

Department of Zoology, Scheme of Study 2025

BS 1st

Course Code	Course Title	Credit Hour	Structure of Subjects
ZOL-301	Basics of Animal Life	4(3-1)	Major Course 1
BOT-301	Diversity of Plants	3(2-1)	Interdisciplinary 1
CHM-321	Basic Organic Chemistry	3(2-1)	Interdisciplinary 2
ENG-321	Functional English	3(3-0)	Gen. Education 1
PST-322	Pakistan Studies	2(2-0)	Gen. Education 2
ICT-321	Applications of Information and Communication Technologies	3(3-0)	Gen. Education 3
GSC-321	Science of Global Challenges	3(2-1)	Gen. Education 4
UHQ-301	Understanding of Holy Quran-I	1(0-1)	
	Total	21	

Title: Zol-301. Basics of Animal Life 4(3-1)

Aims and Objectives

The course aims to impart knowledge and understanding of:

- a. The concept and status of Zoology in life sciences.
- b. The common processes of life through its chemistry, biochemical and molecular processes.
- c. The structure and function of cell organellae and how common animal cell diversified in various tissues, organs and organ systems.
- d. Biochemical mechanisms eventually generating energy for animal work.
- e. Animals and their relationship with their environment.

Course Learning Outcomes

1. Acquire the concept that different organelles, cells and tissues for the performance of a specific function in living body.
2. Understand that diverse forms of compounds for example Proteins, lipids, carbohydrates and enzymes perform different functions are because of the diversity in chemical structure.
3. Solve the emergence of diversity of organisms for the ecosystem.
4. Analyze the requirements of diverse forms for the performance of similar function in their past and present needs.

Course Outline

1. Place of Zoology in Science

A one-world view: genetic unity, the fundamental unit of life, evolutionary oneness and the diversity of life, environment and world resources; what is Zoology? The classification of animals; the scientific method.

2. The Chemical Basis of Animal Life

Atoms and elements: building blocks of all matter; compounds and molecules: aggregates of atoms; acids, bases, and buffers; the molecules of animals: fractional account of carbohydrates, lipids, proteins, nucleotides and nucleic acids based on their structural aspects.

3. Cells, Tissues, Organs, and Organ System of Animals

Introduction to Cell. Tissues: diversity in epithelial tissue, connective tissue, muscle tissue and nervous tissue to perform various functions. Structural integrations for functions in organs and organ systems.

4. Energy and Enzymes: Life's Driving and Controlling Forces. Energy and the laws of energy transformation; activation energy; enzymes: structure, function and factors affecting their activity; cofactors and coenzymes; ATP: how cells convert energy? An overview.

5. How Animals Harvest Energy Stored in Nutrients:

Glycolysis: the first phase of nutrient metabolism; fermentation: "life without oxygen"; aerobic respiration: the major source of ATP; metabolism of fats and proteins; control of metabolism; the metabolic pool.

6. Ecology I:

Individuals and Populations Animals and their abiotic environment; populations; interspecific interactions.

7. Ecology II:

Communities and Ecosystems Community structure and diversity; ecosystems; ecosystems of the earth; ecological problems; human population growth, pollution, resource depletion and biodiversity.

Practicals

1. Tests for different carbohydrates, proteins and lipids.

Note: Emphasis on the concept that tests materials have been ultimately obtained from living organisms and constituted their body.

2. Study of the prepared slides of epithelial tissue (squamous, cuboidal, columnar), connective tissue (adipose, cartilage, bone, blood), nervous tissue and muscle tissue (skeletal, smooth and).

Note: Prepared microscopic and/or projection slides and/or CD ROM computer projections must be used.

3. Plasmolysis and deplasmolysis in blood.

4. Protein digestion by pepsin.

5. Ecological notes on animals of a few model habitats.

6. Field observation and report writing on animals in their ecosystem (a terrestrial and an aquatic ecosystem study).

Books Recommended

1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 17th Edition (International), 2017. Singapore: McGraw Hill.
2. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 12th Edition (International), 2004. Singapore: McGraw Hill.

3. Miller, S.A. and Harley, J.B. ZOOLOGY, 10th Edition (International), 2016. Singapore: McGraw Hill.
4. Miller, S.A. and Harley, J.B. ZOOLOGY, 6th Edition (International), 2005. Singapore: McGraw Hill
4. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 5th Edition (International), 2000. Singapore: McGraw Hill.
5. Campbell, N.A. BIOLOGY, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
6. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5th Edition (International), 2002. Singapore: McGraw Hill.
7. Hickman, C.P. and Kats, H.L., LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.
8. Molles, M.C. ECOLOGY: CONCEPTS AND APPLICATIONS. 6th Edition. 2005. McGraw Hill, New York, USA.

