CURRICULUM FOR TWO-YEAR ASSOCIATE DEGREE / BS (4-YEAR) IN ZOOLOGY

DEPARTMENT OF ZOOLOGY
UNIVERSITY OF MALAKAND
Chakdara, Dir Lower
(For session 2023 and Onward)

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

REVISED SCHEME OF STUDIES FOR ASSOCIATE/BS 4-YEAR PROGRAM IN ZOOLOGY AS PER HEC UG POLICY 2023

Following is the breakup of Credit Hours (CH):

- General Education (Gen-Ed): 30 CH
- Interdisciplinary (Inter-Disp): 12 CH
- Major: 84 CH (72 CH minimum)
- Field experience/Research work: 3 CH
- Capstone project/Thesis: 3 CH
- Duration: 4 years
- Semester duration: 16-18 weeks
- Semesters: 8
- Course Load per Semester: 15-18 CH
- Number of courses per semester: 5-6

Total Credit Hours: 130-142

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SCHEME OF STUDIES FOR BS (4-YEAR)/ASSOCIATE DEGREE PROGRAM IN ZOOLOGY

BS 1st YEAR SEMESTER–I

Course Code	Course Title	Couse Nature	CH
ENG 101	Functional English	Gen-Ed	3
CHEM 110/BOT 112	Chemistry in Everyday Life/Plant Sciences	Gen-Ed	3
BOT 111	Diversity of Plants	Inter-Disp	3 (2+1)
CS 110	Introduction to Information and Communication Technologies	Gen-Ed	3 (2+1)
ISL 112/ETH 118	*Islamic Studies/Ethics (for Non-Muslims)	Gen-Ed	2
ZOOL 111	Principles of Animal Life-I	Major	3 (2+1)
Teaching of Holy Quran with Translation		Non-Credit	
Total			**17**

* Islamic Studies for Muslim Students and Ethics for Non-Muslims Students

BS 1st YEAR SEMESTER–II

Course Code	Course Title	Couse Nature	CH
ENG 102	Introduction to Expository Writing	Gen-Ed	3
BCH 112	Introductory Biochemistry	Inter-Disp	3 (2+1)
PSC 116	Ideology and Constitution of Pakistan	Gen-Ed	2
SOC 227/ SOC 114	Social Problems of Pakistan/ Civic and Community Engagements	Gen-Ed	2
BOT 122	Plant Systematics, Anatomy and Development	Inter-Disp	3 (2+1)
ZOOL 121	Principles of Animal Life-II	Major	3(2+1)
Teaching of Holy Quran with Translation		Non-Credit	
Total			**16**

BS 2nd YEAR SEMESTER–III

Course Code	Course Title	Couse Nature	CH
MGT 215	Entrepreneurship	Gen-Ed	2
QR 101	Quantitative reasoning-1 (Mathematics)	Gen-Ed	3
CHEM 127	Organic Chemistry	Inter-Disp	3 (2+1)
ZOOL 231	Animal Diversity-I	Major	3 (2+1)
SOC 116/ PSC 112	Introduction to Sociology/ Introduction to Political Science	Gen-Ed	2
ZOOL 232	Zoogeography and Paleontology	Major	3 (2+1)
Teaching of Holy Quran with Translation (for Muslim Students)		Non-Credit	
Total			**16**

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BS 2nd YEAR SEMESTER–IV

Course Code	Course Title	Couse Nature	CH
QR 102	Quantitative Reasoning-2 (Statistics)	Gen-Ed	3
ZOOL 241	Animal Diversity- II	Major	3(2+1)
ZOOL 242	Animal Form & Function-I	Major	3(2+1)
ZOOL 243	Animal Behavior	Major	3(2+1)
ISL 113	*Seerah and its Contemporary Application سیرت رسول ﷺ اور اس کی عصری معنویت	Gen-Ed	2
ZOOL 244	Molecular Biology	Major	3(2+1)
Teaching of Holy Quran with Translation		Non-Credit	
Total			**17**

*Seerah for Muslim students and any course can be selected from arts and humanities for non-Muslim students

BS 3rd YEAR SEMESTER–V

Course Code	Course Title	Course Nature	Credits
ZOOL 351	Cell Biology	Major	3(2+1)
ZOOL 352	Animal Form & Function-II	Major	3(2+1)
ZOOL 353	Evolution	Major	3
ZOOL 354	Developmental Biology	Major	3(2+1)
ZOOL 355	Research Methodology & Synopsis	Major	3
ZOOL 356	General Microbiology	Major	3(2+1)
Teaching of Holy Quran with Translation		Non-Credit	
Total			**18**

BS 3rd YEAR SEMESTER–VI

Course Code	Course Title	Course Nature	Credits
ZOOL 361	Genetics	Major	3(2+1)
ZOOL 362	Biological Techniques	Major	3(2+1)
ZOOL 363	Principles of Systematics	Major	3(2+1)
ZOOL 364	Wildlife	Major	3(2+1)
ZOOL 365	Animal Physiology	Major	3(2+1)
ZOOL 366	General Biochemistry	Major	3(2+1)
Teaching of Holy Quran with Translation		Non-Credit	
Total			**18**

Chairman
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BS 4th YEAR SEMESTER–VII

Course Code	Course Title	Course nature	Credits
ZOOL 471	Ecology and Environmental Biology	Major	3(2+1)
ZOOL 472	Economic Zoology	Major	3(2+1)
Optional*	Special Paper	Major	3(2+1)
Optional*	Elective- I	Major	3(2+1)
ZOOL 473	Field work/Research work	Major	3
Teaching of Holy Quran with Translation		Non-Credit	
Total			**15**

*. - the course should be selected from the list of special/ elective courses

BS 4th YEAR SEMESTER–VIII

Course Code	Course Title	Course Nature	Credits
ZOOL 481	Bioinformatics	Major	3 (2+1)
Optional*	Elective-II	Major	3 (2+1)
Optional*	Elective-III	Major	3 (2+1)
Optional*	Elective-IV	Major	3 (2+1)
ZOOL 500	Capstone Project/Thesis	Major	3
Teaching of Holy Quran with Translation		Non-Credit	
Total			**15**

*. - the course should be selected from the list of special/ elective courses

Gen-Ed Credit Hours: 30
Inter-Disp Credit Hours: 12
Major Courses Credit Hours: 84 (minimum 72)
Field /Research work Credit hours: 03
Capstone project/Thesis: 03 credit hours
Total Credit Hours: 132

Note:

Courses included in the General Education Category are designed by the respective departments including their course codes, credit hours and titles (reflected in the scheme of studies). All such courses approved by the Syndicate are available on the university website. For any query the office of the Registrar Academics may be approached for clarification/guidance.

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CURRICULUM OF ZOOLOGY

BS 1st YEAR SEMESTER–I

Course Code	Course Title	Couse Nature	CH
ENG 101	Functional English	Gen-Ed	3
CHEM 110/BOT 112	Chemistry in Everyday Life/Plant Sciences	Gen-Ed	3
BOT 111	Diversity of Plants	Inter-Disp	3 (2+1)
CS 110	Information and Communication Technologies	Gen-Ed	3 (2+1)
ISL 112/ETH 118	*Islamic Studies/Ethics (for Non-Muslims)	Gen-Ed	2
ZOOL 111	Principles of Animal Life-I	Major	3 (2+1)
Teaching of Holy Quran with Translation		Non-Credit	
Total			**17**

* Islamic Studies for Muslim Students and Ethics for Non-Muslims Students

CHEMISTRY IN EVERYDAY LIFE/
PLANT SCIENCES
Course Code: CHEM 110/BOT 112
Credit Hours: 3 (2+1)

Note: The course contents are provided at the end of this document as Annexure A.

BOT 111 DIVERSITY OF PLANTS 3(2+1)

Theory

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

a) Viruses (RNA and DNA types) with special reference to TMV;

b) Bacteria and Cyanobacteria (Nostoc, Anabaena, Oscillatoria) with specific reference to biofertilizers, pathogenicity and industrial importance.

c) Algae (Chlamydomonas, Spirogyra, Chara, Vaucheria, Pinnularia, Ectocarpus, Polysiphonia)

d) Fungi (Mucor, Penicillium, Phyllactinia, Ustilago, Puccinia, Agaricus), their implication on crop production and industrial applications.

e) Lichens (Physcia)

f) Bryophytes

i. Riccia
ii. Anthoceros
iii. Funaria

f). Pteridophytes.

i. Fossils and fossilization
ii. Psilopsida (Psilotum)
iii. Lycopsida (Selaginella)
iv. Sphenopsida (Equisetum)

Chairman
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v. Pteropsida (Marsilea)
vi. Seed Habit

g). Gymnosperms Cycas, Pinus, Ephedra.

Practical

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

Books recommended:

1. Agrios, G.N. 2004. Plant pathology. 8th ed. Academic press London.
2. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 1996. Introductory Mycology. 4th ed. John Wiley and Sons Publishers.
3. Andrew, H. N. 1961. Studies in Paleobotany. John Willey and Sons.
4. Ingrouille , M. 1992. Diversity and Evolution of Land Plants. Chapman & Hall.
5. Lee, R.E. 1999. Phycology. Cambridge University Press, UK
6. Mauseth**,** J.D**.** 2003**.** Botany**:** An Introduction to Plant Biology 3rd ed., Jones and Bartlett Pub. UK
7. Prescott, L.M., Harley, J.P. and Klein, A.D. 2004. Microbiology, 3rd ed. WM. C. Brown Publishers.
8. Vashishta, B.R. 1991. Botany for degree students (all volumes). S. Chand and Company. Ltd. New Delhi.

PRINCIPLES OF ANIMAL LIFE – I

Course Code: ZOOL 111

Theory Credit Hour: 2

Objectives

The course aims to impart knowledge and understanding of:

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

Course Contents

Scope of Zoology: Introduction; significance and applications of Zoology; animal diversity; the scientific method; environment and world resources.
The Chemical Basis of Animal Life: Brief introduction to biomolecules; carbohydrates, lipids, proteins, and nucleic acids.
Cellular Organization: Structure of animal cells, cell membrane, cytoplasm and its organelles: ribosomes, endoplasmic reticulum, Golgi apparatus, lysosomes, mitochondria, cytoskeleton, cilia and flagella, centrioles and microtubules, vacuoles; the nucleus: nuclear envelope, chromosomes and nucleolus.
Animal tissues: Types: epithelial, connective, muscle and nervous tissue; organs and organ systems.
Enzymes: Structure, types; function and factors affecting their activity; cofactors and coenzymes.

Chairman
Department of Zoology,
University of Malakand

Energy Harvesting: Aerobic and anaerobic respiration: glycolysis, citric acid cycle and electron transport chain; fermentation, the major source of ATP.
Reproduction and Development: Types; asexual and sexual, gametogenesis, fertilization, metamorphosis, zygote and early development.
Ecological Concepts: Ecosystem, types, homeostasis, biomes, food chain, food web, energy flow and thermodynamics; biogeochemical cycles, and limiting factors, populations and communities, human population growth, pollution, resource depletion and biodiversity.

PRACTICAL

Credit Hour: 1

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 cardiac).
   Note: *Prepared microscopic and/or projection slides and/or CD ROM computer projections must be used.*
3. Plasmolysis and deplasmolysis in blood.
4. Preparation of blood smears.
5. Protein digestion by pepsin.
6. Ecological notes on animals of a few model habitats.
7. 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. 2005. Zoology, 6th Ed. (International), Singapore: McGraw-Hill.
2. Molles, M.C. 2005. Ecology: Concepts and Applications. 6th Ed. McGraw Hill, New York, USA.
3. Hickman, C.P., Roberts, L.S. and Larson, A. 2004. Integrated Principles of Zoology, 12th Ed. (International), Singapore: McGraw Hill.
4. Campbell, N.A. 2002. Biology. 6th Ed. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
5. Miller, S.A. 2002. General Zoology Laboratory Manual. 5th Ed. (International), Singapore: McGraw Hill.
6. Hickman, C.P. and Kats, H.L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill.
7. Odum, E. P. 1994. Fundamentals of Ecology. 3rd Ed. W.B. Saunders. Philadelphia.

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05-Dec-2023

BS 1st YEAR SEMESTER–II

Course Code	Course Title	Couse Nature	CH
ENG 102	Introduction to Expository Writing	Gen-Ed	3
BCH 112	Introductory Biochemistry	Inter-Disp	3 (2+1)
PSC 116	Ideology and Constitution of Pakistan	Gen-Ed	2
SOC 227/ SOC 114	Social Problems of Pakistan/ Civic and Community Engagements	Gen-Ed	2
BOT 122	Plant Systematics, Anatomy and Development	Inter-Disp	3 (2+1)
ZOOL 121	Principles of Animal Life-II	Major	3(2+1)
Teaching of Holy Quran with Translation (for Muslim Students)		Non-Credit	
Total			**16**

INTRODUCTORY BIOCHEMISTRY

Course Code: BCH 112
Credit Hours: 3 (2+1)
Course Objective
This course will provide:

- Fundamental concepts in biochemistry
- Understanding of classification, structures, properties, and biological functions of major macromolecules
- Basic laboratory skills

Course Outline
A general introduction to the science of biochemistry; Importance and the scope of biochemistry; Prebiotic molecular evolution and rise of living systems; Forms, functions and brief classification of prokaryotes; Cellular architecture and diversity of eukaryotes; Structure, physical properties and importance of water; pH and buffer; Biologically important organic compounds; Composition, properties and functions of proteins, carbohydrates, lipids and nucleic acids; Brief introduction of vitamins, hormones and enzymes
Practical

- Safety measures in the laboratory
- Preparation of solutions routinely used in biochemical experiments (e.g., percent, normal and molar solutions)
- pH determination using various methods.
- Preparation of buffers

Recommended Books

1) Rodwell, V. W., Bender, D. A., Botham, K. M., Kennelly, P. J., Weil, P. A., *Harper's Illustrated Biochemistry*, 31st Ed. McGraw-Hill Education, (2018).
2) Mathews, C. K., Van Holde, K. E., Ahern, K.G. *Biochemistry*. 3rd Ed. Prentice Hall (1999).
3) Voet, D. J., Voet, G.J. Pratt, C. W., *Fundamentals of Biochemistry: Life at the Molecular Level*. 3rd Ed. Wiley & Sons Inc, (2008).

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05-Dec-2023

BOT 122 PLANT SYSTEMATICS, ANATOMY AND DEVELOPMENT
3(2+1)

Theory

a) Plant Systematics

1. Introduction to Plant Systematics: 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 International Code of Botanical Nomenclature (ICBN). St. Luis code.
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:
    i) Ranunculaceae
    ii) Brassicaceae (Cruciferae)
    iii) Fabaceae (Leguminosae)
    iv) Rosaceae
    v) Euphorbiaceae
    vi) Cucurbitaceae
    vii) Solanaceae
    viii) Lamiaceae (Labiatae)
    ix) Apiaceae (Umbelliferae)
    x) Asteraceae (Compositae)
    xi) Liliaceae (Sen. Lato)
    xii) Poaceae (Graminae)

b) Anatomy

1. Cell wall: structure and chemical composition
2. Concept, structure, and function of various tissues like:
    i. Parenchyma
    ii. Collenchyma
    iii. Sclerenchyma
    iv. Epidermis (including stomata and trichomes)
    v. Xylem
    vi. Phloem
3. Meristem: types, stem and root apices
4. Vascular cambium
5. Structure and development of root, stem and leaf. Primary and secondary growth of dicot stem, periderm
6. Characteristics of wood: diffuse porous and ring –porous, sap and heart wood, soft and hard wood, annual rings.

c) Development / Embryology.

1. Early development of plant body: *Capsella bursa-pastoris*
2. Structure and development of Anther
    - Microsporogenesis
    - Microgametophyte
3. Structure of Ovule
    - Megasporogenesis
    - Megagametophyte
4. Endosperm formation
5. Parthenocarpy

6. Polyembryony

Practical

Anatomy

1. Study of stomata, epidermis,
2. Tissues of primary body of plant
3. Study of xylem 3-dimensional plane of wood.
4. T.S of angiosperm stem and leaf.

Taxonomy

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

Books Recommended

1. Esau, K. 1960. Anatomy of Seed Plants. John Wiley, New York.
2. Fahn, A. 1990. Plant Anatomy. Pergamon Press, Oxford.
3. Lawrence, G.H.M. 1951 Taxonomy of Vascular Plants. MacMillan & Co. New York.
4. Maheshwari, P.1971. Embryology of Angiosperms, McGraw Hill.New York.
5. Mauseth, J.D. 1998. An Introduction to Plant Biology: Multimedia Enhanced. Jones and Bartlett Pub. UK.
6. Moore, R.C., W.D. Clarke and Vodopich, D.S. 1998. Botany. McGraw Hill Company, U.S.A.
7. Panday, B.P. 2004. A textbook of Botany (Angiosperms). S. Chand and Co. New Delhi.
8. Raven, P.H., Evert, R.E. and Eichhorn, S.E. 1999. Biology of Plants. W.H. Freeman and Company Worth Publishers.
9. Raymond E, S. E. Eichhorn. 2005. Esau's Plant Anatomy. Meristems cells and tissues of the plant body, 3rd ed. John Wiley & Sons. Inc.
10. Stuessy, T.F. 1990. Plant Taxonomy. Columbia University Press, USA.

PRINCIPLES OF ANIMAL LIFE–II

Course Code: ZOOL 121

Theory Credit Hour: 2

Objectives:

The course will impart knowledge and understanding of:

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

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05-Dec-2023

Course Contents

Cell Division: Cell cycles: Mitosis and meiosis; control of the cell cycle.

Inheritance Patterns: Mendelian genetics; inheritance patterns; gene, structure, chemical composition and types.
Chromosomes and Gene Linkage: Eukaryotic chromosomes; linkage and crossing over; chromosomal aberrations.

Cellular Control: DNA: the genetic material; DNA replication in prokaryotes and eukaryotes; control of gene expression in eukaryotes; gene mutation; recombinant DNA technologies and their applications.

Animal Behavior: Behavior and its types, proximate and ultimate causes; anthropomorphism; development of behavior; learning; factors controlling animal behavior; communication; behavioral ecology; social behavior.

Evolution: A Historical Perspective: Theories of evolution: Natural selection Lamarckism and neo-Lamarckism, Darwinism, and neo-Darwinian.

Evolution and Gene Frequencies: Hardy-Weinberg principle; evolutionary
mechanisms: population size, genetic drift, gene flow, de Vries mutation theory and rates of evolution, polymorphism; species and speciation; molecular evolution; mosaic evolution.

PRACTICAL

Credit Hour: 1

1. Study of mitosis in onion root tip.
2. Study of meiosis in grasshopper testis (students should prepare the slide).
3. Problem based study of Mendelian ratio in animals.
4. Multiple alleles study in blood groups.
5. Survey study of a genetic factor in population and its frequency.
6. Study of karyotypes of *Drosophila*, mosquito.
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 behavior (documentary film be shown, honey bee, monkey group in a Zool).
   Note for1-2: Prepared microscopic and/or projection slides and/or CD ROM computer projections must be used).

Books Recommended

1. Pechenik, J.A. 2012. Biology of Invertebrates, 4th Edition (International), Singapore: McGraw Hill.
2. Hickman, C.P., Roberts, L.S., Larson, A. 2004. Integrated Principles of Zoology, 11th Edition (International). Singapore: McGraw Hill.
3. Miller, S.A., Harley, J.B. 2002. Zoology, 5th Edition (International), Singapore: McGraw Hill.
4. Miller, S.A. 2002. General Zoology Laboratory Manual. 5th Ed. (International). Singapore: McGraw Hill.
5. Campbell, N.A. 2002. Biology. 6th Edition. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
6. Kent, G.C., Miller, S. 2000. Comparative Anatomy of Vertebrates. New York: McGraw Hill.

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7. Hickman, C.P., Kats, H.L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill.

BS 2nd YEAR SEMESTER–III

Course Code	Course Title	Couse Nature	CH
MGT 215	Entrepreneurship	Gen-Ed	2
QR 101	Quantitative reasoning-1 (Mathematics)	Gen-Ed	3
CHEM 127	Organic Chemistry	Inter-Disp	3 (2+1)
ZOOL 231	Animal Diversity-I	Major	3 (2+1)
SOC 116/ PSC 112	Introduction to Sociology/ Introduction to Political Science	Gen-Ed	2
ZOOL 232	Zoogeography and Paleontology	Major	3 (2+1)
Teaching of Holy Quran with Translation (for Muslim Students)		Non-Credit	
Total			**16**

ORGANIC CHEMISTRY

Course Code: CHEM 127
Theory Credit Hour: 3 (2+1)
Course Objectives:
Students will acquire knowledge about basic concepts of organic chemistry, chemistry of hydrocarbons and functional groups and the mechanism of organic reactions. Such information will be useful for qualitative analysis and synthesis of organic compounds.
Course Content:
Basic Concepts of Organic Chemistry: Bonding and hybridization, localized and delocalized bonding, structure- aromaticity, inductive effect, dipole moment, resonance, and its rules, hyperconjugation, classification and nomenclature of organic compounds including IUPAC system, types of organic reactions (an overview).
Chemistry of Hydrocarbons: Saturated, unsaturated, and aromatic hydrocarbons with emphasis on synthesis and free radical, electrophilic addition and electrophilic substitution reactions.
Chemistry of Functional Groups: Hydroxyl, ether and amino groups, preparation and properties of alcohols, phenols, ethers, and amines with focus on reaction mechanism and applications, carbonyl compounds, preparations and reaction mechanism of aldehydes and ketones and their applications, carboxylic acids and their derivatives, acidity of carboxylic acids and effect of substituents on their acidity, preparation and reactions of carboxylic acids and their derivatives including esters, amides, acid halides and acid anhydrides.
Recommended Books:

1. Brown, W. and Poon, T., Introduction to Organic Chemistry, 3rd ed., John- Wiley & Sons, Inc., (2005).
2. John, E. M. Organic Chemistry, 8th ed., Brooks/Cole Publishing Co, USA, (2012).
3. Robert, T. M. and Robert, N. B., Organic Chemistry, 6th ed., Prentice Hall, New Jersey, (1992).
4. Younus, M., A Textbook of Organic Chemistry, Ilmi Kitab Khana, Urdu Bazar, Lahore, Pakistan, (2006).
5. Sykes, P., A Guidebook to Mechanism in Organic Chemistry, 6th ed., Pearson Education Limited, England, (1986).

