



UNIVERSITY OF SARGODHA
OFFICE OF THE REGISTRAR
(ACAD BRANCH)

NOTIFICATION

On the recommendations of Academic Council made in its 19th (4/2023) meeting held on 13.09.2023, the Syndicate in its 64th (4/2023) meeting held on 03.11.2023 approved the revised scheme of studies/curriculum of BS in Zoology (5th Semester Intake) for implementation w.e..f. **Fall 2025 (Annex-'A')**.


(WAQAR AHMAD)
Additional Registrar (General)

Dated: 05.11.2025

No. SU/Acad/25/ 1194

Distribution:

- Chairman Department of Zoology
- Controller of Examinations
- Director Academics

C.C:

- Dean Faculty of Sciences
- Director, QEC
- Secretary to the Vice-Chancellor
- PA to Registrar
- Notification File

- Title of Degree Program:** BS in Zoology (5th Semester Intake)
- Program Learning Objectives:** The Department of Zoology comprises of diverse and excellent faculty members and researchers who aim to develop the best possible research environment for the students in the field of Zoology. We intend to train the student in a wide range of biological fields of Zoology like Vertebrate and Invertebrate Zoology, Wildlife and Fisheries, Paleontology and Zoogeography, Evolution and Systematics, Cell and Molecular Biology, Biochemistry, Immunology, Genetics, Developmental Biology, Ecology, Toxicology, Microbiology, Vascular Biology, Immunology, Integrated pest management, Endocrinology.

3. Eligibility Requirements:

For Candidates having Associate Degree or equivalent in same field	Student secured 45% marks in BSc or CGPA 2.00 out of 4.00 in ADS with Zoology of 200 marks (for annual system) as major subject or at least zoology of 16 credit hours (for semester system). Students have to complete the deficiency courses to fulfill the requirement of degree		
For Candidates where disciplines of Associate Degree or equivalent and Undergraduate program are different	Student secured 45% marks in BSc or CGPA 2.00 out of 4.00 in AD Chemistry/ AD Botany. Students have to complete the deficiency courses to fulfill the requirement of degree		
Degree Completion Requirements:	Interdisciplinary	II	(08 CHs)
	Disciplinary / Major	D	(52 CHs)
	Internship	I	(3 CHs)
	Capstone Project	R	(3 CHs)
			66

4. Deficiency courses: (For students other than AD Zoology; AD Botany & AD Chemistry)

Category	Course Code	Course Title	Credit Hours	Pre-Requisite	Semester
Deficiency	ZOOL-5101	Animal Diversity-I (Invertebrates)	4(3-1)	Nil	1 st
Deficiency	ZOOL-5102	Animal Diversity-II (Chordates)	4(3-1)	Nil	2 nd
Deficiency	ZOOL-5103	Animal Form & Function-I (A comparative Perspective)	4(3-1)	Nil	3 rd
Deficiency	ZOOL-5104	Animal Form & Function-II	4(3-1)	ZOOL-5103	4 th

5. Deficiency courses: (For students of ADS [annual system] and BS: Zoology)

Category	Course Code	Course Title	Credit Hours	Pre-Requisite	Semester
Deficiency	ZOOL-5106	Cell and Molecular Biology	4(3-1)	Nil	1 st
Deficiency	ZOOL-5108	Fisheries	3(2-1)	Nil	2 nd
Deficiency	ZOOL-5107	Biochemistry	4(3-1)	Nil	3 rd
Deficiency	ZOOL-5105	Economic Zoology	3(2-1)	Nil	4 th
Deficiency	ZOOL-5109	Seminar	1(1-0)	Nil	4 th

15-18 credit hours; depending on the number of deficiency courses needed by concerned students to

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full fill the requirement of degree.

Semester-I

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
Major-1	ZOOL-6109	Developmental Biology	4(3-1)	Nil
Major-2	ZOOL-6110	Physiology	4(3-1)	Nil
Major-3	ZOOL-6111	Evolution & Principles of Systematics	4(3-1)	Nil
ID-1	CHEM-5103	Organic chemistry	4(3-1)	Nil
Deficiency 1	ZOOL-5101/ ZOOL-5106	Animal Diversity-I (Invertebrates)/ Cell and Molecular Biology	4(3-1) 4(3-1)	Nil

Semester Total Credit Hours: 16

Semester-II

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
Major-4	ZOOL-6112	Research Methodology	2(2-0)	Nil
Major-5	ZOOL-6113	Genetics	4(3-1)	Nil
ID-2	BOTN-5102	Plant Systematics, Anatomy and Development	4(3-1)	Nil
Major-6	ZOOL-6114	Wildlife	3(2-1)	Nil
Major-7	ZOOL-6115	Biotechnology	3(2-1)	Nil
Deficiency 2	ZOOL-5102/ ZOOL-5108	Animal Diversity-II (Chordates)/ Fisheries	4(3-1)/ 3(2-1)	Nil

Semester Total Credit Hours: 16

Summer Semester

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
Compulsory	ZOOL-6116	Internship*	3(3-0)	

* Offered in summer semester only (after 4th semester for fall intake and after 5th semester for spring intake)

Semester-III

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
Major-8	ZOOL-6117	Biostatistics	3(3-0)	Nil
Major-9	ZOOL-6118	Bioinformatics	3(2-1)	Nil
Major-10	ZOOL-6119	Principles & Kinetics of Toxicology	3(2-1)	Nil
Major-11	ZOOL-6120	Ecology	3(2-1)	Nil
Compulsory	ZOOL-6121	Capstone Project	3(3-0)	Nil
Deficiency 3	ZOOL-5103/ ZOOL-5107	Animal Form & Function-I (A comparative Perspective) / Biochemistry	4(3-1)	Nil

Semester Total Credit Hours: 15

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Semester-IV

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
Major-12	ZOOL-6122	Biological Techniques	3(2-1)	Nil
Major-13	ZOOL-6123	Animal Behavior	3(3-0)	Nil
Major-14	ZOOL-6124	Zoogeography & Paleontology	4(3-1)	Nil
Major-15	ZOOL-6125	Entomology	3(2-1)	Nil
Major-16	ZOOL-6126	Fundamental Microbiology	3(2-1)	Nil
Deficiency 4	ZOOL-5104/	Animal Form & Function-II/ Economic Zoology/Seminar	4(3-1)/	ZOOL-5103
	ZOOL-5105/		3(2-1)/	Nil
	ZOOL-5109		1(1-0)	

Semester Total Credit Hours: 16
Degree Program Total: 66

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Semester I

Course Code	ZOOL-6109	Course Title	Developmental Biology	Credit Hours	4(3-1)
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Course Brief:

The course aims to provide information on transmission of traits from the parents in their gametes, the formation of zygote and its development; impart detailed knowledge about cellular basis of morphogenesis, mechanisms of cellular differentiation and induction. It provides understanding of the mechanisms of organogenesis, factors controlling growth and oncogenesis. Students will learn how developmental biology is having a significant impact on our understanding of evolution and modern medicine, including the treatment of birth defects, infertility and cancer in humans.

Course Learning Objectives:

The students will be able to understand and compare basic principles of embryology through understanding the developmental patterns with help of morphology and anatomy of embryos of different vertebrates. The practical section will enable them to go through the structure of gametes of animals (like. frog, fish and mammal), to study of fertilization, early development of frog/fish through induced spawning under laboratory conditions and to know about the dactylography and its uses in developmental biology.

Course Contents:

1. Introduction: History and Basic Concepts of developmental biology, Principal features of developmental biology and embryology with special emphasis on vertebrate models, origin of sexual reproduction, developmental patterns
2. Spermatogenesis: Mammalian spermatogenesis as model for all vertebrates, Spermiogenesis or (spermateliosis), The role of Sertoli and Leydig cells in spermatogenesis, Hormonal control of spermatogenesis
3. Primates menstrual cycle
4. Oogenesis: mechanism of oogenesis among various classes of vertebrates, vitellogenesis hormonal control of vitellogenesis and oogenesis
5. Fertilization: external & internal fertilization, species-specific recognition of sperm and egg, fusion of male and female gametes
6. Polyspermy: slow and fast blocks to polyspermy, activation of egg metabolism
7. *IN VITRO* Fertilization (IVF): history, steps and advantages of IVF, disadvantages and risk factors
8. Cleavage & blastulation, patterns of embryonic cleavage and blastulation among different vertebrate classes, mechanism of cleavage
9. Gastrulation: fate maps, gastrulation in amphibians, birds and mammals
10. Early vertebrate development
11. Neurulation, ectoderm, mesoderm and endoderm formation
12. Placenta and extraembryonic membranes

13. Cellular basis of morphogenesis: differential cell affinity, cell adhesion molecules,
14. Organogenesis, Mechanism of teratogenesis
15. 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.

Recommended Texts:

1. Gilbert, S. F., & Barresi, M. J. F. (2020). *Developmental Biology* (11th ed.). Oxford: Oxford University Press, Incorporated.
2. Dale, L., & Slack, J. M. W. (2021). *Essential Developmental Biology*. Wiley: United Kingdom.

Suggested Readings:

1. Carlson, B. M. (2023). *Human Embryology and Developmental Biology*. Elsevier Health Sciences: United States.
2. Micheal, J. F., & Scott, F.G. (2019). *Developmental Biology*. United States: MJP Publisher.
3. Carlson B. M. (2014). *Human Embryology and Developmental Biology* (5th ed.). Elsevier/Saunders: United States.

Course Code	ZOOL-6110	Course Title	Physiology	Credit Hours	4(3-1)
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Course Brief:

This course will provide an introduction to the basic physiological principles common to humans and other animals. It will include basic physical and chemical processes in animal tissues, detailed consideration of organ systems, and an integrative approach to understand how animals meet the demands in variable conditions. It will not only emphasize human physiology, but also will consider other animal systems for comparison.

Course Learning Objectives:

This course will enable the students to understand the molecular and cellular mechanisms of physiological function as the basis of unity in diverse animals e.g. membrane excitability, exchange of respiratory gases, removal of nitrogenous wastes, osmosis and other physiological mechanisms underlying animal homeostasis and temperature effects. On the completion of course students will be able to understand mechanisms and adaptations of physiological systems in animals and understand the working of various systems of organisms. The practical portion will let the learners to investigate physiological questions, and collecting, analyzing, interpreting, and reporting experimental data.

Course Contents:

1. Concept of Physiology: Principles of homeostasis and conformity, principles of regulation and adaptation
2. Membrane Physiology: Ionic distribution across membrane, resting membrane potentials: electrogenic ion pump, Donnan equilibrium, Ion channels
3. Muscle Physiology: Action potentials in neurons, electrical and chemical synaptic transmission, Neurotransmitters in communications, receptors of neurotransmitters in diverse physiological responses, excitatory and inhibitory postsynaptic potentials, neuronal networks and their role in nervous integration,
4. Muscles: Structure, types, components, muscle proteins, molecular basis of muscle contraction, Sarcoplasmic reticulum and role of calcium. neuromuscular interaction at cell and molecular level muscle, types of muscle contractions and muscle fatigue.
5. Endocrine Physiology: Hormones of invertebrates and specifically of arthropods for the functions in their modes of life. hormones of various vertebrates' endocrine organs and comparison of their roles in adaptability of mode of life, mechanisms of hormone actions, hormone receptors, signal transduction and hormonal coordination.
6. Cardiovascular Physiology: Electrical activity of heart; self-excitability and auto-rhythmicity of myogenic heart, neurogenic heart and their expression, electrocardiography and Kymograph, hemodynamics, relationship between blood flow, pressure and resistance. Their role in performance of the function in variety of vertebrates, control of cardiac activity, cardiac output and peripheral circulation
7. Respiratory Physiology: mechanism of respiratory gases exchange in aquatic and terrestrial respiratory structures, Control of respiration and stimulus factors in various animals, respiration adaptations in hypoxia and percapniae, air breathing and respiratory adaptations diver animals.
8. Excretory Physiology: Strategy of mammalian large glomerular filtration and reabsorption in nitrogenous excretion, patterns of nitrogenous excretion in various animals and their phylogenetic significance.

9. Physiology of Nutrition: Adaptation of nutritive canal for digestion and absorption of nutrients in different animals specifically the vertebrates, regulation of digestive secretions, mechanisms of water, ions and nutrients absorptions and their significances in diverse groups, potential and movements in gastrointestinal tract and control of motility.

