

REVISED SCHEME OF STUDIES FOR BS 4-YEARS PROGRAM IN ZOOLOGY

BS Semester-I

Course #	Name of Subject	Cr. Hours
IS-301	Islamic Studies	2 (2+0)
Eng-301	Functional English	3 (3+0)
Math-321	Algebra	3 (3+0)
Zoo-301	Animal Diversity-I	3 (2+1)
Bot-301	Diversity of non-flowering plants	4 (3+1)
Stats—301	Statistics	3(2+1)
Total		18

BS Semester-II

Course #	Name of Subject	Cr. Hours
CS-351	Introduction to Computer	3 (2+1)
PS-351	Pak Studies	2 (2+0)
Eng- 351	Communicational Skills	3 (3+0)
Zoo -351	Animal Diversity-II	3(2+1)
Soc-351	Introduction to Sociology	3 (3+0)
Chem-Org—351	Organic Chemistry	4(3+1)
Total		18

BS Semester-III

BS Semester- IV

Course #	Name of Subject	Cr. Hours
Eng-401	Technical writing	3 (2+1)
Math-401	Calculus	3 (3+0)
Chem-Phy-401	Physical Chemistry	4 (3+1)
Zoo -401	Principles of Animal Life	4(3+1)
Ent-401	Introductory Entomology	3 (2+1)
Total		17

Course #	Name of Subject	Cr. Hours
Zoo-451	Animal form and function-I	3 (2+1)
Zoo-452	Animal form and function-II	3 (2+1)
Zoo-453	General Nematology	3 (2+1)
Zoo-454	Biological Techniques	2 (1+1)
Chem-Env-451	Environmental chemistry	4 (3+1)
Total		15

BS Semester V/ M.Sc-I

Course #	Name of Subject	Cr. Hours
ZOO-501	Animal Behavior	2 (2+0)
ZOO-502	Biochemistry	4 (3+1)
ZOO-503	Cell and Molecular Biology	4 (3+1)
ZOO-504	Developmental Biology	4 (3+1)
ZOO-505	Ecology	3 (2+1)
Total		17

BS Semester VI / M.Sc-II**BS Semester VII / M.Sc-III**

Course #	Name of Subject	Cr. Hours
ZOO-551	Basic Biotechnology	3 (2+1)
ZOO-552	Genetics	4 (3+1)
ZOO-553	Evolution and Principles of Systematic Zoology	4 (3+1)
ZOO-554	Animal Physiology	4 (3+1)
ZOO-555	Biostatistics	3 (2+1)
Total		18

Course #	Name of Subject	Cr. Hours
ZOO-601	Fundamentals of Microbiology	3 (2+1)
ZOO-602	Bioinformatics	3 (2+1)
ZOO-603	Fundamentals of Endocrinology	3 (2+1)
ZOO-604/ ZOO-605, ZOO-606	Parasitology A/ Fish Biology/ Insect Biology	3 (2+1)
ZOO-607	Research methodology	2 (2+0)
ZOO-608	Research/Special paper	3
Total		17

BS Semester VIII / M.Sc-IV**Total Credit Hours for BS= 136**

Course #	Name of Subject	Cr. Hours
ZOO-651	Zoogeography and Paleontology	3 (2+1)
ZOO-652	Economic Zoology	2 (2+0)
ZOO-653	Basic immunology	3 (2+1)
ZOO-654/ZOO-655 /ZOO-656	Parasitology B/Applied Fisheries / Applied Entomology	3 (2+1)
ZOO-657	Wild Life of Pakistan	2 (2+0)
ZOO-658	Research/Special paper	3
Total		17

Total Credit Hours for M.Sc= 68

BS Semester-I

Course #	Name of Subject	Cr. Hours
IS-301	Islamic Studies	2 (2+0)
Eng-301	Functional English	3 (3+0)
Math-321	Algebra	3 (3+0)
Zoo-301	Animal Diversity-I	3 (2+1)
Bot-301	Diversity of non-flowering plants	4 (3+1)
Stats—301	Statistics	3(2+1)
Total		18

ZOO-301 ANIMAL DIVERSITY-I Cr. Hours: 3 (2+1)

Aims and Objectives:

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:

Classification of organisms; Five kingdom classification, evolutionary relationships/ evolutionary perspective and tree diagrams; patterns of organization.

Animal-Like Protists: The Protozoa

Classification (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.

Multicellular and Tissue Levels of Organization

Phylum porifera: cell types, body wall, and skeletons; 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.

Triploblastics and Acoelomate Body Plan

Phylum platyhelminthes: classification up to class; the free-living flatworms and the tapeworms; phylum nemertea; phylum gastrotricha; further phylogenetic considerations.

Aschelminths

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.

Annelida

Metamerism and tagmatization; classification up to class. External structure and locomotion, feeding and the digestive system, gas exchange and circulation, nervous and sensory functions, excretion, regeneration, reproduction and development, in polychaeta, oligochaeta and hirudinea.

Arthropods

Classification, metamerism and tagmatization; the exoskeleton; metamorphosis; classification up to class.

Molluscs. Important characteristics, classification upto class.

Books Recommended

1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11th Edition (International), 2004. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5th Edition (International), 2002. Singapore: McGraw Hill.
3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4th Edition (International), 2000. Singapore: McGraw Hill.
4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill.

Practicals

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 Coelenterata.
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.
10. Collection and preservation techniques, collection of specimens by students.

Books Recommended

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

BS SEMESTER II

Course #	Name of Subject	Cr. Hours
CS-351	Introduction to Computer	3 (2+1)
PS-351	Pak Studies	2 (2+0)
Eng- 351	Communicational Skills	3 (3+0)
Zoo -351	Animal Diversity-II	3(2+1)
Soc-351	Introduction to Sociology	3 (3+0)
Chem-Org—351	Organic Chemistry	4(3+1)
Total		18

ZOO-351 Animal Diversity-II Cr. Hours: 3 (2+1)

Aims and Objectives:

The course provides knowledge and understanding about the different animal groups, emphasizing their phylogenetic relationships.

Course Contents:

1. Echinoderms

Evolutionary perspective: relationships to other animals; echinoderm characteristics; classification up to class, ambulacral system, tube feet, larvae

2. Hemichordates and Invertebrate Chordates

Evolutionary perspective Introduction to hemichordates

3. Fishes: Vertebrate Success in Water

Evolutionary perspective, Introduction and brief classification of fishes, adaptations in locomotion, circulation, gas exchange, lateral line system, excretion and osmoregulation, reproduction and development.

4. Amphibians: The First Terrestrial Vertebrates

Evolutionary perspective, brief classification of amphibians, adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction, development, and metamorphosis; further phylogenetic considerations.