For Sister Departments

Title: ZOL-303. Basics of Animal Life 3(2-1)

Aims and Objectives

The concept and status of Zoology in life sciences.

- a. The common processes of life through its chemistry, biochemical and molecular processes.
- b. The structure and function of cell organellae and how common animal cell diversified in various tissues, organs and organ systems.
- c. Biochemical mechanisms eventually generating energy for animal work.
- d. Animals and their relationship with their environment.

Course Learning Outcomes

1. Acquire the concept that different organelles, cells and tissues for the performance of a specific function in living body.
2. Understand that diverse forms of compounds for example Proteins, lipids, carbohydrates and enzymes perform different functions are because of the diversity in chemical structure.
3. Solve the emergence of diversity of organisms for the ecosystem.
4. Analyze the requirements of diverse forms for the performance of similar function in their past and present needs.

Course Outlines

1. Place of Zoology in Science

A one-world view: genetic unity, the fundamental unit of life, evolutionary oneness and the diversity of life, environment and world resources; what is Zoology? The classification of animals; the scientific method. Acids, bases, and buffers; brief introduction of biomolecules like carbohydrates, lipids, proteins, nucleotides and nucleic acids based on their structural aspects.

2. Cells, Tissues, Organs, and Organ System of Animals

Structure and functions of cell membranes; various movements across membranes; cytoplasm and its organelles like ribosomes, endoplasmic reticulum, Golgi apparatus, lysosomes, mitochondria, cytoskeleton, cilia and flagella, centrioles and microtubules, and vacuoles based on their structural aspects. The nucleus: nuclear envelope, chromosomes and nucleolus.

Animal tissues: diversity in epithelial tissue, connective tissue, muscle tissue and nervous tissue and functions. Organs and organ systems.

3. Energy and Enzymes:

Energy and the laws of energy transformation; activation energy.

Enzymes: structure, function and factors (pH and Temperature) affecting their activity; cofactors and coenzymes; ATP: how cells convert energy?

4. How Animals Harvest Energy Stored in Nutrients:

Glycolysis: the first phase of nutrient metabolism; fermentation: “life without oxygen”; aerobic respiration: the major source of ATP; metabolism of fats and proteins; control of metabolism.

5. Ecology

Individuals and Populations Animals and their abiotic environment; populations; interspecific interactions. Communities and Ecosystems Community structure and diversity; ecosystems; ecosystems of the earth; ecological problems; human population growth, pollution, resource depletion and biodiversity.

Practicals

1. Tests for different carbohydrates, proteins and lipids.
2. Study of the prepared slides of epithelial tissue (squamous, cuboidal, and columnar), connective tissue (adipose, cartilage, bone, and blood), nervous tissue and muscle tissue (skeletal, smooth and cardiac).
3. Plasmolysis and deplasmolysis in blood (**Hemolysis and Crenation in blood cells**)
4. Protein digestion by pepsin.`
5. Ecological notes on animals of a few model habitats.
6. Field observation and report writing on animals in their ecosystem (a terrestrial and an aquatic ecosystem study).

Books Recommended

1. Miller, S.A. and Harley, J.B. ZOOLOGY, 4th and 5th Edition (International), 2005. Singapore: McGraw Hill.
2. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 12th Edition (International), 2004. Singapore: McGraw Hill.

3. Campbell, N.A. 2002. Biology. 6th Ed. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
4. Miller, S.A. 2002. General Zoology Laboratory Manual. 5th Ed. (International), Singapore: McGraw Hill.
5. Hickman, C.P. and Kats, H.L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill.

BS 2nd

ZOL-302	Principles of Animal Life	4(3-1)	Major Course 2
ZOL-304	Cell Biology	3(2-1)	Major Course 3
CHM-322	Basic Inorganic Chemistry	3(2-1)	Interdisciplinary 3
MTH-321	Algebra and Trigonometry	3(3-0)	Interdisciplinary 4
ENG-322	Expository Writing	3(3-0)	Gen. Education 5
ISL-321/322	Islamic Studies/Ethics	2(2-0)	Gen. Education 6
	Total	18	

For Sister Departments

ZOL-306	Principles of Animal Life	3(2-1)	
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Title: ZOL-302. Principles of Animal Life 4(3-1)

Aims and Objectives

The course imparts knowledge and understanding of:

- a. Cell division and its significance in cell cycle.
- b. Concepts and mechanisms of inheritance pattern, chromosome and gene linkage and molecular basics of genetics.
- c. Theories of evolution, gene flow and mechanism of evolution with reference to animals and diversity.
- d. Animal behaviour and communication.

Learning Outcomes

-The students will be able to achieve the aims and objectives of the course. How cell divide and genetic information is distributed evenly to the daughter cells, concepts and patterns of inheritance. The students will be able to understand the Theories of evolution and different types of animal behaviors.