Practical

1. Respiration and Circulation: Study of respiratory pigments in various animals and hemoglobin in various vertebrates, normal cardiac activity in amphibian model, effect of temperature, effect of drug, heart block, tantalization of heart, measurement and effects of various factors on blood pressure.
2. Nervous System: Study of brains in different animals in relation to complexity of functions, Study of human brain model and different areas eliciting behaviors, videos study on 1 and 2 studies.
3. Hormones System: Video studies on the effects of hormones in breeding season behaviors of various behaviors, Study through clinics data on the insulin and glycaemia in type1 and type 2 diabetic subjects.
4. Methods of handling and restraint of different domestic animals for blood collection, determination of body temperature and pulse; Collection of blood; Sites of blood collection in different animal species; Precautions during blood collection; Different types of anticoagulants used routinely and their mechanisms of action;
5. Practical demonstration of measuring body temperature, pulse, respiration rate in different domestic animals;
6. Practical demonstration of blood collection in different domestic animals; Determination of total red blood cell count of the blood sample obtained from some animal source or human volunteer; Determination of total white blood cell count of the blood sample obtained from some animal source; Determination of packed cell volume; Determination of haemoglobin concentration; Determination of coagulation and bleeding time;
7. Practical performance of erythrocyte sedimentation rate; Practical performance of differential leukocyte count; Demonstration and practical performance for the determination of blood groups

Recommended Texts:

1. Moyes, C. D., & Schulte, P. M. (2015). *Principles of animal physiology*. New Jersey: Pearson.
2. Hall, J. E., & Hall, M. E. (2020). *Guyton and Hall textbook of medical physiology* (14th ed.). Philadelphia: Elsevier.

Suggested Readings:

1. Hill, R., Cavanugh, D., & Anderson, M. (2021). *Animal Physiology* (5thed.). Massachusetts: Sinauer Associates.
2. Sherwood, L., Klandorf, H., & Yancey, P. (2012). *Animal physiology: from genes to organisms* (2nd ed.). California: Brooks/Cole

Course Code	ZOOL-6111	Course Title	Evolution and Principles of Systematics	Credit Hours	4(3-1)
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Course Brief:

The course aims to provide extensive knowledge about origin of life and concepts about forces responsible for evolutionary changes. This study covers the importance and history of systematics with basic rules and regulations about the identification and naming of organisms. This course will also provide information about origin, classification and evolution of fauna. The students will be able to understand classification, philosophy of nomenclature, species concepts, phylogenetic inference and evolutionary perspectives of biodiversity.

Course Learning Objectives:

The students will be able to understand the basic principles of evolution and systematics, and the inference of evolutionary patterns in the major animal groups. Students will be able to demonstrate evolutionary implications of animal diversity, nature and origin to life, Systematic Zoology, microtaxonomy and taxonomic categories. The practical section will enable the students to preserve invertebrate species and classify them up to class level, how to identify animal by the help of key and how to make keys of different types for identification of animals

Course Contents:

Evolution

1. Theories of Evolution: theories to explain diversity of life – modern synthetic theory.

Factors initiating elementary evolutionary changes (micro-evolution) and change of gene frequencies. Mutation pressure, selection pressure, immigration and crossbreeding, genetic drift.

2.Role of isolation in evolution: factors of large evolutionary changes (macroevolution).concepts of allometry, orthogenesis, adaptive radiation.

3.Modern concept of Natural Selection: levels of selection, selection patterns, some examples of Natural Selection.

4.Impacts of Natural Selection leading to convergence, radiation, regression and extinction,

Batesian mimicry, Mullerian mimicry, sexual selection: Darwin's concept, Fisher's view, Zahavi's handicap theory and recapitulation theory

Contents

Principles of Systematics

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

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

3. Taxonomic characters: Kinds and weightage, micro taxonomy, taxonomic categories: specific category, intraspecific category, higher categories; Species concept.
4. Typological species concept: Nominalist species concept, biological species concept, Evolutionary species concept. Kinds of different species, Speciation
5. Taxonomic procedures, taxonomic collection; their preservation and duration, Taxonomic keys, different kinds of keys and their merits and demerits.
6. Formation of specific names, brief concept of cladistics, phylogenetics. Theory and practice of cladistics and phylogenetic systematics.
7. Systematics publications: International code of zoological nomenclature; its objective, principles, interpretation, application of important rules, with reference to: Zoological nomenclature, law of priority and validity of names.

Practical

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

Recommended Texts:

Evolution

1. Strickberger's Evolution Hall, B.K. & Hallgrímsson, B. (2013). *Jones & Barrett Publishers*.
2. Ridley, M. (2004). Evolution. Blackwell Scientific Publications.
3. Freeman, S. & Herron, J. C. (2014). Evolutionary analysis, 5th ed. Pearson Prentice Hall.

Systematics

1. Wiley, E. O. & Lieberman, B. S. (2011). Phylogenetics: Theory and practice of phylogenetic systematics. (2nd ed). Wiley-Blackwell.
2. Mayer, E. Principles of Systematic Zoology. (1994). McGraw Hill, New York.
3. Kapoor, V.C. (2001). Principles and practices of animal Taxonomy. Science Publishers, 2nd ed

Suggested Readings:

Evolution

1. Wiley, E. O. and Lieberman, B. S. (2011). Phylogenetics: Theory and Practical Practice of Phylogenetic systematics. 2nd Ed. Wiley-Blackwell.
2. Moody, P.A. (1989). Introduction to Evolution, Harper and Row, Publishers, New York Systematics
3. Heywood, V.H. Taxonomy and Ecology. (1975). Academic Press, London.
4. Whili, M.J.D. Modes of Speciation, (1978). W.H. Freeman and Co., San Francisco.
5. Andrew V. Z. Brower & Randall T. Schuh. (2021). Biological Systematics: Principles and Applications (3rd ed.) Oxford Academic Books.

Course Code	URCQ-5111	Course Title	Translation to Holy Quran III	Credit Hours	1(0-1)
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Course Brief:

- To introduce ethics and highlight its importance, need and relevance for individual and collective life.
- To illuminate the students with the Quranic norms of Morality i.e. truthfulness, patience, gratitude, modesty, forgiving, hospitality etc.
- To familiarize the students with immoral values like falsify, arrogance, immodesty, extravagance, backbiting etc.

Course Learning Objectives:

- To inculcate ethical and moral values in our youth.
- To develop a balanced dynamic and wholesome personality.
- To introduce the students to Quranic Arabic grammar in practical manner.

Course Contents:	<p>(اخلاق) (تعارف، ضرورت و اہمیت اقسام، معنویت (اخلاقِ حسنہ) :</p> <p>برائی کو نیکی سے مٹانا نیکی کے کاموں میں مسابقت لوگوں کے درمیان صلح عدل و انصاف سچائی ایثار سلیم قلب مہمان نوازی لغویات سے اعراض عاجزی و انکساری نگاہ اور اواز کو پست رکھنا چال میں میانہ روی شرمگاہوں کی حفاظت صبر شکر امور میں میانہ روی اخلاقِ سنہ :</p> <p>ظلم اور زیادتی غرور و تکبر نفسانی خواہشات کی پیروی بدگمانی جھوٹ چغلی اور تہمت تمسخر اور شیخی خوری لہو و لعب برے ناموں سے پکارنا احسان جتانا اور تکلیف دینا فضول خرچی اور حد سے بڑھنا حسد اور تنگ دل بے پردگی</p>
Grammar:	<p>قرآنی عربی گرامر کے اصول اور انکے اطلاقات (منن قرآنی پر اطلاق سے توضیحات)</p>

<p>Details of Chapters and verse Numbers:</p>	<p>منتخب آيات مع ترجمه وتجويد البقره (٨٧٧، ٤٥٨، ٢٢، ٨٢٧، ٨١٧، ٨٤٧، ٨١٧، ٨١٧، ٨٤، ٣٤٧، ١١٧، ١٤٨، ٤٨٧، ٨٨٨، ١٨، ١١، ٨٢٧، ٢٥٧، ١٢٧، ٢١٧، ٥٢٨، ٣٢٨، ٨٢٨، ٨٧٨، ١٢، ٧٣٨، ١٧، ٥٢٣، ٥٨٧، ٢٤٨، ١٨، ٧١، ٢٢، ٢٨٨، ٤٢٧، ٢١، ٤٨٧، ١١٨، ١٧، ٤٥٧، ٥٢٧، ٢٥٧، ٨٢٧، ٤٢٧، ٥٨، ٥٧، ٥٤٧) ال عمران (٣٣٧، ٥٧٧، ٥١٧، ٥١٧، ٢٨، ٢١، ٧٥٧، ١٥٧، ٢٤٧، ١٥، ٥٨، ٤٨، ٢٣، ٣١٧، ١٨، ١٨، ٥٤، ٤١٧، ١١٧، ٢١٧، ٨٨، ٣٨، ٤٣٧) النساء (١٤، ٥٨، ١٤، ٢٤، ٣٧، ٣٢، ١٤، ٢٤) المائدة (٧٥، ٢، ٣٧، ٣٢، ١٤، ٢٤) النحل (٢٧، ٢٨٧، ١٢، ٣٧٧، ٤١٧، ٢٨٧، ١٢، ٢٨٧، ١٣، ٣٧٧، ٤١٧، ٢٨٧، ١٣، ٣٧٧، ٤١٧، ٢٨٧، ١٣، ٣٧٧) ٤٨٧</p>
	<p>الرعد (٢، ٨٨، ٥٨، ١٨، ٤٨) العراف (٧٣، ٢٢، ٧٤، ٢٥٧، ١٥، ٥، ١٨، ٥٥٧، ٢٢٧، ٤٢، ٧٢) القصص (٥٤، ٥٢) فصلت (٥٣) الانعام (٨٣، ١١، ١١، ١٢٧، ٤٤٧، ١٣٧، ١٢٧، ١٢، ٢٥) الحج (١٣، ٢٤، ١٢، ٢٢، ١١) الحجرات (٢، ٧٧، ٢، ٧٧، ٣، ٨٧، ٤٧، ١٧) الحزاب (٣٨، ١٤، ٢٤، ٢٤، ٨٤، ٢٤، ٤٤، ٤٤، ٥٨، ٤٣) الحشر (٢) طه (٨١) الانعام (٥٢٧، ٧٥٧، ٢٧٧، ٧٤٧، ٣٢، ١٨٧) ق (٥٣) النفال (١٨، ٢٥، ٧٢) الفتح (٤٧) يونس (١٧، ٢٧، ٨٧، ٢٢، ٨٨، ٨٨، ٢٢، ٢٢، ٧٨، ٣٢) ١٢، ٣٢، ٣٨، ١٣، ٥، ٢، ١٣، ٧٣، ٣٣، ٣٣، ٧٢، ٧٢، ٧٣، ٨٨) لقمان (٢، ٣٣، ٢٧، ٨٣، ٢٧) السراء (١٣، ٤، ١٧٧، ١٣) المزمل (٢٧) المدثر (٢، ٥) المدثر (٥١) فاطر (٨٣) الفتح (٢٨) البلد (١٧) الزمر (٣، ١٧) الحجر (٤٢) النجم (٧٣) الرح من (١٢) هود (٢) الكهف (٨، ٢٤) الثورى (١٣) غافر (٢٨، ١٨) الحديد (١٨، ١٨) مريم (٢٤) النازعات (٧٥) التوبه (٤٢، ٥٢) الهمزه (٧) ١١</p>

Course Code	CHEM-5103	Course Title	Organic Chemistry	Credit Hours	4(3-1)
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Course Brief:

The students will acquire knowledge about the basic concepts of organic chemistry, chemistry of hydrocarbons, functional groups and the mechanism of organic reactions. It will be useful for the qualitative analysis and synthesis of organic compound. Understanding and knowledge of new and advanced field of organic and also significances the importance of application of advanced techniques. This course is a foundation course for Organic Chemistry major courses of higher semester.

Course Learning Objectives:

The main objectives emphasized in this course involve developing an understanding of basic principles of organic chemistry. It develops critical thinking skills enabling students to solve general chemistry problems that incorporate their cumulative knowledge. Students learned in class to advanced organic chemistry concepts which give them opportunities to upgrade their knowledge about advanced organic concepts. The essence of this course is to develop study skills that students need to succeed in university-level chemistry courses and preparation of students for professional positions in the field of synthesis chemistry.

Course Contents:

1. Basic concepts: atomic, molecular and hybrid orbitals: multiple localized and delocalized bonds, properties of bonds, inductive effect, dipole moment. The concept of resonance, rules of resonance, resonance energy, steric inhibition of resonance, hyperconjugation, resonance effect, hydrogen bonding, tautomerism.
2. Introduction to spectroscopy with special reference to the infrared, ultraviolet/visible spectroscopy.
3. Hydrocarbons: classification of hydrocarbons. Nomenclature. Methods of preparation, physical characteristics and chemical reactions of alkanes, alkenes and alkynes. Source of aromatic hydrocarbons. Structure of benzene and the concept of aromatic hydrocarbon. Aromatic electrophilic substitution.
4. Stereoisomerism: conformational analysis of ethane and butane. Optical isomerism, optical activity, chiral carbon atom and optical isomerism, relative and absolute configuration, creation of chiral carbon and racemization. Optical isomerism in compounds containing two chiral carbons atom, diastereoisomer, elements of symmetry, resolution of racemic mixture, geometric isomerism, cis/trans isomerism, designation of isomerism, determination of configuration.
5. Alkyl halide: nomenclature, method of preparation and chemical reaction with special reference to the nucleophilic substitution and elimination reaction of alkyl halide. Preparation, structure and synthetic application of grignard reagent.
6. The hydroxyl group and ether: nature of hydroxyl group in phenol and alcohol.
7. Alcohol: classification and nomenclature, preparation method and chemical reaction, distinction between primary, secondary and tertiary alcohol, polyhydric alcohols. Phenol: preparation method, acidity of phenol, chemical reaction.
8. Ether: preparation and reactions.
9. The carbonyl group: nature and its reactivity, nomenclature of aldehyde and ketone, aldehyde and ketone preparation and reactions along with distinction between them. Carboxylic acid and their derivatives: nomenclature, preparation and chemical reactions, strength of acid and factors

affecting it, formation and hydrolysis of acid anhydrides, acid halides, acid amides, esters including glycerides. Introduction to amino acid.

