment
d. BLAST (BLASTN and BLASTP), FASTA, ClustalW/MEGA softwares
e. Applications in taxonomy, evolutionary studies

4. Structural and Functional Genomics

a. Gene prediction and annotation
b. Protein structure basics and prediction approaches
c. Molecular modeling (Protein Modelling as an example)
d. Comparative genomics
e. Applications in Zoology and Conservation

5. Molecular Phylogeny

a. Population genetics and molecular evolution
b. Wildlife genetics, conservation genomics
c. Applications in medicine (disease markers, drug discovery)

Practical

Hands-on exercises using free online tools and databases:

1. Introduction to biological databases (NCBI, UniProt, Swiss-Prot, PDB, PROSITE).
2. Sequence retrieval in different formats (FASTA format, Genebank format etc).
3. Basic use of BLAST for sequence similarity searches.
4. Multiple sequence alignment using Clustal Omega / MUSCLE/ MEGA.
5. Construction of phylogenetic trees using MEGA (or online tree builders).
6. Retrieval of protein structure from PDB and visualization (e.g., PyMol / RasMol).
7. Case study: DNA sequence analysis for species identification.
8. Project/report: computational analysis of a selected gene/protein relevant to zoology.
9. Primer 3 plus

Recommended Books

1. Mount, D.W. (2004). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
2. Lesk, A.M. (2019). Introduction to Bioinformatics. Oxford University Press.
3. Xiong, J. (2006). Essential Bioinformatics. Cambridge University Press.
4. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Wiley-Blackwell.
5. Clote, P., & Backofen, R. (2000). Computational Molecular Biology: An Introduction. Wiley.

Internship		Internship	3

Internship of 3 credit hours is a mandatory degree award requirement for Bachelor of Science in Zoology. Internship of 6 to 8 weeks (preferably undertaken during semester or winter break) must be graded by a faculty member in collaboration with the supervisor in the field. This requirement cannot be substituted with additional course work, capstone or project work.

Semester 8			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-681	Fish Farm and Hatchery Management	3(2-1)
Major	ZOO-682	Helminthology	3(2-1)
Major	ZOO-683	Taxidermy	3(2-1)
Major	ZOO-684	Vector Biology and Public Health	3(2-1)
Capstone	CAP-685	Capstone	3
Total Credits			15

Major	ZOO-681	Fish Farm and Hatchery Management	3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Describe the components and setup of fish farms and hatcheries.
2. Apply techniques of induced breeding and broodstock management.
3. Manage water quality, feeding, and nursery operations effectively.
4. Recognize common fish diseases and apply preventive measures.
5. Evaluate sustainable fish farming and hatchery management practices.

Course Contents

1. **Introduction to Fish Farming and Hatchery Management**
   a. Overview and importance of aquaculture
   b. Fish farming systems: extensive, semi-intensive, and intensive
   c. Site selection and farm layout
   d. Hatchery design and operations
2. **Breeding Techniques and Broodstock Management**
   a. Broodstock selection and maintenance
   b. Natural and induced breeding methods
   c. Spawning, fertilization, and egg incubation
   d. Hatchery water management
3. **Larval Rearing and Nursery Management**
   a. Care and feeding of larvae and fry
   b. Nursery pond management
   c. Stocking density and growth monitoring
   d. Common problems in larval rearing
4. **Water Quality and Environmental Management**
   a. Important water quality parameters
   b. Monitoring and maintaining water quality
   c. Aeration, water exchange, and waste management
   d. Impact of environment on growth and survival
5. **Nutrition and Feeding**

a. Nutritional requirements of cultured fish species
b. Types and preparation of fish feed
c. Feeding methods and feed management
d. Feed efficiency and waste reduction

6. Disease Management and Biosecurity

a. Common fish diseases and their symptoms
b. Disease prevention and treatment strategies
c. Biosecurity measures in farms and hatcheries
d. Record keeping and health monitoring

7. Sustainable Fish Farming Practices

a. Environmental impacts and mitigation
b. Integrated fish farming systems
c. Economic considerations and profitability
d. Policies and regulations in aquaculture

Practical

1. Construction and management of fish ponds and hatcheries
2. Induced breeding and egg incubation
3. Larval and fry feeding techniques
4. Water quality testing (pH, dissolved oxygen, temperature, turbidity)
5. Disease identification and preventive measures

Books Recommended

1. Fish Hatchery Management by Jhingran and Pullin
2. Principles and Practices of Aquaculture by T.V.R. Pillay
3. Aquaculture: An Introductory Text by Robert R. Stickney
4. FAO Technical Guidelines for Aquaculture

Major	ZOO-682	Helminthology	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

1. Describe the morphology, classification, and life cycles of medically and economically important helminths.
2. Analyze the epidemiology, pathogenesis, clinical features, and control measures of helminthic diseases in humans.
3. Demonstrate laboratory skills in identifying helminth specimens (eggs, larvae, adults) and apply diagnostic methods used in helminthology.

Course Contents

1. Introduction & General Aspects

a. Scope and importance of helminthology.
b. General morphology, structure, nutrition, and reproduction of helminths.
c. Host–parasite relationships, transmission, and epidemiology.

2. Trematodes (Flukes)

a. General characteristics of trematodes.
b. *Fasciola hepatica* (liver fluke): life cycle, pathogenesis, diagnosis, control.
c. *Fasciolopsis buski* (intestinal fluke).
d. *Clonorchis sinensis*, *Opisthorchis* spp. (liver flukes).

e. *Paragonimus westermani* (lung fluke).
f. *Schistosoma* spp. (blood flukes) – schistosomiasis.

3. Cestodes (Tapeworms)

a. General characteristics of cestodes.
b. *Taenia saginata* and *T. solium* (beef and pork tapeworms).
c. *Echinococcus granulosus* and *E. multilocularis* (hydatid disease).
d. *Diphyllobothrium latum* (fish tapeworm).
e. *Hymenolepis nana* (dwarf tapeworm).
f. Clinical features, diagnosis, and control of cestode infections.

4. Nematodes (Roundworms)

a. General characteristics of nematodes.
b. *Ascaris lumbricoides* (roundworm).
c. *Enterobius vermicularis* (pinworm).
d. *Trichuris trichiura* (whipworm).
e. *Hookworms* (*Ancylostoma*, *Necator*).
f. *Strongyloides stercoralis*.
g. *Trichinella spiralis*.
h. Filarial worms (*Wuchereria bancrofti*, *Brugia malayi*, *Onchocerca volvulus*, *Loa loa*).
i. Dracunculiasis (*Dracunculus medinensis*).

Practicals

1. Microscopy: Study of preserved slides of trematodes, cestodes, and nematodes (adult worms, larvae, eggs).
2. Identification: Diagnostic stages of common helminths in stool, blood, and tissue samples.
3. Staining & Mounting: Preparation of temporary mounts, simple staining of helminth eggs/larvae.
4. Blood Smear: Identification of microfilariae in stained smears.
5. Case Study Demonstrations: Lab diagnosis of helminth infections (direct smear, concentration techniques).
6. Morphological Keys: Use of taxonomic keys for identification of major helminths.
7. Virtual / Molecular Tools (Demo): PCR/ELISA techniques for diagnosis (if facilities available).
8. Field Component (Optional): Visit to diagnostic lab/public health lab for demonstration of helminth detection methods.

Recommended Books (Latest Editions)

1. Markell and Voge's Medical Parasitology – 10th Edition, 2021, by David T. John & William A. Petri.
2. Foundations of Parasitology – 10th Edition, 2021, by Gerald D. Schmidt & Larry Roberts.
3. Human Parasitology – 5th Edition, 2019, by Burton J. Bogitsh, Clint E. Carter & Thomas N. Oeltmann.
4. Medical Parasitology: A Self-Instructional Text – 6th Edition, 2019, by Rosemary Gordon & Veronica Wong.
5. WHO / CDC Guidelines (latest online resources for control and diagnosis of helminthic diseases

Major	ZOO-683	Taxidermy	3(2-1)

Course Learning Outcomes:

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

1. Practice basic taxidermy techniques.
2. Produce taxidermy mounts using a variety of taxidermy techniques.
3. Review state and federal taxidermy laws.
4. Compare different taxidermy techniques in order to recommend appropriate techniques for preserving specimens.

Course Content

1. **Introduction to Taxidermy**
   a. Definition, history, scope, and significance of taxidermy in science and education
   b. Ethical considerations and legal frameworks (Wildlife Protection Laws, CITES)
   c. Modern alternatives to traditional taxidermy (e.g., 3D scanning and modeling
2. **Museum Establishment and Specimen Collection**
   a. Concept, types, and development of natural history museums
   b. Key features of an ideal museum
   c. Methods of specimen collection: Hand capturing, netting, digging, draining, trapping, and shooting, Protection, preservation, and storage prior to taxidermy
3. **Materials and Equipment**
   a. Chemicals and preservation solutions
   b. Tools for skinning, mounting, and modeling
4. **Taxidermy Techniques**
   a. Skinning procedures
   b. Dehydration and drying methods
   c. Tanning processes
   d. Preparation and mounting of reptiles, birds, and mammals
   e. Head mounting of large mammals (e.g., deer, markhor)
   f. Skeletal articulation and mounting
   g. Resin embedding techniques
   h. Preparation of head casts
   i. Labeling and cataloging of specimens
5. **Laws of Transportation**
   a. International and national laws on transportation of biological specimens
   b. Contemporary relevance and status of taxidermy in scientific and cultural institutions
6. **Wet Preservation**
   a. Materials and preservatives for wet specimens
   b. Pinning and curation techniques
   c. Wet mounting of invertebrates and vertebrates
   d. Long-term storage and display considerations

Practicals

1. Complete mounting of a small mammal (domestic or ethically sourced wild specimen)
2. Complete mounting of a bird specimen
3. Demonstration of resin embedding (including video or virtual resources)
4. Demonstration and practice of wet preservation methods using various invertebrate and vertebrate specimens

5. Field visit to a professional taxidermy facility (e.g., Pakistan Museum of Natural History, Islamabad or an equivalent institution)

Recommended Textbooks and References

1. Eastoe, J. (2020). *The Art of Taxidermy*. Pavilion Books.
2. Pat Morris (2010). *A Practical Guide to Modern Taxidermy*. The Crowood Press.
3. Fraser, M. (2008). *Taxidermy: A Complete Guide*. Creative Publishing.
4. Hall, E.R. (1991). *Preparation of Mammals for Museum Study*. University of Kansas Publications.
5. Knudsen, J. (2015). *Anatomical Preparation: Techniques and Tools for Preserving Animal Specimens*. Academic Press.
6. Wildlife Protection Act, 1972 (Pakistan and International Variants)
7. Manuals and Specimen Preparation Guidelines – Smithsonian Institution and Natural History Museum Resources Bottom of Form.

Major	ZOO-684	Vector Biology and Public Health	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

1. Explain the biology and life cycles of major arthropod vectors.
2. Analyze the transmission and epidemiology of vector-borne diseases.
3. Evaluate vector surveillance, control, and integrated management strategies.

Course Contents (Theory)

1. **Introduction:**
   a. Scope of vector biology
   b. Host–vector–pathogen relationships.
2. **Major Arthropod Vectors:**
   a. Mosquitoes, flies, fleas, lice, ticks, and mites.
3. **Vector-Borne Diseases:**
   a. Malaria, dengue, filariasis, leishmaniasis, Trypanosomiasis, Typhus, Plague, Zika, etc.
4. **Epidemiology:**
   a. Factors affecting disease transmission and control programs.
5. **Vector Control:**
   a. Mechanical, chemical, biological, and genetic methods; Integrated Vector Management (IVM); role of WHO and national health programs.

Practical Work

1. Collection and identification of major vectors.
2. Study of diagnostic features of mosquitoes, flies, and ticks.
3. Demonstration of breeding habitats and control methods.
4. Preparation of life cycle charts/models.
5. Field visit to a vector control or public health facility (if available).

Recommended Books

1. Service, M.W. (2020). *Medical Entomology for Students* (6th Ed.). Cambridge University Press.

2. Becker, N. et al. (2023). *Mosquitoes and Their Control* (3rd Ed.). Springer.
3. Mullen, G.R. & Durden, L.A. (2019). *Medical and Veterinary Entomology* (3rd Ed.). Academic Press.
4. WHO (2022). *Handbook for Integrated Vector Management.* WHO Press

Capstone	CAP-685	Capstone	3

It is a mandatory degree award requirement of 3 credit hours for Bachelor of Science in Zoology. The capstone is a multifaceted body of work that serves as a culminating academic and intellectual experience for students. It must be supervised and graded by a faculty member as per the protocols prescribed by the concerned department. This requirement cannot be substituted with additional course work or internship.

MAJOR SPECIATIONS in BS ZOOLOGY

Specializations (BS)

Major Specializations For BS Zoology

Following are a few example specialization streams in case where the Bachelor of Science in Zoology is offered with specialization. The department may consider to offer the degree program with specialization or otherwise, keeping in view the available academic, human and infrastructural resources.

ZOOLOGY WITH SPECIALIZATION IN ENTOMOLOGY

Semester 7			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOE-671	Forensic Entomology	3(2-1)
Major	ZOE-672	Insect Physiology	3(2-1)
Major	ZOO-673	Insect systematics and Taxonomy	3(2-1)
Major	ZOE-674	Insects in Climate Change and Environmental Monitoring	3(2-1)
Interdisciplinary	CB-675	Computational Biology	3(2-1)
Internship		Internship	3
Total Credits			18

Major	ZOE-671	Forensic Entomology	3(2-1)

Course Learning Outcomes (CLOs)

By the end of the course, students will be able to:

1. Explain principles and scope of forensic entomology.
2. Identify forensically important insect taxa.
3. Apply insect life cycles to determine time since death.
4. Demonstrate scientific handling of insect evidence.
5. Prepare forensic reports based on entomological data

Course Contents:

1. **Introduction to Forensic Entomology**

a. Definition, history, and scope of forensic entomology

b. Role of entomologists in criminal and civil investigations (Medico-legal entomology)

c. Importance in legal and environmental contexts

2. Basics of Decomposition and Entomological Succession

a. Stages of human and animal decomposition
b. Factors affecting decomposition rate
c. Insect succession patterns and ecological roles

3. Insects of Forensic Importance

a. Major orders and families: Diptera (Calliphoridae, Sarcophagidae, Muscidae), Coleoptera (Dermestidae, Silphidae, Cleridae).
b. Biology, identification, and developmental stages of forensically relevant insects
c. Life cycle parameters and their forensic significance

4. Estimation of Post-Mortem Interval (PMI)

a. Methods of PMI estimation using insect evidence
b. Accumulated degree hours/days (ADH/ADD)
c. Role of temperature, humidity, and environment

5. Collection and Preservation of Insect Evidence

a. Field techniques: insect sampling from body and surroundings
b. Preservation, labeling, and documentation methods
c. Chain of custody and forensic report preparation
d. Rearing techniques to adult stage for identification

6. Forensic Entomology in Legal and Investigative Contexts

a. Use of insect evidence in courts
b. Case studies from international and national contexts
c. Legal procedures, ethics, and expert witness testimony
d. Limitations and challenges in forensic entomology
e. Forensic entomology in wildlife crime

Practical / Laboratory Contents

1. Collection and preservation of forensic insect specimens
2. Identification of important forensic insect families and species
3. Study of insect succession on decomposing animal carcasses
4. Measurement of developmental stages (larval instars, pupae, adults)
5. Calculation of post-mortem interval using developmental data
6. Preparation of forensic insect rearing containers
7. Mock crime scene: collection, labeling, and report preparation
8. Field visit to biological decomposition study site (if feasible)

Recommended Textbooks

1. **Byrd, J. H., & Castner, J. L. (2020).** *Forensic Entomology: The Utility of Arthropods in Legal Investigations.* CRC Press.
2. **Catts, E. P., & Haskell, N. H. (1990).** *Entomology and Death: A Procedural Guide.* Joyce's Print Shop.
3. **Gennard, D. E. (2012).** *Forensic Entomology: An Introduction.* Wiley-Blackwell.
4. **Amendt, J., Campobasso, C. P., Gaudry, E., Reiter, C., LeBlanc, H. N., & Hall, M. J. R. (2007).** *Forensic Entomology: Applications and Limitations.* Forensic Science International.
5. Relevant research papers and case studies (latest journal articles).