Course Contents

CELL DIVISION AND INHERITANCE

Eukaryotic Chromosomes, Sex Chromosomes and Autosomes, Number of Chromosomes, The Cell Cycle and Mitotic Cell Division, Interphase: Replicating the Hereditary Material, M-Phase: Mitosis, M-Phase: Cytokinesis, Meiosis: The Basis of Sexual Reproduction,

Spermatogenesis and Oogenesis

DNA: The Genetic Material, The Double Helix Model, DNA Replication in Eukaryotes, Genes in Action, Changes in DNA and Chromosomes

Inheritance Patterns in Animals, Segregation, Independent Assortment, Other Inheritance Patterns, The Molecular Basis of Inheritance Patterns.

EVOLUTION: HISTORY AND EVIDENCE

Pre-Darwinian Theories of Change, Darwin's Early Years and His Journey, Early Development of Darwin's Ideas of Evolution, The Theory of Evolution by Natural Selection, Microevolution, -Macroevolution, and Evidence of Macroevolutionary Change.

EVOLUTION AND GENE FREQUENCIES

Populations and Gene Pools, Must Evolution Happen?, Evolutionary Mechanisms, Species and Speciation, Rates of Evolution, Molecular Evolution, Mosaic Evolution.

ANIMAL BEHAVIOUR

Four approaches to animal behaviour; proximate and ultimate causes; anthropomorphism; development of behavior; learning; control of behavior; communication; behavioral ecology; social behavior.

Practicals

1. Study of mitosis in onion root tip.

2. Study of meiosis in grasshopper testis (students should prepare the slide).
3. Multiple alleles study in blood groups.
4. Study of karyotypes of *Drosophila*, mosquito.
5. Survey study of a genetic factor in population and its frequency.
6. Problem based study of Mendelian ratio in animals.
7. Study of cytochemical detection of DNA in protozoa and avian blood cell.
8. Study to demonstrate nervous or endocrine basis of behaviour (conditioned reflex or aggression or parental behavior).
9. Study to demonstrate social behaviour (documentary film be shown, honey bee, monkey group in a zoo).

Note for 1-2: Prepared microscopic and/or projection slides and/or CD ROM computer projections must be used).

Books Recommended

- Miller, A.S. and Harley, J.B. 2016. Zoology, 10th Edition (International), Singapore : McGraw Hill.
- Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11th Edition (International), 2004. Singapore: McGraw Hill.
- Campbell, N.A. Biology. 9th Ed. 2011. Menlo Park, California Benjamin/Cummings Publishing Company, Inc.
- Kent, G.C. and Miller, S., 2001. Comparative Anatomy of Vertebrates. New York: McGraw Hill. Miller, A.S. and Harley, J.B. ; 1999 , 2002., 2007, 2009, 2012 & 2016 Zoology, 5th, 10th Edition (International), Singapore : McGraw Hill.
- Miller, S.A. and Harley, J.B. ZOOLOGY, 4th Edition (International), 2002. Singapore: McGraw Hill.

Title: ZOL-304. CELL BIOLOGY 3(2-1)

Course Objectives:

The objectives of the course are:-

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

Course Learning Outcomes:

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

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

Course Outline:

1. Cell structure and function

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

2. Cell membranes

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

3. Cell Organelles (structure and function)

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

4. Nucleus

- a. Structure and function
- b. Nuclear membrane

c. Chromatin

5. Cytoskeleton

a. Structure and types

b. Function of cytoskeleton

6. Cellular transport

a. Diffusion and osmosis

b. Facilitated and active transport

c. Endocytosis and exocytosis

7. Cellular reproduction

a. Cell cycle

b. Mitosis

c. Meiosis

Practical:

1. Microscopy

2. Staining techniques (Gram staining)

3. Identification of cell organelles (prepared slides)

4. Preparation of temporary whole mount.

5. Preparation of permanent whole mount.

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

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

Books Recommended:

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

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

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

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

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

For Sister Departments

Title: ZOL-306. Principles of Animal Life 3(2-1)

Aims and Objectives

- a. Cell division and its significance in cell cycle.
- b. Concepts and mechanisms of inheritance pattern, chromosome and gene linkage and molecular basics of genetics.
- c. Animal behavior and communication.
- d. Theories of evolution, gene flow and mechanism of evolution with reference to animal diversity.

Learning Outcomes

The students will be able to achieve the aims and objectives of the course. How cell divide and genetic information is distributed evenly to the daughter cells, concepts and patterns of inheritance. The students will be able to understand the Theories of evolution and different types of animal behaviors.

Course Outline

1. Cell Division

Mitosis, cytokines is, and the cell cycle: an overview; control of the cell cycle; meiosis: the basis of sexual reproduction; gamete formation.