5. Reptiles: The First Amniotes

Evolutionary perspective cladistic interpretation of the amniotic lineage; survey of order testudines or chelonia, rhynchocephalia, squamata, and crocodilia; evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions,

excretion and osmoregulation, reproduction and development; further phylogenetic considerations.

6. Birds: Feathers, Flight, and Endothermy

Evolutionary perspective, ancient birds and the evolution of flight; diversity of modern birds; evolutionary pressures: adaptation in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory systems, excretion and osmoregulation, reproduction and development; migration and navigation.

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

Evolutionary perspective: diversity of mammals; evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, behavior, reproduction and development.

Books Recommended

1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11th Edition (International), 2004. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5th Edition (International) 2002. Singapore: McGraw Hill.
3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4th Edition (International), 2000. Singapore: McGraw Hill.
4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill.
5. Campbell, N.A. BIOLOGY, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.

Practicals

1. Study of a representative echinoderms.
2. Study of representatives of group Fishes.
3. Study of representative groups of class Amphibia.
4. Study of representative groups of class Reptilia.
5. Study of representative groups of class Aves.
6. Study of representative groups of class Mammalia.
7. Field trips to study animal diversity in an ecosystem.
8. Visit to zool and wildlife park.

9. Collection and preservation techniques, collection of specimens by students.

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

Books Recommended

1. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.

2. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5th Edition (International), 2002. Singapore: McGraw Hill.

BS Semester- III

Course #	Name of Subject	Cr. Hours
Eng-401	Technical writing	3 (2+1)
Math-401	Calculus	3 (3+0)
Chem-Phy-401	Physical Chemistry	4 (3+1)
Zoo -401	Principles of Animal Life	4(3+1)
Ent-401	Introductory Entomology	3 (2+1)
Total		17

ZOO-401 PRINCIPLES OF ANIMAL LIFE Cr. Hours: 4 (3+1)

Aims & Objectives:

- The concept and scope of Zoology in life sciences.
- The common processes of life through its chemistry, biochemical and molecular processes.
- The structure and function of cell organelle 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:

1. Introduction: Concept and scope of zoology.

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

Structure and functions of cell membranes; various movements across membranes; cytoplasm, organelles, and cellular components: functional account of ribosomes, endoplasmic reticulum, golgi apparatus, **lysosomes**, mitochondria, cytoskeleton, cilia and

flagella, centrioles and microtubules, and vacuoles based on their structural aspects. The nucleus: nuclear envelope, chromosomes and nucleolus. Tissues: diversity in epithelial tissue, connective tissue, muscle tissue and nervous tissue to perform various functions. Structural integrations for functions in organs and organ systems.

3. Energy and Enzymes: Life's Driving and Controlling Forces

Energy and the laws of energy transformation; activation energy; enzymes: structure, function and factors affecting their activity; cofactors and coenzymes; ATP: how cells convert energy? An overview.

4. How Animals Harvest Energy Stored in Nutrients

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

5. 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.

6. 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.

Practicals

1. Study of excretory system in an invertebrate and a vertebrate representative (Models + Fresh specimens).
2. Study of nutritive canal in an invertebrate and a vertebrate representative (Dissection).
3. Tests for different carbohydrates, proteins and lipids.
4. 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).

5. Plasmolysis and deplasmolysis in blood.
6. Protein digestion by pepsin.

Books Recommended

1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11th Edition (International), 2004. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5th Edition (International), 2002. Singapore: McGraw Hill.
3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4th Edition (International), 2000. Singapore: McGraw Hill.
3. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill.
4. Campbell, N.A. BIOLOGY, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc
5. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.

ENT-401 INTRODUCTORY ENTOMOLOGY Cr. Hrs: 3(2+1)

OBJECTIVES:

1. To familiarize the students with insects and arachnids and their external and internal features
2. To equip the students to identify insects and arachnids of economic importance.
3. To acquire working skills for collecting, mounting, and preserving insects

COURSE CONTENTS

THEORY:

Introduction; phylum Arthropoda and its classification; morphology, anatomy and physiology of a typical insect, metamorphosis and its types; insect classification, salient characters of insect orders; families of economic importance with examples of each family.

PRACTICAL:

Characters of classes of Arthropoda; collection and preservation of insects; morphology and dissection of a typical insect (digestive, reproductive, excretory, nervous, circulatory and

tracheal systems); temporary mounts of different types of appendages of insects; types of metamorphosis.

BOOKS RECOMMENDED:

1. Ahmad, I. 2010. Hashriat "Insects". National Book Foundation, Lahore
2. Awastheir, V.B. 2009. Introduction to General and Applied Entomology. Scientific Publisher, Jodhpur, India.
3. Dhaliwal, G.S. 2007. An Outline of Entomology. Kalyani Publishers, Ludhiana.
4. Elzinga, R.J. 2003. Fundamentals of Entomology. Prentice Hall.
5. Lohar, M.K. 2001. Introductory Entomology. Department of Entomology, Sindh Agriculture University Tandojam Sindh, Pakistan.
6. Richards, O.W. and Davies, R. G. 2004. Imm's General Text-book of Entomology, Vol. I. and II, 10th Ed. Chapman & Hall, London, N.Y.
7. Triplehorn, C.A. and Johnson, N.F. 2005. Borror and DeLong's Introduction to the study of Insects. Brooks Cole. 7th Ed.
8. Trigunayat, M.M. 2009. A Manual of Practical Entomology. 2nd Edition Scientific Publisher (India) Jodhpur.
9. Yousuf, M. Tayyab, M. and Shazia, Y. 2007. Manual of Introductory Entomology, University of Agriculture, Faisalabad.

BS SEMESTER-IV

Course #	Name of Subject	Cr. Hours
Zoo-451	Animal form and function-I	3 (2+1)
Zoo-452	Animal form and function-II	3 (2+1)
Zoo-453	General Nematology	3 (2+1)
Zoo-454	Biological Techniques	2 (1+1)
Chem-Env-451	Environmental chemistry	4 (3+1)
Total		15

ZOO-451 ANIMAL FORM AND FUNCTION – I (A COMPARATIVE PERSPECTIVE)

Cr. Hours: 3(2+1)

Aims and Objectives:

The course aims to teach the students about:

- Animals 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 that determines its particular function.

Course Contents

1. Protection, Support, and Movement

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

2. Communication I: Nerves

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

3. Communication II: Senses

Sensory reception: baroreceptors, chemoreceptors, georeceptors, hygrometers, phonoreceptors, photoreceptors, proprioceptors, tactile receptors, and thermoreceptors of invertebrates; lateral-line system and electrical sensing, lateral-line system and mechanoreception, hearing and equilibrium in air, hearing and equilibrium in water, skin sensors of damaging stimuli, skin sensors of heat and cold, skin sensors of mechanical stimuli, sonar, smell, taste and vision in vertebrates.