Major	ZOE-672	Insect Physiology	3(2-1)

Course Learning Outcomes

By the end of the course, students will be able to:

1. Explain the structure and function of major physiological systems in insects, including digestion, respiration, circulation, excretion, nervous, and reproductive systems.
2. Analyze the physiological processes such as metabolism, growth, molting, and hormonal regulation that control insect development and behavior.
3. Apply physiological knowledge to understand insect adaptation, pest management strategies, and responses to environmental stresses.

Course Contents:

1. Introduction to Insect Physiology

a. Importance of insect physiology and relationship with insect's morphology and ecology.

2. Integumentary System

a. Structure and composition of the insect cuticle.
b. Physiology of molting and sclerotization.
c. Hormonal control of ecdysis (ecdysone and juvenile hormone).

3. Digestive System and Nutrition

a. Structure and types of alimentary canal.
b. Physiology of digestion and absorption.
c. Nutritional requirements and symbiotic digestion.
d. Adaptations in feeding mechanisms (chewing, sucking, etc.).

4. Circulatory System

a. Open circulatory system and hemolymph composition.
b. Function of dorsal vessel and accessory pulsatile organs and Hemocytes

5. Respiratory System

a. Structure of tracheal system and gas exchange mechanisms.
b. Regulation of respiration and adaptations to terrestrial/aquatic life.

6. Excretory and Osmoregulatory System

a. Structure and function of Malpighian tubules and rectal glands.
b. Mechanisms of excretion and osmoregulation.
c. Adaptations to arid and aquatic environments.

7. Nervous System and Sense Organs

a. Central, peripheral, and visceral nervous systems.
b. Structure and function of neurons and synapses.
c. Types and physiology of sense organs (mechanoreceptors, chemoreceptors, photoreceptors).

8. Endocrine System and Hormonal Control

a. Structure and function of endocrine glands (corpora cardiaca, allata, prothoracic glands).
b. Hormonal control of development, metamorphosis, diapause, and reproduction.

9. Muscular System

a. Types of insect muscles and their physiology.
b. Mechanism of flight and muscle contraction.

10. Reproductive Physiology

a. Male and female reproductive systems.
b. Physiology of reproduction, fertilization, and egg development.
c. Parthenogenesis and reproductive strategies.

11. Thermoregulation and Environmental Physiology

a. Temperature tolerance and adaptations.
b. Water balance, desiccation resistance, and diapause physiology.

12. Insect Immunity and Defense Mechanisms

a. Innate immune responses.
b. Hemocyte-mediated and humoral defense.
c. Role of antimicrobial peptides.

Practical / Laboratory Work

1. Study of alimentary canal and associated glands.
2. Dissection of insect nervous and reproductive systems.
3. Observation of tracheal system and spiracles.
4. Demonstration of digestive enzyme activity (e.g., amylase).
5. Estimation of hemolymph components.
6. Demonstration of hormonal effects (ecdysone/juvenile hormone models).
7. Study of insect sense organs under microscope.
8. Report writing and viva-voce.

Recommended Books

1. Nation, J. L. (2015). *Insect Physiology and Biochemistry* (3rd Ed.). CRC Press.
2. Chapman, R. F. (2013). *The Insects: Structure and Function* (5th Ed.). Cambridge University Press.
3. Klowden, M. J. (2013). *Physiological Systems in Insects* (3rd Ed.). Academic Press.
4. Wigglesworth, V. B. (2012). *The Principles of Insect Physiology*. Springer.
5. Gillott, C. (2005). *Entomology* (3rd Ed.). Springer.

Major	ZOO-673	Insect systematics and Taxonomy	3(2-1)

Course Outcomes

By the end of the course, students will be able to:

1. Identify and classify insects up to family level.
2. Understand evolutionary relationships among major insect orders.
3. Use morphological and molecular data for systematic inference.
4. Prepare and maintain a basic insect reference collection.

Course Contents

1. Introduction to Insect Systematics

a. Scope and significance of insect systematics in biological sciences.
b. Historical development of insect classification.
c. Relationship between taxonomy, phylogeny, and evolution in insects.
d. Overview of traditional vs. modern (phylogenetic/molecular) systematics.

2. Morphological Basis of Classification

a. Taxonomically important external morphological characters: head, antennae, mouthparts, wings, legs, genitalia.
b. Types of wing venation and their systematic value.
c. Internal anatomical characters used in higher-level classification.
d. Role of larval and pupal characters in taxonomy.

3. Principles and Methods in Insect Classification

a. Hierarchical categories in insect taxonomy (species to order).

b. Concepts of species in insects (biological, morphological, phylogenetic, ecological).
c. Preparation and use of dichotomous keys.
d. Phylogenetic trees and cladograms — interpretation and construction.
e. Use of molecular tools (DNA barcoding, COI gene) in insect taxonomy.

4. Classification and Diagnostic Features of Major Insect Orders

a. Diagnostic characteristics, diversity, and phylogenetic relationships of major insect orders:
b. Apterygota (primitive wingless insects), Ephemeroptera, Odonata, Orthoptera, Hemiptera, Coleoptera, Lepidoptera, Diptera, Hymenoptera, etc.
c. Key families of economic or ecological importance.
d. Recent changes in higher classification based on molecular systematics.

Practical / Laboratory Work

1. Study of diagnostic morphological characters in major insect orders.
2. Collection and preservation of insect specimens from different habitats.
3. Preparation of dry and wet insect collections.
4. Identification of insects to family/order level using standard keys.
5. Construction of simple dichotomous keys for local fauna.
6. Taxonomic description and labeling of collected specimens.
7. Visit to entomological museum or insect reference collection (if available).

Recommended Books

1. Triplehorn, C. A., and Johnson, N. F. (2005). Borror and DeLong's Introduction to the Study of Insects.
2. Gullan, P. J., and Cranston, P. S. (2021). The Insects: An Outline of Entomology.
3. Ross, H. H. (1974). A Textbook of Entomology.
4. IMMs, A.D (1925) A general text book of Entomology (Volume I & II).

Major	ZOE-674	Insects in Climate Change and Environmental Monitoring	3(2-1)

Course Learning Outcomes

By the end of the course, students will be able to:

1. Explain the impacts of climate change on insect distribution, abundance, and pest outbreak dynamics.
2. Analyze how insects function as bioindicators of environmental changes such as pollution, habitat degradation, and ecosystem health.
3. Evaluate the economic and ecological significance of monitoring insect populations under changing climatic conditions.

Course Contents

1. Introduction

a. Overview of global climate change and environmental challenges
b. Role of insects in ecosystems and environmental assessment

2. Climate Change and Insect Biology

a. Effects of temperature, precipitation, and CO_2 levels on insect physiology and behavior
b. Phenological shifts: changes in breeding and migration patterns

c. Range expansion, invasion biology, and pest outbreaks under changing climates

3. Insects as Bioindicators

a. Concept and criteria for selecting bioindicator species
b. Indicator vs. sentinel species
c. Use of aquatic insects (e.g., Odonata, Ephemeroptera, Trichoptera, Diptera) in water quality assessment
d. Terrestrial insects (e.g., ants, beetles, butterflies) as indicators of habitat quality and land degradation

4. Insects and Ecosystem Services under Climate Stress

a. Pollination ecology and climate impacts
b. Decomposition and nutrient cycling
c. Insect-mediated pest control and food web alterations

5. Case Studies and Regional Perspectives

a. Insect responses to climate change in Pakistan
b. Effects of deforestation, pollution, and urbanization on insect communities
c. Integration of insect data in biodiversity and conservation programs

6. Climate Change Adaptation and Mitigation

a. Insect conservation in changing environments
b. Role of insects in climate-smart agriculture
c. Policy frameworks and environmental management strategies

Practical

1. Collection and identification of aquatic and terrestrial indicator insects.
2. Measurement of environmental parameters (temperature, humidity, pH, dissolved oxygen, etc.).
3. Calculation of diversity and biotic indices (Shannon, Simpson, BMWP, EPT).
4. GIS-based mapping of insect distribution patterns.
5. Case study presentation: "Odonata as bioindicators of freshwater quality."
6. Short project: Assessment of local insect diversity in response to habitat disturbance.

Recommended Books and References

1. Parmesan, C. & Yohe, G. (2003). A globally coherent fingerprint of climate change impacts across natural systems. *Nature.*
2. New, T. R. (2012). *Insect Conservation: Past, Present and Prospects.* Springer.
3. Hickling, R. et al. (2006). The distributions of a wide range of taxonomic groups are expanding polewards. *Global Change Biology.*
4. Samways, M. J. & Sharratt, N. J. (2010). Conservation biology of dragonflies and damselflies. *Biological Conservation.*
5. McGeoch, M. A. (1998). The selection, testing, and application of terrestrial insects as bioindicators. *Biological Reviews.*
6. Gullan, P. J. & Cranston, P. S. (2020). *The Insects: An Outline of Entomology.* Wiley-Blackwell.
7. EPA & UNEP Reports on bioindicator monitoring and environmental assessment.
8. Recent research articles from Pakistan on Odonata, butterflies, and beetles as indicators of environmental change.

Interdisciplinary	CB-675	Computational Biology	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

6. Describe the scope and importance of computational biology.
7. Retrieve and interpret information from biological databases.
8. Perform basic sequence alignment and phylogenetic analysis using online tools.
9. Apply computational approaches to zoological and conservation problems.
10. Communicate results of computational analysis in scientific format.

Course Contents

1. **Introduction**

c. Definition, scope, and significance of "Computational Biology" in zoology
d. Relationship with bioinformatics, genomics, proteomics, systems biology

2. **Biological Databases**

d. Primary and secondary databases
e. NCBI, EMBL, UniProt, Swiss-Prot, ENSEMBLE, PDB, GeneBank
f. Data retrieval and annotation

3. **Sequence Analysis**

f. Introduction to primer designing
g. DNA, RNA, and protein sequences
h. Pairwise and multiple sequence alignment
i. BLAST (BLASTN and BLASTP), FASTA, ClustalW/MEGA softwares
j. Applications in taxonomy, evolutionary studies

4. **Structural and Functional Genomics**

f. Gene prediction and annotation
g. Protein structure basics and prediction approaches
h. Molecular modeling (Protein Modelling as an example)
i. Comparative genomics
j. Applications in Zoology and Conservation

5. **Molecular Phylogeny**

d. Population genetics and molecular evolution
e. Wildlife genetics, conservation genomics
f. Applications in medicine (disease markers, drug discovery)

Practical

Hands-on exercises using free online tools and databases:

1. Introduction to biological databases (NCBI, UniProt, Swiss-Prot, PDB, PROSITE).
2. Sequence retrieval in different formats (FASTA format, Genebank format etc).
3. Basic use of BLAST for sequence similarity searches.
4. Multiple sequence alignment using Clustal Omega / MUSCLE/ MEGA.
5. Construction of phylogenetic trees using MEGA (or online tree builders).
6. Retrieval of protein structure from PDB and visualization (e.g., PyMol / RasMol).
7. Case study: DNA sequence analysis for species identification.
8. Project/report: computational analysis of a selected gene/protein relevant to zoology.
9. Primer 3 plus

Recommended Books

1. Mount, D.W. (2004). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.

2. Lesk, A.M. (2019). Introduction to Bioinformatics. Oxford University Press.
3. Xiong, J. (2006). Essential Bioinformatics. Cambridge University Press.
4. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Wiley-Blackwell.
5. Clote, P., & Backofen, R. (2000). Computational Molecular Biology: An Introduction. Wiley.

Internship		Internship	3

Internship of 3 credit hours is a mandatory degree award requirement for Bachelor of Science in Zoology. Internship of 6 to 8 weeks (preferably undertaken during semester or winter break) must be graded by a faculty member in collaboration with the supervisor in the field. This requirement cannot be substituted with additional course work, capstone or project work.

Semester 8			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOE-681	Integrated Pest Management	3(2-1)
Major	ZOE-682	Economic Entomology	3(2-1)
Major	ZOE-683	Medical and Veterinary Entomology	3(2-1)
Major	ZOO-684	Vector Biology and Public Health	3(2-1)
Capstone	CAP-685	Capstone	3
Total Credits			15

Major	ZOE-681	Integrated Pest Management	3(2-1)

Course Learning Outcomes

By the end of the course, students will be able to:

1. Explain the principles, components, and strategies of Integrated Pest Management and their role in sustainable crop protection.
2. Analyze pest problems using ecological and economic principles to develop appropriate IPM strategies.
3. Design and evaluate integrated pest management programs incorporating cultural, biological, mechanical, and chemical control methods within environmental and economic constraints.

Course Contents:

1. Introduction to IPM

a. Concept, history, and evolution of pest management
b. Limitations of conventional pest control
c. Definitions and philosophy of IPM
d. Basic ecological principles in IPM and Components of an IPM system

2. Economic and Ecological Concepts

a. Economic injury level (EIL) and economic threshold level (ETL)
b. Pest population dynamics and modeling
c. Sampling methods and pest surveillance
d. Decision-making and forecasting in IPM

3. Components of IPM

a. Cultural control: crop rotation, sanitation, tillage, planting time, resistant varieties
b. Mechanical and physical control: traps, barriers, hand-picking, mechanical devices
c. Biological control: types, agents (predators, parasitoids, pathogens), augmentation and conservation methods
d. Host plant resistance: genetic basis, development, and role in IPM
e. Chemical control: selective use, pesticide compatibility, resistance management, and safety

f. Behavioral control: pheromones, attractants, repellents, mating disruption

4. Pesticide Resistance and Its Management

a. Mechanisms and development of resistance
b. Cross-resistance and multiple resistance
c. Strategies for resistance management

5. IPM in Major Crops of Pakistan

a. Cotton, wheat, rice, maize, sugarcane, fruits, vegetables, and stored grain pests
b. Area-wide IPM and Farmer Field Schools (FFS) concepts

6. Environmental and Social Aspects

a. Impact of pesticides on environment, natural enemies, and human health
b. Socio-economic constraints and adoption of IPM technologies

Practical:

1. Collection, preservation, and identification of major crop pests and natural enemies.
2. Calculation of Economic Threshold Level (ETL) and Economic Injury Level (EIL).
3. Demonstration of biological control agents.
4. Use of traps (light trap, pheromone trap, sticky trap) and monitoring techniques.
5. Field visits to observe IPM practices on farms.
6. Preparation of an IPM program for a selected crop.

Recommended Books:

1. Pedigo, L.P. & Rice, M.E. (2021). *Entomology and Pest Management*. Waveland Press.
2. Kogan, M. (1998). *Integrated Pest Management: Historical Perspectives and Contemporary Developments*. Annual Review of Entomology.
3. Dent, D. (2000). *Insect Pest Management*. CABI Publishing.
4. Metcalf, R.L. & Luckmann, W.H. (1994). *Introduction to Insect Pest Management*. Wiley.
5. FAO (2002). *Integrated Pest Management in Developing Countries*.
6. CABI Manuals on IPM for major crops.