10. Nitrogen compounds: amines; classification, nomenclature, preparation and chemical reactions, distinction between primary, secondary and tertiary amines. Preparation and reaction of aniline. Basicity of aromatic and aliphatic amines and factors affecting it. Diazonium salts and their synthetic applications. *Practical*

1. Qualitative organic analysis; systematic identification of organic compounds containing group like COOH, OH, NH₂, C=O.
2. Purification techniques viz solvent extraction distillation and recrystallization, etc.
3. Preparation of simple organic compounds viz, Ethyl benzoate, benzoic acid, tribromophenol, aspirin, nitrobenzene.

Recommended Texts:

1. Younas, M. (2006). *Organic spectroscopy*. Lahore: A. H. Publisher.
2. Solomons, T.W.G. (2016). *Fundamentals of organic chemistry*(12thed.). New York: Wiley.
3. Vogel, A. I. (1996). *A textbook of practical organic chemistry*. New Jersey: Prentice Hall.

Suggested Readings:

1. Kemp, W. (1990). *Organic spectroscopy*. London: Macmillan.
2. Chughtai, F. A. (1995). *Organic reactions*. Lahore/ Faisalabad: Majid Book Depot.
3. Streitwieser, A., Heathcock, C., & Kosower, E.M. (2017). *Introduction to organic chemistry*(4thed.). New York: Macmillan.

Course Code	ZOOL-5101	Course Title	Animal Diversity-I (Invertebrates)	Credit Hours	4(3-1)
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Course Brief:

This course will provide the knowledge of evolutionary/phylogenetic relationship. It imparts the basic taxonomic characteristics and classification of all the invertebrate phyla. This includes more than 95% of all of the described species of animals and far more than 99% of all of the individual animals on the planet. The central theme running throughout this course will be phylogeny. It provides understanding of body organization, mode of feeding, digestion, reproduction and development of invertebrates. It delivers information to students about economic and ecological importance of invertebrates. Students will understand invertebrate organismal concepts in laboratory and field.

Course Learning Objectives:

The primary objectives for the laboratory section of this course includes; introduction of structure, function and behavior of selected invertebrate types through the observation of both living and preserved specimens, to reinforce basic laboratory skills of students like microscopy, dissection and careful observation, to provide students with the ability to recognize the major groups of invertebrate and to increasing understanding of the methods of investigating animal evolution. **Course Contents:**

1. Introduction: classification of organisms, evolutionary relationships and tree diagrams: patterns of organization.
2. Animal-like protists: the protozoa: evolutionary perspective; life within a single plasma membrane, symbiotic life-styles, Protozoan taxonomy, pseudopodia and amoeboid locomotion; cilia and other pellicular structure, nutrition; genetic control and reproduction; symbiotic ciliates, further phylogenetic consideration.
3. Multicellular and tissue levels of organization: Evolutionary Perspective, Origins of Multicellularity: Animal Origins, Phylum Porifera, Cnidaria, Ctenophora, Characters and Classification, Maintenance functions.

4. The triploblastic and with acoelomate body plan: Phylum Platyhelminthes, Phylum Nematode, Gastrotricha, evolutionary perspective; classification up to class, body plan and functions.
5. Pseudocoelomate body plan: Phylum Aschelminths, evolutionary perspective; general characteristics; classification up to order with external features, feeding and digestive system; other organ system; reproduction and development including Phylum Rotifera, Phylum Nematoda and Phylum Kinorhyncha. some important nematode parasites of human.
6. Phylum Mollusca: evolutionary perspective; relationship to other animals; origin of the coelom; characteristics, classification up to class. the characteristics of shell and associated structures, feeding, digestion, gas exchange, locomotion, reproduction and development, other maintenance functions and diversity in gastropods, bivalves and cephalopods.
7. Phylum Annelida: the metameric body form; evolutionary perspective; relationship to other animals, metamerism and tagmatization, classification up to class. external structure and locomotion, feeding and the digestive system, gas exchange and circulation, nervous and sensory functions, excretion, regeneration, reproduction and development, Polychaeta, Oligochaeta and Hirudinea, Further phylogenetic consideration.
8. Phylum Arthropoda: evolutionary perspective: classification and relationship to other animals; metamerism and tagmatization; the exoskeleton; metamorphosis; classification up to class.
9. The Hexapods and Myriapods: evolutionary perspective: classification up to class. external structure and locomotion, nutrition and the digestive system, gas exchange, circulation and temperature regulation, nervous and sensory functions, excretion, chemical regulation, reproduction and development in hexapoda, insects behavior, insect and human.
10. Phylum Echinoderms: evolutionary perspective: relationship to other animals; echinoderm characteristics; classification up to class, maintenance functions, regeneration, reproduction, and development in Asterozoa, Ophiurozoa, Echinozoa, Holothurozoa and Crinozoa.

11. Some lesser known Invertebrates: Lophorates, Entoprocts, Cyclophores, and Cheatognaths.

Practical

Note: Classification of each member of each phylum upto order with adaptations in relation to habitat of the specimen. Preserved specimen and colored projection slide and CD ROM projection of computer must be used.

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

Recommended Texts:

1. Miller, A. S., & Harley, J. P. (2016 & 2019). *Zoology* (10 & 11) Singapore: McGraw Hill
2. Hickman, C. P., Roberts, L. S., Keen, S. L., Larson, A., l'Anson, H & Eisenhour., D. J. (2009). *Integrated principles of zoology* (14th ed.). Singapore: McGraw-Hill.

3. Hickman, C. Jr., Keen, S., Eisenhour, D., Larson, A., l'Anson, H., (2019). *Integrated principles Of zoology* (18th ed.). Singapore: McGraw-Hill.

Suggested Readings:

1. Hickman, C. P., Roberts, L. S., & Larson, A. (2018). *Integrated principles of zoology* th (15 ed.). Singapore: McGraw-Hill.
2. Hickman, C., Jr., Keen, S., Eisenhour, D., Larson, A., l'Anson, H., (2019). *Integrated principles of zoology* (18th ed.). Singapore: McGraw-Hill.
3. Pechenik, J. A. (2015). *Biology of invertebrates* (7th ed.). Singapore: McGraw-Hill

Course Code	ZOOL-5106	Course Title	Cell and Molecular Biology	Credit Hours	4(3-1)
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Course Brief:

The course aims to impart knowledge about the animal cell and its complex organization and architecture. It enables students to understand various ultra-structural, molecular and functional aspects of the cells. Students will be able to describe and discuss the properties and biological significance of the major classes of molecules found in living organisms and the relationship between molecular structure and biological function, can relate how cell movement and cell-cell communication occur and discuss mechanisms of signal transduction and the lab work will provide platform to become familiar with various cell types through techniques of slide preparation.

Course Learning Objectives:

Understanding of microscopy to study cell structure and cellular compartmentalization will be provided to learners. Main emphasis of course is to develop familiarity with structure and function of cells at the molecular level, including the flow of information from genes to proteins, and regulation of cellular processes, signaling and proliferation in eukaryotic cells.

Course Contents:

1. Introduction to prokaryotic and eukaryotic cells: plasma membrane, its chemical composition structure and functions of plasma membranes, cell permeability, active transport, endocytosis, phagocytosis.
2. Cytoskeleton: microfilaments, microtubules, intermediate filaments.
3. Cytoplasmic Organelles: Membrane system, structural and functional commonalities.

4. Ultrastructure, chemical composition and functions of endoplasmic reticulum and their role in protein synthesis and drug metabolism, golgi apparatus its role in synthesis of glycoprotein,
5. Mitochondrial respiration and its significance as semi- autonomous organelle;
6. Lysosome, its diverse roles due to hydrolytic activity of enzymes, Peroxisome, its role in metabolism of hydrogen peroxide, glyoxysome with reference to glyoxylic acid cycle.
7. Nucleus: chromatin, heterochromatin, euchromatin, chromosome structure,coiling and nucleosome during different phases of cell cycle.
8. Replication: mechanism, DNA replication in prokaryotes specially withreference to variety of DNA polymerases and other proteins involved, DNA replication in eukaryotes with emphasis on DNA polymerases, concept of replicons etc.,
9. Transcription: variety of RNA and their characteristics, synthesis of mRNA, rRNA and tRNA with special reference to enzymes involved, RNA splicing, split genes, concept of ribozymes and Post transcriptional processing, RNA transduction, Genetic code, point mutations.
10. Translation: specific role of ribosomes, various factors, andposttranslational processing, control of gene expression in Prokaryotes.

Practical

1. Preparation of whole mount.
2. Preparation of human blood smear and identification of Leucocytes.
3. Tissues (permanent slides of epithelial tissues, striated muscle, smooth muscle, cartilage, bone).
4. Squash preparation of onion root tip for mitotic stages
5. Mounting of polytene chromosome (*Drosophila/Chironomous.*) Demonstration.
8. Cultural and staining of bacteria.

Recommended Texts:

1. Cooper, G. M., & Adams, K. (2022). *The cell: A molecular approach* (9th ed.). Massachusetts: Sinauer Associates.

2. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Martin, K. C., Yaffe, M., & Amon, A. (2021). *Molecular cell biology* (9th ed.). New York: W. H. Freeman.
3. Karp, G., Iwasa, J., & Marshall, W. (2020). *Karp's cell and molecular biology: concepts and experiments* (9th ed.). New Jersey: John Wiley and Sons.

Suggested Readings:

1. De-Robertis, E. D. (2014). *Cell and molecular biology* (8th ed.). New York: Lea & Febiger.
2. Alberts, B., Hopkin, H., Johnson, A., Morgan, D., Walter, P., & Heald, R. (2023). *Essential cell Biology* (6th ed.). New York: W. W. Norton & Company.
3. Hofmann, A., & Clokie, S. (2018). *Wilson and Walker's principles and techniques of Biochemistry and molecular biology* (8th ed.). Cambridge: Cambridge University Press.

Semester II

Course Code	ZOOL-6112	Course Title	Research Methodology	Credit Hours	2(2-0)
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Course Brief:

The course aims to develop research skills, provide understanding how to design scientific research, to collect data and its interpretation; emphasize the importance of ethics in scientific research and enable students to write a research proposal. It also introduces the data collection methods, data processing techniques, analysis options, writing review of literature, to deal with research problem and hypothesis development.

Course Learning Objectives:

The primary objective of this course is to develop a research orientation among the scholars and to acquaint them with fundamentals of research methods. Specifically, the course aims introducing them to the basic concepts used in research and to scientific social research methods and their approach. It includes discussions on sampling techniques, research designs and techniques of analysis by developing an understanding of the ethical dimensions of conducting applied research, identifying various sources of information for literature review and data collection and appreciating the components of scholarly writing and evaluate its quality.

Course Contents:

1. Introduction: objectives of research, motivations
 2. Research process: research methods vs. research methodology, scientific method,
 3. Types of research, general steps involved in research, problems of research in Pakistan 4. Topic selection
 5. Problem identification for research, criteria and evaluation
 6. Literature review: importance and sources, referencing and citation and bibliography, plagiarism
 7. Research design: parts, important concepts in research design
 8. Aims and objectives: Research objectives, qualities of research objectives
 9. Material and methods: bioethics, sampling, data collection and data analysis, sampling requirement, scales of measurement, error of measurement and its sources
 10. Data analysis: processing, statistics in research, hypothesis testing, t-tests and ANOVA
 11. Scientific writing: difference between thesis/report/synopsis/research proposal, parts of synopsis/project proposal, parts of thesis/report.
 12. Budgeting: Cost estimates for a research project, funding sources e.g. USAID, HEC, DOST, HED, PMRC, WWF, PSF etc. **Recommended Texts:**
1. Leedy, P.D., & Ormrod, J.E. (2018). *Practical research: planning and design* (12thed.). New York: Pearson.
 2. Creswell, J.W., & Creswell, J.D. (2022). *Research design quantitative qualitative and mixed methods approaches* (6thed.). California: SAGE Publications

Suggested Readings:

1. Khan, J. A. (2008). *Research methodology*. New Delhi: APH Publishing.

2. Walliman, N. (2005). *Your research project, a step by step guide for the first-time researcher* (2nded.). California: SAGE Publications.
3. Hess-Biber, S.N., & Leavy, P. (2003). *Approaches to qualitative research, a reader on theory and practice*. (1st ed.) New York: Oxford University Press.
4. Laurel, B. (2003). *Design research, methods and perspectives*. Cambridge: The MIT Press.