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ANIMAL DIVERSITY-I
Course Code: ZOOL 231
Theory Credit Hour: 2

Objectives The course is designed to provide students with:

- Taxonomic characteristics and classification of each phylum
- Concepts of evolutionary relationship of animal kingdom
- Knowledge about animal kingdom, emphasizing their phylogenetic relationships and simple to complex mode of animal life

Course Contents

Introduction: Architectural pattern of an animal, taxonomy and phylogeny, major subdivisions of animal kingdom with evolutionary perspective.

Animal-Like Protists: The Protozoa; life within a single plasma membrane; symbiotic life-styles. Protozoan taxonomy: (up to phyla, subphyla and super classes, wherever applicable). Pseudopodia and amoeboid locomotion; cilia and other pellicular structures; nutrition; genetic control and reproduction; symbiotic ciliates; further phylogenetic considerations.

Multicellular and Tissue Levels of Organization: origins of multicellularity; animal origins. Phylum porifera: cell types, body wall, and skeletons; water currents and body forms; maintenance functions; reproduction. Phylum Cnidaria (coelenterata) the body wall and nematocysts; alternation of generations; maintenance functions; reproduction and classification up to class. Phylum Ctenophora; further phylogenetic considerations.

Triploblastic and Acoelomate Body Plan: Phylum Platyhelminthes: classification up to class; the free-living flatworms and the tapeworms; Phylum Nemertea; Phylum Gastrotricha; further phylogenetic considerations.

Pseudocoelomate Body Plan: Aschelminths: general characteristics; classification up to phyla with external features; feeding and the digestive system; other organ systems; reproduction and development of Phylum Rotifera and Phylum Nematoda; Phylum Kinorhyncha. Some important nematode parasites of humans; further phylogenetic considerations.

Molluscan Success: relationships to other animals; origin of the coelom; molluscan 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; further phylogenetic considerations.

Annelida: The Metameric Body Form: relationship to other animals, metamerism and tagmatization; External structure and locomotion, feeding and the digestive system, gas exchange and circulation, nervous and sensory functions, excretion, regeneration, reproduction and development in different classes; further phylogenetic considerations.

Arthropods: Blueprint for Success: classification and relationships to other animals; metamerism and tagmatization; the exoskeleton; metamorphosis; classification up to class; further phylogenetic considerations; phylogeny and adaptive diversification.

Echinoderms: relationships to other animals; echinoderm characteristics; classification up to class. Maintenance functions, regeneration, reproduction, and development; further phylogenetic considerations.

Lesser Invertebrates: The lophophorates, entoprocts, cycliophores, and chaetognaths.

PRACTICAL

Credit Hour: 1

Museum study of representative Phyla, Permanent slide preparations

1. Study of *Euglena, Amoeba, Entamoeba, Plasmodium, Trypanosoma, Paramecium* as representative of animal like protists. (Prepared slides).
2. Study of sponges and their various body forms.

3. Study of principal representative classes of Phylum Cnidaria.
4. Study of principal representative classes of Phylum Platyhelminthes.
5. Study of representative of Phylum Rotifera, Phylum Nematoda.
6. Study of principal representative classes of Phylum Mollusca.
7. Study of principal 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, Entamoeba histolitica, Leishmania, Liverfluke, Tapeworm, Earthworm, Silkworm, Citrus butterfly.

Books Recommended

1. Hickman, C.P., Roberts, L.S., Larson, A. 2011. Integrated Principles of Zoology, 15th Ed. (International). Singapore: McGraw Hill.
2. Miller, S.A., Harley, J.B. 2011. Zoology, 8th Ed. (International), Singapore: McGraw Hill.
3. Pechenik, J.A. 2010. Biology of Invertebrates, 4th Ed. (International), Singapore: McGraw Hill.
4. Campbell, N.A. 2002. Biology, 6th Ed. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
5. Miller, S.A., 2002. General Zoology Laboratory Manual. 5th Ed. (International). Singapore: McGraw Hill.
6. Hickman, C.P., Kats, H.L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill.

ZOOGEOGRAPHY AND PALEONTOLOGY

Course Code: ZOOL 232

Theory Credit Hour: 2

Objectives The course aims to:

- Provide information on the distribution of animals and their associations in the past and to rationalize their relationship in the present time.
- Impart knowledge and concepts of evolution mainly based on fossil record.
- Give understanding that fossil records also provide information about the distribution of animals in the past eras.

Course Contents

Zoogeography:

Animal distribution: cosmopolitan distribution, discontinuous distribution, isolation distribution, bipolar distribution and endemic distribution, barriers, and dispersal.

Zoogeographical regions (Palaearctic, Nearctic regions, Oriental, Ethiopian, Australian, and Neotropical Regions).

Paleogeography: Theories of continental drift and plate tectonics.

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

Zoogeography of Pakistan.

Palaeontology

The Planet Earth: History, age, shells of earth.

Rocks: types; ligneous rocks, sedimentary rocks, and metamorphic rocks. Fossil types and uses of fossils, nature of fossils.
Fossilization: Geological time scale. Pre-Cambrian life. Post Cambrian life, Palaeozoic life, Mesozoic life, Cenozoic life.

Geochronometry: Uranium/Lead dating, radiocarbon dating.

PRACTICAL
Credit Hour: 1

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

Books Recommended

Zoogeography

1. Beddard, F. E. 2008. A textbook of Zoogeography. Bibliobazar, LLC.
2. Tiwari, S.K. 2006. Fundamentals of world Zoogeography. Wedams eBooks Ltd (India) Sarup & Sons. Delhi.
3. Ali, S.S. 1999. Paleontology, Zoogeography and Wildlife Management. Nasim Book Depot, Hyderabad, India.
4. Darlington, P. J. Jr. 1963. Zoogeography, John Wiley and Sons.

Paleontology

1. Michael, J. B. David, A and Haper, T. 2009. Paleobiology and the fossil record. 3rd Ed. Wiley Black, UK.
2. Foote, M and Millar, A. I. 2007. Principles of paleontology. 3rd Ed. W. H. Freeman & Co. USA.
3. Ali, S.S. 1999. Paleontology, Zoogeography and Wildlife Management. Nasim Book Depot, Hyderabad, India.
4. Brouwer, A. 1977. General Paleontology, Oliver and Boyed, London.

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University of Malakand
05-Dec-2023

BS 2nd YEAR SEMESTER–IV

Course Code	Course Title	Couse Nature	CH
QR 102	Quantitative Reasoning-2 (Statistics)	Gen-Ed	3
ZOOL 241	Animal Diversity- II	Major	3(2+1)
ZOOL 242	Animal Form & Function-I	Major	3(2+1)
ZOOL 243	Animal Behavior	Major	3(2+1)
ISL 113	Seerah and its Contemporary Application سیرت رسول ﷺ اور اس کی عصری معنویت	Gen-Ed	2
ZOOL 244	Molecular Biology	Major	3(2+1)
Teaching of the Holy Quran with Translation		Non-Credit	
Total			**17**

*Seerah for Muslim students and any course can be selected from arts and humanities for non-Muslim students

ANIMAL DIVERSITY-II
Course Code: ZOOL 241
Theory Credit Hour: 2

Objectives The course aims to:

- Provide understanding about taxonomic characteristics and classification of each phylum
- Develop concepts of evolutionary relationship of animal kingdom
- Provide knowledge and understanding about the different animal groups with special emphasis on their phylogenetic relationships

Course Contents
Protochordates: anatomy and organ systems.
Fishes: Agnetha and Gnathostomata: locomotory adaptations and maintenance function.
Amphibians: Taxonomy of amphibia (Caudata, Gymnophiona, and Anura) and maintenance functions (locomotion, digestion circulation, excretion and osmoregulation, reproduction).
Reptiles: The First Amniotes: cladistic interpretation of the amniotic lineage; Taxonomy of reptiles (Testudines or Chelonia, Rhynchocephalian, Squamata, and Crocodilia); maintenance functions (locomotion, digestion circulation, excretion and osmoregulation and reproduction).
Birds: Feathers, evolution of flight; survey of modern birds; maintenance functions (locomotion, digestion circulation, excretion and osmoregulation and reproduction), migration and navigation.
Mammals: hair and endothermy, taxonomy of mammals; maintenance functions (locomotion, digestion circulation, excretion and osmoregulation and reproduction).

PRACTICAL
Credit Hour: 1
Museum study of: Protochordates, Pisces, Amphibia, Reptilia, Aves, Mammalia, 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.*

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
05-Dec-2023

Books Recommended

1. Hickman, C.P., Roberts, L.S., Larson, A. 2011. Integrated Principles of Zoology, 15th Ed. (International). Singapore: McGraw Hill.

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

2. Campbell, N.A. Biology, 9th Ed. 2011. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.

3. Miller, S.A. and Harley, J.B. 2010. Zoology, 8th Edition (International) Singapore: McGraw Hill.

4. Miller, S.A. 2002. General Zoology Laboratory Manual. 5th Ed. (International), Singapore: McGraw Hill.

5. Kent, G.C., Miller, S. 2001. Comparative Anatomy of Vertebrates. Latest edition New York: McGraw Hill.

6. Hickman, C.P., Kats, H.L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore: McGraw Hill.

ANIMAL FORM AND FUNCTION–I

Course Code: ZOOL 242

Theory Credit Hour: 2

Objectives

The course aims to teach the students about:

- Animal diversity adapted in different ways for their functions through modifications in body parts.
- 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.
- Organ systems, their specialization and coordination with each other and constantly changing internal and external environment, inside and outside the animal's body.
- The basic structure of each system determines its function.

Course Contents

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

Communication I: Nerves: Neurons: structure and function; neuron-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 ventral nerve cord and ganglia, the vertebrate brain, the spinal cord, cranial and spinal nerves; autonomic nervous system.

Communication II: Senses: Sensory reception: baroreceptors, chemoreceptors, georeceptors, hygroreceptors, photoreceptors, 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.

Communication III: The Endocrine System and Chemical Messengers: Chemical messengers: hormones chemistry; and their feedback systems; mechanisms of hormone action; some hormones 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.

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

Credit Hour: 1

1. Study of insect chitin, fish scale, amphibian skin, reptilian scales, feathers and mammalian skin.
2. Study and notes of skeleton of *Labeo, Rana tigrina, Varanus,* fowl and rabbit.
   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 rabbits are representative animals for study in dissections.
4. Study of models or preserved brains of representative animals and notes on adaptations.
5. Study of nervous system of earthworm and a fish.
6. Study of endocrine system in an insect and a rabbit.
7. Study of different types of blood cells in blood smear of rabbit.
8. Study of heart, principal arteries and veins in a representative vertebrate (dissection of representative fish/mammals).
9. Study of respiratory system in cockroach or locust and a vertebrate representative (Model).

Books recommended

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

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05-Dec-2023

ANIMAL BEHAVIOR

Course Code: ZOOL243

Theory Credit Hour: 2

Objectives

The course aims to

- Impart knowledge about animal responses to external stimuli
- Emphasize different kinds of behaviors classical and modern concepts
- Explain through examples development, evolution and occurrence of behavior
- understand the genetic and neurophysiological basis of behavior

Course Contents

Foundations of animal behavior: ethology, classical ethology
Development of behavior: innate mechanisms, imprinting
Kinds of behavior: innate, conditioned, complex behavior patterns, habituation.
Mechanisms of behavior: Nervous system and behavior, hormones and behavior,
Social behavior: agonistic, altruistic, kinship, mating, ritualization, dominance, territoriality
Biological rhythms: circadian clocks, clock genes etc.
Social organization: conflict, sexual behavior, reproduction and fitness, parental care, social system.
Animal Communication: chemical attraction, in moths, honeybees, communication displays, pheromones etc.PRACTICAL

Credit Hour: 1

1. Locomotory behavior of small animals, earthworm, garden snails etc.
2. Ear pinna reflex responses in domestic cats
3. Preparation of skinner box or maze for study of mouse or rat behavior
4. Mother-pup bond in mice and rats
5. Infant killing behavior
6. Pecking behavior of chickens
7. Hiding behavior of chicks
8. Observation of birds' nests and study of parental behavior
9. Altruistic behavior in monkeys

Books Recommended

1. Dugatkin, L. A. 2012. Principles of Animal Behavior. W.W. Nortan and Co. New York.
2. Scott, G. 2005.Essential Animal Behavior. Blackwell Pub. New York.
3. Goodenough, J., McGuire, B., Wallace, R.A. 2001.Perspective on Animal Behavior. John Wiley & Sons, New York.

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05-Dec-2023

MOLECULAR BIOLOGY
Course Code: ZOOL 244
Credit Hour: 2
Course Objectives

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

Course learning outcomes:

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

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

Course outline:

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

PRACTICAL
Credit Hour: 1

- Preparation of different stock solutions used in molecular biology (solution used in PCR, electrophoresis, DNA isolation, RNA isolation and Protein isolation.

Chairman
Department of Zoology,
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

- Isolation of DNA from human blood.
- Quantification of DNA and RNA through spectrophotometer.
- DNA amplification through polymerase chain reaction.
- Separation of different sized DNA fragments on agarose gel.

Text and Reference books:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D. 2017. Molecular Biology of the Cell. 6th Edition. Garland Publishing Inc., New York.
2. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey C. Martin. 2016. Molecular Cell Biology. W. H. Freeman Publishers, Scientific American Inc.
3. Geoffrey M.C., Robert E.H. 2007. The cell: A Molecular Approach, Sinauer Associates, INC.
4. Karp, J. 2005. Cell and Molecular Biology, Concepts and Experiments, Jhon Wiley and Sons, INC.
5. De Robertis, E. D. P. 2017. Cell and Molecular Biology, 8th edition, Lea & Febiger, New York.

Chairman
Department of Zoology
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Assistant Registrar
University of Malakand
05-Dec-2023

BS 3rd YEAR SEMESTER–V

Course Code	Course Title	Course Nature	Credits
ZOOL 351	Cell Biology	Major	3(2+1)
ZOOL 352	Animal Form & Function-II	Major	3(2+1)
ZOOL 353	Evolution	Major	3
ZOOL 354	Developmental Biology	Major	3(2+1)
ZOOL 355	Research Methodology & Synopsis	Major	3
ZOOL 356	General Microbiology	Major	3(2+1)
Teaching of Holy Quran with Translation (for Muslim Students)		Non-Credit	
Total			**18**

CELL BIOLOGY

Course Code: ZOOL ZOOL 351
Credit Hour: 2
Course Objectives

The objectives of the course are: -

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

Course outline:

1. **Introduction (cell structure and function)**
   a. Cell theory
   b. Comparison of plant and animal cells
   c. Comparison of prokaryotic and eukaryotic cells
2. **Cell membranes**
   a. Structural models
   b. Chemical composition and function
3. **Cell Organelles (structure and function)**
   a. Endoplasmic reticulum
   b. Golgi Bodies
   c. Mitochondria
   d. Lysosomes
   e. Peroxisomes
   f. Ribosome
4. **Nucleus**
   a. Structure and function
   b. Nuclear membrane
   c. Chromatin
5. **Cytoskeleton**
   a. Structure and types
   b. Function of cytoskeleton
6. **Cellular transport**
   a. Diffusion and osmosis
   b. Facilitated and active transport

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

c. Endocytosis and exocytosis

7. **Cellular reproduction**
   a. Cell cycle
   b. Mitosis
   c. Meiosis

PRACTICAL

Credit Hour: 1

Practical:

Microscopy, staining techniques (Gram staining), Identification of cell organelles (prepared slides), Preparation of temporary whole mount. Preparation of permanent whole mount. Squash preparation of onion root tip for mitotic stages. Study of mitotic and meiotic stages (prepared slides)

Books Recommended

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D. 2017. Molecular Biology of the Cell. 6th Edition. Garland Publishing Inc., New York.
2. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, 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. 200 5. Cell and Molecular Biology, Concepts and Experiments, Jhon Wiley and Sons, INC.
5. De Robertis, E. D. P. 2017. Cell and Molecular Biology, 8th edition, Lea & Febiger, New York.

Animal Form & Function-II

Course Code: ZOOL 352

Theory Credit Hour: 2

Objectives The course:

- provides understanding of the basis of structure and functions of animal nutrition, digestion, homeostasis and temperature regulation.
- introduce the basic concepts in reproduction and development in animal kingdom.
- impart knowledge about the development of chordate body plan and fate of germinal layers.

Course Contents

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.

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.

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.

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 and fate of mesoderm.

PRACTICAL
Credit Hour: 1

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).
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 (Model).
7. Study of stages in the development of an Echinoderm.

Study of early stages in the development of a frog, chick and a mammal.

Note: Prepared slides and preserved specimen and/or projection slides and/or CD ROM computer projections may be used.

Books Recommended

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

EVOLUTION

Course Code: ZOOL 353
Credit Hour: 3

Course objectives

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

Course learning outcomes

1. To acquire basic knowledge for the factors and theories related to the origin of life.
2. To understand the vital concepts proposed by various scientists for the appearance of life on earth.

3. To solve the critical issues for the discrepancies based on origin of life.
4. To analyse certain issues regarding the animal phyla, classes, orders till sub-species levels.

Contents

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

Text and Reference Books

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

DEVELOPMENTAL BIOLOGY

Course Code: ZOOL 354
Theory Credit Hour: 2

Objectives 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.
- Provide understanding of the mechanisms of organogenesis, factors controlling growth and oncogenesis.

Course Contents

Introduction: Principal features of development, origin of sexual reproduction, developmental patterns; Spermatogenesis; Oogenesis.
Fertilization: Recognition of sperm and egg, fusion of gametes, activation of egg metabolism, rearrangement of egg cytoplasm.

Cleavage: Patterns of embryonic cleavage, mechanism of cleavage. Gastrulation: Fate maps, gastrulation in sea urchin, amphibians, birds and mammals.
Early Vertebrate Development: Neurulation, ectoderm, mesoderm and endoderm.
Cellular Basis of Morphogenesis: Differential cell affinity, cell adhesion molecules.
Mechanism of Cellular Differentiation: RNA processing, translational regulation of developmental process, cell-fate by progressive determinants, autonomous cell specification by cytoplasmic determinants, establishment of body axes and mechanism of teratogenesis; Secondary Induction.
Organogenesis: A brief account; Origin and migration of germ cells in vertebrates.

Factors controlling growth and oncogenesis.

Post embryonic Development and metamorphosis

Hormones as mediators of development; Regeneration in vertebrates.

PRACTICAL

Credit Hour: 1

1. Study of the structure of gametes in some representative cases, i.e. frog, fish, fowl and a mammal.
2. Study of cleavage and subsequent development from prepared slides and/or whole mounts in various animals i.e., frog, chick etc. Study of fertilization, early development of frog/fish through induced spawning under laboratory conditions.
3. Preparation and study of serial sections of frog or chick embryos.
4. Application of microsurgical techniques on chick embryos *In vitro*. Preparation and staining of histological slides.

Books Recommended

1. Gilbert, S. F. 2012. Developmental Biology, Sinauer Associates, Sunderland, MA.
2. Klaus, K. 2001. Biological Development. 2nd Ed., McGraw Hill.
3. Balinsky, B. I. 1985. An Introduction to Embryology, Saunders.
4. Oppenheimer, S.S. 1984. Introduction to Embryonic Development, Allen and Bacon.
5. Saunders, J. W. 1982. Developmental Biology, McMillan, and company.
6. Ham, R. G., Veomett, M. J. 1980. Mechanism of Development. C. V. Mosby Co.

RESEARCH METHODOLOGY & SYNOPSIS

Course Code: ZOOL 355

Credit Hour: 3

Course Objectives

The course is 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.
- Enable students to write research proposal.

Course outcomes

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

- **UNDERSTAND** a general definition of research design.
- **IDENTIFY** the overall process of designing a research study from its inception to its report.
- Become **FAMILIAR** with ethical issues in educational research, including those issues that arise in using quantitative and qualitative research.
- **KNOW** the primary characteristics of quantitative research and qualitative research.
- **IDENTIFY** a research problem stated in a study.
- Become **FAMILIAR** with how to write a good introduction to an educational research study.
- To **DISTINGUISH** a purpose statement, a research question or hypothesis, and a research objective.