4. 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, nemertans, nematodes, molluscs, annelids, arthropods, and echinoderms invertebrates; an overview

of the vertebrate endocrine system; endocrine systems of vertebrates, endocrine systems of birds and mammals.

5. Circulation, 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.

Books recommended

1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11th Edition (International), 2004. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5th Edition (International), 2002. Singapore: McGraw Hill.
3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4th Edition (International), 2000. Singapore: McGraw Hill.
4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill.
5. Campbell, N.A. BIOLOGY, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.

Practicals

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

ZOO – 452 ANIMAL FORM AND FUNCTION-II (A COMPARATIVE PERSPECTIVE)

Crdt hrs. 3 (2+ 1)

Aims and Objectives:

The course deals with the:

- a. Basis of structure and functions of animal nutrition, digestion, homeostasis and temperature regulation.
- b. It introduces the basic concepts in reproduction and development in animal kingdom.
- c. Provides knowledge about the development of chordate body plan and fate of germinal layers.

Course Contents

1. Nutrition and Digestion

Evolution of nutrition; the metabolic fates of nutrients in heterotrophs; digestion; animal strategies for getting and using food, diversity in digestive structures of invertebrates and vertebrates; the mammalian digestive system: gastrointestinal motility and its control, oral cavity, pharynx and esophagus, stomach, small intestine: main site of digestion; large intestine; role of the pancreas in digestion; and role of the liver and gallbladder in digestion.

2. Temperature and Body Fluid Regulation

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

3. Reproduction and Development

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

4. Descriptive Embryology

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

Books Recommended

1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11th Edition (International), 2004. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5th Edition (International), 2002. Singapore: McGraw Hill.
3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4th Edition (International), 2000. Singapore: McGraw Hill.
4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill.

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

Practicals

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

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

Books Recommended

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

Aims and objectives

To familiarize the students with the basics of nematology, and let them know about the importance of nematodes in agro-eco system and natural-eco system. The course will however, focus on soil nematodes.

Course contents**Theory**

Introduction to the subject

History and importance of nematodes.

Classification (terrestrial, aquatic, animal parasites, plant parasites and free living. Taxonomic classification upto genus level)

Life cycle of a typical nematode (egg, juvenile stages and adult).

Morphology, and study of the various systems of nematodes.

Nematode as parasites of plants, animals and the free living.

An overview of Entomopathogenic nematodes.

Practical

1. Isolation of nematodes from soil
2. Isolation of nematodes from plants
3. Isolation of nematodes from insects
4. Preparation of temporary and permanent slides
5. Culturing nematodes
6. Field visits.

Books Recommended

1. Bird AF, Bird J (1991) The structure of nematodes. San Diego, California: Academic Press, Inc. 316 p.
2. Maggenti A (2011) General Nematology: Springer New York.
3. Gaugler R (2002) Entomopathogenic Nematology. Wallingford: CABI publishing. 388 p.
4. Chen ZX, Chen SY, Dickson DW (2004) Nematology: Nematode morphology, physiology, and ecology: CABI Publishing.
5. Webster JM, Eriksson KB, McNamara DG (2008) An Anecdotal History of Nematology: Pensoft.
6. Perry RN, Moens M (2013) Plant Nematology: , 2nd Edition: CABI Publishing.

Course Contents (Theory and Practical)

Microscopy: Principles of light microscopy. Magnification, Resolution, Contrast. Types of microscopy, Phase Contrast Dark field Interference microscope, Electron microscope.

Micrometry and Morphometry: Use of stage and ocular micrometer. Calibration of ocular micrometer. Size measurement (length, width, diameter).

Specimen preparation for optical microscopy.

Standard system for weight, length and volume. Preparation of stock solutions of various strengths.

Microtomy: Fixation, embedding, Section cutting (transverse, longitudinal section, mounting and staining. Sections in paraffin and cryosections.

Extraction techniques: Centrifugation, Ultra centrifugation, cell fractionation, filtration, Distillation, Use of Soxhlet and Rotary evaporator for extraction.

Separation Techniques: Chromatography: Principle, applications, types, thin layer, paper, 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.

Books Recommended

1. Dean, J. R. EXTRACTION METHODS FOR ENVIRONMENTAL ANALYSIS. 1999. John Wiley and Sons Ltd. UK.
2. Curoso, M. ENVIRONMENTAL SAMPLING AND ANALYSIS: LAB MANUAL. 1997. CRC Press LLC. USA.
3. Curoso, M. ENVIRONMENTAL SAMPLING AND ANALYSIS: FOR TECHNICIAN. 1997. CRC Press LLC. USA.
4. Cheesbrough, M. DISTRICT LABORATORY PRACTICE IN TROPICAL COUNTRIES. Part I. 1998. University Press Cambridge, UK.
5. Cheesbrough, M. DISTRICT LABORATORY PRACTICE IN TROPICAL COUNTRIES. Part II. 1998. University Press Cambridge, UK.
6. Slingsby, D. and Cock, C. PRACTICAL ECOLOGY. 1986. McMillan Education Ltd. London.

BS Semester V / M.Sc I

Course #	Name of Subject	Cr. Hours
ZOO-501	Animal Behavior	2 (2+0)
ZOO-502	Biochemistry	4 (3+1)
ZOO-503	Cell and Molecular Biology	4 (3+1)
ZOO-504	Developmental Biology	4 (3+1)
ZOO-505	Ecology	3 (2+1)
Total		17

ZOO-501 ANIMAL BEHAVIOR Cr. Hours: 2 (2+0)

Course contents:

Introduction to ethology, Perception, Taxes, Reflexes, integration and storage of information, learning and its classification- habituation, conditioned or reflex learning, instrumental learning, latent learning, insight learning, imprinting. Instinct according to ethnologists, psychologists and physiologist. Instinctive behavior in three spined male fish, Sexual behavior, action of pituitary and reproductive hormones on sexual chemical signals. Evolution of behavior. Social behavior.

Books Recommended:

1. Manning A, Dawkins MS (2012) An Introduction to Animal Behaviour: Cambridge University Press
2. Mandal FB (2012) Textbook Of Animal Behaviour: PHI Learning
3. Ridley, M. (latest edition) Animal Behaviour. Black well Scientific Publications, London

ZOO-502 BIOCHEMISTRY Cr. Hours: 4 (3+1)

Aims and Objectives:

The course will provide in depth knowledge about the polymerized organic compounds of life. The dynamism of the life proceeds with inter-conversion of the chemicals from feeding to the liberation of energy for work. It will deal with the inter-conversion is performed by various tools called as enzymes. Thus, in this course the concepts of the chemical basis of life and all the mechanisms involved in harvesting of energy for growth, duplication etc., are given.