Course Code	ZOOL-6113	Course Title	Genetics	Credit Hours	4(3-1)
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Course Brief:

This course aims to provide understanding of basic concepts of genetics, providing a conceptual framework for future reference. It provides understanding about the continuity of the life from one generation to other generation is based on the mechanisms involving nucleus, chromosomes and genes. The course develops the concept that continuity not only transfers the traits of the parents but also imparts variations that render the generations sustainable in changing environment; understanding of probability concepts and using these concepts to solve problems.

Course Learning Objectives:

The main goals of this subject are to accurately diagram and describe the processes of replication, transcription, translation, as well as predict the outcomes of these processes, to identify and describe the process and purposes of the cell cycle, meiosis, and mitosis and to describe what causes and consequences of DNA sequence changes and how cells prevent these changes, as well as make predictions about the causes and effects of changes in DNA.

Course Contents:

1. Introduction: Forward and reverse genetics. The basic principles of inheritance (Mendelism): monohybrid and dihybrid crosses (definition - characteristics criss-cross inheritance),
2. Multiple alleles: blood groups and coat color in rabbits, genetics of Rh factor and erythroblastosis foetalis.
3. Chromosomal basis of inheritance: chromosomal theory of inheritance, interaction of genes, epistasis, lethality and pleiotropism.
4. Chromosomal aberrations: changes in chromosomal number, euploidy, aneuploidy (Klinefelters syndrome, and turners syndrome, down syndrome and Edwards syndrome), structural changes, insertion, deletion (Cri du chat syndrome), duplication, inversion and translocation
5. Pedigree Analysis: Normal human chromosome complement; karyotyping, sex-determination and sex-linkage, sex determination in animals and humans, sex linked (hemophilia, muscular dystrophy, color blindness), sex influenced and sex limited traits,
6. Prenatal diagnosis: amniocentesis and choriovillus sampling - ultrasound scanning and fetoscopy. genetic counselling, Eugenics and Euthenics
7. Chromosome mapping: linkage, recombination (crossing over), chromosome mapping in eukaryotes.
8. Molecular genetics: gene concept (classical and modern), genetics of viruses and bacteria, transposons, mutation and DNA repair molecular genetic analysis,
9. Regulation of gene expression in prokaryotes: gene regulation in eukaryotes, genetic basis of diseases, like cancer,
10. Genetic control of animal development, the genetic control of the vertebrate immune system
11. Recombinant technology: the techniques of molecular genetics (elements of genetic engineering), PCR
12. Human genetics: single and multifactorial disorders, autosomal anomalies, pseudoautosomal genes, single gene disorders: gene mutation and disorders;

13. Autosomal single gene disorders (sickle cell anemia, brachydactyly; inborn errors of metabolism such as phenylketonuria, alkaptonuria), complex inheritance patterns, polygenic traits- cleft lip and cleft palate, population genetics,
14. Hardy-Wienberg equilibrium, systematic and dispersive pressures, inbreeding and heterosis
Practical

1. Identification of male and female fruit fly and isolation
2. Study of polytene chromosomes from the salivary glands of *Drosophila melanogaster*
3. Human karyotyping from photographs prepared slides: paper cut out method
4. Study of mitosis in plants by using onion root tip cells
5. Study of meiosis in the testes of male grasshopper
6. Study of blood group polymorphisms in local population
7. Study of qualitative traits in humans: a survey of common physical heritable (monogenic) polymorphisms
8. Human Pedigree analysis problems (Determination of inheritance pattern of different human characters (Widows Peak, ear loop, etc.), risk estimation and genetic counseling
9. Study of quantitative traits in humans: finger prints as model of polygenic traits
10. Probability problems. Tossing of coins. χ^2 test

Recommended Texts:

1. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A., & Killian, D. (2021). *Concepts of genetics* (12thed.). New Jersey: Pearson.
2. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2018). *Lewin's Gene-XII* (12th ed.). Massachusetts: Jones & Bartlett Learning.
3. Benjamin A. Pierce (2020). *Genetics: A conceptual Approach* (7th ed.). Macmillan International Higher education.

Suggested Readings:

1. Snustad, D. P., Simmons, M. J., & Gardner, E. J. (2003). *Principles of genetics* (8thed.). New York: John Wiley and Sons Ltd.
2. Tamarin, R. H. (2001). *Principles of genetics* (7thed.). New York: McGraw-Hill.
3. Van Hoeck, Kathy (2023). *Genetics: Laboratory and Classroom activities*. (2001 edition). Plinn Scientific.

Course Code	BOTN-5102	Course Title	Plant Systematics, Anatomy and Development/Embryology	Credit Hours	4(3+1)
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Course Brief:

Plant systematics is a science that includes and encompasses traditional taxonomy; however, its primary goal is to reconstruct the evolutionary history of plant life. It divides plants into taxonomic groups, using morphological, anatomical, embryological, chromosomal and chemical data. However, the science differs from straight taxonomy in that it expects the plants to evolve, and documents that evolution. Determining phylogeny -the evolutionary history of a particular group; is the primary goal of systematics.

Course Learning Objectives:

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

Course Contents:

Plant Systematic

1. Introduction to Plant Systematic: aims, objectives and importance.
2. Classification: Brief history of various systems of classification with emphasis on Takhtajan.
3. Brief introduction to nomenclature, importance of Latin names and binomial system with an introduction to ICBN/ ICN for plants.
4. Morphology: A detailed account of various morphological characters root, stem, leaf, inflorescence, flower, placentation and fruit types.
5. Diagnostic characters, economic importance and distribution pattern of the following families:
Ranunculaceae, Brassicaceae (Cruciferae), Fabaceae (Leguminosae), Rosaceae
Euphorbiaceae, Cucurbitaceae, Lamiaceae (Labiatae), Apiaceae
(Umbelliferae), Asteraceae (Compositae), Liliaceae (Sen. Lato)

Anatomy

6. Cell wall: structure and chemical composition
7. Concept, structure and function of various tissues like: Parenchyma, Collenchyma, Sclerenchyma, Xylem, Phloem, Epidermis (including stomata and trichomes)
8. Meristem: types, stem and root apices
9. Vascular cambium
10. Structure and development of root, stem and leaf.
11. Primary and secondary growth of dicot stem, periderm
12. Characteristics of wood: diffuse porous and ring porous, sap and heart wood, soft and hard wood, annual rings.

Development/Embryology

13. Early development of plant body: *Capsella bursa-pastoris*
14. Structure and development of Anther (microsporogenesis, microgametophyte)

15. Structure and development of Ovule (megasporogenesis, megagametophyte)
16. Endosperm formation
17. Parthenocarpy
18. Polyembryony

Lab outline

Anatomy and Embryology

- a) Study of stomata and epidermis.
- b) Tissues of primary body of plant.
- c) Study of xylem 3-dimensional plane of wood.
- d) T. S of angiosperm stem and leaf.
- e) Anatomy of germinating seeds
- f) Study of pollens

Taxonomy

- g) Identification of families given in syllabus with the help of keys.
- h) Technical description of common flowering plants belonging to families mentioned in theory.
- i) Field trips shall be undertaken to study and collect local plants.
- j) Students shall submit 40 fully identified herbarium specimens.

Recommended Books:

1. Steeves, T.A. and V.K. Sawhney, *Essentials of developmental plant anatomy*. (Oxford University Press, 2017).
2. Spichiger, R. E. *Systematic Botany of flowering plants: a new phylogenetic approach of the angiosperms of the temperate and tropical regions*. (CRC Press, 2019).
3. Hickey, M. and C. King, *The Cambridge Illustrated Glossary of Botanical Terms*. (Cambridge University Press, 2015).
4. Lyons-Sobaski, R.C., W. Sheila and W. Robert. *Plant anatomy*. (Springer-Verlag. 2018).

Suggested Books:

1. Clive A., C.A. Stace and M. J. Crawley, *Alien Plants* (Harper Collins Publishers, 2015).
2. Hather, J.G., *Archaeological parenchyma*. (Routledge Publishers, 2016).

Course Code	ZOOL-6114	Course Title	Wildlife	Credit Hours	3(2-1)
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Course Brief:

The objective of this course is to enable the student to understand philosophy and significance of wildlife its conservation and management. Literature about geographical distribution, factors effecting distribution and status of different wildlife species will be discussed in this course. Rules and regulations, role of national and international agencies involved in conservation and management of wildlife will be familiarized. Students will be able to apply knowledge to solve problems related to wildlife conservation and management. They will learn about the conservation and management of threatened species (of amphibians, reptiles, birds and mammals).

Course Learning Objectives:

The major aim of the subject includes knowing what type of wildlife exist in Pakistan and what are the threats it is facing and how it can be secured in Pakistan? After this course students will become able to participate in conservation of wildlife. The practical section will cover the visit to protected areas of Pakistan (captive, semi-captive and wild areas). Knowledge about use of ecological indices and animal distribution maps will be provided.

Course Contents:

1. Wildlife of Pakistan: biodiversity and its categories, wildlife in context of its services, wildlife prior to the establishment of Pakistan,
2. Current status of wildlife, vegetative zones and its associated wildlife in Pakistan
3. Conservation and management of threatened amphibians, reptiles, birds and mammals of major importance in Pakistan
4. Major challenges faced during wildlife conservation
5. Threats to wildlife in Pakistan.
6. Wildlife rules and regulations in Pakistan
7. National and international agencies involved in conservation and management of wildlife in Pakistan, national organizations, international organizations
8. Protected Areas in Pakistan: sanctuaries, game reserves, national parks
9. Ramsar convention: wetlands, ramsar criteria, ramsar sites
10. Threatened species of Pakistan: vulnerable, endangered, critically endangered

Practical

1. Visit to protected areas of Pakistan (captive, semi-captive and wild areas)
2. Animal distribution maps

Recommended Texts:

1. Cardinale, B., Primack, R., Murdoch, J. (2019). *Conservation biology*. Sinauer Associates: Oxford University Press.
2. Miller, A. S., & Harley, J. B. (2018). *Zoology* (11th ed.). New York: McGraw Hill.

Suggested Readings:

1. Khan, M. S. (2011). *Amphibian and Reptiles of Pakistan*. Krieger Publishing Company.
2. Grimmett, R., Roberts, T. J., Inskipp, T., & Byers, C. (2008). *Birds of Pakistan*. A&C Black.
3. Roberts, T. J. (1997). *The mammals of Pakistan*. Oxford: Oxford University Press.

Course Code	ZOOL-6115	Course Title	Biotechnology	Credit Hours	3(2-1)
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Course Brief:

This course is designed to familiarize students with the basic concepts and significance of biotechnology. This course is designed to introduce learners with a solid understanding of science, technology and business management, along with the entrepreneurial skills required to exploit technological advances within a competitive environment.

Course Learning Objectives:

The goal of biotechnology is to produce pharmaceutical products by using living organisms such as bacterial cells, yeast, mammalian cells, etc., that are placed in culture to produce substances with pharmacological activity, such as monoclonal antibodies for the treatment of tumors. The main objectives of the subject are to teach, train and qualify skilled scientists in many disciplines of biotechnology and to provide an intensive and in-depth learning about technical and critical thinking skills necessary for success in the field of biotechnology. Upon completion of the course, the students will develop awareness and knowledge of different basic topics of biotechnology through lectures and practical classes.

Course Contents:

1. Introduction: definitions, classes, types of modern biotechnology and historical perspective,
2. Genetics and biotechnology: genome, human genome, diversity of human genome, short tandem repeats, nomenclature,
3. Polymerase Chain Reaction, principle, requirements, procedures and applications, gel electrophoresis, definition, principle, steps/methods involved, DNA ladder, allelic ladder
4. Genetic engineering introduction, steps, vectors and its types, characteristics of vectors, plasmids and restriction enzymes, screening, blue white screen, negative and positive control, competent cells, insulin as an example, genetically modified organisms,
5. Cloning, its types of cloning, cell cloning, molecular cloning, organism cloning, applications and uses
6. Animal and insect biotechnology: introduction, reasons for producing GM animals.
7. Bioprocess technology: introduction, requirements of bioreactors, types of bioreactors, bacterial and mammalian cell culturing, production of industrially important chemicals
8. Biotechnology and medicine: applications, monoclonal antibodies, importance, steps for production of monoclonal antibodies
9. Public perception of biotechnology: current issues in bioethics (autopsy, GMOs, stem cells, euthanasia, organ transplant, human cloning, IVF, surrogacy and sperm donor)
10. Bioethics and Islam: introduction and principles of bioethics, concept of bioethics in different religions, principles of Islamic bioethics.

Practical

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

Recommended Texts:

1. Clark, D. B., & Pazdernik, N. J. (2015). *Biotechnology* (2nd ed.). Amsterdam: Academic Cell.
2. Schmid, R. D., Schmidt-Dannert, C., & Hammelehle, R. (2016). *Biotechnology: an illustrated primer*. New York: Willey-Blackwell.