Major	ZOE-682	Economic Entomology	3(2-1)

Course Learning Outcomes

By the end of the course, students will be able to:

1. Evaluate the economic impacts of major insect pests on crops, livestock, stored products, and forests.
2. Quantify economic losses and gains associated with insects.
3. Identify beneficial insects and their roles in pollination, biological control, and industry.
4. Apply economic decision-making in pest management programs.
5. Discuss insect-based industries and their contribution to the economy.

Course Contents

1. Introduction

a. Definition and importance of Economic Entomology
b. Historical background and development of the field

2. **Insects of Economic Importance (Harmful Insects)**

a. Agricultural pests: Major field crop pests (Maize and wheat)
b. Forestry pests: Termites, defoliators, bark beetles
c. Stored product pests: Beetles, moths, and weevils in grains and processed food
d. Veterinary and medical pests: Insects affecting livestock and humans (flies, lice, mosquitoes, fleas, ticks)
e. Household and structural pests: Termites, cockroaches, bed bugs, ants

3. **Assessment of Economic Losses**

a. Concepts of economic damage, loss, injury, and pest status
b. Methods for estimating losses due to insects
c. Cost-benefit analysis in pest control programs
d. Impact of insect pests on agricultural economy and trade

4. **Beneficial Insects and Economic Utilization**

a. Pollinators: Economic value of insect pollination (bees, butterflies, etc.)
b. Parasitoids and predators: Role in natural and applied biological control
c. Silkworms: Sericulture and silk industry economics
d. Honeybees: Apiculture, honey, wax, propolis, and pollination services
e. Lac insects: Lac production and trade value
f. Insects in biotechnology and pharmaceuticals (e.g., maggot therapy, chitosan, enzymes)

5. **Insect Products and By-products**

a. Commercial insect products: honey, silk, lac, dyes, wax, chitin, protein
b. Industrial applications and economic potential of insect-derived compounds
c. Insects as human food and animal feed (entomophagy and insect protein industry)

6. **Insects and the Environment**

a. Role of insects in ecosystem services (pollination, decomposition, nutrient cycling)
b. Economic value of ecosystem services provided by insects

Laboratory / Practical

1. Collection and identification of major economic pests and beneficial insects.
2. Estimation of crop losses caused by insect pests.
3. Observation of commercial insect products (honey, silk, lac).
4. Visit to apiary, sericulture, or lac industry units.
5. Survey of local markets for insect-based products.
6. Preparation of charts/models of beneficial and harmful insects.

Recommended Books

1. Pedigo, L.P. & Rice, M.E. (2009). *Entomology and Pest Management.* Prentice Hall.
2. Metcalf, R.L. & Luckmann, W.H. (1994). *Introduction to Insect Pest Management.* Wiley.
3. Hill, D.S. (1987). *Agricultural Insect Pests of the Tropics and Their Control.* Cambridge Univ. Press.
4. Mani, M.S. (1995). *General Entomology.* Oxford & IBH.
5. Richards, O.W. & Davies, R.G. (1977). *Imms' General Textbook of Entomology.* Chapman & Hall.
6. Kapoor, V.C. (2008). *Theory and Practice of Economic Entomology.* Oxford & IBH.
7. Dent, D. (2000). *Insect Pest Management.* CABI Publishing.

Major	ZOE-683	Medical and Veterinary Entomology	3(2-1)

Course Learning Outcomes

By the end of the course, students will be able to:

1. Describe pathogen transmission mechanisms and vector–host interactions.
2. Identify major insect-borne diseases of humans and domesticated animals.
3. Understand principles of epidemiology, vector ecology, and surveillance systems.
4. Skill Identify medically important insects and acarines using keys and microscopes.
5. Conduct field sampling, preservation, and slide mounting of vectors.

Course Contents

- Scope and importance of medical & veterinary entomology
- Diagnostic characters of medically important orders
- Basics of acarology (ticks & mites)
- Vector–host relationships
- Types of pathogen transmission: mechanical, biological
- Concepts of zoonoses

- Biology & life cycle, Anopheles, Aedes, Culex (differences & identification)
- Diseases: malaria, dengue
- Control strategies
- **Sandflies;** Identification, Leishmaniasis.

- Myiasis (obligatory & facultative)
- **Tsetse Flies;** Trypanosomiasis
- **Fleas (Siphonaptera) & Lice (Phthiraptera);** Identification, Plague, typhus, Fleas & lice in livestock
- **Ticks (Ixodidae & Argasidae);** Hard vs soft ticks, Theileriosis, Babesiosis, Lyme disease
- **Mites (Acari)**;

Practical / Laboratory Work

1. Use of microscopes
2. Safety protocols
3. Identification of mosquitoes (Aedes, Anopheles, Culex) using keys
4. Permanent slide preparation of mosquito larvae
5. Identification of sandflies
6. Fleas & lice: slide mounting and recognition of morphological characters
7. Hard & soft tick identification
8. Preparation of tick slides using lactophenol
9. Tick mouthparts and spiracular plates
10. Field collection techniques:
11. Preservation techniques for adult insects and larvae

Recommended Books

1. Service, M. W. (2012). *Medical Entomology for Students*. Cambridge University Press.

2. Mullen, G. & Durden, L. (2009). *Medical and Veterinary Entomology*. Academic Press.
3. Eldridge & Edman (2004). *Medical Entomology: A Textbook on Public Health and Veterinary Problems*.

Major	ZOO-684	Vector Biology and Public Health	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

1. Explain the biology and life cycles of major arthropod vectors.
2. Analyze the transmission and epidemiology of vector-borne diseases.
3. Evaluate vector surveillance, control, and integrated management strategies.

Course Contents (Theory)

1. **Introduction:**
a. Scope of vector biology
b. Host–vector–pathogen relationships.
2. **Major Arthropod Vectors**:
a. Mosquitoes, flies, fleas, lice, ticks, and mites.
3. **Vector-Borne Diseases:**
a. Malaria, dengue, filariasis, leishmaniasis, Trypanosomiasis, Typhus, Plague, Zika, etc.
4. **Epidemiology:**
a. Factors affecting disease transmission and control programs.
5. **Vector Control:**
a. Mechanical, chemical, biological, and genetic methods; Integrated Vector Management (IVM); role of WHO and national health programs.

Practical Work

1. Collection and identification of major vectors.
2. Study of diagnostic features of mosquitoes, flies, and ticks.
3. Demonstration of breeding habitats and control methods.
4. Preparation of life cycle charts/models.
5. Field visit to a vector control or public health facility (if available).

Recommended Books

1. Service, M.W. (2020). *Medical Entomology for Students* (6th Ed.). Cambridge University Press.
2. Becker, N. et al. (2023). *Mosquitoes and Their Control* (3rd Ed.). Springer.
3. Mullen, G.R. & Durden, L.A. (2019). *Medical and Veterinary Entomology* (3rd Ed.). Academic Press.
4. WHO (2022). *Handbook for Integrated Vector Management.* WHO Press

Capstone	CAP-685	Capstone	3

It is a mandatory degree award requirement of 3 credit hours for Bachelor of Science in Zoology. The capstone is a multifaceted body of work that serves as a culminating academic and intellectual experience for students. It must be supervised and graded by a

faculty member as per the protocols prescribed by the concerned department. This requirement cannot be substituted with additional course work or internship.

Specializations (BS)

Major Specializations for BS Zoology

Following are a few example specialization streams in case where the Bachelor of Science in Zoology is offered with specialization. The department may consider to offer the degree program with specialization or otherwise, keeping in view the available academic, human and infrastructural resources.

ZOOLOGY WITH SPECIALIZATION IN FISHERIES AND AQUACULTURE

Semester 7			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOF-671	Climate Change and Fisheries	3(2-1)
Major	ZOF-672	Fish Breeding and Physiology	3(2-1)
Major	ZOF-673	Fish Diseases and Health Management	3(2-1)
Major	ZOO-674	Ichthyology	3(2-1)
Interdisciplinary	CB-675	Computational Biology	3(2-1)
Internship		Internship	3
Total Credits			18

Major	ZOF-671	Climate Change and Fisheries	3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Explain the fundamental processes of climate change and their relevance to aquatic ecosystems.
2. Analyze the impacts of climate variability on fish physiology, distribution, and productivity.
3. Evaluate the effects of climate change on inland and marine fisheries and aquaculture systems.
4. Propose adaptation and mitigation strategies for sustainable fisheries under changing climatic conditions.

Course Contents

1. **Introduction:**

a. Overview of global climate change
b. greenhouse gases, carbon cycle, and climate drivers
c. evidence and trends in temperature, precipitation, and ocean chemistry.

2. **Climate Change and Aquatic Environments:**
a. Impacts on water temperature, hydrology, salinity, stratification, and dissolved oxygen
b. effects on freshwater, estuarine, and marine habitats.
3. **Biological Responses:**
a. Effects on fish physiology, growth, metabolism, migration, and reproductive success; range shifts and species invasions
b. phenological mismatches.
4. **Fisheries and Aquaculture:**
a. Impacts on capture fisheries productivity, fish stocks, and food webs
b. vulnerability of inland and coastal fisheries
c. implications for aquaculture and feed resources.
5. **Socioeconomic and Policy Dimensions:**
a. Impacts on livelihoods, food security, and communities dependent on fisheries
b. adaptation strategies
c. climate-smart fisheries management
d. global and national policy responses (FAO, IPCC, Pakistan's Climate Change Policy).
6. **Adaptation and Mitigation:**
a. Ecosystem-based approaches, habitat restoration, improved governance, and sustainable practices; role of innovation and research in building climate resilience in fisheries.

Practicals:

1. Read case studies on impacts climate change on fish distributions.
2. Demonstration of modelling tools or climate data sources (e.g., IPCC datasets, NOAA).
3. Field visit to a hatchery or fish farm to assess climate-related challenges.
4. Demonstrate current and future bioclimatic layers from Worldclim to observe the difference between current and future climatic conditions.

Recommended Books:

1. Climate Change, Small-Scale Fisheries, and Blue Justice: Fishscapes and Alternative Worldviews — Sunil D. Santha, 2023, Routledge
2. Climate Change Impacts on Fisheries and Aquaculture: A Global Analysis (2 Volumes) — Manuel Barange, Keith Brander, et al. (eds), Wiley, 2017.
3. An Introduction to Sustainable Aquaculture — Daniel Peñalosa-Martinell, Francisco Vergara-Solana, Marcelo Araneda-Padilla, Fernando Aranceta-Garza; 2024, Taylor & Francis**.**

ZOF-672	Fish Breeding and Physiology	3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Explain the reproductive biology and endocrine control of fish breeding.
2. Describe the physiological processes involved in fish reproduction, gametogenesis, and spawning.

3. Demonstrate understanding of artificial breeding techniques used in hatcheries for major cultured fish species in Pakistan.
4. Apply knowledge of environmental and hormonal manipulation to improve breeding success in aquaculture systems.

Course Contents:

1. **Introduction:**
a. Overview of fish reproduction
b. breeding behavior and strategies
c. importance of artificial breeding in aquaculture and fisheries enhancement.
2. **Fish Reproductive Physiology:**
a. Structure and function of gonads; gametogenesis (spermatogenesis and oogenesis)
b. reproductive hormones (GnRH, LH, FSH, estrogen, androgen, prostaglandins)
c. hypothalamo–pituitary–gonadal axis.
3. **Environmental and Physiological Control:**
a. Role of photoperiod, temperature, rainfall, water flow, and nutrition in reproduction
b. influence of climate and monsoon patterns in South Asia.
4. **Induced Breeding Techniques:**
a. Principles of hypophysation
b. hormonal induction using pituitary extracts, Ovaprim, Ovatide, HCG, and other synthetic hormones
c. dosage calculation, injection techniques, and handling.
5. **Hatchery Design and Operation:**
a. Layout and management of carp and mahseer hatcheries
b. broodstock maintenance
c. spawning tanks and incubation systems
d. larval rearing and early fry care.
6. **Breeding of Cultured and Indigenous Species:**
a. Artificial propagation of major carps (*Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*), mahseer (*Tor putitora*), tilapia (*Oreochromis spp.*), and other candidate species
b. seed production and quality control.
7. **Reproductive Disorders and Management:**
a. Causes of breeding failure
b. broodstock nutrition
c. genetic deterioration and hybridization issues
d. broodstock selection and record keeping.
8. **Recent Advances:**
a. Cryopreservation of gametes
b. hormonal analogs
c. molecular and genetic approaches in fish reproduction
d. sustainable hatchery practices under climate stress.

Practical Work

1. Dissection and microscopic observation of fish gonads.
2. Demonstration of pituitary gland extraction and preparation of pituitary suspension.
3. Hands-on practice with induced breeding and stripping techniques (in coldwater and warmwater hatcheries).
4. Study of hatchery design and operation through field visits
5. Calculation of hormone doses and record keeping for breeding trials.

Recommended Books:

1. Nihar Ranjan Chattopadhyay 2016 "Induced Fish Breeding: A Practical Guide for Hatcheries"
2. Maria J. Rocha, Augustine Arukwe & B. G. Kapoor (eds) 2008 Fish Reproduction CRC Press
3. David H. Evans, James B. Claiborne, Suzanne Currie, 2013 The Physiology of Fishes, 4th Edition CRC Press.

ZOF-673	Fish Diseases and Health Management	3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Identify and describe common infectious and non-infectious diseases affecting freshwater and cultured fish species in Pakistan.
2. Explain the physiological and environmental factors influencing fish health and disease outbreaks.
3. Apply diagnostic techniques for parasitic, bacterial, viral, and fungal diseases of fish.
4. Propose preventive and control measures, including biosecurity, therapeutic treatments, and best management practices for aquaculture health management.

Course Contents:

1. Introduction:

a. Importance of fish health in aquaculture
b. causes of fish diseases, i.e., biological, environmental, nutritional, and management-related
c. host–pathogen–environment interactions.

2. Fish Immunology and Stress Physiology:

a. Overview of fish immune system (innate and adaptive immunity)
b. role of stress in disease susceptibility
c. environmental stressors such as temperature, dissolved oxygen, ammonia, and handling.

3. Parasitic Diseases:

a. Protozoan infections (*Ichthyophthirius multifiliis*, *Trichodina*, *Myxobolus*)
b. helminth and crustacean parasites (*Dactylogyrus*, *Gyrodactylus*, *Lernaea*, *Argulus*)
c. diagnosis and control measures.

4. Bacterial Diseases:

a. Major bacterial pathogens

b. *Aeromonas hydrophila*, *Pseudomonas fluorescens*, *Edwardsiella tarda*, *Streptococcus iniae*
c. disease signs, transmission, diagnosis, and antibiotic treatments.

5. Fungal and Viral Diseases:

a. Fungal infections (*Saprolegnia*, *Branchiomyces*)
b. viral diseases (Koi herpesvirus, Spring viremia of carp, Tilapia Lake virus)
c. recognition, prevention, and control.

6. Nutritional and Environmental Disorders:

a. Deficiency diseases
b. Deformities
c. poor water quality impacts
d. toxicants and pollutants
e. algal blooms and oxygen depletion syndromes.

7. Health Management in Hatcheries and Farms:

a. Routine health monitoring
b. biosecurity and quarantine practices
c. vaccination and probiotics
d. hygienic handling and record keeping
e. integrated disease management approach.

8. Public Health and Regulatory Aspects:

a. Fish-borne zoonoses (e.g., *Streptococcus*, *Mycobacterium*)
b. drug residue issues
c. national and international guidelines on fish health management.