2. Inheritance Patterns and cellular control

The birth of modern genetics; Mendelian genetics; other inheritance patterns; environmental effects and gene expression.

Eukaryotic chromosomes; linkage relationships; changes in chromosome number and structure. DNA: the genetic material; DNA replication in eukaryotes; genes in action; control of gene expression in eukaryotes; mutations; recombinant DNA technology and its applications.

3. Animal Behavior

Four approaches to animal behavior; proximate and ultimate causes; anthropomorphism; development of behavior; types of behavior; control of behavior; communication; behavioral ecology; social behavior.

4. Evolution: A Historical Perspective

Pre-Darwinian theories of change; Lamarck: an early proponent of evolution; early development of Darwin's ideas of evolution and evidences. The theory of natural selection, adaptations, Alfred Russel Wallace.

5. Evolution and Gene Frequencies

The Hardy-Weinberg theorem; Evolutionary mechanisms: population size, genetic drift, natural selection, gene flow, mutation, and balanced polymorphism; species and speciation; rates of evolution; molecular evolution; mosaic evolution.

Practical

1. Study of mitosis in onion root tip.
2. Study of meiosis in grasshopper testis
3. Problem based study of Mendelian ratio in animals.
4. Multiple alleles study in blood group.
6. Study of karyotypes of *Drosophila*, mosquito.

Books Recommended

1. Miller, S.A. and Harley, J.B. ZOOLOGY, 4th and 5th Edition (International), 2005. Singapore: McGraw Hill.
2. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 12th Edition (International), 2004. Singapore: McGraw Hill.
3. Campbell, N.A. 2002. Biology. 6th Ed. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
4. Miller, S.A. 2002. General Zoology Laboratory Manual. 5th Ed. (International), Singapore: McGraw Hill.
5. Hickman, C.P. and Kats, H.L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill

BS 3rd

ZOL-401	Diversity of Invertebrates	4(3-1)	Major Course 4
ZOL-403	Diversity of Vertebrates	4(3-1)	Major Course 5

BOT-302	Systemic Anatomy and Development	3(2-1)	Interdisciplinary 5
ENG-421	Communication Skills	3(3-0)	Interdisciplinary 6
QTR-421	Quantitative Reasoning I	3(3-0)	Gen. Education 7
CCE-421	Civics and Community Engagement	2(2-0)	Gen. Education 9
UHQ-401	Understanding of Holy Quran-II	1(0-1)	
	Total	20	

For Sister Departments

ZOL-407	Diversity of Invertebrates & Vertebrates	3(2-1)	
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Title: ZOL. 401. Diversity of Invertebrates 4(3-1)

Aims and Objectives

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

Course Learning Outcomes

This course will be based on following outcomes:

1. Acquire the basic concepts of invertebrates with explanation of evolutionary origin and diversification.
2. Understand invertebrate organismal concepts in laboratory and field.

3. Demonstrate major evolutionary innovations for invertebrates with functional importance.
4. Understand how reproduction and development occurred and able to breed animal in the laboratory/field
5. Analyze economic and ecological importance of invertebrate

Course Outlines

INTRODUCTION a. Classification of Organisms: b. Evolutionary Relationships and Tree Diagrams: Patterns of organization.

2. ANIMAL-LIKE PROTISTS: THE PROTOZOA a. Evolutionary perspective; Life within a single plasma Membrane; b. Symbiotic Life-styles. c. Protozoon Taxonomy; (up to Phyla, subphyla and super Classes, wherever applicable). d. Pseudopodia and Amoeboid Locomotion; Cilia and other pellicular structure; e. Nutrition; Genetic Control and Reproduction; Symbiotic ciliates; f. Further Phylogenetic Consideration.

3. MULTICELLULAR AND TISSUE LEVELS OF ORGANIZATION a. Evolutionary Perspective: b. Origins of Multicellularity; Animal Origins. **Phylum Porifera** a. Characteristics and classification. Cell Types, Body Wall, and Skeletons; b. Water Current and Body Forms; c. Maintenance Functions, Reproduction. **Phylum Cnidaria (Coelenterate)** a. Characteristics and classification. The body Wall and Nematocysts: Alteration of Generations; b. Maintenance Functions; Reproduction and c. Classification up to Class. **Phylum Ctenophore;** a.Characteristics, body organization

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

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

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

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

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

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

Practicals

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

1. Study of *Euglena*, *Amoeba*, *Entamoeba*, *Plasmodium*, *Trypanosoma*, *Paramecium* as representative of animal like protists. (Prepared slides and from fresh water).
2. Study of sponges and their various body forms (prepared slides).
3. Study of principal representative classes of phylum Cnidaria.
4. Study of principal representative classes of phylum Platyhelminthes.
5. Study of representative classes of phylum Annelida.
8. Study of principal representative classes of groups of phylum Arthropoda.
9. Brief notes on medical/economic importance of the following:

Plasmodium, *Entamoebahistolitica*, *Leishmania*, Liverfluke, Tapeworm, Earthworm, Silkworm, Citrus butterfly.