Suggested Readings:

1. Brown, T. A. (2016). *Gene cloning and DNA analysis: an introduction* (7th ed.). New York: Willey- Blackwell.
2. Butler, J. M. (2009). *Fundamentals of forensic DNA typing*. Amsterdam, Boston: Academic Press.
3. Furr, A. K. (2008). *CRC handbook of laboratory safety* (5th ed.). Florida: CRC Press.
4. Smith, J. E. (2009). *Biotechnology* (5th ed.). Cambridge: Cambridge University Press.

Course Code	ZOOL-6116	Course Title	Field experience / internship	Credit Hours	3(3-0)
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Course Code	ZOOL-5103	Course Title	Animal Diversity-II (Chordates)	Credit Hours	4(3-1)
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Course Brief:

This course will enable students to understand the taxonomic characteristics of protochordates and chordates. It provides knowledge about the phylogenetic relationships of protochordates and various classes of chordates. Students will understand the phylogenetic relations, physiological adaptations, behavior and diversity of Pisces, amphibians, reptiles and mammals and able to analyze the process of micro evolution within chordates. After this course the students will understand what the chordates are, can recognize different categories of chordates, understands the level of organization in chordate subphylum, can comprehend the general characters of chordates and know about the origin and evolutionary relationship in different subphylum of chordates.

Course Learning Objectives:

Upon successful completion of this subject students will be able to describe unique characters of urochordates, cephalochordates and fishes, can recognize difference in life functions of urochordates and fishes, will understand the ecological role of different groups of chordates and understand the diversity of chordates. Identification of the morphological and anatomical structure for the major groups of vertebrates from an evolutionary point of view will be discussed.

Course Contents:

Protochordates: classification of protochordates. Structure, anatomy and organ systems of acorn worms, urochordates and cephalochordates, reproduction; life histories and metamorphosis of protochordates. phylogenetic relationships.

1. Fishes: vertebrate success in water. Phylogenetic relationships of Pisces. Classification of Chondrichthyes, Osteichthyes, Dipnoi and Holocephali. Locomotor adaptations, nutrition and the digestive system, circulation, gas exchange, nervous and sensory functions, excretion and osmoregulation, reproduction and

development of Chondrichthyes (Scoliodon) and Osteichthyes (Cyprinus carpio and Wallago attu).

2. Amphibians: The first terrestrial vertebrates. Characteristics of amphibians. Phylogenetic relationships. Classification of amphibians and characteristics of order Caudata, Gymnophiona, and Anura. Structure and locomotor adaptations, nutrition and the digestive system, circulation, gas exchange, temperature regulation, nervous and sensory functions, excretion and Osmoregulation, reproduction, development, and metamorphosis of caudate, anura and Gymnophiona.
3. Reptiles: The First Amniotes and cladistic interpretation of the amniotic lineage. General characteristics of reptiles. Characteristics of Order Testudines or Chelonia, Rhynchocephalia, Squamata, and Crocodilia. Adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction and development of chelonia, squamata, Rhynchocephalia and crocodilian. Further phylogenetic considerations
4. Birds: Classification, feathers, flight and endothermy. Phylogenetic relationships; ancient birds and the evolution of flight. Diversity of modern birds. Adaptation in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and regulation, nervous and sensory systems, excretion and osmoregulation, reproduction and development. Migration and navigation.
5. Mammals: Classification, Specialized teeth, endothermy, hair and viviparity. Diversity of mammals. Adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, behavior, reproduction and development.

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.

Recommended Texts:

1. Miller, A. S., & Harley, J. P. (2016 & 2019). *Zoology* (10 & 11 ed.). Singapore: McGraw Hill.
2. Hickman, C. P., Roberts, L. S., Keen, S. L., Larson, A., l'Anson, H & Eisenhour., D. J. (2009). *Integrated principles of zoology* (14 ed.). Singapore: McGraw-Hill.
3. Hickman, C., Jr., Keen, S., Eisenhour, D., Larson, A. & l'Anson, H., (2019). *Integrated principles of zoology* (18 ed.). Singapore: McGraw-Hill.

Suggested Readings:

- h 1. Hickman, C. P., Roberts, L. S., & Larson, A. (2018). *Integrated principles of zoology* (15 ed.). Singapore: McGraw-Hill.
2. Hickman, C., Jr., Keen, S., Eisenhour, D., Larson, A. & l'Anson, H., (2019). *Integrated principles of th zoology* (18ed.). Singapore: McGraw-Hill.
3. Peckenik, J. A. (2015). *Biology of Invertebrates*. 7 Ed Singapore: McGraw-Hill.

Course Code	ZOOL-5108	Course Title	Fisheries	Credit Hours	3(2-1)
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Course Brief:

This course focuses on disseminating the history, needs and importance of fisheries and aquaculture. Moreover, it elaborates the basic components of pond fish culture and improves knowledge about local fish species, including culturable fishes, and their biology. It also imparts knowledge regarding fish gears and post-harvest techniques.

Course Learning Objectives:

Declining fish populations, marine pollution and destruction of important coastal ecosystems has introduced increasing uncertainty in important fisheries worldwide, threatening economic security and food security in many parts of the world. These challenges are further complicated by the changes in the ocean caused by climate change, which may extend the range of some fisheries while dramatically reducing the sustainability of other fisheries.

Course Contents:

1. Introduction to fisheries and aquaculture, national and international trends
2. Fish morphology and diversity in size and shape
3. Distribution of fishes in Pakistan, commercial fishes, marine and freshwater
4. Fish diseases: viral, bacterial, fungal and parasitic
5. Fish habitat, ecology and extant of distribution, water quality parameters (abiotic: temperature, light, salinity, pH, turbidity, etc.) and their effects on fish health and production
6. Biotic parameters (plankton, insects, aquatic vegetation etc.) of ponds, lakes, rivers and impacts on fish growth.
7. Induced breeding
8. Fish enemies and their control: insects, fishes, amphibians, reptiles, birds and mammals
9. Fishing gears, fishing techniques, fishing communities

10. Fish preservation, processing transportation and marketing

Practical

1. Morphological characters of a typical fish
2. Species identification, fin formula, key to identification of commercial fishes
3. Dissection of common fish to study its various systems
4. Visit to a fish hatchery
5. Introduction to artificial feed ingredient

Recommended Texts:

1. Sharma, O.P. (2009). *Handbook of Fisheries and Aquaculture*. Agrotech Publishing Academy, Udaipur, New Delhi, India.
2. Stickney, R.R. (2009). *Aquaculture: An Introductory Text*. CABI Publishing, London, UK.

Suggested Readings:

1. Pillay, T.V.R., & Kutty, M.N. (2005). *Aquaculture: Principles and Practices*. Blackwell Science Limited. New York.
2. Ali, S.S. (1999). *An Introduction to Freshwater Fishery Biology*. University Grants Commission, H-9 Islamabad

Semester III

Course Code	ZOOL-6117	Course Title	Biostatistics	Credit Hours	3(3-0)
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Course Brief:

The course aims to provide knowledge about the importance and use of statistics in life sciences and familiarize students with the methods of data analysis pertaining to their research work and to assess the significance of their experimental designs. Specific topics include tools for describing central tendency and variability in data; methods for performing inference on population means and proportions. After finishing this course, students will be able to recognize the importance of data collection and its role in determining scope of inference, can demonstrate a solid understanding of interval estimation and hypothesis testing.

Course Learning Objectives:

Apply appropriate statistical methods for analyzing one or two variables and can interpret statistical results correctly, effectively, and in context. More specifically, by the end of the course they will be able to identify cases and variables in a dataset, and classify variables as categorical or quantitative and to recognize when it is, and is not, appropriate to use sample data to infer information about a population.

Course Contents:

1. Introduction: Definition, branches of statistics, scope and importance of statistics
2. Data: Population and sample, variable, categorical and non-categorical data, Scales of measurements, Errors of measurements
3. Presentation of data: descriptive statistics , tabulation of data , parts of table and construction of table, diagrams and graphs, pictogram, histogram, line chart, histogram, applications and uses of histogram, construction of histogram, comparison of data using histogram, bar chart, multiple bar chart, pie chart, gantt chart, timeline, infograph, pedigree chart
4. Frequency distribution: empirical FD, relative FD, cumulative FD, class frequency, class limits, class boundaries, class mark, class interval, midpoints
5. Measures of central tendency : 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, advantages and disadvantages of arithmetic mean, harmonic mean, geometric mean, median and mode.
6. Measures of dispersion: range, grouped and ungrouped data, coefficient of range, mean deviation of grouped and ungrouped data, coefficient of mean deviation, standard deviation and variance of grouped and ungrouped data, variance and standard deviation of population and sample data
7. Probability: definition and properties, experiment and random experiment, event, outcome, trial and multiplication rule, sample space and sample point, mutually exclusive event, combinations and permutations, probability distribution, binomial experiment
8. Tests of significance: hypothesis testing, steps of hypothesis testing, Z-test, t-test; its types, Chi-square, ANOVA, its uses and LSD, Correlation, Regression,

Recommended Texts:

1. Field, A. (2017). *Discovering statistics with IBM SPSS statistics*(5thed.). New York: SAGE Publications Ltd.
2. Belle, G. V., Fisher, L. D., Heagerty, P. J., & Lumley, T. (2004). *Biostatistics – A methodology for the health sciences* (2nded.).John Wiley & Sons, Inc.

Suggested Readings:

1. Campbell, M. J., & Swinscow, T. D. V. (2021). *Statistics at square one*(12thed.). WileyBlackwell.
2. Quinn, G. P., & Keough, M. J. (2002). *Experimental design and data analysis for biologists*.

Course Code	ZOOL-6118	Course Title	Bioinformatics	Credit Hours	3(2-1)
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Course Brief:

The course will provide an introduction to bioinformatics with a focus on fundamental bioinformatics problems and information on the tools used to compute solutions to those problems, and the theory upon which those tools are based. This involves algorithm, and storage/database development of genomics data. It also describes the different types of data found at the NCBI and EBI resources. This course has three main objectives i.e. to organize vast reams of molecular biology data in an efficient manner; to develop tools that aid in the analysis of such data; and to interpret the results accurately and meaningfully.

Course Learning Objectives:

The advent and rapid rise of bioinformatics has been due to the massive increases in computing power and laboratory technology in recent years. These advances have made it possible to process and analyze the digital information regarding DNA, genes and genomes. A student completing Bioinformatics course shall be able to apply it for problem-solving skills, including the ability to develop new algorithms and analysis methods.

Course Contents:

1. Introduction: Introduction to computers, software, hardware, operating systems
2. Bioinformatics: scope of bioinformatics, useful websites, aims of bioinformatics, disciplines related to bioinformatics, major tasks involved in bioinformatics analysis, bioinformatics tools
3. Biological databases: data and information, databases, data acquisition, NCBI, major DNA databases around the world, major protein databases in the world, primary protein sequence databases, secondary protein databases, tertiary protein databases, protein structure databases, specialized databases, genome and organism databases, miscellaneous databases
4. Genome mapping: genetic and linkage mapping, physical mapping
5. Gene family: introduction and types, protein family, globin family as an example, globin genes and chains, evolution of globin proteins in human, combination and types of globin proteins in human
6. Data retrieval: Searching sequence databases, FASTA format, retrieval of nucleotide sequence data, retrieval of protein sequence and structure data, retrieval of literature and map data
7. Primer designing: primer and probe, qualities of primer, general rules for primer designing
8. Websites used for primer designing
9. Sequence alignment: importance and significance of alignment, methods for sequence alignment, Local and global alignment, pair-wise local alignment, uses of local alignment
10. BLAST: introduction and types, uses, algorithm, BLAST Score
11. Amino acid matrices: amino acids and their symbols, amino acid scoring matrices, PAM and BLOSUM, comparison of PAM and BLOSUM
12. Multiple sequence alignment: introduction, tools for MSA, uses and importance

13. Phylogenetic analysis: Introduction, interpretation, rooted and unrooted tree, phylogenetic methods, tree terminology, comparison of methods, software
14. Protein structure prediction: homology modelling, threading, *ab initio* modelling, motivation to acquire structure, protein 3D structure, software/databases
15. Molecular docking: introduction, steps, importance and uses
16. Microarrays: Gene expression, differential expression, DNA chips, principle of microarray, types, steps of a microarray experiment, qualitative interpretation of results, applications of microarray, advantages and disadvantages of microarray.

Practical

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

Recommended Texts:

1. Selzer, P. M., Marhofer, R. J., & Kock, O. (2018). *Applied bioinformatics: an introduction*. Berlin: Springer Publishing.
2. Lesk, A. (2019). *Introduction to bioinformatics* (5th ed.). Oxford: Oxford University Press.

Suggested Readings:

1. Rastogi, S. C., Mendiratta, N., & Rastogi, P. (2013). *Bioinformatics methods and applications: genomics, proteomics and drug discovery*. Dehli: PHI Publishing.
2. Primrose, S. B., & Twyman, R. M. (2004). *Genomics: applications in human biology*. New York: Willey-Blackwell.
3. Krane, D. E., & Raymer, M. L. (2002). *Fundamental concepts of bioinformatics*. New Jersey: Benjamin Cummings.