Practical Work

1. Examination of diseased fish specimens and identification of external and internal symptoms.
2. Microscopic examination of skin scrapings, gills, and internal organs for parasites.
3. Demonstration of bacterial isolation and simple culture techniques (using non-pathogenic strains where possible).
4. Water quality analysis and correlation with disease occurrence.
5. Field visit to an aquaculture hatchery or farm for fish health assessment.

Recommended Books:

1. Lisa Goranson – 2024 – *Fish Diseases and Health Management* – Oryson Press.
2. S. Felix; A. Gopalakannan; A. Uma – 2024 – *Fish Diseases and Management* – Daya Publishing House.
3. K. M. Shankar (ed.) – 2024 – *Fish and Shellfish Health Management* – New India Publishing Agency.
4. Sumanta Kumar Mallik; Neetu Shahi; Pramod Kumar Pandey (eds.) – 2025 – *Management of Fish Diseases* – Springer (Singapore).

ZOO-674	Ichthyology	3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Identify major fish groups and their distinguishing characteristics.
2. Explain fish anatomy, physiology, and adaptations to aquatic environments.
3. Analyze ecological roles and behaviors of fishes in aquatic ecosystems.
4. Evaluate fishery resources and conservation strategies.

Course Content

1. **Introduction to Ichthyology**
   a. Definition, scope, and significance of ichthyology
   b. Evolutionary history of fishes
   c. Classification and taxonomy of fishes: major classes and orders
2. **Morphology and Anatomy of Fishes**
   a. External morphology: body shapes, fins, scales, coloration
   b. Internal anatomy: skeletal system, muscular system, digestive system, respiratory system, circulatory system, nervous system, reproductive system
3. **Fish Physiology**
   a. Osmoregulation in freshwater and marine fishes
   b. Respiratory adaptations
   c. Sensory systems: vision, lateral line, electroreception
   d. Locomotion and buoyancy
4. **Fish Ecology and Behavior**
   a. Habitat types and distribution
   b. Feeding habits and trophic interactions
   c. Reproductive strategies and life cycles
   d. Migration and schooling behavior
5. **Fish Diversity and Systematics**
   a. Overview of major fish families with representative species
   b. Identification techniques: keys and guides
   c. Freshwater fishes of Pakistan: diversity and ecological significance
6. **Fisheries and Conservation**
   a. Importance of fisheries and aquaculture
   b. Fishery management principles
   c. Threats to fish populations: overfishing, habitat destruction, pollution
   d. Conservation strategies and sustainable practices

Practical

1. Identification of common freshwater and marine fish species
2. Examination of external and internal fish anatomy
3. Use of dichotomous keys for fish identification
4. Study of fish behavior and adaptation under controlled conditions
5. Water quality analysis in fish habitats

Recommended Textbooks

1. Fishes: An Introduction to Ichthyology by Peter B. Moyle & Joseph J. Cech Jr.
2. Ichthyology by Peter W. Scott & Mark C.Every
3. Inland Fisheries of Pakistan by M.A. Baig

4. Fish Morphology and Systematic by Rajendra Kumar

Interdisciplinary	CB-675	Computational Biology	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

1. Describe the scope and importance of computational biology.
2. Retrieve and interpret information from biological databases.
3. Perform basic sequence alignment and phylogenetic analysis using online tools.
4. Apply computational approaches to zoological and conservation problems.
5. Communicate results of computational analysis in scientific format.

Course Contents

1. Introduction

a. Definition, scope, and significance of "Computational Biology" in zoology
b. Relationship with bioinformatics, genomics, proteomics, systems biology

2. Biological Databases

a. Primary and secondary databases
b. NCBI, EMBL, UniProt, Swiss-Prot, ENSEMBLE, PDB, GeneBank
c. Data retrieval and annotation

3. Sequence Analysis

a. Introduction to primer designing
b. DNA, RNA, and protein sequences
c. Pairwise and multiple sequence alignment
d. BLAST (BLASTN and BLASTP), FASTA, ClustalW/MEGA softwares
e. Applications in taxonomy, evolutionary studies

4. Structural and Functional Genomics

a. Gene prediction and annotation
b. Protein structure basics and prediction approaches
c. Molecular modeling (Protein Modelling as an example)
d. Comparative genomics
e. Applications in Zoology and Conservation

5. Molecular Phylogeny

a. Population genetics and molecular evolution
b. Wildlife genetics, conservation genomics
c. Applications in medicine (disease markers, drug discovery)

Practical

Hands-on exercises using free online tools and databases:

10. Introduction to biological databases (NCBI, UniProt, Swiss-Prot, PDB, PROSITE).
11. Sequence retrieval in different formats (FASTA format, Genebank format etc).
12. Basic use of BLAST for sequence similarity searches.
13. Multiple sequence alignment using Clustal Omega / MUSCLE/ MEGA.
14. Construction of phylogenetic trees using MEGA (or online tree builders).
15. Retrieval of protein structure from PDB and visualization (e.g., PyMol / RasMol).
16. Case study: DNA sequence analysis for species identification.
17. Project/report: computational analysis of a selected gene/protein relevant to zoology.

18. Primer 3 plus

Recommended Books

6. Mount, D.W. (2004). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
7. Lesk, A.M. (2019). Introduction to Bioinformatics. Oxford University Press.
8. Xiong, J. (2006). Essential Bioinformatics. Cambridge University Press.
9. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Wiley-Blackwell.
10. Clote, P., & Backofen, R. (2000). Computational Molecular Biology: An Introduction. Wiley.

Internship		Internship	3

Internship of 3 credit hours is a mandatory degree award requirement for Bachelor of Science in Zoology. Internship of 6 to 8 weeks (preferably undertaken during semester or winter break) must be graded by a faculty member in collaboration with the supervisor in the field. This requirement cannot be substituted with additional course work, capstone or project work.

Semester 8			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-681	Fish Farm and Hatchery Management	3(2-1)
Major	ZOO-682	Fish Nutrition and Feeding	3(2-1)
Major	ZOO-683	Principles and Practices of Aquaculture	3(2-1)
Major	ZOO-684	Inland Water Fisheries Management	3(2-1)
Capstone	CAP-685	Capstone	3
Total Credits			15

Major	ZOO-681	Fish Farm and Hatchery Management	3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Describe the components and setup of fish farms and hatcheries.
2. Apply techniques of induced breeding and broodstock management.
3. Manage water quality, feeding, and nursery operations effectively.
4. Recognize common fish diseases and apply preventive measures.
5. Evaluate sustainable fish farming and hatchery management practices.

Course Contents

1. Introduction to Fish Farming and Hatchery Management

a. Overview and importance of aquaculture
b. Fish farming systems: extensive, semi-intensive, and intensive
c. Site selection and farm layout
d. Hatchery design and operations

2. Breeding Techniques and Broodstock Management

a. Broodstock selection and maintenance
b. Natural and induced breeding methods
c. Spawning, fertilization, and egg incubation
d. Hatchery water management

3. Larval Rearing and Nursery Management

a. Care and feeding of larvae and fry
b. Nursery pond management
c. Stocking density and growth monitoring
d. Common problems in larval rearing

4. Water Quality and Environmental Management

a. Important water quality parameters
b. Monitoring and maintaining water quality
c. Aeration, water exchange, and waste management
d. Impact of environment on growth and survival

5. **Nutrition and Feeding**

a. Nutritional requirements of cultured fish species
b. Types and preparation of fish feed
c. Feeding methods and feed management
d. Feed efficiency and waste reduction

6. **Disease Management and Biosecurity**

a. Common fish diseases and their symptoms
b. Disease prevention and treatment strategies
c. Biosecurity measures in farms and hatcheries
d. Record keeping and health monitoring

7. **Sustainable Fish Farming Practices**

a. Environmental impacts and mitigation
b. Integrated fish farming systems
c. Economic considerations and profitability
d. Policies and regulations in aquaculture

Practical

1. Construction and management of fish ponds and hatcheries
2. Induced breeding and egg incubation
3. Larval and fry feeding techniques
4. Water quality testing (pH, dissolved oxygen, temperature, turbidity)
5. Disease identification and preventive measures

Books Recommended

1. Fish Hatchery Management by Jhingran and Pullin
2. Principles and Practices of Aquaculture by T.V.R. Pillay
3. Aquaculture: An Introductory Text by Robert R. Stickney
4. FAO Technical Guidelines for Aquaculture

Major	ZOO-682	Fish Nutrition and Feeding	3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Explain the nutritional requirements of fish and the physiological basis of nutrient utilization.
2. Identify different feed ingredients and their role in fish growth, reproduction, and health.
3. Formulate and evaluate cost-effective fish feeds suitable for local aquaculture species.
4. Apply feeding strategies and feed management practices for efficient and sustainable aquaculture production.

Course Contents

1. **Introduction to Fish Nutrition:**

a. Scope and importance of nutrition in aquaculture
b. relationship between nutrition, growth, reproduction, and health.

2. **Nutrients and Their Functions:**

a. Macronutrients, proteins, lipids, carbohydrates

b. micronutrients vitamins, minerals, trace elements
c. energy requirements
d. nutrient deficiency signs in fish.

3. Digestive Physiology of Fish:

a. Anatomy and functions of digestive systems in herbivorous, carnivorous, and omnivorous fishes
b. digestion, absorption, and metabolism of nutrients.

4. Feed Ingredients and Additives:

a. Animal and plant protein sources (fishmeal, soybean meal, groundnut cake, rice bran, maize gluten, blood meal)
b. lipid and carbohydrate sources
c. vitamin-mineral premixes
d. use of probiotics, attractants, and binders.

5. Feed Formulation and Processing:

a. Principles of feed formulation
b. feed types dry, moist, and semi-moist
c. feed manufacturing techniques (pelleting, extrusion)
d. use of local ingredients for low-cost feed production
e. feed quality evaluation and storage.

6. Feeding Management:

a. Feeding strategies in hatchery, nursery, and grow-out ponds
b. feed conversion ratio (FCR) and feeding rates
c. feeding frequency, ration size, and seasonal adjustments.

7. Nutritional Diseases and Deficiencies:

a. Symptoms and diagnosis of protein, vitamin, and mineral deficiencies
b. prevention through balanced diets.

8. Sustainable Nutrition and Future Trends:

a. Use of alternative feed ingredients (insect meal, algae, single-cell proteins)
b. integrated feed management and climate-smart feeding strategies for sustainable aquaculture.

Practical Work

1. Identification of common feed ingredients used in local hatcheries and farms.
2. Feed formulation exercises using Pearson's square and computer-based methods.
3. Demonstration of feed pellet preparation and drying.
4. Calculation of feed conversion ratio (FCR) and growth performance indices.
5. Visit to a fish feed mill or aquaculture facility for demonstration of feed production and feeding practices.

Recommended Books:

1. Hardy, Ronald W. & Kaushik, Sadasivam J. – 2021 – Fish Nutrition (4th Edition) – Academic Press.
2. Paolucci, Marina & Koshio, Shunsuke (eds.) – 2023 – Fish Nutrition and Feed Technology – MDPI Books.

3. Kumar, Vikas – 2024 – Feed and Feeding for Fish and Shellfish: Nutritional Physiology – Academic Press.
4. Kumar, Vikas (ed.) – 2025 – Nutrition and Physiology of Fish and Shellfish: Feed Regulation, Metabolism and Digestion – Academic Press.
5. Ninawe, A. S., Dhanze, J. R., Dhanze, R., Indulkar, S. T. (eds.) – 2021 – Fish Nutrition and Its Relevance to Human Health – CRC Press.
6. Felix, S.; Maheshwari, K. Sai; Porkodi, M.; Rujan, J.; Uday Kumar G. – 2024 – Developing Sustainable Feed Ingredients for Fish Nutrition and Climate-Resilient Aquaculture –
7. National Institute of Agricultural Extension Management (MANAGE) & Aquaculture Technology & Research Foundation.
8. Belsare, Satyajit Sharad (ed.) – 2024 – Aquaculture Nutrition: Gut Health, Probiotics and Prebiotics – Delve Publishing

Major	ZOO-683	Principles and Practices of Aquaculture	3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Explain the basic principles, scope, and importance of aquaculture in national food security and rural development.
2. Identify different aquaculture systems, culture environments, and major cultured species in Pakistan.
3. Demonstrate understanding of pond construction, water quality management, and stocking practices.
4. Apply knowledge of feeding, breeding, health, and harvesting practices for efficient and sustainable aquaculture production.

Course Contents:

1. Introduction to Aquaculture:

a. Definition, history, and development of aquaculture
b. global and national perspectives
c. comparison with capture fisheries
d. contribution of aquaculture to Pakistan’s economy and food security.

2. Principles of Aquaculture:

a. Basic requirements for successful culture, i.e., species, seed, feed, and water
b. ecological principles
c. carrying capacity
d. productivity and trophic dynamics in ponds.

3. Culture Systems:

a. Types of aquacultures: extensive, semi-intensive, and intensive systems; monoculture, polyculture, and integrated fish farming; cage, pen, raceway, and recirculating aquaculture systems (RAS).

4. Aquaculture Environments:

a. Freshwater, brackish water, and marine aquaculture systems
b. site selection, pond layout, construction materials, and water supply.

5. **Important Cultured Species:**

a. Biology and culture practices of major carps (*Catla*, *Rohu*, *Mrigal*), mahseer (*Tor putitora*), tilapia (*Oreochromis spp.*), catfish (*Clarias*, *Pangasius*), and shrimp (*Penaeus indicus*, *Macrobrachium rosenbergii*).

6. **Seed Production and Stocking:**

a. Hatchery operations; collection, rearing, and transportation of seed
b. optimal stocking density and species ratios in polyculture systems.

7. **Water Quality and Environmental Management:**

a. Physical, chemical, and biological parameters of pond water; fertilization and liming
b. aeration and waste management
c. maintaining pond health and productivity.

a. **Feeding and Growth Management:**

b. Nutritional requirements
c. feed types and feeding regimes; feed conversion ratio (FCR)
d. growth monitoring and record keeping.

8. **Health and Disease Management:**

a. Common diseases in aquaculture systems
b. stress management, biosecurity, and preventive measures.

9. **Harvesting, Marketing, and Economics:**

a. Harvest techniques, post-harvest handling, marketing channels, and basic cost–benefit analysis
b. entrepreneurship in aquaculture.

10. **Sustainability and Future Prospects:**

b. Integrated aquaculture–agriculture systems
c. eco-friendly and climate-smart aquaculture
d. policy and extension aspects in Pakistan.

Practicals:

1. Identification of major cultured fish and shellfish species.
2. Demonstration of pond preparation and water quality analysis (pH, DO, alkalinity, and transparency).
3. Estimation of stocking density and feed requirement.
4. Observation of pond fertilization and aeration techniques.
5. Visit to a government or private fish farm for demonstration of culture practices.

Recommended Books:

1. Stickney, Robert R. & Gatlin, Delbert M. III – 2022 – Aquaculture: An Introductory Text – CABI.
2. Pillay, T. V. R. & Kutty, M. N. – 2005 – Aquaculture: Principles & Practices (2nd Edition) – Wiley-Blackwell.
3. Faudzi, Norfazreena Mohd. (ed.), Shah, Muhammad Dawood; Mazlan, Nurzafirah; Muhamad Shaleh, Sitti Raehanah – 2024 – Essentials of Aquaculture Practices – Springer Nature Singapore.
4. Bunting, Stuart W. – 2013 – Principles of Sustainable Aquaculture: Promoting Social, Economic and Environmental Resilience – Routledge.