10. Preparation of permanent stained slides of the following: *Obelia*, *Daphnia*, Cestode, Parapodia of *Nereis*.

11. How to make grade-wise series for preparation of temporary and permanent slides

Books Recommended

1. Miller, A.S. and Harley, J.B. ; 1999 , 2002., 2007, 2009, 2012 & **2016** Zoology, 4th , 5th, 6th, 7th, **8th , 9th & 10th** Edition (International), Singapore : McGraw Hill.

2. Hickman, C.P., Roberts, L.C/, AND Larson, A., **2018**. INTEGRATED PRINCIPLES OF ZOOLOGY, 15th Edition (International), Singapore: McGRAW-Hill.

3. Hickman, C.P., Roberts, L.C/, AND Larson, A., 2007. INTEGRATED PRINCIPLES OF ZOOLOGY, 12th & 13th Edition (International). Singapore:

4. Pechenik, J.A., 2015. BIOLOGY OF INVERTEBRATES, 7th Edition, (International), Singapore: McGraw-Hill. 5.

5. Kent, G. C. and Miller, S., 2001. COMPARATIVE ANATOMY OF VERTEBRATES New York: McGraw-Hill.

6. Campbell, N.A., 2002; BIOLOGY 6 th Edition, Menlo Park, California; Benjamin Cummings Publishing Company, Inc. BOOKS FOR PRACTICAL

Title: ZOL. 403. Diversity of vertebrates 4(3-1)

Course Title	Diversity of vertebrates
Course Code	ZOL-403
Credit Hours	4(3-1)
Theory	3
Practical	1
Follow up	BS
Category	
Aims and Objectives	The course provides knowledge and understanding about the different animal groups, emphasizing their phylogenetic relationships.

Learning
Outcomes

Syllabus in Brief Course Contents

1. Echinoderms

Evolutionary perspective: relationships to other animals; echinoderm characteristics; classification up to class. Maintenance functions, regeneration, reproduction, and development in asteroidea, ophiuroidea, echinoidea, holothuroidea and crinoidea; further phylogenetic considerations; some lesserknown invertebrates: the lophophorates, entoprocts, cycliophores, and chaetognaths.

2. Hemichordates and Invertebrate Chordates

Evolutionary Perspective: Phylogenetic Relationships; Classification up to subphylum or class where applicable; Further Phylogenetic Considerations.

3. Fishes: Vertebrate Success in Water

Evolutionary perspective: phylogenetic relationships; survey of super class agnatha and gnathostomata; evolutionary pressures: adaptations in locomotion, nutrition and the digestive system, circulation, gas exchange, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations.

4. Amphibians: The First Terrestrial Vertebrates

Evolutionary perspective: phylogenetic relationships; survey of order caudata, gymnophiona, and anura. Evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction, development, and metamorphosis; further phylogenetic considerations.

5. Reptiles: The First Amniotes

Evolutionary perspective: cladistic interpretation of the amniotic lineage; survey of order testudines or chelonina, rhynchocephalia, squamata, and crocodilia; evolutionary pressures: 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; further phylogenetic considerations.

6. Birds: Feathers, Flight, and Endothermy

Evolutionary perspective: phylogenetic relationships; ancient birds and the evolution of flight; diversity of modern birds; evolutionary pressures: 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.

7. Mammals: Specialized Teeth, Endothermy, Hair, and Viviparity

Evolutionary perspective: diversity of mammals; evolutionary pressures: 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.

Books Recommended

1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATEDth
PRINCIPLES OF ZOOLOGY, 11 Edition (International), 2004.
Singapore: McGraw Hill.

th

2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5 Edition
(International) 2002.
Singapore: McGraw Hill.

th

3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4
Edition
(International), 2000. Singapore: McGraw Hill.
4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF
VERTEBRATES. 2001. New York: McGraw Hill.

th

5. Campbell, N.A. BIOLOGY, 6 Edition. 2002. Menlo Park,
California: Benjamin/Cummings Publishing Company, Inc.

Practicals

1. Study of a representative of Hemichordate and Invertebrate Chordate.
2. Study of representative groups of class Fishes.
3. Study of representative groups of class Amphibia.
4. Study of representative groups of class Reptilia.
5. Study of representative groups of class Aves.
6. Study of representative groups of class Mammalia.
7. Field trips to study animal diversity in an ecosystem.

*Note: Preserved specimen and/or colored projection slide and/or CD
ROM projection of computer must be used.*

Books Recommended

1. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.
th
2. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5 Edition
(International), 2002. Singapore: McGraw Hill.