Course Code	ZOOL-6119	Course Title	Principles and Kinetics of Toxicology	Credit Hours	3(2-1)
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Course Brief:

The course objectives are to provide knowledge about the nature and mode of action of different categories of toxicants and to provide knowledge about the procedural protocols used in toxicological studies. The major contents of the course include measuring toxicity and assessing risk, chemistry of toxicants; toxicity testing methods; routes of exposure, responses to varying doses of substances and LD50 experiments. Toxicokinetics aims to empower the students with the understanding of absorption and bioavailability and contrasting kinetics of lipophilic substances, routes of absorption (the oral, respiratory and dermal) and elimination. In addition, students will learn about biotransformation (phase I reaction and phase II reaction), cellular sites of action, effect of toxicants on enzymes and mechanism of cell death (apoptosis, necrosis, stress, repair) and recovery.

Course Learning Objectives:

The aim of this subject is to train high-quality scientists in applied toxicology with a heightened respect for the environment. Students will develop a broad range of skills, knowledge and experience required for successful careers.

Course Contents:

1. Introduction, Chemistry of toxicants; routes of exposure, responses to varying doses of substances, time of exposure; the LD50 experiments,
2. Toxicokinetics: Introduction; pharmacokinetics and toxicokinetics,
3. Absorption: the oral, respiratory and dermal route of exposure, distribution, Elimination, toxicokinetic models: mathematical models of elimination, Absorption and bioavailability; contrasting kinetics of lipophilic substances.
4. Biotransformation: Introduction, Primary biotransformation (phase I reaction)
5. Secondary metabolism (phase II reaction).
6. Cellular sites of action, introduction, interaction of toxicants with proteins,
7. Effect of toxicants on enzymes, receptors and ion channels,
8. Effects of toxicants on lipids and nucleic acids,
9. Mechanism of cell death; apoptosis, necrosis, stress, repair and recovery.

Practical

1. Study the effects of different toxicants on the rat systems.
2. Study the effect of toxicants on chick with different doses.

Recommended Texts:

1. Stine, K. E., & Brown, T. M. (2015). *Principles of toxicology*. London: CRC press, Taylor and Francis Group.
2. Marquardt, H., Schafer, S. G., Mcclellan, R. O., & Welsch, F. (2004). *Toxicology*. San Diego: Academic press.
3. Barile, F. A. (2013). *Principles of toxicology testing*. London: CRC Press, Taylor and Francis Group.

Suggested Readings:

Klaassen, C.D. (2013). *Casarett and Doull's Toxicology: The Basic Science of Poisons* (8th ed.). McGraw-Hill Professional Hub.

Course Code	ZOOL-6120	Course Title	Ecology	Credit Hours	3(2-1)
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Course Brief:

This course will enable students to understand about habitat, ecology, ecosystems and environmental threats. Students will learn about the rehabilitation of destroyed ecosystems. They will also be capable to learn methods to protect and safe environment. The students will be literate about the biogeochemical cycles, applied ecology, population ecology, community ecology and global ecosystems. Upon successful completion of the course students will develop an appreciation of the modern scope of scientific inquiry in the field of Ecology, become familiar with the variety of ways that organisms interact with both the physical and the biological environment and develop an understanding of the differences in the structure and function of different types of ecosystems.

Course Learning Objectives:

Moreover, this subject imparts knowledge to compare the relationships among organisms, including predation, parasitism, competition, commensalism, and mutualism. The students will also able to explain the general distribution of life in aquatic systems as a function of chemistry, geography, light, depth, salinity, and temperature.

Course Contents:

1. Energy: Basic concepts of and types of ecology, laws of thermodynamics, primary and secondary productions, trophic levels and energy variation with increasing trophic levels, energy flow, food chains and food webs.
2. Biogeochemical cycle: nitrogen, phosphorus, sulphur, water, carbon and nutrient.
3. Limiting factors: basic concepts, temperature, soil, water, humidity, light and fire.
4. Global ecosystems: atmosphere, hydrosphere, lithosphere and ecosphere, an overview of ecosystem with special reference to ecological niche, basic concepts and types, major ecosystem of world, forest, grassland, desert, tundra and agricultural ecosystems. marine, estuarine, freshwater and wetlands
5. Population ecology: basic population characters, growth and growth curves. population dynamics and regulations.
6. Community ecology: basic concepts, community analysis, ecotones, inter-population interactions
7. Applied Ecology: Resources and their ecological management; mineral, agricultural desalination, weather modification, forest and range management, landscape and land use
8. Pollution: definition, types, water, air, land and noise, sources and management.
9. Radiation ecology: global environmental changes (ozone depletion, acid rain, greenhouse effect and global warming, koyota protocol, radioactivity leakage, environmental laws).
10. Exotic and Invasive Species: desertification, deforestation, exotic and invasive species

Practical

1. Population Sampling Techniques (quadrant, line transect, point count, focal scan and capture and recapture method).
2. Study of different Ecosystems (fresh water, terrestrial, marine/mountain/ desert).
3. Ecological notes.
4. Measurements of physical factors of different ecosystems.
5. Adaptive features of animals in relation to food and environment.
6. Food chain studies through analysis of gut contents.
7. Analysis of polluted and fresh water for biotic and abiotic variations.
8. Field visits for study of selected terrestrial habitat and writing notes.
9. Experimental design and approaches in ecological research; writing a research project
10. Development of an ecological management plan of some selected area

Recommended Texts:

1. Molles, M. C. (2005). *Ecology: concepts and applications* (6thed.). New York: McGraw Hill.
2. Cox, C. B., & Morre, D. (2000). *Biogeography: an ecological and evolutionary approach* (6thed.). London: Life Sciences King's College.
3. Morrison, M.L., Brennan, L.A., Marcot, B.G., Block, W.M., & McKelvey, K.S. (2020). *Foundations for advancing animal ecology (wildlife management and conservation)*. Maryland: John Hopkins University Press.

Suggested Readings:

1. 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: Oxford Univ. Press.
2. Chapman, J. L., & Reiss, M. J. (1997). *Ecology: principles and applications*. Cambridge: Cambridge University Press.
3. Odum. E. P. (2005). *Fundamentals of ecology* (5th ed.) Philadelphia: W.B. Saunders

Course Code	URCG-5111	Course Title	Translation of Holy Quran-IV	Credit Hours	1(0-1)
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Course Brief:

- To familiarize the students with commandments of trade and inheritance mentioned in the Quranic text (with the help of Urdu translation).
- Students
- To introduce the students to scientific facts and miracles of the Holy Quran and Quranic stress on deep study of Allah's explored universe.

Course Learning Objectives:

- To motivate the students for reading and exploring the last Holy Book revealed by Almighty Allah.
- Through memorization students will develop their relation with last revelation.

Course Contents:

Course Contents:	<p>تجارت اور وراثت: 0</p> <p>مال کی تقسیم</p> <p>نادان کا مال</p> <p>عوام الناس کا مال</p> <p>عورتوں کا مال</p> <p>یتیموں کا مال</p> <p>کفار کا مال</p> <p>جائز مال</p> <p>معابدے</p> <p>قرض</p> <p>سانسی حقائق: 0</p> <p>تخلی ق</p> <p>کائنات</p> <p>اجرا</p> <p>م فلکی</p> <p>شجر و حجر</p> <p>زمین و آسمان کے اسرار</p> <p>بوائی اور طوفان</p> <p>بہائم اور مویشی</p> <p>حشرات الارض</p> <p>پہاڑ اور سمندر</p>
Grammar :	<p>قرآنی عربی گرامر کے اصول اور ان کے اطلاقات (متن قرآنی پر اطلاق سے توضیحات)</p>

	الكهف (٧٤، ٢١٧، ١٥، ٨٣، ٤٥، ١٧، ٤٥)
	الجنائز (٤)
	فاطر (١٨، ٨٧، ٣٧)
	العنكبوت (١٨، ٣٢، ٧٥)
	الروم (١٤)
	السراء (١١، ٢٢)
	الرعء (٨)
	السبا (١٧، ٣، ٨٨)
	يونس (٢٢، ٧١٧، ٥٨، ٥٨، ٤، ٨٨)
	يوسف (٥٢، ٥٧) الفرقان (٨٢، ٣٤)
	لقمان (٢٨، ٢٧)
	طه (٥٧٧، ٣٤)
	النحل (٤١، ٧٧، ٧٢، ٢٥، ٢١، ٢٢، ٢٢، ٢٢، ٢، ٢)
	النمل (٥٢، ٥٢، ٢٢، ١٢، ٨٢، ٢٧، ١٧، ٢٧)
	النسجده (١٨) الحديد (٢) هود (٣٥، ٢)
	يسين (١٣، ٧٥)
	الروم (٢٣، ٢٣، ١٤، ٢٧، ٥٨، ٢٥)
	فصلت (٢٣، ٢٣)
	الحج (٧٢، ٤٢، ٨٨، ٣١)
	الحجر (٢٧، ٨٨)
	الانبيا (٧٣، ١٣، ١٥)
	الزاريات (١٥) الزلزله (٧)
	القصص (٢١، ٢١، ١٢، ٧٢، ٨٢)
	النور (١٣، ٨٨، ٨٨، ١٥، ٤٥، ٣٥)
	الجمعه (٧٧، ٨٢، ١٧، ٧٧، ٤) القمر (١)
	الواقعه (٢٢)
	الفاطر (١٨، ٣٧)
	الملك (٢٧)
	الصف (١٧)
	الجن (٣٧) الشور
	ى (٢٨)
	الزخرف (٧٧)
	الفيل (٧)

Course Code	ZOOL-6121	Course Title	Capstone Project	Credit Hours	3(3+0)
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Course Code	ZOOL-5102	Course Title	Animal Form and Function-I (A Comparative Perspective)	Credit Hours	4(3-1)
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Course Brief:

This course teaches about animal diversity adapted strategically for performance of their similar functions through modifications in body parts in past and present times. It imparts understanding of diverse structural adaptations in each of the functions of integumentary, skeletal, muscular, nervous, sensory, endocrine, circulatory and respiratory systems for effective survival in their specific conditions.

Course Learning Objectives:

The course mainly aims to teach the students about animal diversity adapted in different ways for their functions through modifications in body parts, about the diversity in integumentary, skeletal, muscular, nervous and sensory, endocrine, circulatory, respiratory, nutritive, excretory, osmoregulatory and reproductive systems according to strategies to survive in their specific conditions. It will also introduce about organ systems, their specialization and coordination with each other and constantly changing internal and external environment, inside and outside the animal's body along with the basic structure of each system that determines its particular function of animal body.

Course Contents:

1. Protection, support, and movement: protection: the integumentary system of invertebrates and vertebrates; movement and support: the skeletal system of invertebrates and vertebrates; movement: non-muscular movement; an introduction to animal muscles; the muscular system of invertebrates and vertebrates
2. Communication I: nerves: neurons: structure and function.
3. Communication II: senses: sensory reception: baroreceptors, chemoreceptors, georeceptors, hygrometers, phonoreceptors, photoreceptors, proprioceptors, tactile receptors, and thermoreceptors of invertebrates lateral line system and electrical sensing, lateral-line system and mechanoreception, hearing and equilibrium in air and water, skin sensors of mechanical stimuli, sonar, smell, taste and vision in vertebrates.

4. Communication III: The Endocrine System and Chemical Messengers: Chemical messengers: hormones chemistry; and their feedback systems; mechanisms of hormone action, Hormones with principal function each of porifera, cnidarians, platyhelminthes, nemertean, nematodes, molluscs, annelids, arthropods, and echinoderms invertebrates; an overview of the vertebrate endocrine system; endocrine systems of vertebrates, endocrine systems of birds and mammals
5. Circulation and immunity: internal transport and circulatory systems in invertebrates characteristics of invertebrate coelomic fluid, hemolymph, and blood cells, transport systems in vertebrates; characteristics of vertebrate blood, blood cells and vessels; the hearts and circulatory systems of bony fishes, amphibians, reptiles, birds and mammals; the human heart: blood pressure and the lymphatic system; immunity: nonspecific defenses, the immune response.

Practical:

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 (*Hoplobatrachustigerinus*), Varanus (*Varanus bengalensis*), fowl (*Gallus domesticus*) and rabbit (*Oryctolagus cuniculus*).

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

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

Recommended Texts:

1. Miller, A. S., & Harley, J. P. (2016 & 2019). *Zoology* (10th & 11th ed). Singapore: McGraw Hill
2. Hickman, C. P., Roberts, L. S., Keen, S. L., Larson, A., l'Anson, H & Eisenhour., D. J. (2009).

Integrated principles of zoology (11 ed.). Singapore: McGrawHill.

Suggested Readings:

1. Hickman, C., Jr., Keen, S., Eisenhour, D., Larson, A., l'Anson, H., (2019). *Integrated principles of th zoology* (18 ed.). Singapore: McGraw-Hill.