5. Lekang, Odd-Ivar – 2022 – Aquaculture Engineering (2nd Edition) – Wiley-Blackwell.
6. Costa-Pierce, Barry (ed.) – 2020 – Ecological Aquaculture: The Evolution of the Blue Revolution – Blackwell Science.
7. Malakai, Giovanni – 2024 – Complete Guide to Fish Farming: Expert Techniques, Sustainable Practices, and Profit Strategies for Successful Aquaculture – (Independent/industry-press

Major	ZOO-684	Inland Water Fisheries Management	3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Explain the principles and objectives of inland fisheries management in rivers, lakes, and reservoirs.
2. Assess ecological, biological, and environmental factors influencing inland fish production.
3. Apply management strategies for sustainable utilization of inland fishery resources.
4. Evaluate the role of community participation, policy, and habitat conservation in inland fisheries development.

Course Contents

1. Introduction to Inland Fisheries:

a. Scope and importance of inland fisheries
b. types such as riverine, lacustrine, reservoir, floodplain, and pond fisheries
c. contribution to food security, livelihoods, and rural economy of Pakistan.

2. Fish Communities and Ecology:

a. Ecological characteristics of inland water bodies
b. species composition and trophic dynamics
c. productivity and carrying capacity
d. influence of hydrology and water quality on fish assemblages.

3. Assessment of Fish Stocks:

a. Sampling methods and gear types
b. estimation of abundance, growth, recruitment, and mortality
c. yield models (Schaefer and Beverton–Holt concepts)
d. population dynamics and sustainable harvest.

4. Conservation and Habitat Management:

a. Degradation of freshwater habitats; role of riparian vegetation, flow regulation, and connectivity
b. restoration measures
c. integration with watershed management and biodiversity conservation.

5. Socioeconomic and Institutional Aspects:

a. Role of provincial fisheries departments, cooperatives, and community organizations;
b. licensing, enforcement, and conflict resolution
c. women's participation and rural development linkages.

6. Policies, Challenges, and Future Directions:

a. National inland fisheries policy framework

b. governance challenges
c. invasive species control
d. climate change adaptation
e. digital monitoring and ecosystem-based management approaches.

Practicals:

1. Identification and classification of inland water bodies.
2. Sampling of fish populations using nets and traps.
3. Estimation of catch per unit effort (CPUE) and species diversity indices.
4. Field visit to a river, reservoir, or wetland fishery for assessment of management practices.
5. Demonstration of basic stock assessment and yield estimation methods.

Recommended Books:

1. *Welcomme, R.L. – 2001 –* Inland Fisheries: Ecology and Management – *R.L. Welcomme – 2001 – Blackwell Science / Wiley.*
2. *Hubert, W.A. (Ed.) – 1999 –* Inland Fisheries Management in North America – *W.A. Hubert (Ed.) – 1999 – American Fisheries Society.*
3. *Bennett, A.; Coates, D.; Gondwe, E.; Shrestha, R.; Valbo-Jørgensen, J. – 2023 –* Livelihoods-based Restoration of Inland Aquatic Ecosystems for Poverty Reduction, Food and Nutrition Security and Biodiversity Conservation: Guidance for Policymakers and Practitioners on Putting Livelihoods First in Ecosystem Restoration *– A. Bennett, D. Coates, E. Gondwe, R. Shrestha, J. Valbo-Jørgensen – 2023 – Food & Agriculture Organization of the United Nations.*

Capstone	CAP-685	Capstone	3

It is a mandatory degree award requirement of 3 credit hours for Bachelor of Science in Zoology. The capstone is a multifaceted body of work that serves as a culminating academic and intellectual experience for students. It must be supervised and graded by a faculty member as per the protocols prescribed by the concerned department. This requirement cannot be substituted with additional course work or internship.

MAJOR SPECIALIZATIONS FOR BS ZOOLOGY

Following are a few example specialization streams in case where the Bachelor of Science in Zoology is offered with specialization. The department may consider to offer the degree program with specialization or otherwise, keeping in view the available academic, human and infrastructural resources.

BS ZOOLOGY WITH SPECIALIZATION IN PARASITOLOGY

Semester 7			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOP-671	Avian Parasitology	3(2-1)
Major	ZOO-672	Protozoology and Protozoic Diseases	3(2-1)
Major	ZOP-673	Parasite Systematics and Taxonomy	3(2-1)
Major	ZOP-674	Veterinary Parasitology	3(2-1)
Interdisciplinary	CB-675	Computational Biology	3(2-1)
Internship		Internship	3
Total Credits			18

Major	ZOP-671	Avian Parasitology	3(2-1)

Course Learning Outcomes:

On the completion of the course, the students will:

1. Identify and classify major protozoan, helminth, and ectoparasitic species affecting birds.
2. Understand the life cycles, transmission, and pathogenic effects of avian parasites.
3. Analyze the ecological and economic impacts of parasitic infections in wild and domestic birds.
4. Demonstrate competence in laboratory and field-based diagnostic techniques.
5. Evaluate and propose eco-friendly, plant-based approaches for parasite control.
6. Understand the relationship between climate change and the spread of avian parasites.

Course Contents:

1. **Introduction to Avian Parasitology**

a. Scope and importance
b. Host-parasite interactions
c. Classification of avian parasites

2. **Avian Anatomy and Physiology Relevant to Parasitism**

a. Digestive system

b. Circulatory system
c. Feather and skin structure

3. Protozoan Parasites of Birds

a. *Haemoproteus*, *Plasmodium*, *Leucocytozoon*
b. *Trichomonas*, *Eimeria*
c. Coccidiosis in poultry

4. Helminth Parasites

a. Trematodes: Life cycles and hosts
b. Cestodes: Tapeworms of birds
c. Nematodes: *Ascaridia*, *Capillaria*, *Syngamus*

5. Ectoparasites of Birds

a. Lice, mites, fleas, ticks
b. Myiasis and its significance

6. Diagnosis and Pathology of Avian Parasitic Infections

a. Microscopy, blood smear, fecal flotation
b. Clinical signs and lesions

7. Ecological Aspects and Transmission

a. Seasonal and altitudinal distribution
b. Vector ecology and climate change effects

8. Parasitic Diseases in Poultry and Wild Birds

a. Economic losses and health effects
b. Zoonotic risks and public health concerns

9. Control and Prevention

a. Synthetic chemicals and resistance
b. Role of sanitation and biosecurity
c. Plant-based alternatives (botanical insecticides)

10. Recent Trends in Avian Parasitology

a. Molecular diagnosis
b. Integrated parasite management
c. Case studies from conservation and poultry sectors

Practicals

1. Microscopic identification of protozoa, helminths, and ectoparasites
2. Preparation and staining of blood and fecal samples
3. Field collection and preservation of parasites
4. Diagnostic techniques: fecal flotation, blood smears, larval recovery
5. Extraction and testing of plant-based mosquitocidal compounds

Text and Reference Books:

1. Atkinson, C.T., Thomas, N.J., Hunter, D.B. (2008). *Parasitic Diseases of Wild Birds*. Wiley-Blackwell.
2. Soulsby, E.J.L. (1982). *Helminths, Arthropods and Protozoa of Domesticated Animals*. Baillière Tindall.
3. Permin, A., Hansen, J.W. (1998). *Epidemiology, Diagnosis, and Control of Poultry Parasites*. FAO.
4. Schmidt, G.D. & Roberts, L.S. (2009). *Foundations of Parasitology*. McGraw Hill.
5. Bowman, D.D. (2014). *Georgis' Parasitology for Veterinarians*. Elsevier.
6. Valkiūnas, G. (2005). *Avian Malaria Parasites and Other Haemosporidia*. CRC Press

Major	ZOO-672	Protozoology and Protozoic Diseases	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

1. Explain the taxonomy, morphology, life cycles, and physiology of medically and economically important protozoa.
2. Analyze the epidemiology, pathogenesis, diagnosis, prevention, and control strategies of protozoan diseases affecting humans.
3. Demonstrate basic protozoological laboratory techniques (microscopy, staining, culture, slide preparation) and apply diagnostic approaches in identifying protozoa.

Course contents:

1. Introduction & General Protozoology

a. Scope and importance of Protozoology.
b. General morphology, locomotion, nutrition, and reproduction in protozoa.
c. Host–parasite relationships and protozoan transmission.

2. Amoebae

a. *Entamoeba histolytica* – morphology, life cycle, pathogenesis (amoebiasis).
b. Other amoebae of human importance (*Naegleria fowleri*, *Acanthamoeba*).
c. Laboratory diagnosis and treatment of amoebic infections.
d. Control and prevention strategies.

3. Flagellates

a. *Giardia lamblia* – giardiasis.
b. *Trichomonas vaginalis* – trichomoniasis.
c. *Trypanosoma* spp. –African sleeping sickness & Chagas disease.
d. *Leishmania* spp. – cutaneous, mucocutaneous, and visceral leishmaniasis.
e. Control, vectors, and epidemiology of flagellate infections.

4. Ciliates

a. *Balantidium coli* – morphology, life cycle, pathogenesis, diagnosis. Control and prevention of balantidiasis.

5. Sporozoa & Apicomplexa

a. *Plasmodium* spp. – malaria (life cycle, vector, pathogenesis).
b. Clinical features, diagnosis, treatment, and drug resistance in malaria.
c. *Toxoplasma gondii* – toxoplasmosis.
d. *Cryptosporidium parvum* – cryptosporidiosis.
e. *Cyclospora* and *Isospora* infections.
f. General epidemiology and control measures of apicomplexan diseases.

6. Emerging & Opportunistic Protozoa

a. Opportunistic protozoa in immunocompromised hosts (HIV/AIDS).
b. Zoonotic and waterborne protozoa of current public health concern.

7. Applied & Public Health Aspects

a. Laboratory and molecular diagnostic approaches in protozoology.
b. Control strategies: drugs, vaccines, vector management, sanitation.

Practicals

1. Microscopy & Slide Preparation

a. Wet mounts of protozoa (using cultures or preserved specimens).
b. Permanent stained slides (Giemsa, Trichrome).

2. Identification

a. Morphology of amoebae, flagellates, ciliates, and sporozoa under microscope.
b. Recognition of diagnostic stages (cysts, trophozoites, oocysts).

3. Blood Protozoa

a. Examination of *Plasmodium* stages in stained blood smears.
b. Identification of *Trypanosoma* in prepared slides.

4. Fecal Protozoa

a. Concentration techniques and microscopic detection of *Giardia, Entamoeba, Balantidium*.
b. Demonstrations / Virtual Labs
c. PCR / ELISA in diagnosis of malaria or leishmaniasis.
d. Culture techniques for *Leishmania* and *Trichomonas*.
e. Field / Case Studies
f. Visit to diagnostic labs or public health centers (if possible).
g. Epidemiological data analysis of protozoan diseases in the local area.

Recommended Books

1. Markell and Voge's Medical Parasitology – 10th Edition, 2021, by David T. John & William A. Petri.
2. Foundations of Parasitology – 10th Edition, 2021, by Gerald D. Schmidt & Larry Roberts.
3. Human Parasitology – 5th Edition, 2019, by Burton J. Bogitsh, Clint E. Carter & Thomas N. Oeltmann.
4. CDC & WHO Guidelines (open-access online) – especially for malaria, toxoplasmosis, and cryptosporidiosis.

Major	ZOP-673	Parasite Sytematics and Taxonomy	3(2-1)

Course Learning Outcomes (CLOs)

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

1. Explain the principles and rules of parasite classification, nomenclature, and systematics.
2. Identify and differentiate major groups of parasites based on diagnostic morphological features.
3. Apply molecular and morphological methods for parasite identification and phylogenetic interpretation.
4. Analyze host–parasite co-evolutionary relationships and their taxonomic implications.
5. Demonstrate laboratory proficiency in collection, preservation, and preparation of parasitic specimens.

Course Outline

1. Introduction

a. Definition, scope, and importance of parasite systematics
b. History and development of parasitic taxonomy
c. Hierarchical classification and taxonomic ranks
d. International Code of Zoological Nomenclature (ICZN): rules and applications

2. Principles and Methods in Taxonomy

a. Morphological and morphometric characters in classification

b. Use of dichotomous keys and diagnostic features

c. Molecular taxonomy and DNA barcoding

d. Phylogenetic systematics: cladistics, phylograms, and molecular phylogeny

3. Systematics of Protozoan Parasites

a. Classification and diagnostic features

b. Representative genera: *Entamoeba*, *Trypanosoma*, *Giardia*, *Plasmodium*

c. Evolutionary relationships and host specificity

4. Systematics of Helminths

a. **Trematodes (Flukes):** General characters, classification, examples (*Fasciola*, *Schistosoma*)

b. **Cestodes (Tapeworms):** Classification, morphology, examples (*Taenia*, *Hymenolepis*)

c. **Nematodes (Roundworms):** Classification, examples (*Ascaris*, *Ancylostoma*, *Wuchereria*)

d. **Acanthocephalans:** General characteristics and classification

5. Systematics of Arthropod Parasites

a. Classification and key features of parasitic insects and arachnids

b. Representative examples: lice, fleas, ticks, and mites

c. Vector–parasite relationships

6. Host–Parasite Relationships and Co-evolution

a. Host specificity and co-adaptation

b. Zoogeographical distribution of parasites

c. Evolutionary trends in parasitism

7. Species Description and Modern Taxonomy

a. Concept of holotypes, paratypes, and redescriptions

b. Digital and integrative taxonomy

c. Recent trends in parasite phylogenomics and molecular classification

Practicals

1. Laboratory orientation and safety in handling parasitic specimens
2. Collection and preservation of parasites from vertebrate and invertebrate hosts
3. Preparation of temporary and permanent mounts of parasites
4. Identification of protozoan parasites (*Entamoeba, Trypanosoma*, *Plasmodium*)
5. Identification of trematodes (*Fasciola, Schistosoma*)
6. Identification of cestodes (*Taenia*, *Hymenolepis*)
7. Identification of nematodes (*Ascaris*, *Enterobius*, *Ancylostoma*)
8. Identification of arthropod parasites (*Pediculus*, *Ctenocephalides*, *Ixodes*, *Sarcoptes*)
9. Use of taxonomic keys for parasite identification
10. Demonstration of molecular identification (DNA extraction, PCR concept)
11. Construction of simple phylogenetic trees using morphological or molecular data
12. Field or museum visit for collection and study of parasitic specimens

Text and Reference Books

1. Cox, F. E. G. (2002). *Modern Parasitology: A Textbook of Parasitology*. Wiley-Blackwell.
2. Schmidt, G. D., & Roberts, L. S. (2020). *Foundations of Parasitology*. McGraw-Hill.

3. Anderson, R. C., Chabaud, A. G., & Willmott, S. (2009). *Keys to the Nematode Parasites of Vertebrates*. CABI Publishing.
4. Rohde, K. (Ed.) (2005). *Marine Parasitology*. CSIRO Publishing.
5. Noble, E. R., & Noble, G. A. (1989). *Parasitology: The Biology of Animal Parasites*. Lea & Febiger.
6. ICZN (2012). *International Code of Zoological Nomenclature*, 4th Edition.
7. Protozoology And Helminthology 13th *Edition*. by K.D. *Chatterjee* (2017).

Major	ZOP-674	Veterinary Parasitology	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course students will be able to:

1. Identify common protozoan, helminth and ectoparasite groups of domestic animals, describe their life cycles and recognise diagnostic stages.
2. Explain the basic host–parasite interactions, clinical signs and economic/epidemiological importance of major veterinary parasites.
3. Apply simple diagnostic, prevention and control measures used in the field (basic lab techniques, anthelmintic principles, and ectoparasite management).