Course Contents

1. **Introduction:**
   a. Objectives of Research, Motivations
2. **Research Process:**
   a. Research methods vs. research methodology, scientific method

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

b. Types of research, general steps involved in research
c. Problems of research in Pakistan

3. **Topic Selection:**
   a. Problem identification for research, criteria and evaluation
4. **Literature review:**
   a. Importance and sources
   b. Referencing and citation and Bibliography
   c. plagiarism
5. **Research Design:**
   a. Parts, important features, important concepts in research design
6. **Aims and objectives:**

a. Research objectives, qualities of research objectives

7. **Material and methods:**

a. Bioethics, sampling, data collection and data analysis, sampling requirements, scales of measurement, error of measurement and its sources

8. **Data Analysis:**

a. Processing, statistics in research, hypothesis testing, t-tests and ANOVA

9. **Scientific Writing:**

a. Difference between thesis/report/synopsis/research proposal
b. Parts of synopsis/project proposal, parts of thesis/report

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

Recommended Books:

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

MICROBIOLOGY

Course Code: ZOOL 356
Theory Credit Hour: 2
Aims

Aims of this course are to let the students know about the:

- Science of microbiology and work with microorganisms.
- Pathogenicity, and various diseases and problems caused by microorganisms.
- Agricultural, Industrial and/or Environmental microbiology.
- Identification of specific areas in practical life where the science of microbiology is being applied.

Course Contents

Chairman
Department of Zoology,
University of Malakand

Assistant Registrar
(Examinations)
University of Malakand
05-Dec-2023

The beginning of Microbiology: Discovery of the microbial world, discovery of the role of microorganisms in transformation of organic matter, in the causation of diseases, development of pure culture methods, the scope of microbiology, microbial evolution, systematics and taxonomy, characterization and identification of microorganisms, nomenclature and bergey's manual

Viruses: Bacteriophages and phages of other protists, replication of bacteriophages, viruses, of animals and plants, history, structure and composition, classification and cultivation of animal viruses, effects of virus infection on cells, Cancer and viruses

Morphology and fine structure of bacteria: Size, shape and arrangement of bacterial cells, Flagella and motility, Pili, Capsules, sheaths and stalks, structure and chemical composition of cell wall, cytoplasmic membrane, the cytoplasm, nuclear material.

Eukaryotic microorganisms: Algae; biological and economic importance of algae, characteristics of algae, lichens, fungi and importance of fungi, morphology; physiology and reproduction and cultivation of fungi, economic importance of protozoa

Microbiology and Medicine: Antimicrobial agents, mode of action. Bacterial pathogens and associated diseases. Infective syndromes and diagnostic procedures. Strategy of antimicrobial therapy. Prophylactic immunization for the following organisms.

Pathogenic Microbes: Study of *Staphylococcus aureus*. *Streptococcus*, *Streptococcus pneumoniae, S. viridans (Halitosis)*. *Pneumococcus*, *Neisseria meningitidis*, *Neisseria gonorrhoeae*, *Bacillus anthracis*, *Clostridium tetani*, *C. perfringens* (Gas gangrene), *C. botulinum*, *Listeria monocytogenes*, *Cornyebacterium diphtheriae*, Diphtheria. *Mycobacterium tuberculosi*, *M.leprae*, *Pseudomonas aeruginosa*, *Bordetella pertussis*, *Legionella pneumophila*, *Escherichia coli*, *Salmonella typhae*, *Shigella. Klebsiella*, Herpes simplex viruses. H5N1 avian influenza virus, Rubella virus and Hepatitis viruses.

PRACTICAL

- Preparation of culture media
- Pure culturing and cultivation of microbes
- Simple, Gram, endospore, capsular, flagellar and acid-fast staining of different genera of bacteria/Vital staining and microscopic observations of protozoa
- Isolation of bacteriophages

Books Recommended

1. Patrick R. Murry, Ken S. Rosenthal, Michael A. Pfaller: Medical Microbiology, 5th edition, Philadelphia: Elsevier/Mosby, 2005.

2. P.K. Murray, Ph.D., K.S. Rosenthal, Ph.D., G.S. Kobayashi, Ph.D., and M.A. Pfaller, MD, 4th Edition, Mosby, Inc. 2002. ISBN #0323012132.

3. C. George Ray, Editor; McGraw-Hill/Appleton and Lange 5th edition, McGraw-Hill/Appleton & Lange, 2003. ISBN#0838585299.

4. Microbial Applications (complete version) Laboratory Manual in General Microbiology, 1994. Benson, H.J. WMC Brown Publishers, England.

6. Brock Biology of Microorganisms, 1997. Madigan, M.T., Martinko, J.M. and Parker, J. Prentice-Hall, London.

7. Cruickshank, R, Duguid, J.P., Hermion, B.P. and Swain, R.H.A., (2003). Medical Microbiology. Churchill Livingstone, N.Y.

8. Microbiology: An Introduction, 12th ed. (2018) by Gerard J. Tortora, Berdell R. Funke, Christine L. Case.

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
University of Malakand
05-Dec-2023

9. Prescott's Microbiology,10th ed. (2017) by Joanne Willey, Linda Sherwood and Christopher J. Woolverton.
10. Bergey's Manual of Systematic Bacteriology (2012).
11. Microbiology Principles and Explorations (2001) by Jacquelyn, G.G.

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

BS 3rd YEAR SEMESTER–VI

Course Code	Course Title	Course Nature	Credits
ZOOL 361	Genetics	Major	3(2+1)
ZOOL 362	Biological Techniques	Major	3(2+1)
ZOOL 363	Principles of Systematics	Major	3(2+1)
ZOOL 364	Wildlife	Major	3(2+1)
ZOOL 365	Animal Physiology	Major	3(2+1)
ZOOL 366	General Biochemistry	Major	3(2+1)
Teaching of Holy Quran with Translation (for Muslim Students)		Non-Credit	
Total			**18**

GENETICS

Course Code: ZOOL 361

Theory Credit hour: 2

Objectives

The course aims to:

- In providing understanding about the continuity of the life from one generation to other generation is based on the mechanisms involving nucleus, chromosomes, and genes etc.
- Develop the concept that continuity not only transfers the traits of the parents but also imparts variations that render the generations sustainable in changing environment.

Course Contents

Classical Genetics: Scope and importance of genetics, gene concept; classical and modern),
Multiple Alleles: blood groups and coat color in rabbits.

Chromosomal Basis of Inheritance: interaction of genes, changes in chromosomal number, euploidy, aneuploidy, polyploidy; structural changes, insertion, deletion (Cri du chat syndrome), duplication and translocation Pedigree Analysis: Normal human chromosome complement; Karyotyping. Sex-determination and Sex-linkage: Sex determination in animals and humans, linkage, recombination, and chromosome mapping in eukaryotes. Molecular Genetics: Elements of genetic engineering; genetic basis of diseases, like cancer, genetic control of animal development.

Human Genetics; Single and Multifactorial Disorders: Autosomal anomalies, Pseudoautosomal genes, (eg. Down syndrome, Edwards syndrome and), Single gene disorders Gene mutation and disorders; autosomal single gene disorders (Sickle cell anemia, brachydactyly; inborn errors of metabolism such as Phenylketonuria, alkaptonuria). Definition - characteristics criss- cross inheritance. Polygenic traits - Cleft lip and cleft palate,

Sex-linked Chromosomal anomalies: Klinefelter syndrome, and Turners syndrome.

Sex-influenced inheritance: Hemophilia, muscular dystrophy, color blindness.

Prenatal Diagnosis: Amniocentesis and choriovillus sampling - Ultrasound scanning and Fetoscopy. Genetic counselling, Eugenics and Euthenics.

Population Genetics: Hardy-Wienberg equilibrium, systematic and dispersive pressures, inbreeding and heterosis.

Chairman
Department of Zoology,
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

Practical
Credit Hour: 1

1. Mitosis (Onion root tips.)
2. Meiosis (Grasshopper testes)
3. Blood groups.
4. Salivary gland Chromosomes of *Drosophila melanogaster*
5. General morphology of *Drosophila melanogaster*
6. Human Pedigree analysis problems
7. Human Genetics problems
8. Probability problems. Tossing of coins. X^2 test
9. Study of transformed bacteria based on antibiotic resistance.

Books Recommended

1. Snustad, D.P., Simmons, M.J. 2003. Principles of Genetics. 3rd Ed., John Wiley and Sons Ins. New York, USA.
2. Tamarin, R.H. 2001. Principles of Genetics. 7th Ed., WCB Publishers USA.
3. Lewin, B. 2000. GENE-VIII. Oxford University Press. UK.
4. Gardener, E.J., Simmons, M.J., Snustad, D.P. 1991. Principles of Genetics. John Wiley and Sons Ins. New York, USA.
5. Strickberger, M.W. 2014. Genetics. McMillan, New York. USA.

BIOLOGICAL TECHNIQUES

Course Code: ZOOL 362
Theory Credit Hour: 2

Objectives

The course aims to:

1. Develop scientific technical expertise, culture and work habits.
2. Familiarize with the basic tools and techniques of scientific study with emphasis on biological sciences
3. Develop basic understanding of the equipment usage

Course Contents

Microscopy: Principles of light microscopy. Magnification, Resolution, Contrast. Types of microscopy, Bright field (Compound Microscope), Scanning microscopy, Eyepiece micrometers, Camera Lucida Phase Contrast Dark Field Interference microscope, Electron microscope.
Micrometery and Morphometry: Use of stage and ocular micrometer. Calibration of ocular micrometer. Size measurement (length, width, diameter).
Standard system for weight, length, volume: Calculations and related conversions of each: Metric system- length; surface; weight - Square measures- Cubic measures (volumetric)- Circular or angular measure - Concentrations- percent volume; ppt; ppm - Chemical molarity, normality - Temperature- Celsius, centigrade, Fahrenheit. Preparation of stock solutions of various strengths
Specimen preparation for optical microscopy: **Microtomy:** Fixation, embedding, Section cutting (transverse, longitudinal section, mounting and staining. Sections in paraffin and cryosections.
Extraction techniques: Centrifugation, Ultracentrifugation, cell fractionation, filtration, Distillation, Use of Soxhlet and Rotary evaporator for extraction.

Separation Techniques: Chromatography: Principle, applications, types, thin layer, column, gas, ion exchange chromatography. Electrophoresis: Principle, applications, types.
Spectrophotometry: Principle, applications, types, visible spectrum, UV spectrum, atomic absorption.
Basic principles of Sampling and Preservation: Sampling soil organisms, Invertebrates, Aquatic animals, Mammals, Estimation of population size, Preservation of dry and wet specimens. Preservation techniques – Taxidermy - Rearing techniques, Laboratory and field.

PRACTICAL
Credit Hour: 1

1. Observation of wet mounts of human cheek cells employing bright and dark field microscopy
2. Measurement of cell size: bacterial and eukaryotic
3. Recording of microscopic observations with the help of camera lucida
4. Liquid handling: proper use of pipettes and micropipettes
5. Histological preparations: skeletal muscle, intestine liver and testes
6. Handling of centrifuge machines
7. Thin layer chromatography of amino acids
8. Spectrophotometric estimation of glucose
9. Spectrophotometric estimation of total proteins
10. Preservation of representative animals of various phyla
11. Electrophoretic separation of proteins
12. Electrophoretic separation of DNA

Books Recommended

1. Dean, J. R. 1999. Extraction Methods for Environmental Analysis. John Wiley and Sons Ltd. UK.
2. Cheesbrough, M. 1998. District Laboratory Practice in Tropical Countries. Part I. Cambridge University Press, UK.
3. Cheesbrough, M. 1998. District Laboratory Practice in Tropical Countries. Part II. Cambridge University Press, UK.
4. Curos, M. 1997.Environmental Sampling and Analysis: Lab Manual. CRC Press LLC. USA.
5. Curos, M. 1997.Environmental Sampling and Analysis: For Technician. CRC Press LLC. USA.
6. Slings by, D., Cock, C.1986. Practical Ecology. McMillan Education Ltd. London.

PRINCIPLES OF SYSTEMATICS

Course Code: ZOOL 363
Theory Credit Hours: 2

The course aims to:

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

Course Contents

- **Importance and applications of systematics:** Taxonomy in Animal science, systematics as a profession and its future perspectives.
- **History of taxonomy**: systematics, basic terminology of systematics, theories of biological classifications.

- **Taxonomic characters**: Kinds and weightage, micro taxonomy, taxonomic categories: specific category, intraspecific category, higher categories; Species concept.
- **Typological species concept**: Nominalist species concept, biological species concept, Evolutionary species concept. Kinds of different species, Speciation,
- **Taxonomic procedures**, taxonomic collection; their preservation and duration, Taxonomic keys, different kinds of keys and their merits and demerits.
- **Formation of specific names,** brief concept of cladistics, phylogenetics. Theory and practice of cladistics and phylogenetic systematics.
- **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

Credit Hour: 1

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.

Text and Reference Books

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

WILDLIFE

Course Code: ZOOL 364

Theory Credit Hour: 2

Objectives The students will learn:

- About wildlife, distribution pattern world over
- Regarding wildlife of Pakistan, threatened, endangered species
- Modern techniques used in animal tracking, data collection
- How to protect, maintain, control and preserve the health and environment of wildlife.

Course outline

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

a) Provincial Rules
b) Federal Management of Wildlife (NCCW)

5. **National and International agencies involved in conservation and management of wildlife**
   a) National Organizations
   b) International Organizations
6. **Protected Areas in Pakistan**
   a) Sanctuaries
   b) Game Reserves
   c) National Parks
7. **Ramsar convention**
   a) Wetlands
   b) Ramsar Criteria
   c) Ramsar Sites
8. **Threatened species of Pakistan.**
   a) Vulnerable
   b) Endangered
   c) Critically Endangered

PRACTICAL
Credit Hour: 1

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

Text and Reference Books

1. Miller, A.S. and Harley, J.B., 1999 & 2002. Zoology, Latest Edition (International). Singapore: McGraw Hill.
2. Ali. S.S. 2005 Wildlife of Pakistan.
3. Odum, E.P., 1994. Fundamentals of Ecology, W.B. Saunders.
4. Smith, R.L. 1980. Ecology and Field Biology, Harper and Row.
6. Roberts, T. J., 1991, 1992. The Birds of Pakistan, Vol. I1 and II. Oxford University Press
7. Roberts, T. J., 1997. The Mammals of Pakistan, Oxford University Press
8. Robinson, W.L. and Bolen, E.G., 1984. Wildlife Ecology and Management. McMillan, Cambridge.
9. Wildlife of the Punjab, Punjab Wildlife Department.
10. Khan M. S. 2011, Amphibian and Reptiles of Pakistan
11. Mirza Z.B. 2011 Biodiversity of Pakistan.

ANIMAL PHYSIOLOGY

Course Code: ZOOL 365
Theory Credit Hour: 2

Objectives

The course aims to

- Provide information about the physiological mechanisms underlying animal functions.
- Enable students to understand neuro-endocrine coordination, physiology of heart, hemodynamics and kidney function.
- Impart information on respiratory function and gut physiology
- Give understanding about the mechanism of homeostasis, physiological regulation of

temperature and its maintenance

Course Contents

Central themes in Physiology: Homeostasis, Concepts of conformity and regulation; physiological adaptations.
Membrane Physiology: Ionic distribution across membrane, Resting membrane potentials: Electrogenic ion pump, Donnan equilibrium, Ion channels

Nerve and Muscle Physiology: Action potentials in neurons; Electrical and chemical synaptic transmission; Neurotransmitters; Excitatory and inhibitory postsynaptic potentials; Muscles: Structure, types, components, muscle proteins, molecular basis of muscle contraction:

Receptors Physiology: Receptor types: Mechanoreceptors, Olfactory and taste receptors, Photoreceptors, Photochemistry and Phototransduction.

Endocrine Physiology: Gland types; Hypothalamus, Pituitary, Thyroid, Parathyroid, Pineal, Pancreatic Islets, Gastric glands, Adrenal, Ovary, Testis, and Placenta; Overview of hormones; Feedback mechanisms.

Cardiovascular Physiology: Electrical activity of heart: Autorhythmic, Electrocardiography, Kymography; Hemodynamic, Relationship between blood flow, pressure, and resistance.

Respiratory Physiology: Respiratory epithelia, gas exchange in gills and lungs; Transport of O2 and CO2, Structure of alveoli, lung volumes and capacities, surfactants, control of breathing; hypoxia; Hypercapnia

Renal Physiology: Osmoregulation in aquatic and terrestrial animals; Kidney and Vertebrate nephron as osmoregulatory and excretory organ: Glomerular filtration, Tubular absorption and secretion; Nitrogenous waste products.

Physiology of Digestion: Physiologic anatomy of digestive tract (mammalian model), Regulation of digestive secretions; Absorption of water, ions and nutrients; Deglutition, Peristalsis, Absorption, Assimilation and defecation.
Temperature Regulation: Temperature classification of animals; Temperature relation of ectotherms in freezing and cold and warm and hot environment; Dormancy: Sleep, Torpor, Hibernation and Estivation

PRACTICAL

Credit Hour: 1

1. Determination of haemoglobin content, cell counting.
2. Preparation of blood smears.
3. Nerve muscle preparation
4. Recording of action potential by oscilloscope and demonstration of its various features. Experiments to demonstrate characteristic of reflex arc. Experiment in human (students themselves) to demonstrate some aspect of sensory physiology.
5. Normal cardiac activity, effect of temperature, effect of drug, heart block, tetanization of heart. Measurement of blood pressure.
6. Oxygen consumption in fish and effect of temperature (by dissolved oxygen meter) and terrestrial animal (mouse). Oxygen consumption (by respirometer), heart rate, blood pressure glycemia altered by exercise.
7. Effect of insulin on glycemia, study of stages in oestrous cycle.

Books Recommended

1. Guyton, A.C., Hall, J.E. 2013. Textbook of Medical Physiology, 10th Ed. W.B. Saunders Company, Philadelphia. Sherwood 2013
2. Tharp, G., Woodman, D. 2010. Experiments in Physiology, 10th Ed. Bejamin Cummings.
3. Fox, S. 2010. Laboratory manual of human physiology. McGraw-Hill Sciences.
4. Randall, D., Burggren, W., French, K., Fernald, R. 2002. Eckert Animal Physiology: Mechanisms and Adaptations, 5th Ed. W.H. Freeman and Company, New York
5. Bullock, J., Boyle, J., Wang, M.B. Physiology, 4th Ed. 2001. Lippincott, Williams and Wilkins, Philadelphia.
6. Berne, R.M., Levy, M.N. 2000.Principles of Physiology, 3rd Ed. St. Lious, Mosby.
7. Withers, P.C. 1992. Comparative Animal Physiology. Saunders College Publishing, Philadelphia.
8. Schmidt-Nelsen, K. 1997. Animal Physiology, Adaptation and Environment, 5th Edition. Cambridge University Press,Cambridge.

GENERAL BIOCHEMISTRY

Course Code: ZOOL 366
Theory Credit Hour: 2
Course objectives:

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

Course Contents

1. Introduction to Macromolecules
   a. Structure, types and role of various building blocks their respective macromolecules.
   b. Carbohydrates:
   Introduction; Classification Stereoisomerism in carbohydrate, Structure, types and role of monosaccharides, oligosaccharides and
   c. polysaccharides; Glycosaminoglycans and glycoconjugates.
   d. Carbohydrates as an information carrier molecule.
2. Amino acids, peptides & proteins:
   a. Types of amino acids & their classification.
   b. Uncommon amino acids; Acid/base behaviour of amino acids.
   c. Titration curves in amino acids and their importance:
   d. Peptides & proteins.
   e. Biologically active peptides & polypeptides.
   f. Amino acid sequence in proteins & their importance; Conjugated proteins.

2.1. Purification Techniques for Proteins

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

2.2. **Organization of proteins**:

a. Structural levels of proteins; Covalent structure of proteins.
b. & function of some structural & functional proteins; Haemoglobin, Cytochrome-c: Chymotrypsin, alpha Keratin and Collagen.
c. Proproteins, their examples and role.

3. **Enzymes**
   a. Enzymes, their importance, classification & nomenclature, Function & inhibition.
4. **Lipids**:
   a. Introduction & classification of lipids; Fatty acids, their types; Storage lipids.

4.1. Classification and important characteristics.

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

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

PRACTICAL
Credit hour: 1

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

Books Recommended

1. Nelson, D. L., Cox, M. M. 2012. Lehninger Principles of Biochemistry. McMillan worth Publishers, New York.
2. Berg, J. M., Tymoczko,J. L., Lubert Stryer. 2010. Biochemistry. 7th Ed. Lodish, H., Berk, A., Zipursky, S. L., Paul. M., Baltimore D.,Darnell, J. 2012. Molecular Cell Biology.
3. McKee, T., McKee, J.R. 2003.Biochemistry: The Molecular Basis of Life. 3rd Edition, McGraw Hill.
4. Wilson, K., Walker, J. 1994.Practical Biochemistry: Principles and Techniques, 4th Ed., Cambridge University Press.
5. Mushtaq Ahmad. Biochemistry. Vol. I and II.

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
05-Dec-2023

BS 4th YEAR SEMESTER–VII

Course Code	Course Title	Course nature	Credits
ZOOL 471	Ecology and Environmental Biology	Major	3(2+1)
ZOOL 472	Economic Zoology	Major	3(2+1)
Optional*	Special Paper	Major	3(2+1)
Optional*	Elective- I	Major	3(2+1)
ZOOL 473	Field work/Research work	Major	3
Teaching of Holy Quran with Translation (for Muslim Students)		Non-Credit	
Total			**15**

*. - the course should be selected from the list of special/ elective courses

ECOLOGY AND ENVIRONMENTAL BIOLOGY
Course Code: ZOOL 471
Theory Credit Hour: 2

Objectives The main goal of this course is to:

- Enable students to develop strong expertise in contemporaneous themes in ecological research
- Develop critical thinking and discuss advanced topics in population, community and ecosystem ecology as well as in biodiversity research.
- Develop expertise to update their knowledge continuously, and to design their own research in ecology.