Course Contents

Amino acids, peptides and proteins: standard amino acids, their structure and classification; acid/base properties of amino acids and their titration curves; natural modifications of amino acids in proteins; non-standard amino acids, their structure and role; peptides, their ionic behavior and amino acid composition, cytochrome c; Macromolecular separation techniques in biochemistry; ion exchange chromatography; isoelectric focusing; density gradient centrifugation.

Enzymes: introduction; important characteristics of enzymes; immobilized enzymes; how enzymes work; example of enzymatic reaction; enzyme kinetics, enzyme rate of reaction and substrate concentration, how pH and temperature effect enzyme activity; kinetics of bisubstrate and multisubstrate reactions.

Carbohydrates: classification, types, important characteristics and structure of carbohydrates; history of developments in structure of glucose; monosaccharides; cyanohydrin formation; disaccharides their types structure and function; polysaccharides, storage and structural types; structure and major functions of polysaccharides.

Lipids: fatty acids, their types and major characteristics; storage lipids, acylglycerols; waxes; structural lipids in membranes; major functions of lipids; lipoproteins, their types and major functions.

Vitamins and cofactors: occurrence, structure and biochemical function of vitamins of b-complex group.

Bioenergetics: concept of free energy; standard free energy change: energy rich compounds.

Metabolism: detailed description of glycolysis and catabolism of other hexoses; regulation and bioenergetics of glycolysis. Anabolic role of glycolysis; fate of pyruvate under aerobic and anaerobic conditions, lactate, acetyl CoA and ethanol formation; alcoholic fermentation; gluconeogenesis, its regulation and significance in the tissues; feeder pathways in glycolysis; utilization of other carbohydrates in glycolysis; phosphorolysis of glycogen and starch; regulation of glycogen metabolism; utilization of dietary polysaccharides (starch) and disaccharides (sucrose and galactose). Biosynthesis of glycogen, starch and sucrose.

Citric acid (TCA) cycle: conversion of pyruvate to acetyl CoA, pyruvate dehydrogenase, a multi-enzyme complex; detailed description of citric acid cycle; bioenergetics and conservation of energy produced in the cycle. Anabolic or biosynthetic role of citric acid cycle intermediates; replenishing or anaplerotic reactions and their role; regulation of citric acid cycle.

Lipid metabolism: oxidation of fatty acids; digestion, mobilization and transport of fats; biosynthesis of triacylglycerol; utilization of triacylglycerol; activation of fatty acids and their transportation to mitochondria; beta-oxidation; bioenergetics of beta-oxidation; oxidation of unsaturated and odd chain fatty acids; omega oxidation pathway; biosynthesis of saturated fatty acid, supply of raw material for palmitic acid synthesis; fatty acid synthetase (FAS) multienzyme complex; biosynthesis of unsaturated fatty acids. Ketone bodies their biosynthesis, utilization and role in the tissues; cholesterol metabolism: cholesterol biosynthesis and its regulation; steroid hormones.

Nitrogen metabolism: metabolic fate of amino acids; catabolism of amino acids; deamination and transamination; nitrogen excretion and urea cycle; regulation of urea cycle; Biosynthesis of some amino acids; incorporation of ammonia in glutamate and glutamine; purine and pyrimidine.

Books Recommended

1. Nelson, D. L. and Cox, M.M. LEHNINGER PRINCIPLES OF BIOCHEMISTRY, 3rd Edition, 2000. McMillan Worth Publishers, New York.
2. Murray, R.K., Granner, D.K., Mayer, P.A. and Rodwells, V.W. HARPER'S BIOCHEMISTRY, 25th Edition, 2000. McGraw Hill, New York.
3. Voet, D., Voet, J.G., and Pratt, C.W. FUNDAMENTALS OF BIOCHEMISTRY, 1999. John Wiley and Sons, Inc., New York.

4. Zubay, G. BIOCHEMISTRY, 4th Edition, 1995. Wm. C. Brown Publishers, Inc., Oxford, England.
5. Lubert, S. BIOCHEMISTRY, 4th Edition, 1995. W.H. Freeman & Company, New York.
6. McKee, T. and McKee, J.R. BIOCHEMISTRY, THE MOLECULAR BASIS OF LIFE. 3rd Edition, 2003. McGraw Hill.

Practicals:

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

Books Recommended

1. Plummer, David T. AN INTRODUCTION TO PRACTICAL BIOCHEMISTRY, 1990. 4th Edition McGraw-Hill Book Company, London.
2. Wilson, K & Walker, J. PRACTICAL BIOCHEMISTRY: PRINCIPLES AND TECHNIQUES, 4th Edition, 1994. Cambridge University Press.

ZOO-503 CELL & MOLECULAR BIOLOGY Cr. Hours:4(3+1)

Aims and Objectives:

Objectives of the course are to impart knowledge about the animal cell and its complex organization of architecture and the unified role it plays for the ultimate sustainability of the organisms. The various ultra-structural, molecular and functional aspects of the cells will be communicated in this course.

Course Contents:

Introduction to prokaryotic and eukaryotic cells: Plasma membrane, its chemical composition structure and functions, cell permeability, active transport, endocytosis, phagocytosis.

Cytoskeleton: Microfilaments, Microtubules, Intermediate filaments.

Cytoplasmic Organelles: Membrane system (structural and functional commonalities). Ultrastructure, chemical composition and functions of Endoplasmic Reticulum with special reference to their role in protein synthesis and drug metabolism), Golgi Apparatus (with reference to its role in synthesis of glycoprotein), Mitochondria (with reference to its role in cellular respiration, and its significance as semi-autonomous organelle), Lysosome (with reference to its diverse roles due to hydrolytic activity of enzymes), peroxisome (with reference to metabolism of hydrogen peroxide), glyoxysome (with reference to glyoxylic acid cycle).

Nucleus, chromatin, heterochromatin, euchromatin, chromosome structure with reference to coiling and nucleosome during different phases of cell cycle, Replication (mechanism, DNA replication in prokaryotes specially with reference to variety of DNA polymerases and other proteins involved, DNA replication in Eukaryotes with special reference to DNA polymerases, concept of Replicons etc.), Transcription (variety of RNA and their characteristics, synthesis of mRNA, rRNA and tRNA with special reference to enzymes, involved, RNA splicing, split genes, concept of Ribozymes and posttranscriptional processing), RNA transduction, Genetic code, point mutations, Translation (with reference to the specific role of Ribosomes, various factors, and posttranslational processing).Control of Gene expression in Prokaryotes.