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2. Pechenik, J. A. (2015). *Biology of invertebrates* (7 ed.). Singapore: McGraw-Hill

3. Kent, G. C., & Miller, S. (2001). *Comparative anatomy of vertebrates*. New York: McGraw-Hill.

Course Code	ZOOL-5107	Course Title	Biochemistry	Credit Hours	4(3-1)
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Course Brief:

The course aims to provide in-depth knowledge about the polymerized organic compounds of life. It will develop an understanding about the dynamism in life as it proceeds with inter-conversion of the chemicals from feeding to the liberation of energy for work. It enables students to know how organisms harvest energy for growth and duplication. This course will help students to understand the principles of bioenergetics and the dietary requirements of man and animals. It will also provide knowledge of metabolism of dietary and endogenous carbohydrate, lipid, and protein as well as the principles and major mechanisms of metabolic control and molecular signaling by hormones

Course Learning Objectives:

This course help students with a basic understanding of the principles of bioenergetics and enzyme catalysis, understand the chemical nature of biological macromolecules, their three- dimensional construction, and the principles of molecular recognition and demonstrates understanding of the molecular machinery of living cells in the students.

Course Contents:

1. Amino acids, peptides and proteins: Standard amino acids, their structure and classification; acid/base properties of amino acids and their titration curves; peptides, their ionic behavior and amino acid composition, Cytochrome C; Proteins: level of structural organization, example of structural and functional proteins.
2. Enzymes: Introduction; important characteristics of enzymes; immobilized enzymes; How enzymes work; example of enzymatic reaction; enzyme kinetics, enzyme rate of reaction and substrate concentration, how pH and temperature effect on enzyme activity.
3. Classification, types, important characteristics and structure of carbohydrates; cyclic structure of monosaccharides; cyanohydrin formation; disaccharides their types structure and function;

4. Polysaccharides, storage and structural types; structure and major functions of polysaccharides.
5. Lipids: Fatty acids, their types and major characteristics; storage lipids, acylglycerols; waxes;
6. Structural lipids in membranes; Major functions of lipids; lipoproteins, their types and major functions.
7. Vitamins and cofactors: Occurrence, structure and biochemical function of vitamins B complex group.
8. Metabolism: Detailed description of glycolysis and catabolism of other hexoses; regulation and bioenergetics of glycolysis. Anabolic role of glycolysis; fate of pyruvate under aerobic and anaerobic conditions, lactate, acetyl CoA and ethanol formation; alcoholic fermentation; gluconeogenesis, its regulation and significance in the tissues; feeder pathways in glycolysis; utilization of other carbohydrates in glycolysis phosphorolysis and starch; regulation of glycogen metabolism.
9. Citric acid (TCA) cycle: conversion of pyruvate to acetyl CoA, pyruvate dehydrogenase, a multi-enzyme complex; detailed description of citric acid cycle; bioenergetics and conservation of energy produced in the cycle. Anabolic or biosynthetic role of citric acid cycle intermediates; replenishing or anaplerotic reactions and their role; regulation of citric acid cycle; Electron transport and its components, oxidative phosphorylation, chemiosmotic theory, ATP synthesis, uncouple electron transport and heat generation.
10. Lipid metabolism: oxidation of fatty acids; digestion, mobilization and transport of fats; biosynthesis of triacylglycerol; utilization of triacylglycerol; activation of fatty acids and their transportation to mitochondria; beta-oxidation; bioenergetics of beta-oxidation; oxidation of unsaturated and odd chain fatty acids; omega oxidation pathway; biosynthesis of saturated fatty acid, supply of raw material for palmitic acid synthesis; fatty acid synthetase (FAS) multienzyme complex
 1. Ketone bodies their biosynthesis, utilization and role in the tissues;
 2. Cholesterol metabolism: steroid hormones.

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

Practical

1. Preparation of standard curve for glucose by *ortho*-Toluidine method.
2. Tests for detection of carbohydrates in alkaline and acidic medium.
3. Tests for detection of Disaccharides.
4. Detection of Non-Reducing sugars in the presence of reducing sugars.
5. Demonstration of Acid Hydrolysis of Polysaccharide.
6. Separation and identification of various types of sugars, fatty acid and amino acid Thin Layer Chromatography (TLC).
7. Determination of pKa values of an amino acid by preparation of titration curves.
8. Biochemical tests for detection of different amino acids.
9. Separation of various protein fractions by precipitation method.
10. Demonstration of differential solubility of lipids in various solvents.
11. Quantitative analysis of phospholipids by estimation of inorganic phosphorous.
12. Quantitative analysis of Amylase activity from blood serum or liver.
13. Study on the effect of temperature on the enzymatic rate of reaction

Recommended Texts:

1. Bhagavan N. V. (2022). *Medical Biochemistry - E-Book*. Netherlands: Elsevier Health Sciences.
2. Nelson, D., L, Cox, M. (2021). *Lehninger Principles of Biochemistry*. WH Freeman: New York.
3. McKee J. R & McKee, T (2020). *Biochemistry: The Molecular Basis of Life*. United Kingdom: Oxford University Press.

Suggested Readings:

1. Alison, S., William, H. E & Daphne, C (2017). *Elliott Biochemistry and Molecular Biology*, (6thed). Oxford University Press.
2. Litwack, G. (2017). *Human Biochemistry*. Netherlands: Elsevier Science.
3. Papachristodoulou, D. K. (2014). *Biochemistry and Molecular Biology* (5thed.). Oxford University.

Semester IV

Course Code	ZOOL-6122	Course Title	Biological Techniques	Credit Hours	3(2+1)
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Course Brief:

Students will be able to identify the instrument and to use instrument for identification, measurement, fixation and cutting of tissue. It also enables students to apply a practical and research skill and to operate the lab equipment efficiently. Students will learn to collect and preserve the specimen in dry and wet form and develop expertise in preservation techniques like taxidermy, rearing techniques in laboratory and field.

Course Learning Objectives:

At the end of the course students will have some understanding of the basic generally applicable tools, techniques, methodologies and methods of analysis in biological research and become comfortable and proficient working in the lab, the field, and on the computer for those tools, techniques, etc. Moreover, learner will know how to acquire, learn about and implement a new tool or technique, how to order and store supplies and will learn what scientific lab integrity is all about.

Course Contents:

1. Microscopy: Principles of light microscopy. Magnification, resolution, types of microscopy (bright field, dark field, phase contrast), confocal microscopy, electron microscope: scanning electron microscope and transmission electron microscope (SEM and TEM).
2. Standard unit system for weight, length, volume and Different measurement systems (length; surface; weight, volume, temperature), calculations and related conversions , concentrations-percent volume; ppt; ppm - molarity, normality, molality , preparation of stock solutions of various strength
3. Micrometry: Use of stage and ocular micrometers, calibration of ocular micrometer and measurement of size animal and plant cell and nuclei.
4. Specimen preparation for optical microscopy: introduction to microtome and its types, tissue fixation, dehydration, clearing, embedding, section cutting (transverse, longitudinal section), tissue mounting (dry mount, wet mount), staining: hematoxylin and eosin staining.
5. Separation and purification techniques, cell fractionation, centrifugation and its types, filtration
6. Chromatography: principle, applications, types, paper chromatography and thin layer chromatography, column chromatography, high pressure liquid chromatography,
7. Electrophoresis: principle, applications and types (agarose and PAGE).
8. Spectrophotometry: principle, applications, types, visible/UV spectrophotometry
9. Basic principles of sampling and preservation: sampling from soil, water, air, plants and animals, preservation of dry and wet specimens, preservation techniques, lyophilization, preservation in ethanol, formalin etc.
10. DNA sequencing: Polymerase chain reaction (PCR), principle and application, DNA sequencing.

Practical

1. Preparation of slides (dry mount and wet mount)
2. Observation of wet mounts of human cheek cells
3. Measurement of cell size: bacterial and eukaryotic Cell
4. Recording of microscopic observations
5. Liquid handling: proper use of pipettes and micropipettes
6. Hematoxylin and eosin staining
7. Gram's staining
8. Handling of centrifuge machines
9. Collection of representative animals of various phyla

Recommended Texts:

1. Cheesbrough, M. (2005). *District laboratory practice in tropical countries (Part I)*(2nded.). Cambridge: Cambridge University Press.
2. Cheesbrough, M. (2009). *District laboratory practice in tropical countries (Part II)*. Cambridge: Cambridge University Press.
3. Kiran Singh, Manish Sharma, Vinay Oraon. (2018). *Concept of Laboratory techniques in Biology*. Brillion Publishing.
4. Riley Hunt. (2023). *Introduction to Biological Laboratory Techniques*.

Suggested Readings:

1. Gallagher, S. R., & Wiley E. A. (2008). *Current protocols essential laboratory Techniques*. New Jersey: John Wiley & Sons.
2. Jones, A., Reed, R., & Weyers, J. (1994). *Practical skills in biology*. Singapore: Longman Ltd.
3. Gallagher, S.R., & Wiley, E.A. (2012). *Current protocols Essential Laboratory Techniques*. Current Protocols, John Wiley & Sons.

Course Code	ZOOL-6123	Course Title	Animal Behavior	Credit Hours	3(3-0)
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Course Brief:

This course will give the baseline information about animal behavior and associate the likely role of external and internal stimuli on various animals during the day, season and year. It also relates daily behavioral rhythms in diurnal and nocturnal periodicities and predicts and anticipates variety of animal actions (costs and benefits) as assessed by innate and learned behavioral displays. The unifying theme of this course will be evolution by means of natural and sexual selection

Course Learning Objectives:

It includes the scientific study of the mechanistic and evolutionary causes of animal behavior, including communication, foraging and anti-predator behavior, spatial behavior, mating behavior, parental care, and social behaviors. After successful completion of this course, students should be capable of understand and identify behaviors in a variety of taxa, can competently discuss the evolutionary origins of various behaviors and can design and implementing experiments to test hypotheses relating to animal behavior.

Course Contents:

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

Recommended Texts:

1. Dugatkin, L. A. (2020). *Principles of animal behavior* (4th ed.). University of Chicago Press.
2. Rubenstein, D. (2022). *Animal Behavior* (12th ed.) Oxford University Press

Suggested Readings:

1. Rubenstein, D., & Alcock, J. (2019). *Animal behavior, an evolutionary approach* (11th ed.). New York, Oxford, Oxford University Press.

2. Goodenough, J., McGuire, B., & Wallace, R.A. (2009). *Perspective on animal behavior*. New York: John Wiley & Sons.
3. Scott, G. (2009). *Essential Animal Behavior*. Wiley-Blackwell publishers

Course Code	ZOOL-6124	Course Title	Zoogeography and Paleontology	Credit Hours	4(3-1)
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Course Brief:

The objectives of the course are to provide information on the distribution of animals and their associations in the past and to rationalize their relationship in the present time; to impart knowledge and concepts of evolution mainly on the basis of fossil record and give understanding that fossil records also provide information about the distribution of animals in the past eras. After completion of this course students will be able to reconstruct the biological traits of extinct organisms, can interpret the modes of life of fossil organisms.

Course Learning Objectives:

The students will learn about Paleogeography focusing on theories of continental drift and plate tectonics, zoogeographical regions mainly faunas and affinities of Palaearctic, Nearctic, Oriental, Ethiopian, Australian and Neotropical regions, Zoogeography of Pakistan and Geochronometry. The practical section will empower them with the knowledge of fauna of various zoogeographical regions and invertebrate fossils of coelenterates, trilobites, ammonite, brachiopods, molluscs and echinoderms.

Course Contents:

1. Paleogeography: theories of continental drift and plate tectonics and pangea
2. Animal distribution: cosmopolitan distribution, discontinuous distribution, isolation distribution, bipolar distribution, endemic distribution, barriers and dispersal
3. Zoogeographical regions: zoogeographic division and boundaries, geographic ranges, physical features, climates, faunas and affinities of Palaearctic, Nearctic, Oriental, Ethiopian, Australian, and Neotropical regions,
4. Zoogeography of Pakistan: The planet earth, history, age, shells of earth, atmosphere, hydrosphere, biosphere and lithosphere.
5. Rocks: igneous rocks, sedimentary rocks, metamorphic rocks.
6. Fossil and fossilization: fossil types and uses of fossils, nature of fossils, fossilization, invertebrates and vertebrates fossil, biostratigraphy, fossils of Pakistan, Paleontological important areas of Pakistan.
7. Fossilization: geological time scale, Pre-Cambrian life, Post Cambrian life, Paleozoic life, Mesozoic life, Cenozoic life.
8. Paleontological techniques: excavation techniques, excavation tools and techniques, transportation and processing of fossils, presentation of fossils, pre requisites for paleontological excavation.
9. Geochronometry: Uranium/Lead dating, radiocarbon dating, methods, index fossils, evolutionary history of man, elephant, horse and camel, Paleocology, Paleomagnetism.

Practical

1. Map work for identification of various zoogeographical regions of the World.
2. Field trip to Natural Museum of History to study mould, cast, pseudomorph, coprolite, petrified fossils of plants and animals, invertebrate fossils of coelenterates, trilobites, ammonite, brachiopods, molluscs and echinoderms, vertebrate fossils e.g. horse/elephant/camel/bovids and Igneous, Sedimentary and Metamorphic rocks.