Course Contents

Energy: laws of thermodynamics, primary and secondary productions, trophic levels and energy variation with increasing trophic levels, energy flow, food chains and food webs. Biogeochemical cycle: nitrogen, phosphorus, sulfur, water, carbon, nutrient. Limiting factors: basic concepts, temperature, soil, water and humidity, light, fire.

Global ecosystems: (atmosphere, hydrosphere, lithosphere, ecosphere). An overview of ecosystem with special reference to ecological niche: basic concepts and types. Major ecosystem of world: Marine, Estuarine, Freshwater, Wetlands, Tundra, Forest, Grassland, Desert and Agricultural ecosystems.

Population ecology: basic population characters, growth and growth curves, population dynamics and regulations. Community ecology: basic concepts, community analysis, ecotones, inter-population interactions.

Applied Ecology: resources and their ecological management (mineral, agricultural desalination and weather modification, forest and range management, landscape and land use);

Pollution: (definition, types, cost, origin and management); water (sources, domestic and industrial pollution, heavy metals); air (sulpher dioxide, nitrogen oxide, carbon monoxide, ozone, smog and PAN, MTBE & CFCs); land pollution (pesticides, bacterial toxins, synthetic hormones); noise pollution.

Radiation ecology: global environmental changes (ozone depletion, acid rain, greenhouse effect and global warming, Koyota protocol, desertification, deforestation, exotic and invasive species, radioactivity leakage, environmental laws).

PRACTICAL

Credit Hour: 1

1. Measurement of environmental factors on land, water, and air.
2. Study of different ecosystems: pond, agricultural or grassland, forest.

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

3. Community analysis through different sampling techniques (quadrat, Transect),
4. Population studies mark and recapture method, statistical analysis of field data.
5. Adaptive features of animals in relation to food and environment.
6. Food chain studies through analysis of gut contents.
7. Analysis of polluted and fresh water for biotic and abiotic variations.
8. Field visits for study of selected terrestrial habitat and writing notes.
9. Experimental design and approaches in ecological research; writing a research project
10. Development of an ecological management plan of some selected area.

Books Recommended

1. Molles, M.C. 2005. Ecology: Concepts and Applications. 6th Ed., McGraw Hill, New York, USA.
2. Cox, C.B., Morre, D. 2000. Biogeography: An Ecological and Evolutionary Approach, 6th Ed., Life Sciences King's College, London, UK.
3. Dondson, S.I., Allen, T.F.N., Carpenter, S.R., Ives, A., Jeanne, R.L., Kitchell, J.F., Langston, N.E., Turner, M.G. 1998. Ecology. Oxford Univ. Press, UK.
4. Chapman, J.L., Reiss, M.J.1997. Ecology: Principles and Applications. Cambridge Univ. Press, UK.
5. Odum, E. P. 1994. Fundamentals of Ecology. 3rd Ed. W.B. Saunders. Philadelphia.
6. Newman, I. 1993. Applied Ecology. Black Well Scientific Publications Oxford. UK.
7. Slingsby, D., Cook, C., 1986. Practical Ecology. McMillan Education Ltd. UK.
8. Ali Muhammad (2016). Ecology. Islamia Publications, Qisa Khwani Bazar, Peshawar.

ECONOMIC ZOOLOGY

Course Code: ZOOL 472

Theory Credit Hour: 2

Course Objectives

The objectives of the course are: -

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

Course outline:

1. Basic concepts in Economic Zoology.
2. Parasitic protozoans and human disease. Economic importance of protozoa.
3. Vectors of human and domestic animals.
4. Ecto- and Endo-parasites of fish, poultry, cattle and Man (Crustacea, Helminthes and Arachnida).
5. Pests of pulse crops. Pests of oil seed crops. Stored grain pests. Pests of cotton. Pests of vegetables. Pests of fruits. Pests of tea.

6. Apiculture, and Sericulture, Lac insect culture and Pearl culture
7. Aquaculture and Fisheries (Edible Fresh water, Pond and Marine fish, Prawns, Pearl oysters). Economic importance of fishes.
8. Bird farming (Poultry, Quail, Turkey, Ostrich, and Pigeon.

PRACTICAL

1. To study the prepared slides of various types of ecto- and endo-parasites.
2. To observe and study Museum specimens of vertebrate and invertebrate pests of important crops and stored grains in Pakistan.
3. To visit Honeybee farm. Write a report on their observations.
4. Visit to Sericulture farm in a nearby locality and write report on their observations.
5. Study visit to fish Hatchery, Nursery ponds, Stocking ponds, Commercial fish breeding farms and report writing.
6. Identification of important species of Fish and their natural animal.
7. Visit to any bird farm, Fish farm, bee farm, dairy farm and write a report on their observations.

Text and Reference books:

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

SPECIAL PAPER

Theory Credit Hour: 2

Lab (Practical) credit Hour: 1

Note: Course of Special Paper is optional and should be selected from the list of Elective/ Special courses.

Elective-I

Theory Credit Hour: 2

Lab (Practical) credit Hour: 1

Note: Course of Elective-I is optional and should be selected from the list of Elective/Special courses.

Chairman
Department of Zoology,
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

BS 4th YEAR SEMESTER–VIII

Course Code	Course Title	Course Nature	Credits
ZOOL 481	Bioinformatics	Major	3 (2+1)
Optional*	Elective-II	Major	3 (2+1)
Optional*	Elective-III	Major	3 (2+1)
Optional*	Elective-IV	Major	3 (2+1)
ZOOL 500	Capstone Project/Thesis	Major	3
Teaching of Holy Quran with Translation (for Muslim Students)		Non-Credit	
Total			**15**

*. - the course should be selected from the list of special/ elective courses

BIOINFORMATICS

Course Code: ZOOL 481

Theory Credit Hour: 2
Objectives

The course will provide:

- An introduction to bioinformatics with a focus on fundamental bioinformatics problems,
- Information on the tools used to compute solutions to those problems, and the theory upon which those tools are based.

COURSE CONTENTS

Introduction to BI: What is BI; history of BI; Uses of BI (Protein, Gene); comparison of BI with experimental tools.

Basic principles of computing in bioinformatics: Basic acquisition and database: DDBJ, NCBI and EMBL.

Retrieving protein sequences from database (FASTA): Alignment of protein\ nucleotide sequences (BLAST, CLUSTALW); Computing physico- chemical parameters of proteins (PROTPARAM); Predicting elements of secondary structure of proteins (PSSP); Retrieval, understanding and predicting 3D structure of protein from sequence; UniProt, SwissProt.

Short introduction to DNA/RNA and protein: structure, genetic code; analysing the DNA/RNA, amino acids sequence using BI tools; sequence-structure- function.

Retrieving the DNA sequence from database; Computing the sequence Identifying restriction sites; Predicting elements of DNA/RNA secondary structure; Computing the optimal alignment between two or more DNA sequences.

PRIMER designing for PCR (PRIMER3+, PRIMER-BLAST)

Short introduction to proteomics and genomics, and the role of bioinformatics in the pharmaceutical industry.

Phylogenetic Analysis; MEGA, EMBL, IQ-tree, CIPRES.

PRACTICAL
Credit Hour: 1

1. Retrieval of FASTA sequence
2. Determination of proteins physical and chemical parameters

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

3. Finding similar sequences for protein and DNA
4. Multiple alignment
5. Predicting protein secondary structure
6. Predicting protein PTM
7. Finding protein families
8. Determination of gene location on chromosome
9. SNPs
10. Primer design

Books Recommended

1. Baxevanis, A.D., Ouellette, B.F.F, 2011. Bioinformatics: A Practical Guide to The Analysis of Genes and Proteins. John Wiley & sons, Inc.
2. Rastogi, S.C., Mendiratta, N.,Rastogi, P. 2011. Bioinformatics Methods and Applications: Genomics, Proteomics and Drug Discovery. PHI publishing.
3. Selzer, P., Marhofer, R. and Rohwer, A. 2008. Applied Bioinformatics: An Introduction. Springer publishing, Germany.
4. Westhead, D.R., Parish, J.H., Twyman, R.M. 2003. Instant Notes on Bioinformatics. Viva Books Private Limited.
5. Orengo, C. A., Jones, D.T., Thornton, J.M. 2003. Bioinformatics: Genes, Proteins and Computers (Advanced Text). Roultledge.
6. Krane, D.E. and Raymer, M.L. 2002. FUNDAMENTAL CONCEPTS OF BIOINFORMATICS. Benjamin Cummings.
7. Gibas, C. and Jambeck, P. 2001. Developing Bioinformatics Computer SKILLS. O'Reilly publishers.

Websites

1. http://www.ncbi.nlm.nih.gov
2. http://www.ebi.ac.uk
3. http://foldoc.doc.ic.ac.uk/foldoc/index.html
4. http://wit.integratedgenomics.com/GOLD/

Capstone Project/Thesis — Credit Hour: 3

Elective-II

Theory Credit Hour: 2
Lab (Practical) credit Hour: 1
Note: Course of Elective-II is optional and should be selected from the list of Elective/Special courses.

Elective-III

Theory Credit Hour: 2
Lab (Practical) credit Hour: 1
Note: Course of Elective-III is optional and should be selected from the list of Elective/Special courses.

Elective-IV

Theory Credit Hour: 2
Lab (Practical) credit Hour: 1
Note: Course of Elective-IV is optional and should be selected from the list of Elective/Special courses.

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
University of Malakand
05-Dec-2023

LIST OF ELECTIVE AND SPECIAL COURSES

The courses listed below can be taught as elective subjects. They can also be taught as special subjects provided there is no overlap of the course contents studied earlier.

S. No	Course Title	Course
1	Animal Care	ZOOL 01
2	Animal Management	ZOOL 02
3	Apiculture	ZOOL 03
4	Applied Ecology	ZOOL 04
5	Applied Microbiology	ZOOL 05
6	Aquaculture	ZOOL 06
7	Aquatic Toxicology	ZOOL 07
8	Basic Human Genetics	ZOOL 08
9	Biodiversity and Wildlife	ZOOL 09
10	Biodiversity of Inland and Terrestrial Mollusks	ZOOL 10
11	Biology and Control of Vertebrate Pests	ZOOL 11
12	Cancer Genetics	ZOOL 12
13	Climatology	ZOOL 13
14	Clinical Biochemistry	ZOOL 14
15	Comparative Developmental Biology	ZOOL 15
16	Ecotoxicology	ZOOL 16
17	Endocrinology	ZOOL 17
18	Entomology-I (Insect Morphology and Taxonomy	ZOOL 18
19	Entomology-II (Insect Anatomy and Physiology)	ZOOL 19
20	Entomology-III (Insect Pest Management)	ZOOL 20
21	Environmental Entomology	ZOOL 21
22	Environmental Geology	ZOOL 22
23	Environmental Issues	ZOOL 23
24	Environmental Physiology	ZOOL 24
25	Environmental Pollution	ZOOL 25
26	Environmental Health and Toxicology	ZOOL 26
27	Fish Culture	ZOOL 27
28	Fish Ecology	ZOOL 28
29	Fish Feeding Management	ZOOL 29
30	Fish Physiology and Breeding	ZOOL 30
31	Forensic Entomology	ZOOL 31
32	Fundamentals of Microbiology	ZOOL 32
33	General and Comparative Endocrinology	ZOOL 33
34	General Teratology	ZOOL 34
35	Helminthology and Host-Parasite Relationship	ZOOL 35
36	Hematology	OOL 36

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

37	Herpetology	ZOOL 37
38	Ichthyology	ZOOL 38
39	Immunology	ZOOL 39
40	Insecticides and Public Health	ZOOL 40
41	Insect Ecology	ZOOL 41
42	Medical Entomology	ZOOL 42
43	Introduction to Environment	ZOOL 43
44	Lac Culture	ZOOL 44
45	Limnology	ZOOL 45
46	Mammalogy	ZOOL 46
47	Microbiology and Biotechnology	ZOOL 47
48	Molecular Basis of Endocrinology	ZOOL 48
49	Molecular Toxicology	ZOOL 49
50	Molecular Genetics	ZOOL 50
51	Neurobiology	ZOOL 51
52	Ornithology	ZOOL 52
53	Physiological Systems and Adaptations	ZOOL 53
54	Physiology of Coordination	ZOOL 54
55	Population Biology	ZOOL 55
56	Principles and Kinetics of Toxicology	ZOOL 56
57	Principles of Fish Biology	ZOOL 57
58	Principles of Parasitology	ZOOL 58
59	Protozoology	ZOOL 59
60	Reproductive Biology	ZOOL 60
61	Restoration Ecology and Sustainable Development	ZOOL 61
62	Sericulture	ZOOL 62
63	Teratology	ZOOL 63
64	Toxicology	ZOOL 64
65	Vector Biology	ZOOL 65
66	Vitamins and Hormones	ZOOL 66
67	Wildlife Parasitology	ZOOL 67
68	Malacology	ZOOL 68
69	Agricultural Entomology	ZOOL 69
70	Forest Entomology	ZOOL 70
71	Principles of Ornithology	ZOOL 71
72	Protozoology and immunology	ZOOL 72
73	Quantitative Zoology	ZOOL 73
74	Radiation Biology	ZOOL 74
75	Medical Genetics	ZOOL 75
76	Forensic Genetics	ZOOL 76
77	Taxidermy	ZOOL 77
78	Taxonomy	ZOOL 78

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
(Examinations)
University of Malakand
05-Dec-2023

79	Techniques in Fisheries Research	ZOOL 79
80	General Teratology	ZoolOpt80

COURSE CONTENTS OF ELECTIVE AND SPECIAL COURSES

AQUACULTURE

Course Code: ZOOL 06
Theory Credit Hour: 2
Objectives

- To equip the students with advanced knowledge about aquaculture, its development and future role in human nutrition. This will enable the young students to understand principles of aquaculture and its relationship with biological systems which is important for better planning and management of aquatic resources in Pakistan
- To teach about different aquaculture species, their rearing facilities and management by using advanced techniques

Course Contents

The concept of aquaculture; principles of aquaculture management. Aquaculture in raceways, cages and enclosures, comparative aquaculture economics of a cage, raceway and enclosure. Use of wastewaters in aquaculture. Mariculture: Substrate system, sea water ponds. Aquaculture in fresh and brackish waters. Aquaculture in practice: Culture of algae, seaweeds, mollusks and crustaceans. Integration of aquaculture with agriculture poultry and livestock farming. Culture of freshwater prawns and shrimps: History of development, present status, breeding requirements, incubation and hatching of eggs, rearing of larvae and juveniles. Artificial feeds for aquaculture: Feed constituents, diet formulation and processing. Role of biotechnology in sustainable aquaculture development.

PRACTICAL
Credit Hour: 1

1. Determination of water quality for aquaculture
2. Determination of metals (Cd, Zn, Co, Mn, Fe) in water, plankton and fish
3. Fish feed formulation and processing

Books Recommended

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

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
05-Dec-2023

6. Chakraborty, C. and A. K. Sadhu. 2001. Biology, Hatchery and Culture Technology of Tiger Prawn and Giant Freshwater Prawn. Dya Publishing House, New Delhi, India.

AQUATIC TOXICOLOGY

Course Code: ZOOL 07

Theory Credit Hour: 2

Learning outcomes

After studying this course, student would be able to:

- understand the basic concept of aquatic ecotoxicology, including bioaccumulation, trophic transport of contaminants, biomarkers, specific challenges, and *in vitro* toxicology.
- be aware of the behavior of fish in response to toxicants
- know the factors affecting chronic environmental toxicity

Course Contents

Introduction and background of aquatic toxicology, Definitions, sources of contamination: water pollution, General concepts in toxicology. Transport of pollutants, Factor affecting distribution and fate, bioavailability and bioaccumulation, biotransformation, metabolism and de-toxification, Heavy metals, organics. Behavioral responses of fish to toxicants. Toxicity assessments and environmental regulations. Factors affecting the chronic environmental toxicity, Ecotoxicity.

PRACTICAL

Credit Hour: 1

1. Determination of physico-chemical parameters in relation to metal's toxicity.
2. Determination of acute (LC_{50} and lethal concentrations) toxicity of metals by using Probit Curve
3. Effects of chronic metals toxicity on fish growth

Recommended books

1. Walker, C.H., Sibly, R.M., Hopkin, S.P. and Peakall, D.B., 2012. Principles of ecotoxicology, 4th ed. CRC Press, USA.
2. Adel, D., 2007. Water Pollution Biology. CRC Press, USA.
3. Schwarzenbach, R.P., Gschwend, P.M. and Imboden, D.M., 2005. Environmental Organic chemistry. 3rd ed. Wiley and Sons, USA.
4. Blaise, C. and Ferard, J.F., 2005. Small Scale Freshwater Toxicity Investigation: Toxicity Test Methods. Springer, USA.
5. Mason, C.F., 2002. Biology of Freshwater Pollution. Prentice Hall, USA.
6. Klaasen, C.D., 2001. Casarett and Doull's Toxicology The basic science of poisons. McGraw-Hill Company, USA.
7. Rand, G.M., 2001. Fundamentals of Aquatic Toxicology, 2nd ed. Taylor and Francis Publisher, USA.

BASIC HUMAN GENETICS

Course Code: ZOOL 08
Theory Credit Hour: 2

Objectives

- To provide an overview of human genetic concepts and clinical disorders
- To teach students how to apply the knowledge of medical genetics to a variety of clinical genetic diseases

Course Contents

Nucleic acids.
Genetic linkage: family method, somatic cell hybridization, deletion mapping and duplication mapping.
Introduction to human genome.
Karyotyping. Patterns of transmission of single gene traits: Pedigree analysis with criteria for identification of various modes of inheritance.
Genetic defects in prenatal development; oncogenes and cancer, normal chromosomes, congenital malformations.
Introduction to Human genome project.

PRACTICAL

Credit Hour: 1

1. Pedigree analysis.
2. Karyotyping of normal and abnormal human chromosomes.
3. Screening of metabolic and other disorders.
4. Problems solving on genetic counseling.
5. Orientation with different molecular techniques including PCR, RFLP

Books Recommended

1. Strachan, T., A. P. Read, Human Molecular Genetics, 3rd edition, Garland Science/Taylor & Francis. 2003.
2. Ehrlich P.R., Human Natures: Genes, Cultures, and the Human Prospect, 1st edition, Penguin USA Paper, 2002.
3. Relethford J. H., Genetics and the Search for Modern Human Origins, Wiley-Liss 2001.
4. Molecular Biology of the Cell, 4th Ed. Garland Publishing Inc. New York.2002.

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
University of Malakand
05-Dec-2023

BIODIVERSITY AND WILDLIFE

Course Code: ZOOL 09

Theory Credit Hour: 2

Objectives

- to enable student to understand biodiversity levels, functions and its importance
- to acknowledge Wildlife of Pakistan and its importance
- to learn Wildlife census techniques

Course Contents

Biodiversity: Definition, Types, Levels, Status of Biodiversity; Importance

Natural Resources and Biodiversity: Ecological aspects of Biodiversity, Impacts on Biodiversity, Loss of Biodiversity, Protection/Conservation of Biodiversity.

Wildlife: Introduction, important wild animals of Pakistan, Wildlife importance, Wildlife Management.

Ecozones of Pakistan: wildlife and its distribution in different major ecozones of Pakistan.

Wildlife census techniques: Modern census techniques for Mammals and Birds, diversity indices.

PRACTICAL

Credit Hour: 1

1. Procedures for studying species richness, Simpson Index, Shannon and Weiner Function.
2. Population of some local subterranean animals.
3. Bird's population Census Techniques.
4. Mammal's population Census Techniques.
5. Study of Wildlife habitats.

Books Recommended

1. Kumar & Asija, 2000 Biodiversity, Principles and Conservation.
2. Mary Jenking and Ann Boyce, 1987. The Diversity of Life.

A. R. Rehmani and Salim Ali: Birds Censing Techniques.

BIODIVERSITY OF INLAND AND TERRESTRIAL MOLLUSKS

Course Code: ZOOL 10

Theory Credit Hour: 2

Objectives

The course is designated to provide with:

- Principles of evolutionary relationship to other animals
- Concept of phylogenetic relationship emphasizing on knowledge about animal kingdom

- Knowledge and focuses on strategies regarding the conservation of Gastropods and Bivalves and to develop pearl industry

Course Contents

Evolutionary perspective; Phylogenetic relationship with other animals; Origin of Coelom; Molluscan characteristics; Diagnostic features of shell and associated structures; Mechanism of feeding, digestion, gas-exchange, locomotion, reproduction and development in Gastropods and Bivalves; Slugs Characteristics and classification; Structure and function of Radula; Torsion and Detorsion in Gastropods. Pearl culturing; Threats; Conservative strategies and Economic importance of Molluscs.

Books Recommended

1. Miller, A. S. and Harty, I. B. 2002. Zoology. 4th Edition (International) Singapore McGraw Hill.
2. Baker, G. 2001. The Biology of Terrestrial Molluscs. 3rd Edition.
3. Rober, T. and Dilton, Jr. 2000. The Ecology of Freshwater Molluscas. Cambridge University Press 1-499.
4. Preston, S. B. 1915. Mollusca (Freshwater Gastropods and Decapods). Fauna of British India including Ceylon and Burma. 244 p. Taylor and Francis Red Lion Court, London.