Books Recommended

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. MOLECULAR BIOLOGY OF THE CELL, 1989. Garland Publishing Inc., New York.
2. Damell Jr. J., Lodisch, H. and Balimore, D. MOLECULAR CELL BIOLOGY, 1990. Scientific American Inc. N.Y.
3. De Robertis, E. D. P. and De Robertis Jr. E. N. F. CELL AND MOLECULAR BIOLOGY, 1987. Lea & Febiger, New York.
4. Karp, J. CELL AND MOLECULAR BIOLOGY, CONCEPTS AND EXPERIMENTS, 2005. Jhon Wiley and Sons, INC.
5. Geoffrey M.C., Robert E.H. THE CELL: A MOLECULAR APPROACH, 2007. Sinauer Associates, INC.

Practicals

1. Detection and quantitative determination of chromosomal DNA and RNA
2. Counting of prokaryotic cells (bacteria) and blood cells by using haemocytometer.
3. Isolation and characterization of proteins on polyacrylamide gel electrophoresis (native and sub-unit molecular weights).
4. Separation of different sized PCR amplified DNA fragments on agarose gel and western blotting.

Aims and 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. In the continuity of the animals during reproduction following the union of the traits from the parents in their gametes, the zygote proceeds through enormous phenomena of development up to their emergence resembling to the parents. The concepts of all these developmental mechanisms will be communicated to the students in this course.

Course Contents:

Introduction: Principal features of development, origin of sexual reproduction, developmental patterns; Spermatogenesis; Oogenesis, classification of eggs.

Fertilization: Recognition of sperm and egg, fusion of gametes, activation of egg metabolism, rearrangement of egg cytoplasm, IVF.

Cleavage: Patterns of embryonic cleavage, mechanism of cleavage, process of twinning.

Gastrulation: Fate maps, gastrulation in sea urchin 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.

Placentation in Mammals.

Organogenesis: A brief account; Origin and migration of germ cells in vertebrates (one type).

Brief introduction to Factors controlling growth and oncogenesis.

Hormones as mediators of development; chemical basis of Regeneration in vertebrates.

Books Recommended

1. Gilbert, S. F. DEVELOPMENTAL BIOLOGY, 2006. Sinauer Associates, Sunderland, MA.
2. Balinsky, B. I. AN INTRODUCTION TO EMBRYOLOGY, 1985. Saunders.
3. Saunders, J. W. DEVELOPMENTAL BIOLOGY, 1982. McMillan and company.

4. Oppenheimer, S.S. INTRODUCTION TO EMBRYONIC DEVELOPMENT, 1984. Allen and Bacon.
5. Ham, R. G. and Veomett, M. J. MECHANISM OF DEVELOPMENT. 1980. C. V. Mosby Co.
6. Klaus, K. BIOLOGICAL DEVELOPMENT. 2nd Edition, 2001. McGraw Hill.

Practicals

Study of structure of gametes in some representative cases, i.e., frog, fish, fowl and mammal. 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 through induced spawning under laboratory conditions. Preparation and study of serial sections of frog or chick embryos. Application of microsurgical techniques on chick embryos *in vitro*. Preparation and staining of histological slides.

Slides and models of metamorphosis

ZOO-505 ECOLOGY Cr. Hours: 3 (2+ 1)

Aims and Objectives:

The aim of this course is to make the students aware that all the living organisms including human beings are part of the environment, which consists of biotic and abiotic factors. The abiotic factors consist of all the physical factors while biotic factors include all the living things. However with the increase in population densities increase in productivity is also needed. High technology measures used for this purpose have caused various problems like pollution.

Course Contents:

An overview of concepts of ecosystem with emphasis on interaction and homeostasis. Basic global ecosystems (atmosphere, hydrosphere, lithosphere, ecosphere). Biogeochemical cycle: nitrogen, phosphorus, sulphur, water, carbon, nutrient. Limiting factors: basic concepts, temperature, soil, water and humidity, light, fire. Energy: laws of thermodynamics, primary and secondary productions, trophic levels and energy variation with increasing trophic levels, energy flow, food chains and food webs. Population ecology: basic population characters, growth and growth curves, population dynamics and regulations. Community ecology: basic concepts, community analysis, ecotones, inter-population interactions. Ecological niche: basic concepts and types. An overview of major biomes of the world. Applied Ecology: Resources and their ecological management (mineral, agricultural and forest, range management, desalination and

weather modification, landscape and land use); Pollution (definition, types, cost, origin and management); water (sources, domestic and industrial pollution, heavy metals, water purification, waste water treatment); air (sulphur dioxide, nitrogen oxide, carbon monoxide, ozone, smog and PAN, MTBE & CFCs); land pollution (pesticides, bacterial toxins, synthetic hormones); noise pollution. Radiation. Space biology. Contemporary environmental themes: (ozone depletion, acid rain, greenhouse effect and global warming, desertification, deforestation, exotic and invasive species, radioactivity leakage, environmental laws).

Books Recommended

1. Odum, E. P. 1994. FUNDAMENTALS OF ECOLOGY. 3rd Edition W.B. Saunders. Philadelphia.
2. Molles, M.C. 2005 Ecology: CONCEPTS AND APPLICATIONS. 6th Edition, McGraw Hill, New York, USA.
3. Dondson, S.I., Allen, T.F.N., Carpenter, S.R., Ives, A., Jeanne, R.L., Kitchell, J.F., Langston, N.E. and Turner, M.G., 1998. ECOLOGY. Oxford Univ. Press, UK.
4. Slingsby, D. and Cook, C., 1986. PRACTICAL ECOLOGY. McMillan Education Ltd. UK.
5. Chapman, J.L. and Reiss, M.J. 1997. ECOLOGY: PRINCIPLES AND APPLICATIONS. Cambridge Univ. Press, UK.
6. Smith, R.L. 1980. ECOLOGY AND FIELD BIOLOGY, Harper and Row.
7. Newman, I. 1993. APPLIED ECOLOGY. Black Well Scientific Publications Oxford. UK.
8. Cox, C.B and Morre, D. 2000. BIOGEOGRAPHY: AN ECOLOGICAL AND EVOLUTIONARY APPROACH, 6th Edition. Life Sciences King's College, London, UK.

Practicals:

Measurement of environmental factors on land, water and air. Study of different ecosystems: pond, agricultural or grassland, forest. Community analysis through different sampling techniques (quadrat, Transect). Population dynamics of grasshoppers. Adaptive features of animals in relation to food and environment. Food chain studies through analysis of gut contents. Analysis of polluted and fresh water for biotic and abiotic variations. Field visits for study of selected terrestrial habitat and writing notes. Development of an ecological management plan of some selected area.