For Sister Departments

ZOL-407. Diversity of Invertebrates & Vertebrates 3(2-1)

Course Objectives:

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

Course Learning Outcomes:

This course will be based on following outcomes:

1. Acquire the basic concepts of invertebrates with explanation of evolutionary origin and diversification.
2. Understand invertebrate organismal concepts in laboratory and field.
3. Demonstrate major evolutionary innovations for invertebrates with functional importance.

4. Understand how reproduction and development occurred and able to breed animal in the laboratory/field
5. Analyze economic and ecological importance of invertebrates.

Course Contents:

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

1. INTRODUCTION

- a. Classification of Organisms:
- b. Evolutionary Relationships and Tree Diagrams: Patterns of organization.

2. ANIMAL-LIKE PROTISTS: THE PROTOZOA

- a. Evolutionary perspective; Life within a single plasma Membrane;
- b. Symbiotic Life-styles.
- c. Protozoon Taxonomy; (up to Phyla, subphyla and super Classes, wherever applicable).
- d. Pseudopodia and Amoeboid Locomotion; Cilia and other pellicular structure;
- e. Nutrition; Genetic Control and Reproduction; Symbiotic ciliates; Nutrition; Genetic Control and Reproduction; Symbiotic ciliates;
- f. Further Phylogenetic Consideration.

3. MULTICELLULAR AND TISSUE LEVELS OF ORGANIZATION

- a. Evolutionary Perspective:
- b. Origins of Multicellularity; Animal Origins.

Phylum Porifera

- a. Characteristics and classification. Cell Types, Body Wall, and Skeletons;

- b. Water Current and Body Forms;
- c. Maintenance Functions, Reproduction.

Phylum Cnidaria (Coelenterate)

- a. Characteristics and classification. The body Wall and Nematocysts: Alteration of Generations;
- b. Maintenance Functions; Reproduction and
- c. Classification up to Class.

Phylum Ctenophore;

- a.Characteristics, body organization

4. THE TRIPLOBLASTIC AND WITH ACOELOMATE BODY PLAN PHYLUM PLATYHELMINTHES

- a. Evolutionary Perspective; Classification up to class;
- b. The Free-Living Flatworms and the Tapeworms, adaptive modification for parasitic life style

Phylum Numerate; Characteristics, body organization

Phylum Gastrotrich; Characteristics, body organization

5. PSEUDOCOELOMATE BODY PLAN

PHYLUM ASCHELMINTHS

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

6. PHYLUM MOLLUSCA

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

7. PHYLUM ANNELIDA

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

8. PHYLUM ARTHROPODA:

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

9. The Hexapods and Myriapods:

- a. Evolutionary Perspective: Classification up to class. External Structure and Locomotion,

- b. Nutrition and the Digestive system, Gas Exchange, Circulation and Temperature Regulation,
- c. Nervous and Sensory Functions, Excretion, Chemical Regulation,
- d. Reproduction and Development in Hexapoda, e. Insects Behavior, Insect and Human;

10. PHYLUM ECHINODERMS

- a. Evolutionary Perspective: Relationship to other Animals; Echinoderm Characteristics; Classification up to class.
- b. Maintenance Functions, Regeneration,
- c. Reproduction, and Development in Asterozoa, Ophiurozoa, Echinozoa, Holothurozoa and Crinozoa; SOME LESSER-KNOWN INVERTEBRATES;
- a. The Lophophorates, Entoprocts, Cycliophores, and Chaetognaths.

Practical:

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

1. Study of Euglena, Amoeba, Entamoeba, Plasmodium, Trypanosome, Paramecium as representative of animal like Protists.
2. Study of prepared slides of sponges, spicules of sponges, and their various body forms. Study of representatives of classes of Phylum Porifera.
3. Study of principal representatives of classes of Phylum Coelenterate.
4. Study of principal representatives of classes of Phylum Platyhelminthes.
5. Study of representatives of phylum Rotifer, Phylum Nematode.
6. Study of principal representatives of classes of Phylum Mollusca.

7. Study of principal representatives of classes of Phylum Annelida.
8. Study of principal representatives of classes of groups of Phylum Arthropoda
9. Study of representatives of classes of phylum 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). Drawing and labeling.
12. How to make grade-wise series for preparation of temporary and permanent slides.