PRACTICAL
Credit Hour: 1

1. Study of Museum Molluscan Specimens
2. Study of Gastropods and Bivalves shell
3. Classification of Gastropods and Bivalves representatives
4. Study of different parts and dissection of the representatives of Gastropods and Bivalves
5. Field study trips on diversity with emphasis on their adaptation.

BIOLOGY AND CONTROL OF VERTEBRATE PESTS

Course Code: ZOOL 11
Theory Credit Hour: 2

Objectives

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

Course Contents

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

hazardous diseases by vertebrate pests and their management.

PRACTICAL

Credit Hour: 1

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

Books Recommended

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

COMPARATIVE DEVELOPMENTAL BIOLOGY

Course Code: ZOOL 15
Theory Credit Hour: 2

Objectives

The course will provide detailed knowledge about the:

- Principal features of development, cellular basis of morphogenesis,
- Mechanisms of cellular differentiation and concepts of induction in development. It will provide understanding of the mechanisms of organogenesis, factors controlling growth and organogenesis.
- Concept related to the theory in developmental biology will be practically demonstrated in this course.

Course Contents

Historical review of embryology. Uses of modern molecular techniques in developmental biology. Origin of germ cells (gametogenesis). Spermatogenesis & Oogenesis, Structure, and organization of male and female gametes.
Fertilization: Chemistry of fertilization, Molecular biology of fertilization, surface changes in the egg and sperm surface, *In vitro* Fertilization (test tube technology). Mono- & Di-zygotic Twinning,
Parthenogenesis, Uses of Transgenic animals in Developmental biology, Cleavage, Blastulation, Fate maps and their preparation,
Morphogenetic movements and Gastrulation in Amphioxus, mammals, chick, and frog. Stem cells technology and its uses in developmental biology.
Embryonic adaptations (fetal extra-embryonic membranes) and Placentation, Umbilical cord, Parturition (birth) and its stages.
Regeneration and regenerative powers of vertebrates. Aging

PRACTICAL
Credit Hour: 1

1. Study of model eggs of different invertebrates and vertebrates.
2. Dactylography, and its uses in embryology.
3. Isolation, identification, and culture of various developmental stages of *Ascaris lumbricoides* eggs from human/ *Neoascaris vituolarum* eggs from cattle dung (kept for 3 weeks at 240C in desiccator) by using Telman's centrifugation technique.
4. Study of prepared slides for the development of Amphioxus, mammals, frog and chick.
5. Semen analysis by using improved Neubar Hemocytmeter, Use of dactylography in developmental biology,
6. Peripheral blood smear (abnormal erythrocyte morphology eg., target cells, microcyte, macrocytes, slit cell, acanthocytes & tear drop cells as screening procedure for thalassemia diagnosis.

Books Recommended

1. Scott, F. Gilbert (2010). Developmental Biology, 9th Edition. Sinauer Publishing Co., New York.
2. Patten, B.N. (2004). Foundation of Embryology. McGraw Hill Books Company, Inc, New York, London.
3. Rao, K.V. (2003). Developmental biology: A modern synthesis. Oxford is publishing Co. Ltd., Delhi.
4. Oppenheiner, S.B & Lefevre, G. (1984). Introduction to Embryonic Development. Allen and Bacon Publishers, New York.
5. Saddler, T. W. (1995). Langmans Medical embryology. Library of congress Cataloguing-in-Publication Data. Williams & Wilkins Publishers, USA.
6. Carlson, B.M. (2001). Patten's Foundations of Embryology (6th Edition). McGraw-Hill, Inc. New York, London, Tokyo, Sydney.

ENTOMOLOGY-I (INSECT MORPHOLOGY AND TAXONOMY)

Course Code: ZOOL 18
Theory Credit Hour: 2
Aims and Objectives:
This course will contribute in the understanding of insect morphology, identification and classification of insects.
Course Contents
Insect Morphology
An introduction of Entomology with a brief description of different classes of Arthropods. Complete morphology of an insect. General characteristics of insects. Segmentation, tagmatosis and organization. Exoskeleton and the integument of insects. Cuticle: Detailed structure along with its biochemistry. Epidermal layer; its structure and function. Basement membrane. Cuticular outgrowths and appendages, sclerotization. Head: cephalization, sclerites, modifications. Antennae: parts and types of antennae. Types of mouth parts. Neck: Sclerites. Thorax: sclerites. Legs: parts and modification of legs. Wings: regions of

wings, venation, types of wings, wing coupling. Abdomen: secondary appendages and external genitalia. Colors of insects.

Classification of Insects

A general account including classification of insect orders: Collembola, Orthoptera, Dictyoptera, Isoptera, Hemiptera, Lepidoptera, Diptera, Hymenoptera, Coleoptera. Only diagnostic characters of the remaining insect orders: Thysanura, Diplura, Protura, Ephemeroptera, Odonata, Plecoptera, Grylloblattoidea, Phasmida, Dermaptera, Embioptera, Zoraptera, Psocoptera, Mallophaga, Siphunculata, Thysanoptera, Neuroptera, Mecoptera, Tricoptera, Siphonaptera, Strepsiptera.

PRACTICAL

Credit Hour: 1

1. Preparation of permanent slides. All the hard parts (antennae, mouth parts, wings, legs, terminal segments and genitalia of different insects).
2. To study the whole mounts of Collembola, silverfish, thrips, aphids, lice and fleas.
3. Preparation of killing bottles, collection, preservation, pinning and setting of insects.
4. Field visits for collection of different developmental stages of insects belonging to different orders.
5. Identification and classification of collected specimens.
6. Museum visits

Books Recommended

1. Richards, O.W. and Davies, R.G. IMM'S General Textbook of Entomology. Vol.1, 10th Edition. 1977. Chapman & Hall, London.
2. Richards, O.W. and Davies, R.G. IMM'S General Textbook of Entomology. Vol-2. 1977. Chapman & Hall, London.
3. Snodgrass, R.E., Eickwort, G.C. (1993). Principles of Insect Morphology. Cornell University Press.
4. Gullan, P.J., Cranston, P.S. (2010). The Insects, An Outline of Entomology. 4th Edition, Wiley-Blackwell Publishers.

ENTOMOLOGY-II (INSECT ANATOMY AND PHYSIOLOGY)

Course Code: ZOOL 19

Theory Credit Hour: 2

Objectives:

The students will learn the internal organ systems, their modifications and physiology.

Course Contents

Anatomy and Physiology of various systems with special reference to digestive, nervous, circulatory, respiratory, excretory, and reproductive system. Development and metamorphosis. Hibernation and diapause. Muscular system; basic structure, types of muscles; muscle contraction and its energetics. Sense organs: sound and light producing organs. Nutritive requirements: Fat body, exocrine and endocrine glands including pheromones and their functions. Reproduction: Reproductive organs and different types of reproduction in insects, egg fertilization and maturation. Development: Embryology up to dorsal closure, different types of metamorphosis, apolysis and ecdysis and the role of endocrine secretions.

PRACTICAL

Credit Hour: 1

1. Dissection of insects to study different systems especially digestive and reproductive systems of the following insects: *Periplaneta americana*, *Gryllus*, *Musca domestica*, grasshopper, butterfly, mosquito, any common beetle, red cotton bug, wasp and honey bee.
2. Sympathetic nervous system of *Periplaneta americana* and *Gryllus*.
3. Salivary glands of cockroach, red cotton bug and honey bee.

4. Study of metamorphosis and different types of insects' larvae and pupae.
5. Field visits for the collection of different insects for the study of anatomy and physiology.

Books Recommended

1. Tembhare, Db. Modern Entomology. 2002. Himalaya Publishing House. India.
2. Chapman, R.F. The insects: structure and function. 2000. Blackwell Science Inc., London.
3. Wigglesworth, V. B. The Principles of Insect Physiology 7th Edition. 1982. Springer Publisher.
4. RICHARDS, O. W. and DAVIES, R. G. IMM'S General Textbook of Entomology. Vol.1, 10th Edition. 1977. Chapman & Hall,London.
5. Robert L. Patton. W. B. Insect Physiology. 1963. Saunders Co., Philadelphia.

ENTOMOLOGY-III (INSECT PEST MANAGEMENT)

Course Code: ZOOL 20

Theory Credit Hour: 2

Objectives:

The students will learn to identify the pests damaging to the crops, understand methods of population estimation of the pest, become aware of the applications of different control strategies.

Course Contents:

Study and identification of pests of agriculture, stored grain and households. Insects of economic importance. The principles of pest control/management viz., physical, mechanical, cultural, legislative biological, genetic, chemical and integrated control. Relative merits of various types of insect control. Pest's management practices in Pakistan- an oriental review. Common sampling techniques in insect pest management, concept of economic levels, economic damage and economic boundary, economic injury level and economic threshold. Household pests and their management. Biology and management of the pests of cotton, rice, and sugarcane. Sprayers, dusters, and fumigants.

PRACTICAL

Credit Hour: 1

1. Field visits and report writing of insect fauna of different crops.
2. Field visits for survey of different control strategies being practiced for control of insect pests.
3. Collection, preservation, and identification of different insect pests of agriculture, stored products and household.
4. Operation of various types of sprayers. Dusters, fumigation emulsions.
5. Preparation of insecticide emulsions in different concentrations. The record of laboratory and fieldwork will be maintained and presented at the time of examination.
6. Museum visits.

Recommended Books

1. Pedigo, L.P. Entomology and Pest Management. 1991. Maxwell Macmillan.
2. Metcalf, C.L. and Flint, W.P. Destructive and Useful Insects.1962. McGraw Hill.
3. Atwal, A. S. (1984) Agricultural pests of India and South East Asia. Kalyani Publishers Delhi
4. Green, M. B. Hartley, G.S. & West, T.P. Chemicals for crop protection and pest control, Pergamon Press, New York
5. De Bach, P. Biological control of insect pests and weeds. Chapman and Hall, London

ENVIRONMENTAL HEALTH AND TOXICOLOGY

Course Code: ZOOL 26

Theory Credit Hour: 2

Objectives:

- To provide scientific basis to toxicology as it applies to the workplace and the environment. cover the diverse chemical hazards encountered in the modern workplace and natural environment
- To provide a practical understanding of these hazards for those concerned with protecting the health of humans and ecosystems

Course Contents

Toxicology: History, Terms and Definitions; Principles of Toxicology; Development and present Scope of Environmental Toxicology; Framework of Environmental Toxicology; Toxicological Evaluations. Sources of Environmental Toxicants / Pollutants: Gaseous Chemicals and Heavy Metals. Toxicity Testing. Characteristics of Exposure: Spectrum of Toxic Effects, Indices of Toxicity. Toxico-dynamics. Toxico-Kinetics (Absorption, Distribution, and Elimination of Toxic Agents). Biotransformation, Detoxification & Biodegradation. Pollution and Remediation. Ecological Risk Assessment.

PRACTICAL

Credit Hour: 1

1. Measurement of Environmental Toxicants
2. Sampling of toxicants for Chemical Analysis
3. Risk Assessment

Books Recommended

1. Whitacre, D. M. (Editor) 2012. Reviews of Environmental Contamination and Toxicology. Vol. 223. Spriger, Switzerland.
2. Swarties, F. A. (Editor) 2011. Dealing with Contaminated Sites. From Theory towards Practical Application.1st Edition. 1104 p.
3. Landus, W. G. and Yu, M.H. 2005. Introduction to Environmental Toxicology: Impact of Chemicals upon Ecological Systems. 3rd Edition. Lewis Publishers.
4. James, R. C. and Roberts, S. M. 2000. Principles of Toxicology: Environmental and Industrial Applications, 2nd Edition, Phillip L. Williams (Editor), John Wiley & Sons, Inc.
5. Hughes, W.W. (Editor) 1996. Essentials of Environmental Toxicology. The effects of environmentally hazardous substances on human health. 176 p. Taylor & Francis Ltd.

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Assistant Registrar
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University of Malakand
05-Dec-2023

FISH CULTURE

Course Code: ZOOL 27

Theory Credit Hour: 2

Objectives

- To disseminate the history, needs and importance of fish culture
- To elaborate the basic components of pond fish culture
- To describe the cultureable fish species and their biology
- To impart knowledge regarding pond fertilization and feeding of fish

Course Contents

Aims and evolution of fish culture. Pond fish culture: Planning and construction of fish pond, water quality criteria, conditions suitable for fish culture, biological production cycle of fish pond. Culturable fishes of Pakistan. Fertilization of fish pond: Org

anic and inorganic fertilizers. Artificial feeding in fish culture: Fish feeding methods, different components of fish feed, composition of commonly available feed ingredients, preparation and feed storage methods. Integrated fish farming: Concepts and practices. Fish enemies. Fish diseases and remedial measures. Fish hatchery management. Fishing gears, pre- and post-harvesting care of fish, maintenance of fish catch quality during transportation, storage and marketing. Fish processing technology.

PRACTICAL

Credit Hour: 1

1. Uses of different organic and inorganic fertilizers in fishponds
2. Identification of various fishes
3. Study of morphological characters and identification of culturable fish species
4. Practical demonstration of induced fish breeding

Books Recommended

1. Sharma, O. P. 2009. Handbook of Fisheries and Aquaculture. Agrotech Publishing Academy, Udaipur, New Delhi, India.
2. Hart, P. J. B. and J. D. Reynolds. 2008. Handbook of Fish Biology and Fisheries, Volume 2. Blackwell Science Ltd., New York, USA.
3. Horvaph, L., G. Tanes and C. Seagrave. 2002. Carp and Pond Fish Culture Fishing News Book, New York, USA
4. Huet, M. 1998. Text Book of Fish Culture - Breeding and Cultivation of Fish. Fishing News, London, UK.

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University of Malakand
05-Dec-2023

FISH ECOLOGY

Course Code: ZOOL 28

Theory Credit Hour: 2

Objectives

- To elaborate the interaction of fish and aquatic environment
- To describe the effects of biotic and abiotic factors on fish
- To impart knowledge regarding fish population dynamics

Course Contents

Introduction to fish ecology. Inter-relationship between fish and their abiotic and biotic environments: adaptations of fish to abiotic environmental factors; density, pressure, salinity, temperature, salt content of water, gases in solution and light. Sound and other vibrations. Bottom deposits and particles suspended in water. Movement of water and modes of fish movements. Biotic inter-relationships among fishes; intra-specific relationships between fishes and bacteria, viruses, plants and other animals. Competition and predation in freshwater communities. Fundamental links in life cycle of fishes: reproduction and development in fishes; population dynamics; movement, migration and colonization in fishes, spawning, feeding and over-wintering migrations. Over-wintering and hibernation in fishes; feeding and feeding relationships among fishes.

PRACTICAL

Credit Hour: 1

1. Study of fishes with special reference to food and feeding habits.
2. Fish population estimation.
3. Study of fish with special reference to changes in ecological conditions.

Books Recommended

1. Harold M. Tyus, 2011. Ecology and Conservation of Fishes. CRC Press, Taylor and Francis Group, USA
2. Pandey B.N. 2004. Fish Research. APH Publishing Corporation.
3. Kaui Bansi Lal. 1999. Advances in Fish and Wildlife Ecology and Biology. Daya Publishing House Delhi.
4. Moss, B. 1998. Ecology of Freshwaters. Blackwell Scientific Series, U.K.
5. Kaul, B.l., 1996. Advances in Fish and Wildlife Ecology and Biology (Vols. I & II). Daya Publishing House, N. Delhi.
6. Jafferies, M. and Mills, D. 1992. Freshwater Ecology: Principles and Applications. CBS Publishers and Distributors Ltd., N. Delhi.

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

FISH FEEDING MANAGEMENT

Course Code: ZOOL 29
Theory Credit Hour: 2

Objectives

- To elaborate the significance of fish feeding,
- To impart the basic principles of artificial feed preparation,
- To understand the fate of different nutrients in fish

Course Contents

Need of supplementary/ artificial feeding of fish, Scope of artificial feeding in fish, Metabolism of feed nutrients (Protein, Lipid, Carbohydrate) in fish, Feeding practices, Different types of feeders, Diet preparation and processing techniques, Estimation of apparent nutrient digestibility. FCR and FCE indices, Food acquisition and patterns of estimation of food requirements.

PRACTICAL
Credit Hour: 1

1. Ration calculation for fish feeding based on body weight, body length etc.
2. Estimation of basic nutrients in feed i.e. moisture, protein, lipid, carbohydrates and ash.
3. Formulation of fish feed.

Books Recommended

1. Lovell, T., 2012. Nutrition and Feeding of Fish. 2nd Ed. Springer Science, USA
2. Pillay T V R, M N Kutty. 2005. Aquaculture: Principles and Practices. Balckwell Publishing. UK.
3. Reddy, M.S. and Sambasiva K.R.S. 1999. A Textbook of Aquaculture. Discovery Publishing House, N. Delhi.
4. Pillay, T.V.R. 1999. Aquaculture: Principals and Practices. Fishing News Books, London.

FISH PHYSIOLOGY AND BREEDING

Course Code: ZOOL 30
Theory Credit Hour: 2

Objectives

- to provide enough knowledge about all physiological phenomena in fishes.
- to provide practical information to obtain better growth during extensive or semi-intensive culture.
- to impart knowledge about breeding of most culturable freshwater fishes by manipulating reproductive and endocrinological aspects during natural season as well as off seasons

Course Contents

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

Transportation: Blood; Blood cells (Erythrocytes, leukocytes, Platelets and plasma); Circulation; Arterial system; Venous system; Capillaries; Transport of food material.

Respiration: Gills; Lungs; Skin; Swim bladder; Homeostasis.

Excretion: Kidneys; Hypo-osmotic urine; Hyper-osmotic urine; Osmoregulation.

Reproduction: Gonads; Testes and ovaries; Maturation; Reproductive cells (egg and sperm); Artificial fertilization of sex cells.

Breeding: Natural (seasonal); Artificial; Hormonal induced breeding; Temperature & photoperiod; control induced breeding.

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

Fish health: Water quality; Hygiene of fish culture facilities; Hygiene of equipment used in fish culture.

Diseases and their control: Viral; Bacterial; Fungal; Parasitic; Protozoan; Helminths (trematodes, cestodes, nematodes, acanthocephalons); Crustaceans (cladocera); Annelids (leeches); Arthropods (water ticks, water flea, water mites).

Fish migration: To nursery ground; To maturation grounds; Freshwater to marine water; Marine water to freshwater.

Fish behaviour: Learning and memory; Light response for maturation; Courtship behaviour; Aquarium fish behavior

PRACTICAL
Credit Hour: 1

1. Study of gut contents,
2. Study of feeding modification and adaptation in fish,
3. Study of respiratory adaptation in fish,
4. Study of blood cells and their counts in normal and diseased fish,
5. Study of water quality parameters (DO, NH_3, hardness, alkalinity, turbidity, transparency, temperature, salinity),
6. Study of various forms of swim bladder as hydrostatic organ, Study fecundity of various fish species, Study the effects of reproductive hormone (GnRH) on fish maturation, Diagnosis of bacterial infection in infected fish,
7. Study of fish parasites,
8. Visit to various fish seed hatcheries during breeding seasons

Books Recommended

1. Kestin, S. C. and Warris, P.D. (Editors). 2002, Kestin farmed fish quality, Blackwell Science, oxford, UK.
2. Saksena, D.N. 1999. Ichthyology: recent research advances. Oscar Publications. India**.**
3. Woo, P.T. K 1995.Ffish diseases and disorder. Vol 1. Protozoan and metazoan infections. CABI Publisher.
4. Brenabe, G. 1992. Aquaculture, Vol. I. Blackwell Publishing, Oxford. UK.
5. Maseke C. 1987. Fish aquaculture. Pergamon Press, Oxford. UK.
6. Huet M. 1973. Text book of fish culture: breeding and cultivation. Blackwell Publishing Company
7. Hoar, W.S. 1971. Fish physiology. Academic Press. UK.
8. Hoar, W.S. 1969. Fish reproduction. Academic Press. UK.
9. Matty, A.J. 1985. Fish endocrinology. Timber Press, UK.
10. Gorbman, A. 1983. Comparative Endocrinology. 1st Edition. John Wiley & Sons. UK.

FORENSIC ENTOMOLOGY

Course Code: ZOOL 31

Theory Credit Hour: 2

Course Contents

History and scope of Forensic Entomology. Study of various insect groups and other arthropods related to medico-legal investigations. Involvement of arthropod in puzzling events of murder, suicide, rape, physical abuse, control and trafficking determination of time or post-mortem intervals and location of the death, techniques for gathering evidences. Review and survey of insect life histories, life cycle and faunal succession of arthropods related to medico-legal cases and survey of the following insects as indicators:
Blow flies (Calliphoridae), Flesh flies (Sarcophagidae), House flies (Muscidae), Cheese flies (Piophilidae), Coffin flies (Phoridae), Lesser corpse flies (Sphaeroceridae), Sun flies (Heleomyzidae), Black soldier flies (Stratiomyidae), Rove beetles (Staphylinidae), Hister beetles (Histeridae), Carrion beetles (Silphidae), Ham beetles (Cleridae), Skin hide beetles
(Dermestidae), Scarabs beetles (Scarabaeidae), Wasps (Vespidae), Ants (Formicidae), Bees (Apoidae), Cloth moths (Tineidae) as a mammalian hair feeder, Macrocheles mites as feeder in early stages of decomposition, Tyroglyphids as feeder on dry skin in the later stages of decomposition.
Review of classification of ages in decomposition of human and animal remains, uses of insect and arthropods in investigation of the causes of death and the duration of PMI. Forensic entomology in public health, arthropods borne disease litigation and formulation of health policy.