Course Contents:

1. Foundations & Principles

a. Introduction: scope, terminology, significance in veterinary practice and livestock economy.
b. Host–parasite relationships, pathogenicity, zoonoses and public health importance.
c. Parasite transmission, basic epidemiology, concepts of prevalence, incidence, reservoir, vector.
d. Immunity to parasites (basic concepts) and anthelmintic classes — principles of chemotherapy and resistance.

2. Protozoa of Veterinary Importance

a. Coccidia (Eimeria) — life cycle, diagnosis, control (poultry & ruminants).
b. Toxoplasma gondii & Neospora — life cycle, clinical importance, zoonosis (sheep, cats, dogs).
c. Babesia and Theileria — blood protozoa: life cycles, clinical signs, diagnosis.
d. Trypanosoma (overview) and other protozoan parasites of livestock.
e. Diagnostic techniques for protozoa (microscopy, blood smears, faecal flotation, basics of antigen/antibody tests).
f. Case discussion / lecture summary & short quiz.

3. Helminths

a. Nematodes — general morphology, reproduction, basic life cycles; important nematodes of ruminants and dogs (Haemonchus, Ostertagia, Toxocara, Ancylostoma).
b. Nematode control strategies, pasture management and resistance.
c. Trematodes (liver flukes: Fasciola, Paramphistomum) — life cycle with snail intermediate; diagnosis and control.
d. Cestodes (tapeworms) — Taenia, Dipylidium; life cycles and public health aspects.
e. Diagnostic parasitology lab methods for helminths (faecal egg counts, sedimentation).
f. Anthelmintics in practice (classes, modes of action, resistance management).
g. Helminth case studies (livestock & companion animals).
h. Short test / review.

4. **Ectoparasites & Arthropod Vectors**

a. Ticks: biology, life cycle, diseases transmitted, control measures.
b. Mites, lice, fleas — identification, clinical effects, treatments.
c. Insect vectors (flies, mosquitoes) and role in parasite transmission (mechanical vs biological vectors).
d. Integrated ectoparasite control and farm-level management.

5. **Diagnostics, Control Programms & One Health**

a. Laboratory safety, sampling strategies, record keeping; basic parasitological lab practicals recap.
b. Herd/flock treatment strategies, vaccination concepts where applicable; integrated parasite management.
c. Zoonoses, One Health perspective, food safety and public health links.
d. Final review, student presentations or mini-case projects, course feedback.
e. If you prefer 30 lectures, split larger topics (e.g., give 2 extra lectures for helminth diagnostics and for protozoan molecular diagnostics/serology).

Practicals / Demonstrations

1. Faecal flotation and sedimentation (demonstration + student practice).
2. Blood smear preparation and identification of haemoparasites.
3. Simple worm ID from preserved specimens and microscopy of eggs/ova.
4. Tick/ectoparasite identification and life stage recognition.
5. Basic anthelmintic calculation & dose charting exercise.
6. Short field visit (farm/clinic) or simulated case discussion on parasite control program.

Recommended (up-to-date) textbooks & reading (short list)

1. Veterinary Parasitology — D. Otranto & R. Wall, 5th Ed., 2024.
   — Comprehensive veterinary reference; modern edition with updated chapters on protozoa and ectoparasites
2. Veterinary Clinical Parasitology, Anne M. Zajac & Gary A. Conboy — 9th Ed. (Wiley; latest avl. edn).
   — Practical bench manual focusing on diagnosis and images; excellent for undergraduates and lab work
3. Foundations of Parasitology, Roberts, Janovy & Nadler — 9th Ed. (or latest undergraduate edition).
4. Veterinary Parasitology (classic) — Urquhart, Armour, Duncan, Dunn & Jennings (2nd–3rd edns available).

Interdisciplinary	CB-675	Computational Biology	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

11. Describe the scope and importance of computational biology.
12. Retrieve and interpret information from biological databases.
13. Perform basic sequence alignment and phylogenetic analysis using online tools.
14. Apply computational approaches to zoological and conservation problems.
15. Communicate results of computational analysis in scientific format.

Course Contents

1. **Introduction**

a. Definition, scope, and significance of "Computational Biology" in zoology
b. Relationship with bioinformatics, genomics, proteomics, systems biology

2. **Biological Databases**

a. Primary and secondary databases
b. NCBI, EMBL, UniProt, Swiss-Prot, ENSEMBLE, PDB, GeneBank
c. Data retrieval and annotation

3. **Sequence Analysis**

a. Introduction to primer designing
b. DNA, RNA, and protein sequences
c. Pairwise and multiple sequence alignment
d. BLAST (BLASTN and BLASTP), FASTA, ClustalW/MEGA softwares
e. Applications in taxonomy, evolutionary studies

4. **Structural and Functional Genomics**

a. Gene prediction and annotation
b. Protein structure basics and prediction approaches
c. Molecular modeling (Protein Modelling as an example)
d. Comparative genomics
e. Applications in Zoology and Conservation

5. **Molecular Phylogeny**

a. Population genetics and molecular evolution
b. Wildlife genetics, conservation genomics
c. Applications in medicine (disease markers, drug discovery)

Practical

Hands-on exercises using free online tools and databases:

1. Introduction to biological databases (NCBI, UniProt, Swiss-Prot, PDB, PROSITE).
2. Sequence retrieval in different formats (FASTA format, Genebank format etc).
3. Basic use of BLAST for sequence similarity searches.
4. Multiple sequence alignment using Clustal Omega / MUSCLE/ MEGA.
5. Construction of phylogenetic trees using MEGA (or online tree builders).
6. Retrieval of protein structure from PDB and visualization (e.g., PyMol / RasMol).
7. Case study: DNA sequence analysis for species identification.
8. Project/report: computational analysis of a selected gene/protein relevant to zoology.
9. Primer 3 plus

Recommended Books

1. Mount, D.W. (2004). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
2. Lesk, A.M. (2019). Introduction to Bioinformatics. Oxford University Press.
3. Xiong, J. (2006). Essential Bioinformatics. Cambridge University Press.
4. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Wiley-Blackwell.
5. Clote, P., & Backofen, R. (2000). Computational Molecular Biology: An Introduction. Wiley.

Internship		Internship	3

Internship of 3 credit hours is a mandatory degree award requirement for Bachelor of Science in Zoology. Internship of 6 to 8 weeks (preferably undertaken during semester or winter break) must be graded by a faculty member in collaboration with the supervisor in the field. This requirement cannot be substituted with additional course work, capstone or project work.

Semester 8			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOP-681	Molecular Parasitology and Genomics	3(2-1)
Major	ZOO-682	Helminthology	3(2-1)
Major	ZOP-683	Wildlife Parasitology	3(2-1)
Major	ZOO-684	Vector Biology and Public Health	3(2-1)
Capstone	CAP-685	Capstone	3
Total Credits			15

Major	ZOP-681	Molecular Parasitology and Genomics	3(2-1)

Course Learning Outcomes (CLOs)

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

1. Explain molecular mechanisms of parasite infection, survival, and immune evasion.
2. Describe the structure, organization, and expression of parasitic genomes.
3. Apply molecular biology techniques (PCR, sequencing, cloning) for parasite identification and characterization.
4. Analyze and interpret genomic and proteomic data using molecular bioinformatics tools.
5. Demonstrate laboratory skills in nucleic acid extraction, amplification, and electrophoresis relevant to parasitology.

Course Outline (Theory)

1. Introduction to Molecular Parasitology

a. Scope and importance of molecular parasitology
b. Overview of parasite cell biology and genome organization
c. Comparative genomic complexity of protozoan and helminth parasites

2. Molecular Basis of Host–Parasite Interaction

a. Molecular recognition and adhesion molecules
b. Signaling pathways involved in invasion and pathogenesis
c. Parasite immune evasion: antigenic variation, surface coat remodeling
d. Case studies: *Plasmodium*, *Leishmania*, *Trypanosoma*, *Toxoplasma*

3. Genomics of Parasitic Organisms

a. Structure and features of parasitic genomes
b. Mitochondrial and apicoplast genomes in protozoans
c. Comparative and functional genomics: *Plasmodium*, *Schistosoma*, *Trypanosoma*
d. Genome sequencing approaches and annotation pipelines
e. Applications of genomics in drug and vaccine target discovery

4. Transcriptomics and Gene Regulation

a. Mechanisms of transcription and gene regulation in parasites

b. RNA editing, post-transcriptional modification, and alternative splicing
c. Non-coding RNAs and regulatory RNAs in parasites
d. Transcriptome profiling (RNA-Seq) and data interpretation

5. Proteomics and Molecular Function

a. Overview of parasite proteomics and post-translational modifications
b. Surface and secreted proteins in host–parasite interaction
c. Proteomic methods: 2D electrophoresis, mass spectrometry, protein microarrays
d. Identification of vaccine candidates and drug targets

6. Molecular Diagnostics and Epidemiology

a. DNA/RNA-based diagnostic tools: PCR, qPCR, LAMP, and multiplex assays
b. Molecular markers for strain identification (RFLP, SNP, microsatellites)
c. Real-world applications: molecular diagnosis of malaria, leishmaniasis, trypanosomiasis
d. Genomic epidemiology and tracking of parasite evolution

7. Bioinformatics and Computational Parasitology

a. Overview of major databases: EuPathDB, PlasmoDB, TriTrypDB
b. Sequence retrieval, alignment, and annotation
c. Phylogenetic analysis using genomic and proteomic data
d. Omics integration and systems biology approaches in parasitology

Practicals

1. Laboratory safety and overview of molecular parasitology tools
2. Extraction of genomic DNA from parasite-infected blood or tissue samples
3. Quantification and purity assessment of nucleic acids using spectrophotometer/NanoDrop
4. Polymerase Chain Reaction (PCR) for parasite DNA amplification
5. Agarose gel electrophoresis for visualization of amplified products
6. Restriction enzyme digestion and analysis of parasite DNA (RFLP demonstration)
7. cDNA synthesis and concept of RT-PCR (demonstration)
8. Basic sequence analysis: BLAST, multiple sequence alignment (ClustalW)
9. Construction of simple phylogenetic trees using MEGA or online tools
10. Introduction to genomic databases (PlasmoDB, TriTrypDB) and data exploration

Text and Reference Books

1. Muller, M. & Hemphill, A. (2013). *Molecular Parasitology*. Springer.
2. Melville, S. E. & Barry, J. D. (2020). *Molecular Parasitology: Genomes and Mechanisms*. Cambridge University Press.
3. Schwarz, R. S. et al. (2017). *Parasite Genomics Protocols*. Humana Press.
4. Brown, T. A. (2016). *Genomes 4*. Garland Science.
5. Cox, F. E. G. (2002). *Modern Parasitology: A Textbook of Parasitology*. Wiley-Blackwell.
6. Roberts, L. S., Schmidt, G. D., & Janovy, J. (2020). *Foundations of Parasitology*. McGraw-Hill.
7. Lesk, A. M. (2019). *Introduction to Bioinformatics*. Oxford University Press.

Major	ZOO-682	Helminthology	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

4. Describe the morphology, classification, and life cycles of medically and economically important helminths.
5. Analyze the epidemiology, pathogenesis, clinical features, and control measures of helminthic diseases in humans.
6. Demonstrate laboratory skills in identifying helminth specimens (eggs, larvae, adults) and apply diagnostic methods used in helminthology.

Course Contents

1. **Introduction & General Aspects**

a. Scope and importance of helminthology.
b. General morphology, structure, nutrition, and reproduction of helminths.
c. Host–parasite relationships, transmission, and epidemiology.

2. **Trematodes (Flukes)**

a. General characteristics of trematodes.
b. *Fasciola hepatica* (liver fluke): life cycle, pathogenesis, diagnosis, control.
c. *Fasciolopsis buski* (intestinal fluke).
d. *Clonorchis sinensis*, *Opisthorchis* spp. (liver flukes).
e. *Paragonimus westermani* (lung fluke).
f. *Schistosoma* spp. (blood flukes) – schistosomiasis.

3. **Cestodes (Tapeworms)**

a. General characteristics of cestodes.
b. *Taenia saginata* and *T. solium* (beef and pork tapeworms).
c. *Echinococcus granulosus* and *E. multilocularis* (hydatid disease).
d. *Diphyllobothrium latum* (fish tapeworm).
e. *Hymenolepis nana* (dwarf tapeworm).
f. Clinical features, diagnosis, and control of cestode infections.

4. **Nematodes (Roundworms)**

a. General characteristics of nematodes.
b. *Ascaris lumbricoides* (roundworm).
c. *Enterobius vermicularis* (pinworm).
d. *Trichuris trichiura* (whipworm).
e. *Hookworms* (*Ancylostoma*, *Necator*).
f. *Strongyloides stercoralis*.
g. *Trichinella spiralis*.
h. Filarial worms (*Wuchereria bancrofti*, *Brugia malayi*, *Onchocerca volvulus*, *Loa loa*).
i. Dracunculiasis (*Dracunculus medinensis*).

Practicals

1. Microscopy: Study of preserved slides of trematodes, cestodes, and nematodes (adult worms, larvae, eggs).
2. Identification: Diagnostic stages of common helminths in stool, blood, and tissue samples.
3. Staining & Mounting: Preparation of temporary mounts, simple staining of helminth eggs/larvae.
4. Blood Smear: Identification of microfilariae in stained smears.
5. Case Study Demonstrations: Lab diagnosis of helminth infections (direct smear, concentration techniques).
6. Morphological Keys: Use of taxonomic keys for identification of major helminths.

7. Virtual / Molecular Tools (Demo): PCR/ELISA techniques for diagnosis (if facilities available).
8. Field Component (Optional): Visit to diagnostic lab/public health lab for demonstration of helminth detection methods.

Recommended Books (Latest Editions)

1. Markell and Voge's Medical Parasitology – 10th Edition, 2021, by David T. John & William A. Petri.
2. Foundations of Parasitology – 10th Edition, 2021, by Gerald D. Schmidt & Larry Roberts.
3. Human Parasitology – 5th Edition, 2019, by Burton J. Bogitsh, Clint E. Carter & Thomas N. Oeltmann.
4. Medical Parasitology: A Self-Instructional Text – 6th Edition, 2019, by Rosemary Gordon & Veronica Wong.
5. WHO / CDC Guidelines (latest online resources for control and diagnosis of helminthic diseases

Major	ZOP-683	Wildlife Parasitology	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

1. Explain basic host–parasite relationships and major parasite groups affecting wildlife.
2. Identify common wildlife parasites using basic morphological and diagnostic methods.
3. Evaluate ecological and public-health significance of wildlife parasites and suggest basic management strategies.

Course Contents

1. Introduction, scope, host–parasite concepts.
2. Host–parasite ecology & transmission.
3. Population impacts of parasites.
4. Field sampling methods & ethics.
5. Lab diagnostics I: fecal techniques.
6. Lab diagnostics II: blood smears & serology.
7. Protozoan parasites overview.
8. Important protozoa in wildlife.
9. Helminths overview.
10. Nematodes of wildlife.
11. Cestodes & trematodes.
12. Ticks: biology & wildlife health.
13. Mites, lice, fleas & flies.
14. Parasites of wild birds.
15. Parasites of wild mammals.
16. Parasites of reptiles & amphibians.
17. Aquatic & marine wildlife parasites.

18. Wildlife zoonoses.
19. Wildlife disease surveillance.
20. Outbreak investigation.
21. Parasite control in wild & captive fauna.
22. Conservation medicine.
23. Rehabilitation & captive wildlife parasitology.
24. Molecular identification (intro).