Recommended Book:

1. Miller, A.S. and Harley, J.B. ; 1999 , 2002., 2007, 2009, 2012 & 2016 Zoology, 4th , 5th, 6th, 7th, 8th , 9th& 10th Edition (International), Singapore : McGraw Hill. Additional Readings:
2. Hickman, C.P., Roberts, L.C/, AND Larson, A., 2018. INTEGRATED PRINCIPLES OF ZOOLOGY, 15th Edition (International), Singapore: McGRAW-Hill.
3. Hickman, C.P., Roberts, L.C/, AND Larson, A., 2007. INTEGRATED PRINCIPLES OF ZOOLOGY, 12th& 13th Edition (International). Singapore: McGraw-Hill.
4. Pechenik, J.A., 2015. BIOLOGY OF INVERTEBRATES, 7th Edition, (International), Singapore: McGraw-Hill.
5. Kent, G. C. and Miller, S., 2001. COMPARATIVE ANATOMY OF VERTEBRATES New York: McGraw-Hill.
6. Campbell, N.A., 2002; BIOLOGY 6 th Edition, Menlo Park, California; Benjamin Cummings Publishing Company, Inc. BOOKS FOR PRACTICAL
7. Miller, S.A., 2002. GENERAL ZOOLOGY LABORATORY MANUAL. 5th Edition (International), Singapore : McGraw-Hill. 8. Hickman, C.P. and Kats, H.L., 2000. Laboratory Studies in integrated principal of zoology. Singapore : McGraw-Hill.

8. Hickman, C.P. and Kats, H.L., 2000. Laboratory Studies in integrated principal of zoology. Singapore

BS 4th

ZOL-402	Basics of Animal Form & Function	4(3-1)	Major Course 6
ZOL-404	Principles of Animal Form & Function	4(3-1)	Major Course 7
PSY-422	Introduction to Psychology	3(3-0)	Gen. Education 10
ICP-322	Ideology and Constitution of Pakistan	2(2-0)	Gen. Education 11
ENP-422	Entrepreneurship	2(2-0)	Gen. Education 12
QTR-422	Quantitative Reasoning II	3(3-0)	Interdisciplinary 7
	Total	18	

For Sister Departments

ZOL-406	Animal Form & Function	3(2-1)	
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Title: Zol-402. BASICS OF ANIMAL FORM AND FUNCTION 4(3-1)

Aims and Objectives

The Objectives of the courses are:

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

Course Learning Outcomes:

1. **Acquire the** concept that for the performance of a function for example exchange of respiratory gases the different forms are adapted in t environments e.g. gills in aquatic and lungs in terrestrial environment.

2. **Understand** that diverse forms adapted to perform the same functions are because of the different past and present conditions.
3. **Solve** of emergence of diversity of forms for the performance of similar function.
4. **Analyze** the requirements of diverse forms for the performance of similar function in their past and present needs.
5. **Evaluate** the adaptations in forms for its efficiency in managing the function in differing situations in the past and present times.
6. **Demonstrate** that a form is successfully adapted to perform a function adequately and successfully.

Course 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 and vertebrates; 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; 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 Excretory Systems; How Vertebrates Achieve Osmoregulation; Vertebrate Kidney Variations; Mechanism in Metanephric Kidney Functions.

3. 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.

4. Descriptive Embryology

Fertilization; embryonic development: cleavage, and egg types; the primary germ layers and their derivatives; echinoderm embryology; vertebrate embryology: the chordate body plan, amphibian embryology, development in terrestrial environments, avian embryology, the fate of mesoderm.

Practical:

1. Study of excretory system in an invertebrate and a vertebrate representative (Model).
2. Study of nutritive canal in an invertebrate and a vertebrate representative (Dissection).
3. Study of male reproductive system in an invertebrate and a vertebrate representative (Dissection and Model).
4. Study of female reproductive system in an invertebrate and a vertebrate representative (Dissection).
5. Study of hormonal influence of a reproductive function (Model).
6. Study of preserved advanced stages of avian and mammalian development for amniotic membranes and placenta (performance/Model).
7. Study of stages in the development of an Echinoderm.
8. Study of early stages in the development of a frog, chick and a mammal.

- *Note for 9-10: Prepared slides and preserved specimen and/or projection slides and/or CD ROM computer projections may be used.*

Books Recommended

1. Miller, S.A. and Harley, J.B. ZOOLOGY, 10th Edition (International), 2016. Singapore: McGraw Hill.
2. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 17th Edition (International), 2017. Singapore: McGraw Hill.
3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4th Edition (International), 2000. Singapore: McGraw Hill.
4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill.

5. Campbell, N.A. BIOLOGY, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.

Title: ZOL-404. PRINCIPLE OF ANIMAL FORM AND FUNCTION 4(3-1)

Course Objectives:

The Objectives of the courses are:

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

Course Learning Outcomes:

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

Course Contents

1. Communication I: Nerves

Neurons: structure and function; neuron communication: introductory accounts of resting membrane potential, action potential (nerve impulse) and transmission of the action potential between cells; invertebrate and vertebrate nervous systems: the spinal cord, spinal nerves, the brain, cranial nerves and the autonomic nervous system.