PRACTICAL

Credit Hour: 1

1. Sampling, rearing, and preservation techniques in forensic entomology.
2. Study of the decomposition of corpses and dead bodies; Survey, identification and biology of insects and arthropods of forensic importance.
3. Study and analysis of court room proceedings regarding medico-legal cases.

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

4. Data processing and preparation of project reports.
5. Field visits to NIM, Universities and research centers for the study of forensic insects.

Books Recommended:

1. Byrd, J.H. and Costner, J.L. 2001. Forensic Entomology. CRC Press.
2. Catts, E.P. and Haskell N.H. 1990. Entomology and Death. A Procedural Guide. Joyce‘s Print Inc. Clemson, SC.
3. Goff, M. L. 2000. A fly for the prosecution: how insect evidence helps solve crimes. Harvard University Press, Cambridge.
4. Greenberg, B. and Kunich, J.C. 2002. Entomology and the Law: Flies as Forensic Indicators, Cambridge University Press, Cambridge.
5. Smith, K.G.V.1986. A Manual of Forensic Entomology, Comstock‘s Publishing Associates, Cornell University Press, Ithaca, N.Y.

FUNDAMENTALS OF MICROBIOLOGY

Course Code: ZOOL 32
Theory Credit Hour: 2

Objectives

The course is designed to

- Enable the students to work with micro-organisms.
- Understand the basic techniques of sterilization, culturing and isolation of bacteria and fungi
- Determine different characteristics of the micro-organisms.

Course Contents

Introduction: History of microbiology, Microbes influencing our lives, Characterization and identification of microorganisms.
Virology: Structure of virus, Characteristics of virus, Virus-host cell interaction, viral replication, Transformation, Transmission of transforming viruses, Mechanism of pathogenicity; virus cultivation and propagation.
Morphology and fine structure of bacteria: Size, Shape and arrangement of bacterial cells, motility, Capsules, Structure and composition of cell wall, Cytoplasmic membrane, Protoplasts, Endospore, pili.
Cultivation of Bacteria: Nutritional requirements, Nutritional types of bacteria, Bacteriological media, Physical conditions required for growth.
Pure culture and growth characteristics: Pure culture, Methods of isolating pure culture, maintenance and preservation of pure culture, Cultural characteristics.
Growth and Metabolism: Growth of microbial population, measurement of microbial growth, growth rate, growth curve, determination of number of cells by direct microscopic count, Plate count method, membrane filter count, Turbidimetric method, determination of cell mass by measurement of growth.
Food microbiology: Microbial spoilage of foods, Food poisoning, Food infection, Factors effecting the spoilage of food (water, pH, oxygen, nutrients, physical structure of food), Botlism food poisoning, Mycotoxins, Food preservation (drying, refrigeration, irradiation, canning.

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
University of Malakand
05-Dec-2023

Medical microbiology: Sources and communicability of diseases, Communicable diseases, non-communicable diseases, Chain of infection, Etiological agents, Specificity, Source and reservoirs of etiological agents, Methods of transmission.
Normal microbial flora: Significance of normal microbial flora, Origin of normal Microbial flora, Microbial flora of skin, Microbial flora of gastrointestinal tract, Microbial flora of genito-urinary tract, Sterile sides of human body, Mechanism of bacterial pathogenity.
Microbial Ecology: Distribution and activities of microorganisms in natural systems, Role of bacteria in elemental cycles and plant interaction of microbial communities with their biotic and abiotic environment microbial role in global carbon cycle.
Soil microbiology: Soil environment, Microbial flora of soil, Bacteria, Fungi, Algae, Rhizosphere, Biogeochemical activities of microorganisms in soil.

Air microbiology: Microbial content of air, Indoor air, Outdoor air.

Water microbiology: Microbiology of sea, Lakes and ponds, Rivers and streams, Microbes of domestic water, Microbes of sewage water.

PRACTICAL
Credit Hour: 1

1. Isolation of microorganisms from air.
2. Isolation of microorganisms from water.
3. Isolation of microorganisms from soil.
4. To study the morphology of molds.
5. To study physical characteristics of bacterial colonies.
6. To study bacteria of different morphologies through simple, gram, endospore, flagellar and capsular staining
7. Different techniques for the isolation of microorganisms.
8. Gram staining of mouth flora.
9. To study bacterial motility by hanging drop method.
10. Negative staining of bacteria.
11. Acid fast staining of bacteria.
12. To study different sterilization techniques. Isolation of spore forming bacteria from powdered milk.
13. To study viable counting of bacteria.

Books Recommended

1. Medical Microbiology. Khan, A. M. 2001. 151 ed. Time Publishers Pakistan.
2. Environmental Microbiology Vamam, A. H. and Malcolm, G. M. 2000. 1st ed. Manson Publishing Ltd. USA.

3. Introductory Microbiology. Fredrick, C. R. and Charles, E. M. 1983. 151 ed. Merrill Publishing Company USA.
4. Microbiology. Pelczar, M. J. Chan, E. C. and King, N. R. 1986. 51h ed. McGraw-Hill, Inc. New York.
5. Laboratory Experiments in Microbiology. Johnson, T. R. and Case, C. L. 1992. 3rd ed. The Banjamin/Cummings Publishing Company, USA.
6. Plant and microbial biotechnology Research, NO.3. Wang, K., Herrera-Eastrella A. and Montagu, M. V. 1995. Cambridge University, Press, UK.

GENERAL AND COMPARATIVE ENDOCRINOLOGY

Course Code: ZOOL 33

Theory Credit Hour: 2

Objectives

- General concepts and principles of chemical coordination.
- The details of the endocrine mechanisms in relation to various functions such as reproduction and lactation.
- Recent trends of endocrinology in relation to diversified function.
- Comparative studies of endocrine mechanisms in various invertebrates and vertebrates.

Course Contents

An overview of general concepts and principles of endocrinology: The endocrine system; Type of hormones; Endocrine and nervous system relationship; General principles in function, interaction, nature, synthesis, transport of hormones; General concept of feedback, biorhythms, pathology and assessment of endocrine function; Evolution of endocrine system.
Hypothalamus and pituitary: Hypothalamic hormones: Origin, chemistry and actions; Anterior pituitary & hormones: Hypothalamic pituitary regulation, General chemistry, Physiological action and metabolism of prolactin-growth hormone family, glycoprotein hormone family, corticotrophins and other pro-opiomelanocortin peptides; posterior pituitary: Release, regulation and actions of vasopressin and oxytocin.
Thyroid gland: Anatomy and histology of gland; Formation and secretion of thyroid hormones; Thyroid hormones in peripheral tissues, Regulation and factors affecting thyroid function.
Calciotrophic and Mineral Metabolism Hormones: Chemistry, physiological actions and metabolism of parathyroid hormone, calcitonin and calciferols; Homeostasis of calcium, phosphate and magnesium.
Pancreatic Hormones and Regulatory Peptides of the Gut: Anatomy and histology for sources of the hormones; Chemistry, physiological roles and mechanism of action of insulin and glucagon; Physiological roles of gut peptides.
Adrenal Medulla and Catecholamines: Chromaffin cell and organization; Structure of adrenal medulla; Biosynthesis, storage, release and metabolism; Adrenergic receptors.
Adrenal Cortex: Steroid biochemistry; Physiological actions of corticoid hormones; Regulation and metabolism of glucocorticoids, mineralocorticoids and adrenal sex steroids.
Testes: Androgenic tissue: Structure and chemistry; Transport, metabolism and mechanism of action.

Ovaries: Ovarian hormones: Steroid biochemistry and biosynthesis; Transport, metabolism and mechanism of action.
Endocrinology of Pregnancy: Hormones in conception and implantation; Hormonal actions and adaptation in pregnancy and parturition.
Endocrinology of Lactation: Hormones in lactation.
Endocrinology of Heart, Kidney, Immune system: Growth and pineal gland. Functional diversity of hormones in vertebrates; Overview of endocrine mechanisms in invertebrates.

PRACTICAL
Credit Hour: 1

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

Books Recommended

1. Greenspan, F.S. and Strewler, G.J. Basic and Clinical Endocrinology, 5th Edition. 2002. Prentice Hall International Inc., London.
2. Wilson, J.D., Foster, D.W., Kronenberg, H.M. and Larsen, P.R. WILLIAMS Textbook of Endocrinology, W.D. 2008.Saunders Company, Philadelphia.
3. DeGroot, L.J., Jameson, J.L. Endocrinology, 4th Edition. 2001. W.B. Saunders, Philadelphia.
4. Giffin, J.E. and Ojeda, S.R. Textbook of Endocrine Physiology. 4th Edition. 2000. Oxford University Press, Oxford.
5. Neal, J.M., Basic Endocrinology: An Interactive Approach. 2000. Blackwell Science Inc., London.

GENERAL MICROBIOLOGY

Course Code: ZOOL 34
Theory Credit Hour: 2

Objectives The course aims to:

- Enable the students to work with microorganisms.
- Understand the basic techniques of sterilization, culturing, isolation
- Determine different characteristics of the microorganisms

Course Contents

The beginnings of Microbiology: Discovery of the microbial world; Discovery of the role of

microorganisms in transformation of organic matter, in the causation of diseases, development of pure culture methods. The scope of microbiology.
Microbial evolution, systematics, and taxonomy; Characterization and identification of microorganisms. Nomenclature and Bergey's manual.
Viruses: Bacteriophages and phages of other protests. Replication of bacteriophages. Viruses of animals and plants; History, structure, and composition; classification and cultivation of animal viruses. Effects of virus infection on cells. Cancer and viruses.
Morphology and fine structure of bacteria: Size, shape and arrangement of bacterial cells, Flagella and motility, Pili, Capsules, sheaths, Prosthecae and stalks, structure and chemical composition of cell wall, cytoplasmic membrane, protoplasts, spheroplasts, the cytoplasm, nuclear material.
The Cultivation of Bacteria: Nutritional requirements, nutritional types of bacteria, bacteriological media, physical conditions required for growth, choice of media, conditions of incubation.
Reproduction and growth of bacteria: Modes of cell division, new cell formation, Normal growth cycle of bacteria, synchronous growth, continuous culture, quantitative measurement of bacterial growth; Direct microscopic count, Electronic enumeration of cell numbers, the plate count method, Membrane-filter count, Turbidimetric method, Determination of nitrogen content, Determination of the dry weight of cells, the selection of a procedure to measure growth, Importance of measurement of growth.
Pure cultures and cultural characteristics: Natural microbial populations, selective methods; Chemical methods, Physical methods, biological methods, Selection in nature, Pure cultures; Methods of isolating pure cultures, Maintenance and preservation of pure cultures, Culture collections, Cultural characteristics; Colony characteristics, Characteristics of broth cultures.
Eukaryotic Microorganisms: Algae: Biological and economic importance of algae; Characteristics of algae; Lichens. Fungi: Importance of fungi; Morphology; Physiology and reproduction, Cultivation of fungi. Economic importance of protozoa.
Prokaryotic diversity Bacteria: Purple and green bacteria; cyanobacteria, prochlorophytes, chemolithotrophs, methanotrophs and methylotrophs, sulfate and sulfur-reducing bacteria, homoacetogenic bacteria, Budding and appendaged bacteria, spirilla, spirochetes, Gliding bacteria, Sheathed bacteria, Pseudomonads, Free living aerobic nitrogen fixing bacteria, Acetic acid bacteria, Zymomonous and chromobacterium, Vibrio, Facultatively aerobic Gram-negative rods, Neisseria and other Gram-negative cocci, Rickettsias, Chlamydias, Gram-positive cocci, Lactic acid bacteria,

Endospore forming Gram-positive rods and cocci, Mycoplasmas, High GC Gram-positive bacteria; Actinomycetes, Coryneform bacteria, propionic acid bacteria, Mycobacterium, Filamentous Actinomycetes.
Prokaryotic Diversity: Archaea: Extremely Halophilic archaea, Methane producing archaea: Methanogens, Hyperthermophilic archaea, Thermoplasma.

PRACTICAL
Credit Hour: 1

1. Preparation of culture media
2. Pure culturing and cultivation of bacteria
3. Simple, Gram, endospore, capsular, flagellar and acid fast stainings of different genera of bacteria\Vital staning and microscopic observations of protozoa
4. Cultivation methods of fungi
5. Isolation of bacteriophages

Books Recommended

1. Eugene W. N., Denise, G., Anderson, M. T., Nester, C., Roberts, E. Nancy, N. 2001. Microbiology: A Hhuman Perspective, McGraw Hill Higher Education.
2. Jacquelyn, G.G. 2001. Microbiology: Principles and Explorations, John Wiley & Sons Inc.
3. Madigan, M.T., Martinko, J.M. and Parker, J. 1997. Brock Biology of Microorganisms, Prentice-Hall, London.
4. Benson, H.J. 1994. MICROBIAL APPLICATIONS: LABORATORY MANUAL IN GENERAL MICROBIOLOGY, WMC Brown Publishers, England.
5. Pelczar Jr., Chan, E.C.S. and Krieg, M.R. 1986. MICROBIOLOGY, McGraw Hill, London.
6. Stainier, R.Y., Ingraham, J.L., Wheelis, M.L. and Painter, R.R. 1986. THE MICROBIAL WORLD, Prentice Hall, London.

HELMINTHOLOGY AND HOST-PARASITE RELATIONSHIP

Course Code: ZOOL 35
Theory Credit Hour: 2

Objectives

The course will

- provide knowledge regarding basic principles of host parasite interactions
- impart knowledge on helminth parasites of medical, veterinary and agricultural importance

Course Contents

Part I: Helminthology Theory: Classification, Basic principles and concepts in Parasitology, Taxonomy, etiology, biology, epedemiology, pathology and pathogenesis, diagnosis, control and treatment of
Digenetic Trematodes: Schistosoma mansoni, S.japonicum, S.haematobium, Fasciola hepatica, Fasciolopsis buski, Dicrocoelium dendriticum, Paragonimus westermani, Colonorchis sinensis, Heterophyes heterophyes,
Monogenetic trematodes: Dactylogyrus vastator, Gyrodactylus, DiploZooln paradoxum and Polystoma integrrimum.,
Cestodes: Diphyllobothriam latum, Sparganosis, Taenia saginata, T.solium, Echinococcus granulosus, E.multilocularis, Hymenolepis nana, Dipylidium caninum, Moniezia expansa.,
Nematodes: Trichuris trichiura, Capillaria hepatica, Trichenella spiralis, Strongyloides stercoralis, Ancylostoma duodenale, Necator americanus., Creeping eruption: Haemonchus contortus, Ascaris lumbricoides, Toxocara canis, Anisakis spp., Heterakis gallinarum, Enterobius vermicularis, Wuchereria bancrofti, Brugia malayi, Onchocerca volvulus, Loa loa and Dracunculus medinensis.
Part II: Host Parasite Relationship

Host parasite relationship: as associative organization between two organisms. Structural aspects of the association interface.
Nutrient exchanges in associations.
Physiological and regulatory interactions: between associates. Behavioral Aspects of organism associations.
Ecology and evolution of intimate associations; Anthelmintic resistance detection methods.

Chairman
Department of Zoology,
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

Detection and characterization of parasites causing emerging Zoonosis

PRACTICAL

Credit Hour: 1

1. Stage and ocular micrometry for measurement of helminths. Preparation of temporary and permanent mounts of parasites from the following animals:

   a. Fish b. Frog/toad c. Fowl/Pigeon d. Rat/Mouse.

2. Study of helminths from prepared slides. Study of eggs/larvae from feces and prepared slides. Diagnosis of medically important parasites in fecal specimen by using: Tillman's centrifugation technique, by Lugol's iodine staining technique, Baermanns procedure for nematode culture.

Books Recommended

1. Robberts, L. Sand Janovy John Jr. 2009. Foundation of Parasitology. 8th edition. McGraw Hill, Boston
2. Facust, E. C. and Russell, P. F. 2001. Craig and Faust's clinical Parasitology. Lea and Febiger, 8th edition London
3. Markell, E.K. Mo. Vogo. 1999. Medical Parasitology. W. B. Sundress Co: Philadelphia.
4. Chandrasoma, P. and Taylor, C.R.1997. Concise Pathology. Prentice Hali International Inc. New Jercy USA.
5. Peters, W and Gills, H.M. 1989. A color atlas of Tropical medicine and Parasitology. Wolfe Medical Publications Ltd., Netherlands.
6. Smyth, J. D. 1994. Introduction to Animal Parasitology, 3rd edition. Cambridge University Press, Cambridge.
7. Taylor, A.E.R & Muller, R. (1987). Genetic aspects of host parasite relationships. Symposium of the British Society for Parasitology. Blackwell Scientific Publications Oxford
8. Whitfield, P. J. (Recent edition). The biology of parasitism; an introduction to the study of association organisms. Edward Arnold. Publishers, UK

HEMATOLOGY

Course Code: ZOOL 36

Theory Credit Hour: 2

Objectives

- to provide knowledge about blood formation, morphology, physiology and biochemistry of blood cells, basic mechanisms and types
- to impart knowledge about advanced techniques in studying serological and hematological techniques, blood coagulation
- to gain insight into blood related diseases

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

Course Contents

Blood cell formation, Erythropoises and general aspects of anemia, hyper chromic anemia and iron overload, Megaloblastic anemia and other meroblastic anemia, Hemolytic anemia. Genetic disorders of Hemoglobin. Leukopoises, Lymphocytes and their benign disorders, granulocytes and monocytes. Platelets, blood coagulation and hemostasis, bleeding disorders caused by vascular and platelet disorders.

PRACTICAL

Credit Hour: 1

1. Total erythrocyte and lymphocyte counts
2. Study of granulocytes and leukocytes
3. Differential leukocytes
4. Comparison of blood counts of diseased (Anemia) and healthy individuals.
5. Morphological alterations in erythrocytes in various disease conditions like sickle cell anemia etc.

Books Recommended

1. Hoffbrand, A.V. and Hoffbrand,I.E. 2002. Essential Haematology. Peltit and PAH Moss
2. Dacie and Lewis. 2002. Haematology.

ICHTHYOLOGY

Course Code: ZOOL 38

Theory Credit Hour: 2

Objectives

- To study the evolution and taxonomy of fish,
- To providing the knowledge regarding fish biology,
- To elaborate the anatomy and physiology of fish

Course Contents

Systematic position of fish in animal kingdom, External features of fish, Fish muscular system, locomotion and energetics of swimming. Physiology of respiration and air breathing among fishes. Cardiovascular system, blood, and its circulation and hydromineral balance: Osmoregulation, ionic regulation, stress responses, freezing resistance and acid-base balance. Digestion and control of gastro-intestinal motility in fish. Physiology of gas bladder: Use of gas by the fish as a source of static lift. Gas in the gas bladder: Loss, retention, and secretion of gas. Process of aestivation in fish.

Control of kidney function in fish. Sensory system and communication in fish: Acoustico-lateralis system, sound reception and production.

PRACTICAL

Credit Hour: 1

1. Study of classification of fishes and some selected fish species
2. Study of Fish anatomy, physiology and adaptations, fish dissections

Chairman
Department of Zoology,
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

3. Study of fish habitats, fish fauna of Pakistan
4. Study of fish reproduction, oocytes and aquaculture and food requirements
5. Study of environmental, ecological, and economic importance of fishes
6. Study of ornamental fishes
7. Field visits to fish hatcheries

Books Recommended

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

IMMUNOLOGY

Course Code: ZOOL 39
Theory Credit Hour: 2

Objectives

The course aims to

- Give understanding of the basic concepts of immunology and its importance in biological sciences
- Provide information about immunological mechanisms against different diseases
- Give understanding of immunization, immunological tolerance etc.

Course Contents

Immunology: Immunobiology, Immunophysiology, Immunopathology.

Immunity: Natural and acquired immunity, Active and passive immunity.

Antigens and elicitation of immune responses: antigens and their types, antigenicity and immunogenicity, factors important for immunogenicity of an antigen, cell mediated and humoral: nature of antigens, genetic constitution of individuals and route of administration.
Immunoglobulins: Synthesis of antibodies, Theories of antibodies synthesis.
Detection and application of antigen-antibody reactions: *in vivo* and *in vitro* reactions.
Monoclonal antibodies: Importance, synthesis, isolation and applications
Major histocompatibility complex: types and importance, diversity in MHC proteins.
Cellular basis of immune response: Origin of lymphocytes, Primary and secondary lymphoid organs, Specific response of individual lymphocytes to antigenic stimulation, Histological features of immune response.

Hypersensitivity: Immediate hypersensitivity (anaphylaxis, antibody dependent cytotoxicity, Immune-complex mediated disease, and stimulatory hypersensitivity), Delayed type or cell mediated hypersensitivity.
Immunological tolerance and autoimmunity: Tolerance, autoimmune diseases and types, factors responsible for autoimmunity.
Transplantation immunology, Tumor immunology, Immunity against infectious diseases, Immuno deficiency diseases, Immunity, and malnutrition.
Immunization; Immunization procedures, Vaccines, and their types.

PRACTICAL

Credit Hour: 1

1. Study of different types of leucocytes in: Blood, Bone marrow, Spleen and Thymus in mammals.
2. Estimations of total serum proteins, albumins and globulin concentrations in mammalian blood.
3. Differentiation of globulin proteins in blood serum of mouse by electrophoresis.
4. Diagnosis of immunoglobulin proteins by enzyme linked immunosorbant assay (ELISA).
5. Isolation of lymphocytes and resetting technique.
6. Antigen-antibody reaction by agglutination and precipitation reaction.
7. Antigen antibody reaction by using adjuvant.
8. Diagnosis of typhoid fever by Widal test.
9. Visit to pathological laboratory and report writing.