Practicals:

1. **Introduction to Parasitology Laboratory**

a. Lab layout, safety rules, biosafety levels.

2. **Identification of basic equipment**:

b. microscope, hemocytometer, dissecting tools, flotation apparatus.

3. **Collection and Handling of Wildlife Samples**

c. Methods of collecting fecal, blood, skin scraping, and tissue samples from wildlife.

4. **Preparation of Wet Mounts**

a. Preparation of wet mounts from fecal and blood samples.
b. Identification of protozoan trophozoites, cysts, and helminth eggs under microscope.

5. **Fecal Examination Techniques**

a. Direct smear, sedimentation, and flotation techniques.
b. Identification of helminth ova (Nematodes, Cestodes, Trematodes) from wildlife samples.

6. **Ectoparasite Collection and Identification**

a. Collection methods: combing, brushing, skin scrapes, traps.
b. Identification of common wildlife ectoparasites: ticks, mites, lice, fleas.

7. **Tick Morphology and Identification**

a. Mounting ticks on slides.
b. Identification using keys (Ixodidae, Argasidae).
c. Observing scutum, capitulum, festoons.

8. **Blood Parasites of Wildlife**

a. Thin and thick blood smear preparation.
b. Staining with Giemsa stain.
c. Identification of hemoprotozoa: Babesia, Trypanosomes, Hepatozoon.
d. Internal Parasites in Wildlife Necropsy
e. Demonstration of wildlife necropsy procedure (video or preserved specimens).
f. Recovery and preservation of parasites from gastrointestinal tract.

9. **Parasite Egg Counting**

a. Fecal egg count (FEC) using McMaster technique.
b. Calculation of eggs per gram (EPG) for helminths.

10. **Museum Specimens and Slide Study**

a. Study of permanent slides of wildlife parasites (protozoa, helminths, arthropods).
b. Observation of museum specimens (ticks, cestodes, nematodes)

Recommended Books

1. Wildlife Parasitology: Emerging Diseases and Neglected Parasites (Frontiers Media, 2024).
2. Parasitic Diseases of Wild Mammals, 2nd Ed. Samuel, Pybus & Kocan (Wiley).

3. Veterinary Clinical Parasitology, 9th Ed. Zajac & Conboy (Wiley).
4. Veterinary Parasitology Reference Manual. Foreyt (latest edition).
5. Relevant open-access reviews and chapters (Frontiers, UNL Digital Commons).

Major	ZOO-684	Vector Biology and Public Health	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

4. Explain the biology and life cycles of major arthropod vectors.
5. Analyze the transmission and epidemiology of vector-borne diseases.
6. Evaluate vector surveillance, control, and integrated management strategies.

Course Contents (Theory)

1. **Introduction:**
a. Scope of vector biology,
b. host–vector–pathogen relationships.
2. **Major Arthropod Vectors:**
a. Mosquitoes, flies, fleas, lice, ticks, and mites.
3. **Vector-Borne Diseases:**
a. Malaria, dengue, filariasis, leishmaniasis, Trypanosomiasis, Typhus, Plague, Zika, etc.
4. **Epidemiology:**
a. Factors affecting disease transmission and control programs.
5. **Vector Control:**
a. Mechanical, chemical, biological, and genetic methods;
b. Integrated Vector Management (IVM);
c. role of WHO and national health programs.

Practical Work

1. Collection and identification of major vectors.
2. Study of diagnostic features of mosquitoes, flies, and ticks.
3. Demonstration of breeding habitats and control methods.
4. Preparation of life cycle charts/models.
5. Field visit to a vector control or public health facility (if available).

Recommended Books

1. Service, M.W. (2020). *Medical Entomology for Students* (6th Ed.). Cambridge University Press.
2. Becker, N. et al. (2023). *Mosquitoes and Their Control* (3rd Ed.). Springer.
3. Mullen, G.R. & Durden, L.A. (2019). *Medical and Veterinary Entomology* (3rd Ed.). Academic Press.
4. WHO (2022). *Handbook for Integrated Vector Management.* WHO Press

Capstone	CAP-685	Capstone	3

It is a mandatory degree award requirement of 3 credit hours for Bachelor of Science in Zoology. The capstone is a multifaceted body of work that serves as a culminating academic and intellectual experience for students. It must be supervised and graded by a faculty member as per the protocols prescribed by the concerned department. This requirement cannot be substituted with additional course work or internship.

BS ZOOLOGY WITH SPECIALIZATION IN WILDLIFE

Semester 7			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOO-671	Wildlife Conservation & Management	3(2-1)
Major	ZOW-672	Captive Breeding of Wildlife	3(2-1)
Major	ZOW-673	Endangered Species Management	3(2-1)
Major	ZOW-674	Human-Wildlife Conflict Management	3(3-0)
Interdisciplinary	CB-675	Computational Biology	3(2-1)
Internship		Internship	3
Total Credits			18

Major	ZOO-671	Wildlife Conservation & Management	3(2-1)

Course Learning Outcomes:

On the completion of the course, the students will:

1. Understand the diversity and distribution of wildlife in Pakistan.
2. Explore the roles and significance of protected areas in wildlife conservation.
3. Examine international conventions and agreements related to wildlife conservation.
4. Study the rules and regulations governing zoos and captive wildlife.
5. Identify and understand the threats to species and their habitats.
6. Investigate habitat ecology and the principles of wildlife conservation.
7. Develop skills in conservation planning and management.

Course Contents

1. **Wildlife of Pakistan**
   a. Introduction
   b. Important Definitions
   c. Identification
   d. Distribution
   e. Status
   f. Conservation and Management of fishes, amphibians, reptiles, birds and mammals of major importance in Pakistan
2. **Philosophy and significance of wildlife conservation**
3. **Biodiversity and sustainability of wildlife.**
4. **Wildlife rules and regulations in Pakistan**
   a. Provincial Rules
   b. Federal Management of Wildlife (NCCW)

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

a. National Organizations
b. International Organizations

6. **Protected Areas in Pakistan**

a. Sanctuaries
b. Game Reserves
c. National Parks

7. **Ramsar convention**

a. Wetlands
b. Ramsar Criteria
c. Ramsar Sites
d. Threatened species of Pakistan.
e. Vulnerable
f. Endangered
g. Critically Endangered

8. **Introduction To Modern Techniques Used In Wildlife Conservation**

a. Radio telemetry
b. GIS
c. GPS
d. Remote camera

9. **Climate Change and Its Impact on Wildlife**

a. Definition
b. Factor affecting climate change
c. Impact of climate change on wildlife

Practicals

1. Visit to protected and conserved areas of Pakistan (Captive, Semi-captive and Wild Areas)
2. Visit to National Parks of Pakistan.
3. Ecological Indices
4. 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.
5. Roberts, T. J., 1991, 1992. The Birds of Pakistan, Vol. I1 and II. Oxford University Press
6. Roberts, T. J., 1997. The Mammals of Pakistan, Oxford University Press 8. Robinson, W.L. and Bolen, E.G., 1984. Wildlife Ecology and Management. McMillan

Major	ZOW-672	Captive Breeding of Wildlife	3(2-1)

Course Learning Outcomes:

On the completion of the course, the students will be able:

1. To introduce the principles and practices of *ex situ* conservation, with emphasis on captive breeding and assisted reproductive technologies in wildlife.
2. To understand the physiological, endocrinological, and technological aspects of wildlife reproduction.
3. To explore the ethical and philosophical considerations of human intervention in wildlife reproduction and conservation.
4. To develop practical skills related to gamete handling, cryopreservation, and reproductive assessment in wildlife species.

Course Outcomes:

1. Introduction to Ex Situ Conservation

a. Concepts and importance of *ex situ* conservation
b. Philosophical and ethical concerns in assisted reproduction and captive breeding
c. Comparison between *in situ* and *ex situ* approaches
d. Role of zoos, wildlife parks, and breeding centers in conservation

2. Reproductive Physiology and Endocrinology

a. Factors affecting male fertility in wild populations
b. Methods to enhance female fertility in captivity
c. Non-invasive endocrine monitoring of reproduction and stress in captive wildlife

3. Assisted Reproductive Techniques (ARTs)

a. Introduction and applications of ARTs in wildlife conservation
b. Artificial Insemination (AI): methodology and management
c. Embryo Transfer Technology (ETT)
d. In-vitro Fertilization (IVF) and Intra-Cytoplasmic Sperm Injection (ICSI)
e. Sperm Sexing and Pre-implantation Genetic Diagnosis (PGD)
f. Genome Resource Banking (GRB): semen, embryo, oocyte, and tissue banks
g. Cloning and Somatic Cell Nuclear Transfer (SCNT) in wildlife

4. Reproductive Management in Captivity

a. Control of oestrous cycle and ovulation
b. Regulation of seasonal breeding
c. Management of multiple births and litter sizes

5. Ethical, Philosophical, and Practical Implications

a. Welfare concerns and stress management in captive animals
b. Conservation ethics and sustainable breeding programs
c. Integration of reproductive science with wildlife conservation strategies

Practicals:

1. Morphological study of sperm and ova
2. Collection and cryopreservation of sperm and ova
3. Demonstration of Artificial Insemination (AI) techniques
4. Assessment of sperm motility and viability
5. Staining and acrosomal analysis of spermatozoa

Text and Reference Books:

1. Gordon, I. R. (2005). *Reproductive Technologies in Farm Animals.* CABI Publishing, Comwell Press, Trowbridge. ISBN: 0-85199-862-3. 332 pp.
2. Ryan, M. A. (2001). *Ethics and Economics of Assisted Reproduction.* Georgetown University Press, Washington D.C., USA. 183 pp.

3. Robert, S. W. (1995). *Assisted Reproduction: Progress in Research and Practice.* Parathon Publishing Group Limited, UK. 156 pp.
4. William, V. H., Amanda, R., Ricakard, J. R., & Wildt,

Major	ZOW-673	Endangered Species Management	3(2-1)

Course Learning Outcomes:

By the end of this course, students will be able to:

1. Identify and classify wildlife species according to their conservation status and threat levels.
2. Analyze the causes of species decline, including natural, anthropogenic, and environmental factors.
3. Assess critical habitats and develop strategies for species recovery and habitat protection.
4. Design and evaluate recovery plans and restoration programs for endangered species.
5. Apply principles of restoration ecology to manage wild and captive populations effectively.

Course Contents:

1. Threats to Wildlife

a. Classification and definitions of threat levels (endangered, vulnerable, critically endangered, etc.)
b. Causes of species extinction, including small island effect
c. Modern threats to wildlife populations: habitat loss, environmental contamination, wildlife trade, and overexploitation by humans

2. Critical Habitat and Recovery Planning

a. Concept and significance of critical habitat
b. Identification and designation of critical habitats
c. Principles of recovery planning: development, implementation, and monitoring
d. Protecting species through interagency cooperation and policy integration

3. Restoration Ecology and Management

a. Conceptual foundations and principles of restoration ecology
b. Organizational and managerial guidelines for endangered species restoration programs
c. Techniques for maintaining and managing genetic diversity in captive populations

4. Promoting Wildlife Protection

a. Public awareness, education, and community involvement
b. Role of bird watchers, citizen scientists, and conservation advocacy in species protection

5. Threatened Wildlife Species of Pakistan

a. Biology, ecology, and population status of threatened species
b. Evaluation of current recovery programs and management strategies
c. Analysis of constraints and problems affecting program success

Practicals:

1. Field surveys to monitor threatened species populations
2. Habitat assessment and identification of critical areas
3. Exercises in population estimation and ecological data collection

4. Case studies on recovery programs and restoration initiatives
5. Analysis of genetic diversity in captive populations

Text and Reference Books:

1. Bolen, E. G., & Robinson, W. L. (1995). *Wildlife Ecology and Management.* 3rd Edition. Prentice Hall, New Jersey, USA. 620 pp.
2. Bowles, M. (1994). *Restoration of Endangered Species.* Cambridge University Press.
3. Gilbert, F. F., & Dodds, D. G. (1987). *The Philosophy and Practice of Wildlife Management.* Robert E. Kreiger Publishing Company, Malabar, Florida.
4. Gill, F. B. (1995). *Ornithology.* 2nd Edition. W. H. Freeman and Company, New York. 766 pp.

Major	ZOW-674	Human-Wildlife Conflict Management	3(2-1)

Course Learning Outcomes (CLOs):

By the end of this course, students will be able to:

1. Identify and classify different types of human-wildlife conflicts.
2. Analyze ecological and socio-economic causes of HWC.
3. Conduct field assessments and monitor conflict-prone areas using modern tools.
4. Propose and evaluate practical mitigation strategies for human-wildlife conflicts.
5. Assess the effectiveness of policy and community-based interventions.
6. Develop awareness campaigns and community engagement strategies for coexistence.

Course Contents:

1. Introduction to Human-Wildlife Conflict (HWC)

a. Definition and types of HWC
b. Global and regional trends in HWC
c. Ecological and conservation implications of HWC

2. Causes of Human-Wildlife Conflict

a. Habitat fragmentation and loss
b. Human encroachment and land-use change
c. Wildlife behavior and population dynamics
d. Climate change and natural disasters

3. Socio-Economic and Cultural Dimensions

a. Economic losses and livelihood impacts
b. Cultural perceptions and tolerance towards wildlife
c. Stakeholder analysis and conflict mapping

4. Assessment and Monitoring of HWC

a. Field techniques for conflict assessment
b. Data collection, reporting, and GIS mapping
c. Case studies of HWC in Pakistan and globally

5. Conflict Mitigation Strategies

a. Non-lethal management: barriers, deterrents, and habitat management
b. Community-based conflict resolution approaches
c. Policy frameworks, compensation schemes, and legal instruments
d. Role of education, awareness, and ecotourism

6. Restoration and Coexistence

a. Land-use planning and habitat connectivity

b. Adaptive management and ecological interventions
c. Long-term strategies for human-wildlife coexistence

Practicals:

1. Field assessment of human-wildlife conflict hotspots
2. Participatory rural appraisal (PRA) exercises with local communities
3. GIS-based conflict mapping and analysis
4. Case studies of conflict mitigation in selected species (e.g., elephants, leopards, wild herbivores)
5. Design and evaluation of simple mitigation strategies

Text and Reference Books:

1. Redpath, S. M., Young, J., Evely, A., Adams, W. M., Sutherland, W. J., Whitehouse, A., ... & Gutierrez, R. J. (2013). *Understanding and managing conservation conflicts.* Cambridge University Press.
2. Treves, A., & Karanth, K. U. (2003). *Human-Carnivore Conflict and Coexistence.* Wildlife Conservation Society, Columbia University Press.
3. Woodroffe, R., Thirgood, S., & Rabinowitz, A. (Eds.) (2005). *People and Wildlife: Conflict or Coexistence?* Cambridge University Press.
4. Nyhus, P. J. (2016). *Human-Wildlife Conflict.* Current Biology, 26(21), R1015-R1019.
5. Khan, M. (2015). *Human-Wildlife Conflicts in Pakistan: Strategies for Mitigation.* Wildlife Research & Conservation Center, Islamabad.

Interdisciplinary	CB-675	Computational Biology	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

1. Describe the scope and importance of computational biology.
2. Retrieve and interpret information from biological databases.
3. Perform basic sequence alignment and phylogenetic analysis using online tools.
4. Apply computational approaches to zoological and conservation problems.
5. Communicate results of computational analysis in scientific format.