Population dynamics of flour beetle.

BS Semester VI /M.Sc II

Course #	Name of Subject	Cr. Hours
ZOO-551	Basic Biotechnology	3 (2+1)
ZOO-552	Genetics	4 (3+1)
ZOO-553	Evolution and Principles of Systematic Zoology	4 (3+1)
ZOO-554	Animal Physiology	4 (3+1)
ZOO-555	Biostatistics	3 (2+1)
Total		18

ZOO-551 BASIC BIOTECHNOLOGY Cr. Hours: 3(2+1)

Aims and Objectives:

Aims of this course to let the students know about the applications of the biotechnology in the different fields of life. The course may initiate their interest in agricultural, industrial and/or environmental Biotechnology.

Course Contents:

Introduction to Biotechnology: Definition, scope and achievements. Tools used in biotechnology, Applications of Biotechnology in Agriculture, Medicine and Environment – an elementary knowledge, Prospects and public perception of Biotechnology, Biotechnology as profession; historical perspective and scope of biotechnology with special application to other disciplines and areas; current research and development in genomics and proteomic, nature and scope of Nucleic acid research; environmental and microbiological aspects including anaerobic and aerobic fermentations; production of ethanol and other chemicals of industrial importance; industrially important microorganisms and biotechnological products; Biodiversity conservation and identification of useful variants, biochemical basis of structural and functional variations in the living beings, mammalian and plant cell culture; biotechnology in health, agriculture and industry; future trends in biotechnology, Ethics and biotechnology, genome

Practicals:

1. Preparation of buffer
2. Verification of Beer-Lambert Law.
3. Separation of cell organelles:
4. Methods for cell lysis: rupture-osmotic/chemical /enzymatic lysis of cells followed by centrifugation.
5. Monitoring cell lysis by release of cellular material and any change in light scattering etc.
6. Mechanical rupture of cells: Ultra sonic vibrations; French pressure cell followed by centrifugation for cell organelles
7. Isolation of DNA and quantification
8. Isolation of RNA and quantification
9. PCR techniques.
10. RFLP and RAPD assay
11. Isolation of chromosomal and plasmid DNA from bacterial.

Recommended Books:

1. Cell Biology and Genetics. 9th edition. Starr, C. and Taggard; R. (2001) Thomson Learning USA.
2. Life Science of Biology 6th edition Purves W.K.; Sadava, D.; Orians, G.H. and Heller, H.C. (2001). W.H. Freeman & company, USA.
3. Basic Biotechnology. Ratledge, C. and Kristiansen, B. (2001) Cambridge University Press.
4. Basic Biotechnology. Ignacimuthu, S.J. (2002) Tata McGraw-Hill Pub., New Delhi
5. Genes VII Lewis Benjamin (2002). Oxford Univ. Press Oxford.
6. Biotechnology 3rd Edition. Smith, J.E. (2003) Cambridge University Press.
7. Principles of Microbiology, 2nd Edition. M Ronald. Atlas, W.C. Publishers.1997.
8. Molecular Cell Biology, 4th Edition. H. Lodish, A. Berk, S. Zipursky W. H.Freeman. 2000.
9. Biotechnology for Waste and Waste Water Treatment, Cheremisinoff N, P. Prentice Hall of India Pvt. Ltd. (1996).
10. Environmental Microbiology, Maier R. M. , I. L. Pepper and C. P. Gerba (Editor) Academic Press 2000
11. Techniques in Microbial Ecology, Burlage R. S. , R. Atlas, and D. Stahl academic Press 2000
12. Biodiversity of Microbial Life : Foundations of Earth's Biosphere Staley J. T. , A. Reysenbach, (Wiley Series in Ecological and Applied Microbiology), Wiley-Liss; 2001
13. Basic Biotechnology. C. R. Attedge, and B. Kristiansen Cambridge University Press, U.K. 2001.
14. Applied Plant Biotechnology. V.L., Chopra, V.S. Malik and S.R. Bhat. OxfordIBH Publishers, New Delhi. 2000.
15. Application of Microbes in Biotechnology. Lee, Y.K. and C.L. Poh and H. M. Tan Springer-verlag. 1999
16. Introduction to biotechnology by R.C.Dubey

Book recommended for Practicals

Leung, W, 2007. Centrifugal Separation in Biotechnology. Elsevier. Pp-312.

Aims and Objectives:

The continuity of the life from one generation to other generation is based on the mechanisms involving nucleus, chromosomes and genes etc. The process of continuity not only transfers the traits of the parents but also imparts variations that render the generations sustainable in changing environment. These concepts will be imparted to the students in this course.

Course Contents:

Classical Genetics – Brief introduction to cell cycles. Multiple alleles, genetics of blood groups, chromosomal basis of inheritance, interaction of genes, chromosomal changes (euploidy, aneuploidy, structural changes), sex-determination and sex-linkage, linkage, recombination and chromosome mapping in eukaryotes, quantitative inheritance, gene concept (classical and modern), genetics of viruses, bacteria, transposons, Heritable Diseases.

Molecular Genetics – analysis and techniques of molecular genetics (elements of genetic engineering), genetic basis of cancer, genetic control of animal development, the genetic control of the vertebrate immune system, complex inheritance patterns.

Population genetics – Hardy-Wienberg equilibrium, systematic and dispersive pressures, inbreeding and heterosis

Books Recommended

1. Snustad, D.P. and Simmons, M.J. PRINCIPLES OF GENETICS. 3rd Edition, 2003. Johan Wiley and Sons Ins. New York, USA.
2. Lewin, B. GENE-VIII. 2000. Oxford University Press. UK.
3. Tamarin, R.H. PRINCIPLES OF GENETICS. 7th Edition, 2001.WCB publishers USA.
4. Gardener, E.J., Simmons, M.J. and Snustad, D.P. PRINCIPLES OF GENETICS. 1991. John Wiley and Sons Ins. New York, USA.
5. Strickberger, M.W. GENETICS. 1985.McMillan, New York. USA.

Practicals

1. Mitosis (Onion root tips.) 2. Meiosis (Grass hopper 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. χ^2 test

ZOO-553 EVOLUTION AND PRINCIPLES OF SYSTEMATIC ZOOLOGY

Cr. Hours:3(2+1)

Aims and Objectives:

The course is designed to provide in depth knowledge Systematic Zoology. The students will be taught basic rules and regulations about the identification and naming of organisms.

Course Contents:

Evolution: The nature and origin to life. Evidences of evolution. (molecular, embryological & paleontological). Theories to explain the diversity of life - Modern synthetic theory.