2. Communication II:

Sensory reception: baroreceptors, chemoreceptors, georeceptors, hygroreceptors, 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, hearing and equilibrium in water, skin sensors of damaging stimuli, skin sensors of heat and cold, skin sensors of mechanical stimuli, sonar, smell, taste and vision in vertebrates.

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

4. Circulation, Immunity and Gas Exchange

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; gas exchange: respiratory surfaces; invertebrate and vertebrate respiratory systems: cutaneous exchange, gills, lungs, and lung ventilation; human respiratory system: gas transport.

Practical:

1. Study of insect chitin,
 2. Fish scale
 3. Amphibian skin
 4. Reptilian scales,
 5. Birds feathers
 6. Mammalian skin
- Model study of skeleton of
 1. Labeo (Labeo rohita)
 2. Frog (Hoplobatrachus tigerinus)
 3. Varanus (Varanus bengalensis)
 4. Fowl (Gallus gallus domesticus)
 5. Rabbit (Oryctolagus cuniculus)
 6. Earthworm or leech; cockroach, freshwater mussel, Channa or Catlacatla or Labeo or any other local fish, frog, pigeon and rat or mouse and rabbits dissections as per availability.
 - Study of nervous system of
 1. Earthworm
 2. Fish
 - Study of endocrine system in an
 1. Insect
 2. Rabbit
 3. Study of different types of blood cells in blood smear of rabbit
 4. Study of heart, principal arteries and veins in a representative vertebrate (dissection of representative fish/mammals).

Books Recommended

1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 17th Edition (International), 2017. Singapore: McGraw Hill.
2. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11 th Edition (International), 2004. Singapore: McGraw Hill.

3. Miller, S.A. and Harley, J.B. ZOOLOGY, 5 th Edition (International), 2002. Singapore: McGraw Hill.
4. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4 th Edition (International), 2000. Singapore: McGraw Hill.
5. Campbell, N.A. BIOLOGY, 6 th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
6. Campbell, N.A. BIOLOGY, 6 th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
7. 6 th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.

For Sister Departments

ZOL-406. Animal Form & Function 3(2-1)

Aims and Objectives

The Objectives of the courses are:

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

Course Learning Outcomes:

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

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

Course 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 and vertebrates; the mammalian digestive system:

2. Temperature and Body Fluid Regulation

Homeostasis and Temperature Regulation; The Impact of Temperature on Animal Life; Heat Gains and Losses; Temperature Regulation in Invertebrates, Invertebrate and Vertebrate Excretory Systems; How Vertebrates Achieve Osmoregulation; Vertebrate Kidney Variations; Mechanism in Metanephric Kidney Functions.

3. 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.

4. Descriptive Embryology

Fertilization; embryonic development: cleavage, and egg types; the primary germ layers and their derivatives; echinoderm embryology; vertebrate embryology: the chordate body plan.

5. 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.

6. Communication

Neurons: structure and function; neuron communication: introductory accounts of resting membrane potential, action potential (nerve impulse) and transmission of the action potential

between cells. Sensory reception of invertebrates and vertebrates. Chemical messengers: hormones chemistry; and their feedback systems; mechanisms of hormone action; Hormones with principal function of invertebrates and vertebrates.

7. Circulation, Immunity and Gas Exchange

Internal transport and circulatory systems in invertebrates and transport systems in vertebrates; Immunity: nonspecific defenses, the immune response; gas exchange: respiratory surfaces; invertebrate and vertebrate respiratory systems: cutaneous exchange, gills, lungs, and lung ventilation; human respiratory system: gas transport.

Practical

1. Study of excretory system in an invertebrate and a vertebrate representative (Model).
2. Study of male reproductive system in an invertebrate and a vertebrate representative (Dissection and Model).
3. Study of female reproductive system in an invertebrate and a vertebrate representative (Dissection).
4. Study of preserved advanced stages of avian and mammalian development for amniotic membranes and placenta (performance/Model).
5. Model study of insect chitin, fish scale, amphibian skin, reptilian scales, feathers and mammalian skin.
6. Study and notes of skeleton of Labeo, Rana tigrina, Varanus, fowl and rabbit alongwith models.
7. Study of nervous system of earthworm and a fish.
8. Study of endocrine system in an insect and a rabbit.
9. Study of heart, principal arteries and veins in a representative vertebrate (dissection of representative fish/mammals).

Books Recommended

1. Miller, S.A. and Harley, J.B. ZOOLOGY, 10th Edition (International), 2016. Singapore: McGraw Hill.
2. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 17th Edition (International), 2017. Singapore: McGraw Hill.
3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4th Edition (International), 2000. Singapore: McGraw Hill.

4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill.
5. Campbell, N.A. BIOLOGY, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.