Books Recommended

1. Essential immunology.Roitt, I. 1990. 2nd ed. Black well Scientific Publications. Oxford, UK.
2. Stites, D. P., Stobo, J. D., Fudnberg, H. H. and Wells, J. V. 1990. Basic and clinical immunology. Lange Medical Publications, USA.
3. Essentials of haematology. Hoff - Brand, A. B. and Pedit, J. E. 1981. Black well Scientific Publications. Oxford, UK.

INSECTICIDES AND PUBLIC HEALTH

Course Code: ZOOL 40

Theory Credit Hour: 2

Objectives:

To provide advance concepts of insect poisoning and residual effects on farmers and their perception on safe use of insecticides.

Course Contents:

Insecticides poisoning and its importance to public health; spread of toxic effects of insecticides in farmers, field workers and their domesticated animals; distribution of pesticide residues in soil, ground water, drinking wells and air; symptoms of poisoning due to insecticide residues in blood, fat bodies etc. and the acute diseases they cause; public health and environmental consideration; farmers perception of acute poisoning and safe measures; first aid procedures; laboratory verification; treatment of insecticide poisoning; insecticides monitoring; safe use of insecticides; knowledge of antidotes; transport, storage and disposal of insecticides; registration and labeling.

PRACTICAL

Credit Hour: 1

Determination of pesticide residues in soil, water, vegetables fruits, milk, cereals, human blood, fat bodies and vital organs; questionnaire for finding farmers perception about pesticide poisoning.
Field visits to PCSIR to study the practical aspects of pesticides residues measurement and related safeties involved in the application of pesticides applications.

Books Recommended:

1. Dhaliwal, G.S. and Singh B. 2000. Pesticides and Environment. Commonwealth Publishers. New Delhi. India.
2. Gupta, H.C.L. 2001, Insecticides: Toxicology and Uses. Agrotech Publishing Academy, Udaipur.
3. Oudejans J.H.1991. Agropesticides and Functions in Integrated Crop Protection. ESCAP. United Nations. Bangkok, Thailand.
4. Ashfaq, M. and Saleem. M.A. 2010. Environmental Pollution and Agriculture. Pak Book Empire, Lahore, Pakistan.

INSECT ECOLOGY

Course Code: ZOOL 41

Theory Credit Hour: 2

Objectives:

To provide the basic concepts of population growth of insects in different environmental parameters and to simulate the population structures in marine climatic conditions to software technology.

Course Contents:

Population growth, theories, life-tables, key factors, analysis, regression, co-existence, co-habitation, competition and mutual displacement, variation, speciation and diversity. A mathematical approach to the dynamics of single and multi-species populations and communities with analytical and simulation model techniques: mathematical and statistical techniques applied to population systems and community ecologies; critical survey of models of population growth, niche matrices, competition, predation, ecological genetics, species diversity and distribution, and ecological succession.

PRACTICAL

Credit Hour: 1

Use of computer simulations in population of agricultural pests: computer modeling used by Ecologists to clarify and interpret large field data by clustering, transforming, matrices and multi-variate analysis.
Field visits to Tarnab Farm, Agriculture University Peshawar or research centers for the study of insects in relation to various ecosystems.

Books Recommended:

1. Atwal, A.S. and Bains, S.S. 2005. Applied Animal Ecology. Kalyani Publishers, Ludhiana.
2. Bernstein, R. 2003. Population Ecology: An Introduction to Computer Simulations. Willy, NY.
3. Blackith, R.E. and Rayment, R.A. 1984. Multivariate Morphometrics. Academic Press, London.
4. Price, P.W. 2003. Insect Ecology. 3rd Ed. Wiley Interscience Publishers, N.Y.
5. Rockwood, L.L. 2006. Introduction to Population Ecology. Wiley, John & Sons, Incorporated.
6. Southwood, T.R.E. and Henderson, P.A. 2000. Ecological Methods. 3rd Ed. Wiley-Blackwell.

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
(Examinations)
University of Malakand
05-Dec-2023

7. Vandermeer, J.H. and Goldberg, D.E. 2003. Population Ecology: First Principles. Princeton University Press.

MEDICAL ENTOMOLOGY

Course Code: ZOOL 42
Theory Credit Hour: 2
Objectives

- to provide knowledge about insect vectors, disease borne pests of veterinary and human importance
- to understand their life cycles as they carry viruses and other organisms during transmission of diseases
- to impart knowledge about their control

Course Contents

General introduction to medical and veterinary entomology: phylum arthropoda, salient features of insects, classification, general morphology and physiology of insects, modifications in mouthparts and appendages of insects, metamorphosis and its types.
Insects of medical and veterinary importance: mosquitoes, human louse, houseflies, fleas, bugs, mites and ticks: life cycles, diseases and their control. Insect venoms; bees, wasps, ants. Insect toxins, arthropod allergens. Insect pest management: definition, principles and methods of insects control, components of pest management, techniques, general measures to control insects, economics of pest management.

PRACTICAL
Credit Hour: 1

1. Techniques of collection and preservation of insects.
2. Collection, identification, and classification of insects of veterinary and medical importance.
3. Preparation of slides of mouthparts and appendages of different Insects.
4. Morphometric studies of different Insects and their life cycle.
5. Field studies and report writing to observe different Insects and their life cycles.

Books Recommended

1. Roy, D. N. and Brown, A.W.A .2004. Entomology. Biotech Books, New Delhi.
2. Chandler, A.C. and Read, C.P. 1961. Introduction to Parasitology. 10th ed. WileyToppan, New York, USA
3. Rozendael, J. A. 1999. Vector ConlJ19l. A I. T. B. S. publishers, New Delhi.
4. Service, M.W. 1996. Medical Entomology. Chapman and Hall, USA
5. Pedigo, L. P. 2003. Entomology and Pest Management. 4th ed. Pearson Education, Singapore, Pvt. Ltd.

INTRODUCTION TO ENVIRONMENT

Course Code: ZOOL 43

Theory Credit Hour: 2

Objectives

- to enable students to understand interrelationship between various components of the environment.
- to provide knowledge about basic concepts of matter, energy, birthof universe, solar system and origin of earth.
- to provide knowledge about environmental geology and environment and life and human activity are considered for understanding of environment and its trans disciplinary integration.

Course Contents

Environment; Introduction and definitions. Environmental systems; Atmosphere, Lithosphere, Hydrosphere, Biosphere, Origin and their interrelationships.
Environmental factors; Physical, chemical and biological factors.
Variety of life and environment (brief account).
Environment and human interactions. Environmental pollution; types, sources, causes and effects (brief overview).
Environmental issues and challenges; Deforestation, water logging, salinity, drought and desertification, Loss of natural habitat, Depletion of resources,
Population and genetic diversity.
Environment and sustainable development.
Issues of social environment; Population growth, urbanization, migration, and poverty, Lifestyle and environment.

PRACTICAL
Credit Hour: 1

1. Study of environment in the university campus.
2. Adaptation of animals to various environmental conditions: i) Aquatic ii) Terrestrial iii) Arboreal iv) Fossoreal v) Cursoreal vi) Parasitic
3. Adaptation of plants to various environmental conditions (i) Xerophytic (ii) Mesophytic (iii) Hydrophytic
4. To determine (i) brightness of light by using LUX meter (ii) Intensity of light by using Pyronometer
5. Study of various soil profiles and determination of their moisture contents.
6. Determination of speed of air at different time intervals by using anemometer.
7. Analyzing the quality of different water samples by physical and chemical tests.
8. Study of various types of rocks and fossils.

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
University of Malakand
05-Dec-2023

9. To determine the amount of rainfall in different times by using simple rain gauge.
10. Visit to meteorological department and report writing.

Books Recommended

1. otkin, D. and Keller, E. Environmental Science (Earth as a living planet). 2000. 1st ed. B. John Wiley and Sons Inc. New York, USA.
2. Nebel, B. J. and Wright, R. T. Environmental Science (The way the world works). 1998. 1st ed. Prentice Hall International Inc. London, UK.
3. de Blij, H. J. and Muller, P.O. Physical Geography of the Global Environment. 1993. 1st ed. John Wiley and Sons Inc. New York, USA.
4. Strahler, A. and Strahler, A. 1997. Physical Geography (Science and systems of the human environment). 1st ed. John Wiley and Sons Inc. New York, USA.

LIMNOLOGY

Course Code: ZOOL 45
Theory Credit Hour: 2
Objectives

- To impart the knowledge regarding physicochemical characteristics of water,
- To elaborate the phenomenon of water quality change in natural water bodies,
- To teach about the effects of limnological factors on fish.

Course Contents:

Diversity of aquatic ecosystems. Comparison of fresh, brackish and marine ecosystems. Unusual and extreme habitats, hydrology, physiography and physical properties like temperature, light, turbidity, currents, density, their interactions and relations with aquatic life. Chemical properties like dissolved oxygen, carbon dioxide, pH, alkalinity, hardness, inorganic and organic substances, their distribution, dynamics and influence on aquatic ecosystem. Status and forms of nutrients like nitrogen, sulfur, phosphorus and carbon in natural waters; nutrients use and remineralization with special reference to processes controlling the levels of nitrogen, phosphorus and sulfur in aquatic ecosystem. Stichiometry of autographs and heterotrophs; concepts of trophic state, aquatic productivity & eutrophication. Managing eutrophication in freshwater habitats. Biodiversity of fresh waters. Ecological classification of aquatic biota. Limnological importance of biota. Adaptations and characteristics of aquatic life. Quantitative and qualitative changes in spatial and temporal distribution of aquatic biota.

PRACTICAL
Credit Hour: 1

1. Water sampling and water preservation techniques for physicochemical and biological analyses
2. Estimation of physical characteristics of water viz. temperature, density, light penetration and turbidity
3. Estimation of chemical characteristics of water viz. dissolved oxygen, carbon dioxide, pH, total alkalinity, total hardness, bicarbonates, chlorides, calcium, magnesium, salinity

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
(Examinations)
University of Malakand
05-Dec-2023

4. Collection, preservation and study of fauna and flora of various water bodies

Books Recommended

1. Moss, B. R. 2010. Ecology of Fresh Waters. John Wiley & Sons Inc., New York, USA.
2. Dodds, W. K. 2006. Fresh Water Ecology: Concept and Environmental Applications. Academic Press, New York, USA.
3. Wetzel, R. G. 2001. Limnology: Lake and River Ecosystem. 3rd Ed. Academic Press, New York, USA.
4. Munshi, J. D. and J. S. D. Munshi. 1995. Fundamentals of Freshwater Biology. Narendra Publishing House, New Delhi, India.
5. Ward, H. B. and G.C. Whipple. 1989. Freshwater Biology. John Wiley & Sons Inc., New York, USA.
6. Welch, P. S. 1988. Limnology. 4th Ed. McGraw Hill, New York, USA.

MAMMALOGY

Course Code: ZOOL 46

Theory Credit Hour: 2

Objectives

- To teach the students about phylogenetic relationships of the primitive and present mammals, based on taxonomic and modern approaches
- To study the feeding and foraging periodicities of different mammalian groups and impact of environment on feeding behavior
- To ascertain different mammalian population patterns viz. concept of natality, mortality, modeling signaling and effective communication in various mammals

Course Contents

Introduction to mammalogy. History of mammalogy. Mammalian phylogeny. Dental and cranial characteristics. Evolution of viviparity. Biogeography: Mammalian radiation, biogeography of mammals of Pakistan. Food and feeding: Stenophagy and euryphagy. Population regulation: Natality, mortality, immigration, emigration, population size, mean crowding, population modeling, Signaling: Types and evolution, communication and social organization. Mammalian Adaptations: Molecular basis of torpor, aestivation, hibernation, acoustic orientation (echolocation). Home range and territoriality. Predation: Predator-prey co-evolutionary race.

PRACTICAL

Credit Hour: 1

1. General survey of mammalian species (Visits to Zoological museums and Zools and field study)
2. Study of techniques for the collection of mammals, their identification and systematic relationships

3. Comparative study of mammalian skeleton
4. Dissection of a rabbit or rat to expose its different systems

Books Recommended

1. Vaghuan, T. A., J. M. Ryan and N. J. Czaplewski. 2010. Mammalogy. 5th Ed. The John Hopkins University Press, New York, USA.
2. Feldhamer, G. A., L. C. Drickamer, S. H. Vessey, J. F. Merritt and C. Krajewski. 2007. Mammalogy: Adaptation, Diversity, Ecology. 3rd Ed. The John Hopkins University Press, New York, USA.
3. Genoways, H.H., 2000. Current Mammalogy. Plennium Press, New York, USA.

MOLECULAR BASIS OF ENDOCRINOLOGY

Course Code: ZOOL 48
Theory Credit Hour: 2
Objectives

- To study that degeneration disease are the results of alterations in biochemical homeostasis regulated by endocrine system.
- To provide understanding about the manifestation of degeneration diseases at molecular level.

Course Contents

General Mechanisms in Molecular Endocrinology: Subcellular structure of cells secreting protein hormones; Process of hormone secretion; Transcription factors in developmental organisms in endocrine systems. Recombinant DNA technology and molecular genetics in diagnosis and treatment of endocrine diseases. Measurements of hormones: Radioimmunoassay, immunoradiometric, immunochemiluminometric and radioreceptor assays and their statistical procedures.
Mechanisms of Action of Hormones: Hormone systems and intracellular communication; Hormones acting at cell surface: Properties of hormone receptor interaction, structure, biosynthesis and turnover of membrane receptors; Hormones acting in transcription regulation: Biochemistry and molecular interaction of steroid receptor, gene expression, messenger RNA stability and metabolism in hormone action.
Functional Pathology in Endocrine Glands: Neuroendocrine disorder of gonadotrophin, prolactin, growth hormone, corticotrophin regulation; Pituitary Disorders: Prolactinomas, acromegaly, Cushing's syndrome. Diabetes inspidus, hypo- and hyper-tonic syndromes; Thyroid Diseases of excess and deficient hormones and autoimmunity; Adrenal cortex: Disorders of cortical hypo and hyper function; Disorders of Adrenal Medullary Function; Disorders of Ovarian Function and Hormonal Therapy; Abnormalities of Testicular Functions and Hormonal Therapy.
Fuel Homeostasis: Glucose Homeostasis and Hypoglycemia; Diabetes Mellitus; Disorders of Lipoprotein Metabolism; Eating Disorders: Obesity, anorexia nervosa and bulimia nervosa.
Development and Growth: Disorders of growth and puberty. Endocrine Hypertension. Polyendocrine Syndromes. Hormones and Cancers: Hormones Effect on Tumors, Breast and Prostate Cancer; Endocrine Therapy; Humoral Manifestation of Malignancy. Geriatric Endocrinology: Endocrine and Associated Metabolism in aging: Specifically, thyroid, glucose, and calcium homeostasis.

PRACTICAL

Credit Hour: 1

1. Studies on recognition and response of receptors.
2. Studies of disorders of pituitary by observing anatomical and histological features.
3. Studies of thyroid status in deficient and excess hormone functions.
4. Studies of type 1 and type 2 diabetes mellitus:
5. Epidemiology of the types in population, studies of management of the type 2.
6. Model studies of disorders of Ovarian and Testicular disorders.
7. Model studies of obesity and anorexia
8. Studies of hormonal status in puberty and aging.

Books Recommended

1. Greenspan, F.S. and Strewler, G.J. Basic and Clinical Endocrinology, 5th Edition. 2002. Prentice Hall International Inc., London.
2. Wilson, J.D., Foster, D.W., Kronenberg, H.M. and Larsen, P.R. Williams Textbook of Endocrinology, 9th Edition. 1998. W.D. Saunders Company, Philadelphia.
3. DeGroot, L.J., Jameson, J.L. Endocrinology, 4th Edition. 2001. W.B. Saunders, Philadelphia.
4. Giffin, J.E. and Ojeda, S.R. Textbook of Endocrine Physiology. 4th Edition. 2000. Oxford University Press, Oxford.
5. Neal, J.M. Basic Endocrinology: An Interactive Approach. 2000. Blackwell Science Inc., London.

MOLECULAR GENETICS

Course Code: ZOOL 50

Theory Credit Hour: 2

Objectives

- to understand the molecular basis for transcription, translation, replication and gene regulation
- to understand molecular mechanisms in prokaryotes and eukaryotes
- to understand modern methods and applications of molecular analysis of genetic diseases

Course Contents

Plant and animal viruses (DNA and RNA)
Transposition: transposable elements, detection of transposition in bacteria, types of bacterial transposons, modes of transposition in bacteria. Genetic phenomena mediated by transposons, transposable elements in prokaryotes and eukaryotes.
Gene expression in pro- and eukaryotes.

Genetic transformation (all kinds). Regulation of simple and complex transcription unit.
Current developments in molecular genetics: molecular techniques viz. Southern, Northern and Western blotting, PCR, RFLP, AFLP's, RAPDs, Micro-sattelites, SNPs.

PRACTICAL

Credit Hour: 1

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

Books Recommended

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

ORNITHOLOGY

Course Code: ZOOL 52

Theory Credit Hour: 2

Objectives

The course will

- Provide knowledge about bird diversity
- Avian anatomy, physiology and adaptations
- Bird behavior and socioeconomic and ecological importance

Course Contents:

Introduction to ornithology, class Aves, taxonomy of birds up to orders, families and major species; evolution of birds; biology of fossil birds; archaeopteryx, archaeornithes, neoornithes; morphology and surface anatomy of bird, and development structure of feathers, plumage; structure of bones; basic embryology of birds; internal anatomy of birds; systems physiology; blood circulatory, cardiovascular physiology, heart, blood cells and hemodynamics; respiratory system, air sacs, ventilation of lungs, metabolic rates, oxygen consumption; urinary system, kidney physiology and production of solid or

semisolid excreta, brain physiology and anatomy, special senses, olfaction, vision, taste; digestive system, anatomy, guts and feeding strategies; morphological and physiological adaptations of birds to flying, kinds of flight, mechanisms of aerodynamics; reproductive organs anatomy and physiology, egg laying and breeding seasons; bird migration, song production, bird behavior, courtship, mating, egg incubation strategies, brood parasitism; predator-prey relationship; homing behavior; learning, imprinting; nest building; bird parasite; endangered species of birds; bird conservation and sanctuaries. Introduction, evolution, geographical distribution. Classification Characteristics of birds, external features, identification of sex and age, reproduction and development, behavior (migration, territoriality), populations and their regulation. Anatomical, physiological adaptations to their environment, reproductive strategies, food/feed, communication (vocal, behavioral). Anatomy & physiology of game and predatory species. Birds of Pakistan: Aquatic, Forest and Game birds and birds of prey. Birds as pests.

PRACTICAL

Credit Hour: 1

1. Identification characteristics and taxonomy of birds to orders and families
2. Dissection of sparrow, pigeon, myna, other available birds
3. Anatomy of bones, skull, girdles, spine, vertebrae, feathers, plumage
4. Study of gut contents of birds to understand feeding habits
5. Incubation of chicken eggs to learn avian embryogenesis
6. Bird stuffing and preservation of eggs
7. Identification of bird species through feathers and eggshells
8. Beak and claw structures
9. Study of bird songs, recording bird songs, fundamental experimentation to understand bird songs in sensitive and sensorimotor phases
10. Bird watching and preparation of ethograms
11. Study of Predator-prey relationship among birds
12. Study of Brood parasitism
13. Study of flying mechanics through models

Books Recommended

1. Howell, S. N. G. 2010. Peterson Reference Guide to Molt in North American Birds (Peterson Reference Guides. Amazon Co.
2. Kaiser, G. W. 2008. The Inner Bird: Anatomy and Evolution. Amazon Co.
3. Richard Grimmett, Carol Inskipp and Tim Inskipp 2008. Birds of India: Pakistan, Nepal, Bangladesh, Bhutan, Sri Lanka, and the Maldives. Princeton Book Co.

Chairman
Department of Zoology
University of Malakand

Assistant Registrar
University of Malakand
05-Dec-2023

4. A J Urfi 2009. Birds of India: A Literary Companion, OUP.
5. Frank B. Gill. 2004. Ornithology. 2nd Ed. W. H. Freeman & Co.
6. Handbook of Bird Biology by Cornell Lab of Ornithology. Princeton University Press. New Jersey. 2004
7. Rank B. Gill. 2004. Ornithology: Ecology and Evolution of Darwin's Finches. 99 ed. (rev). Princeton. W. H. Freeman.
8. David Allen Sibley and Alfred A. Knopf 2003.*The Sibley Field Guide to Birds of Eastern North America*. New York Press
9. David Allen Sibley and Alfred A. Knopf 2002.*Sibley's Birding Basics* New York Press.
10. Salim Ali and S. Dillon Ripley 2001. Handbook of the Birds of India and Pakistan: Together with Those of Bangladesh, Nepal, Bhutan and Sri Lanka/. Reprint. New Delhi, Oxford University Press, 10 Vols.
11. Noble S. Proctor, Patrick Lynch, Patrick J. Lynch, Patrick J. Lynch 1998. Manual of Ornithology: Avian Structure and Function. Yale University Press.
12. Audubon Handbook: How to identify birds? 88th ed. McGraw-Hill Publishing Company.
13. Ali, S. 1979. The book of Indian Birds. Bombay Natural History Society, Bombay, India,
14. Bibby, C. J., Burgess, N.D. and Hill, D.A. 1992. Bird Census Techniques. Academic Press London.
15. Del Hayo, J.D., Elliot, A. and Saegatal, J. 1997. Handbook of the birds of the world. Hoatzin to Auks. Birdlife International, Lynx, editions, Barcelona.
16. Ridgway, R. 1974. Ornithology. Ayer Publishing.
17. Rand, A.L. 1974. Ornithology: an introduction. Penguin Books.
18. Roberts, T.J. 1992. Birds of Pakistan. Vol 1& 2. Oxford University Press.