Course Contents

1. Introduction
c. Definition, scope, and significance of "Computational Biology" in zoology
d. Relationship with bioinformatics, genomics, proteomics, systems biology
2. Biological Databases
d. Primary and secondary databases
e. NCBI, EMBL, UniProt, Swiss-Prot, ENSEMBLE, PDB, GeneBank
f. Data retrieval and annotation
3. Sequence Analysis
f. Introduction to primer designing
g. DNA, RNA, and protein sequences
h. Pairwise and multiple sequence alignment
i. BLAST (BLASTN and BLASTP), FASTA, ClustalW/MEGA softwares

j. Applications in taxonomy, evolutionary studies

4. Structural and Functional Genomics

f. Gene prediction and annotation
g. Protein structure basics and prediction approaches
h. Molecular modeling (Protein Modelling as an example)
i. Comparative genomics
j. Applications in Zoology and Conservation

5. Molecular Phylogeny

d. Population genetics and molecular evolution
e. Wildlife genetics, conservation genomics
f. Applications in medicine (disease markers, drug discovery)

Practical

Hands-on exercises using free online tools and databases:

1. Introduction to biological databases (NCBI, UniProt, Swiss-Prot, PDB, PROSITE).
2. Sequence retrieval in different formats (FASTA format, Genebank format etc).
3. Basic use of BLAST for sequence similarity searches.
4. Multiple sequence alignment using Clustal Omega / MUSCLE/ MEGA.
5. Construction of phylogenetic trees using MEGA (or online tree builders).
6. Retrieval of protein structure from PDB and visualization (e.g., PyMol / RasMol).
7. Case study: DNA sequence analysis for species identification.
8. Project/report: computational analysis of a selected gene/protein relevant to zoology.
9. Primer 3 plus

Recommended Books

1. Mount, D.W. (2004). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
2. Lesk, A.M. (2019). Introduction to Bioinformatics. Oxford University Press.
3. Xiong, J. (2006). Essential Bioinformatics. Cambridge University Press.
4. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Wiley-Blackwell.
5. Clote, P., & Backofen, R. (2000). Computational Molecular Biology: An Introduction. Wiley.

Internship		Internship	3

Internship of 3 credit hours is a mandatory degree award requirement for Bachelor of Science in Zoology. Internship of 6 to 8 weeks (preferably undertaken during semester or winter break) must be graded by a faculty member in collaboration with the supervisor in the field. This requirement cannot be substituted with additional course work, capstone or project work.

Semester 8			
Course Category	**Course Code**	**Course Title**	**Credits**
Major	ZOW-681	GIS	3(2-1)
Major	ZOW-682	Wildlife Laws and Policies	3(2-1)
Major	ZOO-683	Taxidermy	3(2-1)
Major	ZOW-684	Wildlife Parasitology	3(2-1)
Capstone	CAP-685	Capstone	3
Total Credits			15

Major	ZOW-681	GIS	3(2-1)

Course Learning Outcomes (CLOs):

By the end of this course, students will be able to:

1. Understand the fundamental principles and components of GIS.
2. Collect, manage, and integrate spatial and ecological data.
3. Perform spatial analyses relevant to wildlife habitats and species distribution.
4. Develop GIS-based habitat suitability and corridor maps.
5. Apply GIS tools in decision-making for wildlife management and conservation planning.
6. Critically evaluate GIS applications in real-world conservation projects.

Course Outline:

1. Introduction to GIS

a. Definition, history, and components of GIS
b. GIS in wildlife research and management
c. Overview of GIS software and tools

2. Spatial Data and Data Sources

a. Types of spatial data: vector and raster
b. Remote sensing, GPS, and field data collection
c. Data accuracy, resolution, and projection systems

3. GIS Data Management

a. Data storage, formats, and databases
b. Attribute data and spatial relationships
c. Data integration and quality control

4. Spatial Analysis in Wildlife Management

a. Habitat mapping and land-use classification
b. Species distribution modeling and niche analysis
c. Connectivity analysis and wildlife corridors
d. Overlay analysis, buffering, and proximity analysis

5. Applications of GIS in Conservation

a. Protected area planning and management
b. Threat assessment and risk mapping
c. Monitoring human-wildlife conflicts
d. Case studies: GIS in wildlife conservation in Pakistan and globally

Practicals:

1. Introduction to GIS software (ArcGIS/QGIS)
2. Mapping wildlife habitats using vector and raster data
3. GPS data collection and integration with GIS
4. Species distribution modeling using GIS layers
5. Habitat suitability and corridor analysis
6. Generation of maps for wildlife management planning and reporting

Text and Reference Books:

1. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2015). Geographic Information Systems and Science. 4th Edition. Wiley.
2. Campbell, J. B., & Wynne, R. H. (2016). Introduction to Remote Sensing. 6th Edition. Guilford Press.
3. DeMers, M. N. (2017). GIS for Environmental Management. 5th Edition. Esri Press.
4. Heywood, I., Cornelius, S., & Carver, S. (2011). An Introduction to Geographical Information Systems. 4th Edition. Pearson Education.
5. Haines-Young, R., & Potschin, M. (2013). Spatial Ecology and Conservation GIS Applications. Springer.

Major	ZOW-682	Wildlife Laws and Policies	3(2-1)

Course Learning Outcomes:

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

1. Identify and compare the key features of national and provincial wildlife laws and policies.
2. Analyze the institutional frameworks responsible for wildlife conservation and enforcement.
3. Interpret Pakistan's obligations under major international conventions (CITES, CMS, Ramsar, CBD, UNFCCC, etc.).
4. Evaluate the gaps and challenges in implementing wildlife and environmental laws in Pakistan.
5. Formulate policy suggestions for effective wildlife conservation and legal enforcement.

Course Contents:

1. Introduction to Wildlife Laws and Policies

a. Definition, purpose, and scope of wildlife laws
b. Importance of wildlife policy in biodiversity conservation
c. Key terminologies: legislation, regulation, governance, and enforcement

2. Historical Development of Wildlife Legislation in Pakistan

a. Colonial legacy and early wildlife protection laws
b. Post-independence developments and legislative reforms
c. Role of judiciary and legal precedents in wildlife cases

3. **National Wildlife and Conservation Policies**
a. Overview of national forest, biodiversity, and conservation policies
b. National Wildlife Policy and Biodiversity Action Plan (1999)
c. Integration of wildlife laws with national sustainable development goals
4. **Provincial Wildlife Acts and Ordinances**
a. Comparative study of provincial laws: Punjab, Sindh, Khyber Pakhtunkhwa, and Balochistan
b. Administrative structure of provincial wildlife departments
c. Key provisions: hunting regulations, protected areas, and penalties
5. **Organizations and Administrative Structures**
a. Federal and provincial institutions involved in wildlife management
b. Role of NGOs, private sector, and local communities
c. Case study: Pakistan Wildlife Foundation, WWF-P, and IUCN Pakistan
6. **Current Wildlife Administration and Enforcement Practices**
a. Mechanisms for monitoring, compliance, and law enforcement
b. Challenges in prosecution and coordination among agencies
c. Illegal trade, poaching, and habitat degradation issues
7. **International Environmental Agreements and Conventions**
a. Background, objectives, and implementation structures of CITES, CMS, Ramsar, CBD, and UNFCCC
b. Institutional arrangements for implementing these conventions in Pakistan
c. Review of Pakistan's commitments and periodic reporting obligations
8. **Implementation Gaps and Policy Challenges**
a. Limitations in legislation, funding, and institutional capacity
b. Overlaps between federal and provincial mandates
c. Policy recommendations for improved governance and enforcement

Practical (01 Credit Hour):

1. Review and presentation on provincial wildlife acts and ordinances.
2. Analysis of a case study related to wildlife law enforcement in Pakistan.
3. Preparation of a brief report on Pakistan's implementation of an international convention (e.g., CITES or Ramsar).
4. Visit to a provincial wildlife department or conservation organization (WWF-P, IUCN, or Wildlife Foundation).
5. Simulation exercise: Drafting an amendment or policy brief for improving wildlife legislation.

Recommended Textbooks and References:

1. GOP. 1999. Biodiversity Action Plan for Pakistan. Ministry of Environment/IUCN/WWF-P. 79 pp.
2. GOP. 2002. National Action Programme to Combat Desertification in Pakistan. Ministry of Environment/PARC/UNESCAP. 268 pp.
3. GOP. 2005. Proceedings of the National Consultative Workshop on the Implementation of CBD, CMS, and Ramsar Convention in Pakistan. Ministry of Environment/UNEP/IUCN, Islamabad. 136 pp.
4. IUCN. 1993. Biodiversity Conservation and the Laws. Environmental Policy and Law Paper No. 29. 292 pp.
5. Khurshid, M. 2004. Environmental Initiatives: Global and National Perspectives. Ministry of Environment, Islamabad. 161 pp.

6. McNeely, J. 1997. Conservation and the Future: Trends and Options Towards the Year 2025. IUCN Headquarters. 119 pp.
7. UNEP. 2005. Selected Texts of Legal Instruments in International Environmental Law. United Nations Environment Programme, Nairobi, Kenya. 734 pp.
8. Shafiq, M. (ed.) 2005. Wildlife Acts an
9. KP Wildlife act, 2015

Major	ZOO-683	Taxidermy	3(2-1)

Course Learning Outcomes:

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

1. Practice basic taxidermy techniques.
2. Produce taxidermy mounts using a variety of taxidermy techniques.
3. Review state and federal taxidermy laws.
4. Compare different taxidermy techniques in order to recommend appropriate techniques for preserving specimens.

Course Content

1. Introduction to Taxidermy

a. Definition, history, scope, and significance of taxidermy in science and education
b. Ethical considerations and legal frameworks (Wildlife Protection Laws, CITES)
c. Modern alternatives to traditional taxidermy (e.g., 3D scanning and modeling

2. Museum Establishment and Specimen Collection

a. Concept, types, and development of natural history museums
b. Key features of an ideal museum
c. Methods of specimen collection: Hand capturing, netting, digging, draining, trapping, and shooting, Protection, preservation, and storage prior to taxidermy

3. Materials and Equipment

a. Chemicals and preservation solutions
b. Tools for skinning, mounting, and modeling

4. Taxidermy Techniques

a. Skinning procedures
b. Dehydration and drying methods
c. Tanning processes
d. Preparation and mounting of reptiles, birds, and mammals
e. Head mounting of large mammals (e.g., deer, markhor)
f. Skeletal articulation and mounting
g. Resin embedding techniques
h. Preparation of head casts
i. Labeling and cataloging of specimens

5. Laws of Transportation

a. International and national laws on transportation of biological specimens
b. Contemporary relevance and status of taxidermy in scientific and cultural institutions

6. Wet Preservation

a. Materials and preservatives for wet specimens
b. Pinning and curation techniques
c. Wet mounting of invertebrates and vertebrates
d. Long-term storage and display considerations

Practicals

1. Complete mounting of a small mammal (domestic or ethically sourced wild specimen)
2. Complete mounting of a bird specimen
3. Demonstration of resin embedding (including video or virtual resources)
4. Demonstration and practice of wet preservation methods using various invertebrate and vertebrate specimens
5. Field visit to a professional taxidermy facility (e.g., Pakistan Museum of Natural History, Islamabad or an equivalent institution)

Recommended Textbooks and References

1. Eastoe, J. (2020). *The Art of Taxidermy*. Pavilion Books.
2. Pat Morris (2010). *A Practical Guide to Modern Taxidermy*. The Crowood Press.
3. Fraser, M. (2008). *Taxidermy: A Complete Guide*. Creative Publishing.
4. Hall, E.R. (1991). *Preparation of Mammals for Museum Study*. University of Kansas Publications.
5. Knudsen, J. (2015). *Anatomical Preparation: Techniques and Tools for Preserving Animal Specimens*. Academic Press.
6. Wildlife Protection Act, 1972 (Pakistan and International Variants)
7. Manuals and Specimen Preparation Guidelines - Smithsonian Institution and Natural History Museum Resources Bottom of Form

Major	ZOW-684	Wildlife Parasitology	3(2-1)

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

4. Explain basic host–parasite relationships and major parasite groups affecting wildlife.
5. Identify common wildlife parasites using basic morphological and diagnostic methods.
6. Evaluate ecological and public-health significance of wildlife parasites and suggest basic management strategies.

Course Contents

25. Introduction, scope, host–parasite concepts.
26. Host–parasite ecology & transmission.
27. Population impacts of parasites.
28. Field sampling methods & ethics.
29. Lab diagnostics I: fecal techniques.
30. Lab diagnostics II: blood smears & serology.
31. Protozoan parasites overview.
32. Important protozoa in wildlife.
33. Helminths overview.
34. Nematodes of wildlife.
35. Cestodes & trematodes.
36. Ticks: biology & wildlife health.

37. Mites, lice, fleas & flies.
38. Parasites of wild birds.
39. Parasites of wild mammals.
40. Parasites of reptiles & amphibians.
41. Aquatic & marine wildlife parasites.
42. Wildlife zoonoses.
43. Wildlife disease surveillance.
44. Outbreak investigation.
45. Parasite control in wild & captive fauna.
46. Conservation medicine.
47. Rehabilitation & captive wildlife parasitology.
48. Molecular identification (intro).

Practicals:

11. Introduction to Parasitology Laboratory

d. Lab layout, safety rules, biosafety levels.

12. Identification of basic equipment:

e. microscope, hemocytometer, dissecting tools, flotation apparatus.

13. Collection and Handling of Wildlife Samples

f. Methods of collecting fecal, blood, skin scraping, and tissue samples from wildlife.

14. Preparation of Wet Mounts

c. Preparation of wet mounts from fecal and blood samples.
d. Identification of protozoan trophozoites, cysts, and helminth eggs under microscope.

15. Fecal Examination Techniques

c. Direct smear, sedimentation, and flotation techniques.
d. Identification of helminth ova (Nematodes, Cestodes, Trematodes) from wildlife samples.

16. Ectoparasite Collection and Identification

c. Collection methods: combing, brushing, skin scrapes, traps.
d. Identification of common wildlife ectoparasites: ticks, mites, lice, fleas.

17. Tick Morphology and Identification

d. Mounting ticks on slides.
e. Identification using keys (Ixodidae, Argasidae).
f. Observing scutum, capitulum, festoons.

18. Blood Parasites of Wildlife

g. Thin and thick blood smear preparation.
h. Staining with Giemsa stain.
i. Identification of hemoprotozoa: Babesia, Trypanosomes, Hepatozoon.
j. Internal Parasites in Wildlife Necropsy
k. Demonstration of wildlife necropsy procedure (video or preserved specimens).
l. Recovery and preservation of parasites from gastrointestinal tract.

19. Parasite Egg Counting

c. Fecal egg count (FEC) using McMaster technique.
d. Calculation of eggs per gram (EPG) for helminths.

20. Museum Specimens and Slide Study

c. Study of permanent slides of wildlife parasites (protozoa, helminths, arthropods).
d. Observation of museum specimens (ticks, cestodes, nematodes)

Recommended Books

6. Wildlife Parasitology: Emerging Diseases and Neglected Parasites (Frontiers Media, 2024).
7. Parasitic Diseases of Wild Mammals, 2nd Ed. Samuel, Pybus & Kocan (Wiley).
8. Veterinary Clinical Parasitology, 9th Ed. Zajac & Conboy (Wiley).
9. Veterinary Parasitology Reference Manual. Foreyt (latest edition).
10. Relevant open-access reviews and chapters (Frontiers, UNL Digital Commons).

Capstone	CAP-685	Capstone	3

It is a mandatory degree award requirement of 3 credit hours for Bachelor of Science in Zoology. The capstone is a multifaceted body of work that serves as a culminating academic and intellectual experience for students. It must be supervised and graded by a faculty member as per the protocols prescribed by the concerned department. This requirement cannot be substituted with additional course work or internship.