Factors initiating elementary evolutionary changes (micro-evolution) by changing gene frequencies, mutation pressure, selection pressure, immigration and crossbreeding, genetic drift. Role of isolation in evolution. Factors of large evolutionary changes (macro/mega evolution) - allometry, orthogenesis, adaptive radiation.

Modern concept of Natural Selection: Levels of selection, selection patterns, laboratory and field example regarding action of Natural Selection. Action 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. Recapitulation theory, Trend and rates in evolution.

Books Recommended Evolution:

1. Ridley, M. EVOLUTION. 1993. Blackwell Scientific Publications.
2. Dobzhansky, T., Ayala, F.J., Stebbins, G.L. and Valentine, J.W. EVOLUTION. 1973. W.H. Freeman and Company.
3. Dobzhansky, T. GENETICS AND THE ORIGIN OF SPECIES, 1951. Columbia University Press, New York.
4. Mayr, E. POPULATIONS, SPECIES AND EVOLUTION, 1965. Harvard University Press.

5. Moody, P.A. INTRODUCTION TO EVOLUTION, latest edition. Harper and Row Publishers, New York.
6. Strickberger. M.W. EVOLUTION. 2000. Jones & Barrett Publishers

Principles of Systematic Zoology

Contribution of systematics to Biology: History of Taxonomy (Downward classification, upward classification, impact of the origin of species, population systematics, current trends); Microtaxonomy, phenon, Taxon; Taxonomic categories: specific category, infraspecific category, higher categories; species concepts (Typological concept; nominalistic concept, Biological concept, evolutionary concept), species mate recognition concept; non-dimensional species concept; Multidimensional species concept; Cohesion species concept; Difficulties in the application of biological species concepts; polytypic species, subspecies, super species, sibling species; study of major type of variation within a single population. Speciation and taxonomic decision, various types of characters, cladistic analysis, Macrotaxonomy; different kinds of taxonomic characters; Taxonomic collection and identification; definitions of Synonym, Homonym, Keys; Evolution of the theory of Nomenclature; interpretation and application of the code (stability, priority, first revisor principle) range of authority of code; concept of availability, type method formation of specific names.

Books Recommended

Systematic Zoology

1. Mayer, E. PRINCIPLES OF SYSTEMATIC ZOOLOGY. 1994. McGraw Hill, New York.
2. Mayer, E. and Asblock, P.D. PRINCIPLES OF SYSTEMATIC ZOOLOGY. 1991. McGraw Hill, New York
3. Mayr, E. ANIMAL SPECIES AND EVOLUTION, 1985. Harvard University Press.
4. Heywood, V.H. TAXONOMY AND ECOLOGY. 1975. Academic Press, London.
5. Whili, M.J.D. MODES OF SPECIATION, 1978. W.H. Freeman and Co., San Francisco.

Practicals

Study of preserved invertebrate species and their classification upto order level. Collection, preservation and identification of common species with the help of keys. Methods of statistical analysis of samples from populations T-test, Analysis of variance etc. Preparation of keys for the identification of specimens. Taxidermy (stuffing of animals).

Aims and Objectives:

The basic functional expression in animals is the membrane irritability understood in the form of nerve impulse. This course particularly imparts the concepts and mechanisms of integration in the different functional systems of the animals. These mainly constitute the mechanisms of nervous system and the hormonal system for the coordination. The motility and locomotion also contributes in the integration of the animal to its environment, therefore, also included in this section.

Course Contents:

Central themes in Physiology: Structure-function relationship, Adaptations, Conformity and Regulation.

Physiological basis of Membrane Function: Mechanisms in resting membrane potentials: Electrogenic ion pump, Donnan equilibrium, Diffusional potentials, Ion channels, Ionic mechanisms in action potentials: Roles of ion channels, Properties of action potential. Propagation of action potential in neurons; Synaptic transmission; Structure and function of electrical synapse structure and function of chemical synapse; Neurotransmitters; Synaptic receptors; Excitatory postsynaptic potentials; Inhibitory postsynaptic potentials; Presynaptic inhibitions; Integration at synapses: Facilitation, Posttetanic Potentiation.

Receptors Physiology: Transduction; Sensory coding; Range fractionation; Sensory adaptations; Mechanoreception: Hair cell mechanism particularly in acoustico-lateralis system of vertebrates; Cutaneous receptors; Cellular and molecular mechanisms in taste and olfactory reception; Photoreception: Ultrastructure of photoreceptors, Photochemistry, Phototransduction and physiological basis of color vision; Physiological mechanisms in electroreception.

Movements and Muscles: Structural basis of muscle contraction: molecular structures of contractile components and their interaction, sarcoplasmic reticulum, calcium and membrane mechanisms in regulation of contraction.

Cardiovascular Mechanisms: Electrical activity of heart: Automaticity, Rhythmicity, Electrocardiography, Kymography; Hemodynamics, Blood flow, pressures and resistance and their interrelationships. Control of cardiac activity (cardiac output) and peripheral circulation.

Exchange of Gases: Transport of O₂ and CO₂ between respiratory surface (the lungs) and body cells. Regulation of lungs respiration; Gas transfer in water (gills) and its regulation. Respiratory responses in extreme conditions as hypoxia; Hypercapnia in air breathing divers.

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. Louis, 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. Bullock, J., Boyle, J. and Wang, M.B. PHYSIOLOGY, 4th Edition. 2001. Lippincott, Williams and Wilkins, Philadelphia.

Practicals:

Muscle and Neuromuscular Activity: Nerve muscle preparation, Muscle twitch, Comparison of muscle and nerve irritability, effect of stimulus strength, effect of stimulus frequency (tetany), effect of load or stretch, effect of prolonged activity (fatigue), neuromuscular fatigue, stimulation of motor points in human.

Excitability, Sensation and Behaviour: 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.

Cardiovascular Activity: Normal cardiac activity, effect of temperature, effect of drug, heart block, tetanization of heart. Measurement of blood pressure. 2. Identification of different type of blood cells in human blood through smear technique.

Respiration and Exercise: 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.

Books Recommended

1. Tharp, G. and Woodman, D. EXPERIMENTS IN PHYSIOLOGY, 8th Edition. 2002. Prentice Hall, London.

Aims and Objectives:

The course will provide knowledge about the importance and use of statistics in life sciences. It will help the students to understand the methods to analyze data pertaining to their research work and to assess the significance of their experimental designs.

After this course students will be able to apply basic statistical procedures for analysis of data for practical and research.

Course Contents:

Introduction and scope, use of statistics in biology. Population and sample. Stages of research, types of data and methods of data collection. Data arrangement and presentation, formation of tables and charts. Measures of central tendency computation of mean, median and mode from grouped and ungrouped data. Measures of dispersion, computation of variance, standard deviation, standard error and their coefficients. Probability rules.