Recommended Texts:

1. Benton, M. J., & Harper, D. A. (2020). *Introduction to paleobiology and the fossil record*. John Wiley & Sons.
2. Beddard, F. E. (2015). *A textbook of zoogeography*. Cambridge: Cambridge University Press.
3. Foote, M & Millar, A. I. (2007). *Principles of paleontology*. (3rd ed). USA: W. H. Freeman & Co.
4. Tiwari, S. K. (2006). *Fundamentals of world zoogeography*. Delhi: Sarup & Sons.

Suggested Readings:

1. Cox, C. B., Moore, P. D., & Ladle, R. J. (2021). *Biogeography: an ecological and evolutionary approach*. John Wiley & Sons.
2. Michael, J. B. David, A and Haper, T. (2009). *Paleobiology and the fossil record*. (3rd ed). UK: Wiley Black.
3. Michael, J. B., & Haper, D. A. T. (2009). *Paleobiology and the fossil record*. New York: Wiley & Blackwell.
4. Foote, M., & Millar, A. I. (2006). *Principles of paleontology*. New York: W. H. Freeman & Co.

Course Code	ZOOL-6125	Course Title	Entomology	Credit Hours	3(2-1)
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Course Brief:

The course is designed to impart knowledge to students about morphology and body parts of the insects. The objective of the entomology undergraduate is to provide students with a broadly-based education in the science and practice of entomology. After this course, students can demonstrate an understanding of insect identification, structure, and function. It includes general characteristics of insects, relationship with other arthropods and evolutionary study of insects splitting up into different evolutionary lines.

Course Learning Objectives:

This subject also imparts knowledge about ecology of insects by learning carrying capacity, food chains, predation and competition, diapause insect population and community studies and insect communication. The practical section will enable the students to prepare permanent slides, distinguish the several body parts (antennae, mouth parts, wings, legs, terminal segments and genitalia) of insects; can study the different systems, especially digestive, reproductive of the insect and be able to address complex problems facing entomology.

Course Contents:

1. General characteristics of insects and their classification
2. Hard parts: general segmentation, tagmatosis and organization.
3. Cuticle: colors of insects, cuticular outgrowths and appendages sclerotization.
4. Head: cephalization, sclerites, modifications.
5. Antennae: different modes of ingestion and types of mouth parts.
6. Neck: sclerites, thorax: sclerites: legs, their different modifications and functions.
7. Wings: origin; development and basal attachments, main veins and their branches 8. Abdomen: secondary appendages and external genitalia, 9. Flight; types of flight.
10. Soft parts: muscular system; basic structure, types of muscles
11. Sense organs: sound and light producing organs.
12. Nutritive requirements: fat body, exocrine and endocrine glands
13. Reproduction: reproductive organs and different types of reproduction in insects,
14. Development: embryology up to dorsal closure, different types of metamorphosis, apolysis and ecdysis and the role of endocrine secretions.
15. Ecology: insect population and community studies, insect communication.

Practical

1. Preparation of permanent slides.
2. All the hard parts (antennae, mouth parts, wings, legs, terminal segments and genitalia).
3. Different systems, especially digestive, reproductive of the following insects.
4. American cockroach, gryllus, grasshopper, housefly, butterfly, mosquito, any common beetle.
5. Red cotton bug.

6. Wasp and honey bee.
7. Sympathetic nervous system of cockroach and gryllus.
8. Salivary glands of cockroach, red cotton bug and honey bee.

Recommended Texts:

1. Richards, O. W., & Davies, R. G. (1977). *Imm's general textbook of entomology* (Vol. 1; 10 ed.). London: Chapman & hall.
2. Chapman, R. F. (2013). *The insects: structure and function* (5th ed.). Cambridge: Cambridge University Press.
3. Wigglesworth, V. B. (2012). *The principles of insect physiology*. London: Springer Science & Business Media.

Suggested Readings:

1. Tembhare, D. B. (2002). *Modern entomology*. Dehli: Himalaya Publishing House.
2. Henderson, P. A., & Southood, T. R. E. (2016). *Ecological methods*. London: Wiley Blackwell.
3. Peterson, P. G. (2018). *Elements of insect ecology*. London: Ed- Tech Press.

Course Code	ZOOL-6126	Course Title	Fundamental Microbiology	Credit Hours	3(2-1)
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Course Brief:

The microbes are the basis of the biosphere. They are the ancestors of all living things and the support system for all other forms of life. Paradoxically, certain microbes pose a threat to human health and to the health of plants and animals. As the foundation of the biosphere and major determinants of human health, microbes claim a primary, fundamental role in life on earth. Hence, the study of microbes is pivotal to the study of all living things, and microbiology is essential for the study and understanding of all life on this planet. Studying microbes is essential to understand how these tiny organisms cause diseases and their diagnosis and cure.

Course Learning Objectives:

Further, understanding these organisms also led to discovering their uses for human health as nutrition or medicine and curating innovative agricultural products. This course will enable the students to work with microorganisms and make them aware of the basic techniques of sterilization, culturing and isolation. They will also be able to determine different characteristics of the microorganisms.

Course Contents:

1. Fundamentals of microbiology
2. Microorganisms and their respective place in the living world
3. Differentiation between pro- and eukaryotic cells
4. Historical development of Microbiology and its scope
5. Microscopy: An outline of the principles and applications of light and electron microscope.
6. Morphology, arrangement and detailed anatomy of bacterial cell
7. Bacterial taxonomy and nomenclature, basis of classification of bacteria
8. Growth, nutrition (physical and nutritional requirement and nutritional types; sources of energy, C, N, H, O, S, P, H₂O, trace elements, growth factors) and reproduction
9. General methods of studying microorganisms: cultivation, isolation, purification and characterization
10. Control of microorganisms by physical and chemical methods
11. Chemotherapeutic agents and antibiotics. Modes of action of antibiotics on microorganisms
12. Basic properties of fungi, protozoa and algae
13. A brief introduction to structure and propagation of viruses and bacteriophages.

Practical

1. Laboratory safety: Containment and decontamination.
2. An introduction to microscopy

3. Principles of Staining Procedures: Simple staining, Gram's staining, Acid-fast staining, cell-wall staining, flagellar staining, capsule staining, spore staining and spirochaete staining. Study of cell motility by hanging drop preparation
4. Preparation and sterilization of bacteriological media and glassware
5. Inoculation techniques. Study of colony characteristics of microorganisms
6. Standard plate count technique (SPC)
7. Microbiological analysis of air

Recommended Texts:

1. Baker, S., Khan, N. Nicklin, J. & Killington, R. (2006). *Instant Notes in Microbiology* (3rd ed.). Taylor and Francis.
2. Black, J. G. (2005). *Microbiology: Principles & Explorations* (6th ed.). New York: John Wiley & Sons.

Suggested Readings:

1. Talaro, K. P. (2008). *Foundations in Microbiology: Basic Principles*, McGraw-Hill Companies, N.Y.
2. Tortora, G. J., Funke, B. R. & Case, C. L. (2012). *Microbiology: An Introduction*. Benjamin Cummings Publishing Company, U.S.A.
3. Tortora, G. J., Funke, B. R. & Case, C. L. (2012). *Study Guide for Microbiology: An Introduction*. (11th ed.). Benjamin-Cummings Publishing Company, U.S.A.

Course Code	ZOOL-5104	Course Title	Animal Form and Function-II	Credit Hours	4(3+1)
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Course Brief:

This course will enable students to understand the diversity in animal form and function adapted according to the modified environmental conditions. Students will also be provided understanding about the need of emergence of diversity of forms for the performance of similar function in variable conditions. It also demonstrates that a form is successfully adapted to perform a function like temperature regulation adequately and successfully according to its own environment.

Course Learning Objectives:

Upon successful completion of course students will have knowledge about nutrition and digestion process among animal groups, temperature regulation strategies adapted by animals and different modes of reproduction adapted by several groups for their successful stay on planet. The practical section will let them to study the excretory system in invertebrate and vertebrate model animals, can study nutritive canal in invertebrate and vertebrate animals through dissection and will be able to study the male and female reproductive system of an invertebrate and a vertebrate animal model with familiarity of major differences in them.

Course Contents:

1. Nutrition and Digestion: Evolution of nutrition; the metabolic fates of nutrients in heterotrophs; digestion, Animal strategies for getting and using food, diversity in digestive structures of invertebrates., The mammalian digestive system: gastrointestinal motility and its control, Oral cavity, pharynx and esophagus, stomach, small intestine: main site of digestion; large intestine; role of the pancreas in digestion; and role of the liver and gallbladder in digestion.
2. Temperature and body fluid regulation: homeostasis and temperature regulation; the impact of temperature on animal life; heat gains and losses; some solutions to temperature fluctuations;
3. Temperature regulation in invertebrates, fishes, amphibians, reptiles, birds and mammals; heat production in birds and mammals, control of water and solutes (osmoregulation and excretion); invertebrate and vertebrate

4. Excretory systems; how vertebrates achieve osmoregulation; vertebrate kidney variations; mechanism in metanephric kidney functions.
5. Reproduction and development: asexual reproduction in invertebrates; advantages and disadvantages of asexual reproduction, sexual reproduction in invertebrates; advantages and disadvantages of sexual reproduction; sexual reproduction in vertebrates; reproductive strategies; examples of reproduction among various vertebrate classes; the human male reproductive system: spermatogenesis, transport and hormonal control, reproductive function; the human female reproductive system: folliculogenesis, transport and hormonal control, reproductive function; hormonal regulation in gestation; prenatal development and birth: the placenta; milk production and lactation.

Practical

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 to develop better understanding among students.

Recommended Texts:

1. Miller, A. S., & Harley, J. P. (2016 & 2019). *Zoology* (10 & 11 ed.). Singapore: McGraw Hill.
2. Hickman, C., Jr., Keen, S., Eisenhour, D., Larson, A., l'Anson, H., (2019). *Integrated principles of zoology* (18 ed.). Singapore: McGraw-Hill.

Suggested Readings:

1. Campbell, N. A. (2002). *Biology* (6th ed.). California: Benjamin Cummings.
2. Kent, G. C., & Miller, S. (2001). *Comparative anatomy of vertebrates*. New York: McGraw-Hill.
3. Pechenik, J. A. (2015). *Biology of invertebrates* (7 ed.). Singapore: McGraw-Hill

Course Code	ZOOL-5105	Course Title	Economic Zoology	Credit Hours	3(2-1)
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Course Brief:

The course will enable students to learn about the relationship of commerce with domestic animals, their products, by-products and associated farming practices. They will also learn about the importance of human and domestic animal diseases and their vital relation to the economy. This course also provides knowledge about internal and external parasites and their effects on domestic animals and their farming practices. It also familiarizes the students with the value of studying various general practices, principles and techniques in farming and rearing of animals in sericulture (silk worms), apiculture (honey bees), aquaculture (fisheries, pearl culture, prawns and oysters), poultry (domestic fowl and ostriches) and cattle husbandry

Course Learning Objectives:

Students will acquire basic knowledge of commerce and economics in relation to Zoology. Economic zoology imparts knowledge about application of zoological knowledge for the benefit of mankind which mainly includes culturing animals for mass production for human use and to control or eradicate animals that are injurious to man directly or indirectly.

Course Contents:

1. Basic concepts in Economic Zoology.
2. Parasitic protozoans and human disease.
3. Economic importance of protozoa.
4. Vectors of human and domestic animals.
5. Ecto- and endo-parasites of fish, poultry, cattle and Man (Crustacea, Helminthes and Arachnida).
6. Pests of pulse crops. Pests of oil seed crops, stored grain pests, pests of cotton, vegetables, fruits and tea.
7. Apiculture, and sericulture, lac insect culture and pearl culture

8. Aquaculture and fisheries (edible fresh water, pond and marine fish, prawns, pearl oysters).
economic importance of fishes
9. Bird farming (poultry, quail, turkey, ostrich and pigeon).

Practical

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

Recommended Texts:

1. Ravindranathan, K. R. (2003). *Economic zoology* (1sted.). New Delhi, India: Dominant Publishers and Distributors.
2. Primack, R. B. (2000). *A Primer of conservation of biology* (2nded.). Massachusetts: Sinauer Associates.

Suggested Readings:

1. Mirza, Z. B. (1998). *Animal biodiversity of Pakistan* (1sted.). Rawalpindi: Printopack.
2. Akhtar, M., & Muzaffar, N. (2008). *Introduction to apiculture*. Lahore: Punjab University Press.
3. Blackiston, H. (2001). *Beekeeping for dummies*. Indiana: Wiley Publishing.

Course Code	ZOOL-5109	Course Title	Seminar	Credit Hours	1(1-0)
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The major aim of the course is to develop the writing and presentation skill among the student as well as to enhance their capacity to conceive the concept and to present at their own. The students will be assigned advanced topics in the field of Zoology.