PHYSIOLOGICAL SYSTEMS AND ADAPTATIONS

Course Code: ZOOL 53

Theory Credit Hour: 2

Objectives:

- To study the details of physiological systems maintaining the homeostasis of animals.
- Interrelations of the systems
- Regulatory features of each system's function.

Course Contents

Cardiovascular System: Blood and homeostasis; Physiology of cardiac muscles; Automaticity and rhythmicity in heart activity and cycle; Electrocardiography; Regulation of heart activity; Hemodynamics; Arterial system; Microcirculation and lymphatics; Control of cardiac output; Special circulations: Cutaneous, skeletal, coronary, cerebral, fetal.
Respiratory System: Overview of respiratory system; Pulmonary and bronchial circulations; Mechanical aspects of breathing; Transport of oxygen and carbon dioxide; Regulation of ventilation; Respiratory responses in extreme conditions.
Renal System: Elements of renal function; Tubular function in nephron; Control of body fluid volume and osmolality; Potassium, Calcium and Phosphate homeostasis; Role of kidney in acid-base balance.
Gastrointestinal System: Gastrointestinal secretions and their control: Salivary, gastric, pancreatic and liver; Digestion and Absorption of carbohydrates, proteins, lipids, vitamins, ions and water; Motility of gastrointestinal tract: Functional anatomy, regulation and motility in various segments.
Osmoregulation: Problems of osmoregulation; Obligatory exchange of ions and water; Osmoregulators and osmoconformers; Osmoregulation in aqueous and terrestrial environments.
Environmental Challenges: Temperature and animal energetics; Temperature relation of Ectotherms, Heterotherms and Endotherms; Dormancy: Special metabolic state; Body rhythms and energetic; Energy, environment and evolution.

PRACTICAL

Credit Hour: 1

1. Experiments on the study of heart in prepared frogs.
2. Study of blood pressure in various physiological states.
3. Study of electrocardiograms.
4. Blood coagulation study. Determination of oxygen consumption in fish and mouse and effects of factors.
5. Demonstration of respiratory volume and pulmonary function tests.
6. Experiments on digestion on nutrients by enzymes and effects of factors; Study of exocrine secretion in stomach or pancreas and effects of factors. Experiments on kidney regulation of osmolality.
7. Urine analysis.
8. Study of osmoregulatory adaptations in animals inhabiting various environments; Demonstration of effect of temperature on several physiological responses; Study of animals in various types of dormancy.

Books Recommended

1. Randall, D., Burggren, W., French, K. and Fernald, R. 2002. Eckert Animal Physiology: Mechanisms and Adaptations, 5th Edition. W.H. Freeman and Company, New York
2. Tharp, G. and Woodman, D. 2002. Experiments in Physiology, 8th Edition. Prentice Hall, London.
3. Bullock, J., Boyle, J. and Wang, M.B. 2001. Physiology, 4th Edition. Lippincott, Williams and Wilkins, Philadelphia.
4. Berne, R.M. and Levy, M.N. 2000. Principles of Physiology, 3rd Edition. St. Lious, Mosby.
5. Guyton, A.C. and Hall, J.E. 2000. Textbook of Medical Physiology, 10th Edition. W.B. Saunders Company, Philadelphia.

Chairman
Department of Zoology,
University of Malakand

Assistant Registrar
(Academics)
University of Malakand
05-Dec-2023

6. Withers, P.C. 1992. Comparative Animal Physiology. Saunders College Publishing, Philadelphia.

7. Schmidt-Nelsen, K. 1997. Animal Physiology, Adaptations and Environment, 5th Edition. Cambridge University Press, Cambridge.

8.

PHYSIOLOGY OF COORDINATION

Course Code: ZOOL 54

Theory Credit Hour: 2

Objectives

- To study the details of nervous and hormonal coordination at molecular and cellular level in animals.
- Biosynthetic, secretary and regulatory aspects of coordination.

Course Contents:

Physiological Mechanisms at Cell: Cellular membrane and transmembrane transport; resting membrane potentials; Generation and conduction of action potentials; synaptic transmission; Membrane receptors, Second messenger and signal-transduction pathways.
Nervous System: Organization of nervous system; General sensory system; Visual, Auditory, Vestibular and Chemical sensory system; Motor system with brainstem, Cortical, Cerebellar and basal ganglia control of posture and movements; Autonomic system and its control; Higher functions of nervous system including state of consciousness, learning, memory.
Muscle and Movements: Molecular basis of contraction; Muscles activity on skeleton; Adaptation of muscles for various activities; Muscles in the walls of hollow organs.
Endocrine System: General principles of endocrine physiology; Hormones in homeostasis of metabolism; Endocrine regulation of metabolism of calcium and phosphate; Parathyroid gland, Calcitonin and Cholecalciferol; Hypothalamus and Pituitary: Hypothalamic regulation of pituitary, pituitary gland hormone in physiological coordination; Thyroid gland: Functional anatomy, biosynthesis, regulation and roles in physiological functions, mechanism of thyroid hormones action; Adrenal cortex: Hormones biosynthesis, physiological roles and control; Adrenal medulla: Hormones biosynthesis, physiological roles, and hypothalamic-pituitary-adrenocortical axis, adrenal medulla and sympathetic nervous system together integrate responses to stress; Endocrine function of kidney, heart and pineal gland; General reproductive mechanisms: Energetics of reproduction; Functional anatomy, synthesis and regulation of gonadal steroids, secretary pattern of gonadal steroid at different stage of life; Male reproduction: Roles of androgen, biology and regulation of spermatogenesis, male puberty; Female reproduction: Roles of ovarian steroids, biology and regulation of oogenesis, female puberty, cyclic changes and adaptations in gestation, parturition, lactation and menopause.

PRACTICAL

Credit Hour: 1

1. Recording of action potentials on oscilloscope and effects of various factors on its characters.
2. Study of synaptic activity with neuromuscular preparations; Sciatic nerve compound action potential.
3. Demonstration of nervous system organization while studying brain, cranial nerve,

4. Spinal cord and spinal nerves. Experiments on sensory organs study. Experiments on characteristics of skeletal muscle contractions.
5. Responses of intestinal muscles and effect of drugs.
6. Demonstration of endocrine glands in a mammal (mouse).
7. Effect of hormones on glycemia and calcemia.
8. Effect of thyroxine on oxygen consumption.
9. Effect of androgen on accessory sex organs and of estrogens on target tissues.
10. Study of estrous cycle and effects of the hormones.

Books Recommended

1. Randall, D., Burggren, W., French, K. and Fernald, R. ECKERT Animal Physiology: Mechanisms and Adaptations, 5th Edition. 2002. W.H. Freeman and Company, New York
2. Bullock, J., Boyle, J. and Wang, M.B. Physiology, 4th Edition. 2001. Lippincott, Williams and Wilkins, Philadelphia.
3. Berne, R.M. and Levy, M.N. Principles of Physiology, 3rd Edition. 2000. St. Lious, Mosby.
4. Guyton, A.C. and Hall, J.E. Textbook of Medical Physiology, 10th Edition. 2000. W.B. Saunders Company, Philadelphia.
5. Withers, P.C. Comparative Animal Physiology. 1992. Saunders College Publishing, Philadelphia.
6. Schmidt-Nelsen, K. Animal Physiology: Adaptation and Environment, 5th Edition. 1997. Cambridge University Press, Cambridge.
7. Tharp, G. and Woodman, D. Experiments in Physiology, 8th Edition. 2002. Prentice Hall, London.

PRINCIPLES AND KINETICS OF TOXICOLOGY

Course Code: ZOOL 56

Theory Credit Hour: 2

Objectives

- to provide knowledge and understanding about the nature and mode of action of different categories of toxicants
- to provide knowledge about the procedural protocols used in toxicological studies
- to enable the students to understand the differential effects of variety of toxicants on different cellular sites

Course Contents

Measuring toxicity and assessing risk: Introduction; chemistry of toxicants; toxicity testing methods; routes of exposure; determining the responses to varying doses of substances; time of exposure; the LD50 experiments; toxicity, hazards, and risks.

Toxicokinetic: Introduction; pharmacokinetics and toxicokinetics; 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.
Biotransformation: Introduction; Primary biotransformation (phase I reaction) Hydrolysis, oxidation, reduction, Secondary metabolism (phase II reaction) Glucuridination, Glutathione conjugation, acetylation and other phase II reactions, factors influencing metabolism.
Cellular sites of action:

Introduction, interaction of toxicants with proteins, effect of toxicants on enzymes, receptors and ion channels, voltage activated ion channels and transport proteins, Effects of toxicants on lipids and nucleic acids, Mechanism of cell death, apoptosis, necrosis, stress, repair, and recovery.

PRACTICAL

Credit Hour: 1

1. Study of Biotoxicity assay for LC_{50}.
2. Study the effects of different teratogenic chemicals on the development of human/rat embryo.
3. Study the effect of Ethanol on the development of chick embryo with different doses.
4. Study the effect of Xylene on the development of chick embryo.

Book Recommended

1. Principles of Toxicology, Karen E. Stine and Thomas M. Brown, CRC press, Taylor and Francis Group.
2. Toxicology, Hans Marquardt, Siegfried, G. Schafer, Roger Mcclellan, Frank welsch, 1999,2004, Academic press, San Diego.
3. Principles of toxicology testing, Frank A. Barile, CRC Press Taylor and Francis Group.
4. M. Lois Murphy, C. P Dagg and David A. Karnofsky, Comparison of teratogenic chemicals in the rat and chick embryos. *Pediatrics*, 19:701-714

PRINCIPLES OF PARASITOLOGY

Course Code: ZOOL 58

Theory Credit Hour: 2

Objectives

This course will

- Introduction to general parasitology
- provide knowledge regarding different modes of transmission of parasites of medical and veterinary importance
- knowledge about their pathology, host parasite relationship and control measures

Course Contents

Introduction to parasitology. Relationship to other sciences, parasitology and human welfare. Parasites of domestic and wild animals. Camers in parasitology. Some basic definitions. Basic principles and concepts. Parasite ecology and evolution. Basic principles and concepts. Immunology and pathology. Susceptibility and resistance, innate defence mechanisms. Acquired immune response in vertebrates. Immunity in

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University of Malakand

Assistant Registrar
(Examinations)
University of Malakand
05-Dec-2023

invertebrates. Immunodiagnosis, pathogenesis of parasitic infections. Accommodation and tolerance in the host-parasite relationship.
Parasitic protozoa, form, function and classification: Kinetoplasta, trypanosomes and their kin, forms of trypanosomatidae. Other flagellated protozoa, order Retortamonadita, order Diplomonadida, order Trichomonadida, order Opalinida. The Amoebas. Order Amoebida, order Schizopyrenida. Phylum Apicomplexa, Gregarines, Coccidia and related organisms. The apical complex, class Gregarinea, class Coccidea. Phylum Apicomplexa, Malana, organisms, and pyroplasms, order Haemospondea, order Pyroplasmida. Phylum ciliophora, ciliated protistan parasites, class Spirotoichea, class Litostomitea, class Oligohymenophorea. Phyla Microspora and Myxozoa.Parasites with polar filaments. Phylum Microspora, Phylum Myxozoa. The Mesozoa, pioneers or Degenerates. Class Rhombozoa, class orthonectida, Phylogenetic position, physiology and Host parasite relationship. Classification of Phylum Mesozoa.
Systematics, morphology and biology of Arthropods (Causing or responsible for transmission of disease). Chemical and non-chemical control of Arthropods of Medical and Veterinary importance.
Pathology of Helminths: Host parasite relationships and control of parasitic Helminths with particular reference to Helminths of Medical and Veterinary importance.

PRACTICAL
Credit Hour: 1

1. Preparation of temporary and permanent slides and identification of parasitic protozoan and local helminthes of medical and veterinary importance.
2. Section cutting of the infected tissues and the study of their pathology.
3. Methods of collection, preservation and transportation of parasitic material.
4. Qualitative and quantitative faecal examination for helminth ova.
5. Collection, preservation and preparation of slides of local helminthes and their identification.
6. Identification of insects of medical and veterinary importance.

Books Recommended

1. Roberts, L.S. and Janovy, J. Jr. 2005. Foundations of Parasitology. 7th Edition. W.M. Brown Publishers, Chicago, London, Tokyo, Toronto.
2. Urquhart, G.M., Hucan, J.L., Dunn, A.M. and Jennings, F.W. 2000. Veterinary Parasitology. Longman Scientific and Technical publications, Longman Group, UK.
3. Roberts, L.S. and Janovy, J. 2000. Foundation of Parasitology, 6th Edition. McGraw Hill Book Co.
4. Smyth, J.D. Introduction to Animal Parasitology. 1994. Cambridge University Press.
5. Cheesbrough, M. 1987. Medical Laboratory Manual for Tropical Medicine. Vol.I. University Press Cambridge.

PROTOZOOLOGY

Course Code: ZOOL 59

Theory Credit Hour: 2

Objectives

This course aims to

- Provide knowledge regarding different modes of transmission of parasites of medical and veterinary importance along with their pathology, life cycles and host parasite relationship
- Impart advance knowledge on various important protozoan parasites
- Give understanding about host parasite relationship and control measure

Course Contents

Part I: Protozoology: Systematic, geographical distribution, habitats, biology, pathogenesis, important symptoms, mode of transmission laboratory methods of diagnosis, and control of protozoa of medical and veterinary importance.

Part II: Pathology and Immunity: The cell and cell injury and its relationship to disease. Acute and chronic inflammations, wound healing, disorders of growth, benign and malignant tumors in case of infections immunity, and hypersensitivity in case of parasitic diseases.

PRACTICAL

Credit Hour: 1

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

Books Recommended:

1. Robberts, L. Sand Janovy John Jr. 2009. Foundation of Parasitology. 8th edition. McGraw Hill, Boston
2. Facust, E. C. and Russell, P. F. 2001. Craig and Faust's clinical Parasitology. Lea and Febiger, 8th edition London
3. Markell, E.K. Mo. Vogo. 1999. Medical Parasitology. W. B. Sundress Co: Philadelphia.
4. Chandrasoma, P. and Taylor, C.R.1997. Concise Pathology. Prentice Hali International Inc. New Jercy USA.

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University of Malakand

Assistant Registrar
(Examinations)
University of Malakand
05-Dec-2023

5. Smyth, J. D. 1994. Introduction to Animal Parasitology, 3rd edition. Cambridge University Press, Cambridge.

RESTORATION ECOLOGY AND SUSTAINABLE DEVELOPMENT

Course Code: ZOOL 61
Theory Credit Hour: 2

Objectives

- to enable the students to identify the main candidates (wetlands, lakes, rivers, forests, etc.) for conservation.
- to train the students to develop approaches for conservation such as designing and
- management of protected areas.
- to make the students able to play the role of an active conservation biologist.

Course Contents

Conservation at the community level: Protected Areas: Existing protected areas, the effectiveness of protected areas, Establishment priorities for protection, international agreements. Designing protected Areas: Reserve size, minimizing edge and fragmentation effects, Habitat corridors, Landscape ecology and Park design. Managing protected areas: Habitat management, Park management and people. Outside protected areas: Wildlife outside parks, Strategies for success, Ecosystem management. Restoration ecology: Restoration ecology in practice. Main candidates for ecological restoration: Wetlands, Lakes, urban areas, Prairies, Tropical dry forests. Restoration ecology and the future of conservation. Government action: local legislation, national legislation.
Conservation and sustainable development: Traditional societies and sustainable development; Conservation ethics of traditional societies, Local people and their governments, biological diversity and cultural diversity, Conservation efforts involving traditional societies. International approaches to conservation and sustainable development: The Earth summit, Funding sustainable development programs, international funding, Funding in developing countries, international development banks and ecosystem damage. An agenda for the future. The role of conservation biologist.

PRACTICAL
Credit Hour: 1

1. To study the principles of reserve design.
2. To study the classification of protected areas (IUCN 1994).
3. Visits to the national parks of Pakistan and report writing.
4. The Ramsar convention on wetlands for Pakistan.
5. To review and study the measures of protecting precious biodiversity in Pakistan with reference to national and international conservation programs.
6. To study and review the threats to biodiversity of Himalayan forests.
7. To study different types of Ex *situ* conservation strategies.

Books Recommended

1. Primack, R. B. 2000. *A* Primer of Conservation Biology. 2nd ed. Sinauer Associates Inc. Publishers Sunderland, USA.
2. Cox, C. B. and Morre, P. D. 2000. Biogeography: An ecological and evolutionary approach.6th ed. Life Sciences King's College London, UK.
3. Mirza, Z. B. 1998. Illustrated Handbook of Biodiversity of Pakistan. Printopack. Rawalpindi, Pakistan.
4. Gaston, K. J. and Spicer, J. I. 1998. Biodiversity, An Introduction.15t ed. Blackwell Science Ltd. UK.
5. McKinny, M. L. and Schoch, M. R. 1998. Environmental science: System and solution. 1st ed. Jones and Bartlett Publications, USA.
6. Bradbury, I. K. 1998. The Biosphere. 1st ed. John Wiley and Sons Inc.UK

PRINCIPLES OF FISH BIOLOG

Course Code: ZOOL 57
Theory Credit Hour: 2

Objectives

- to enable students in obtaining complete understanding about freshwater as well as marine fishes in general and freshwater culturable fishes in particular.
- to impart knowledge of morphology, anatomy, classification and understanding of various feeding groups found in different water bodies.

Course Contents

Fish morphology: Head (size, shape, and orientation); Scales (types, arrangements, coloration, scale less fishes); Operculum; Fins, fin rays and fin spine (dorsal, pectoral, caudal, anal); Barbel (upper lip barbels, lower lip barbels).

Anatomy: Skeleton (skull, backbone, spines); Brain and spinal cord; Gills (Number, size, arrangements); Vital organs (heart, liver, kidney); Viscera and mesenteries (swim bladder, stomach, spleen, pancreas, intestine, gonads).
Systematic: Identification of fishes up to; Families; Order; Genus; Species; Feeding groups of fishes; Herbivore; Plankton eater; Larvivore; Carnivore; Voracious.
Ecology of fishes: Freshwater; Brackish water; Marine

PRACTICAL
Credit Hour: 1

1. Collection, preservation, and identification of freshwater fish species.
2. Study of different organs of various fish species
3. Study and survey of various fish collection present in museums

Books Recommended

1. Kestin, S. C. and Warris, P.D. (Editors). 2002 Kestin Farmed Fish Quality Blackwell Science, Oxford, UK.
2. Woo, P.T.K 1995. Fish diseases and disorder. Vol 1. Protozoan and metazoan infections. CABI Publisher.
3. Brenabe, G. Aquaculture, 1992. Vol. I. Blackwell Publishing, Oxford. UK.
4. Huet M. 1973. Textbook of fish culture: breeding and cultivation. Blackwell Publishing Company.

WILDLIFE PARASITOLOGY

Course Code: ZOOL 67

Theory Credit Hour: 1

Aims and Objectives

- To give knowledge to the students about parasites of wild animals and birds fauna as previously this field of study was ignored.
- To impart tools of parasites survey of wild fauna and methods of parasites collection to students in field study.

Course contents

Overview of wildlife: A brief out line of wild life in Pakistan; introduction and classification.
Introduction to wildlife parasitology: Host parasite relationship; Occurrence and prevalence of parasites in Wild animals such as Mammals with exception to Carnivora; Birds; and Reptiles excluding Crocodilla; Pathogenesis of parasitic infection; Diagnosis, Prevention and Treatments.
Diseases dissemination: Role of wild animals in spreading of parasitic diseases to Domestic Animals and Man; Control of Ecto- and Endo-parasites of wild animals and birds; Zoolnotic and EpiZooltic of wild-wide importance.
PRACTICAL
Credit Hour: 1

1. Collection of literature on parasites of wild animals and birds.
2. Collection of parasites, feces / droppings from wild animals and birds.
3. Processing of parasitic material for examination.
4. Preparation of permanent mounts.
5. Identification of parasites

Books Recommended

1. Bush, A. O., Femandez J. C., Esch, G. W. and Seed, J. R. 2001. Parasitism: The diversity and Ecology of animal Parasites. Cambridge University Press, Cambridge, UK.

2. Fowler, M. E. 1999. Zool and wild animal medicine: Current Theraphy- 4 w. b. Saunders Company Philadelphia, USA.

3. Smyth, J. D. 1994. Introduction to animal Parasitology. 3rd Edition Cambridge University Press, Cambridge, UK.

4. Soluby, E. J. L. 1986. Helminths, Arthropods and Protozoa of Domesticated Animals. 7th Edition Bailliere and Tindal, London.

Lavin. N. D. `990. Veterinary Parasitology. The Iowa State University Press. Ames, Iowa, USA.

Note:

Courses included in the General Education Category are designed by the respective departments including their course codes, credit hours and titles (reflected in the scheme of studies). All such courses approved by the Syndicate are available on the university website. For any query the office of the Registrar Academics may be approached for clarification/guidance.

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