Binomial, Poisson and normal distributions. Hypothesis testing, Student 't' test, Chi square test, Analysis of variance and LSD. Correlation and regression. Experimental designing, planning of an experiment, replication and randomization.

Books Recommended

1. Geoffrey, R. Norman, David L. Streiner Biostatistics: the bare essentials. 2000. B.C. Decker Inc.
2. Gerry, P. Quinn, Michael J. Keough, Experimental design and data analysis for Biologists. 2002. Cambridge University Press.
3. Campbell, R. C. Statistics for biologists. 1989. Cambridge University Press.
4. Walpole latest edition

BS Semester VII / M.Sc III

Course #	Name of Subject	Cr. Hours
ZOO-601	Fundamentals of Microbiology	3 (2+1)
ZOO-602	Bioinformatics	3 (2+1)
ZOO-603	Fundamentals of Endocrinology	3 (2+1)
ZOO-604/ ZOO-605, ZOO-606	Parasitology A/ Fish Biology/ Insect Biology	3 (2+1)
ZOO-607	Research methodology	2 (2+0)
ZOO-608	Research/Special paper	3
Total		17

ZOO-601 FUNDAMENTALS OF MICROBIOLOGY Cr. Hours: 3(2+1)

Aims and Objectives:

The course is designed to introduce students with microorganism and basic techniques of staining, sterilization, culturing, isolation and determining different characteristics of the microorganisms.

Course Contents:

1. Microorganisms and their respective place in the living world.
2. Differentiation between pro- and eukaryotic cells.
3. Historical development of Microbiology and its scope.
4. Microscopy: An outline of the principles and applications of light and electron microscope.
5. Morphology, arrangement and detailed anatomy of bacterial cell.
6. Bacterial taxonomy and nomenclature, basis of classification of bacteria.
7. General methods of studying microorganisms: cultivation, isolation, purification and characterization.
8. Control of microorganisms by physical and chemical methods.
9. Basic properties of fungi, protozoa and algae.
10. A brief introduction to structure and propagation of viruses and bacteriophages.

List of Practicals:

- 1) Laboratory safety
- 2) An introduction to microscopy.
- 3) Principles of Staining Procedures:
 - a) Simple staining,
 - b) Gram's staining,
 - c) Negative staining,
 - d) Acid fast staining
 - e) Spore staining,
- 4) Study of cell motility by hanging drop preparation.
- 5) Preparation and sterilization of bacteriological media and glassware.
- 6) Culturing of microorganisms: Preparation and sterilization of culture media, agar slope, spread plate, streak plates, pour plates methods.
- 7) Study of colony characteristics of microorganisms.

- 8) Enumeration of bacteria from milk, water, food and soil by standard plate count technique (SPC) and/or most probable number technique (MPN).
- 9) Microbiological analysis of air: Microscopic study of fungi isolated from air.

BOOKS RECOMMENDED

1. MICROBIOLOGY: A HUMAN PERSPECTIVE, 2001. Eugene W. Nester, Denise, G., Anderson, Martha, T., Nester, C., Evans Roberts, Nancy, N. McGraw Hill Higher Education.
2. MICROBIAL APPLICATIONS: LAB MANUAL IN GENERAL MICROBIOLOGY, 1994. Benson, H.J. WMC Brown Publishers, England.
3. MICROBIOLOGY, 1983. Nester, E.W., Pearsall, N.N., Roberts, C.E., Nester, M.T. and Lidstorm, .E. Saunders College Publishing, Philadelphia
4. MICROBIOLOGY, CONCEPTS AND APPLICATIONS, 1993. Pelczar Jr. M.J., Chan, E.C.S. and Krieg, N.R. MacGraw-Hill Inc.
5. Tortora, G.J., Christine, L., Case, C.L., Funke, B. R., Funke, B., Case, C. (2006) MICROBIOLOGY: AN INTRODUCTION, Publisher: Pearson Education
6. Talaro, K.P., 2006. FOUNDATIONS IN MICROBIOLOGY: BASIC PRINCIPLES. Mcgraw Hill. Publisher.

ZOO-602

BIOINFORMATICS

Cr. Hours: 3(2+1)

Aims and Objectives:

The course provides an introduction to bioinformatics with a focus on fundamental bioinformatics problems, the tools used to compute solutions to those problems, and the theory upon which those tools are based.

Course Contents:

1. **Overview of Bioinformatics:** the scope of bioinformatics, bioinformatics and internet, Useful Bioinformatics sites on Web.
2. **Data Acquisition:** Sequencing DNA, RNA and proteins, Determination of protein structure, Gene and protein expression data, Protein interaction data.
3. **Database:** Contents, Structure and Annotation: File formats, Annotated sequence databases, Genome and organism-specific databases, Miscellaneous databases.
4. **Retrieval of Biological Data:** Data retrieval with Entrez and DBGET/LinkDB, Data retrieval with SRS (sequence retrieval system).
5. **Searching Sequence Databases by Sequence similarity Criteria:** Sequence similarity searched, Amino acid substitution matrices, Database searched (FAST and BLAST), sequence filters, Interactive database searches and PSI-BLAST.
6. **Multiple Sequence Alignment:** Genes and Protein Families: Multiple sequence alignment and family relationships, protein families and pattern databases, protein domain families.
7. **Phylogenetics:** Phylogenetics, cladistics and ontology, Building phylogenetic trees, Evolution of macromolecular sequences.

8. **Basic Principles of Computing in Bioinformatics:** Running computer software, Computer operating systems, software downloading and installation, Database management.

Recommended Books

1. Gibas, C. and Jambeck, P. DEVELOPING BIOINFORMATICS COMPUTER SKILLS. 2001. O'Reilly publishers.
2. Westhead, D.R., Parish, J.H. and Twyman, R.M. INSTANT NOTES ON BIOINFORMATICS. 2003. Viva Books Private Limited.
3. Lest, A.M. INTRODUCTION TO BIOINFORMATICS. 2002. Oxford University Press.
4. Baxevanic, A.D. and Ouellette, B.F.F. BIOINFORMATICS: 2004. A PRACTICAL GUIDE TO THE ANALYSIS OF GENES AND PROTEINS, 3rd Edition. O'Reilly publishers.
5. Krane, D.E. and Raymer, M.L. FUNDAMENTAL CONCEPTS OF BIOINFORMATICS. 2002. Benjamin Cummings.
6. Moody, G. DIGITAL CODE OF LIFE: HOW BIOINFORMATICS IS REVOLUTIONIZING SCIENCE, MEDICINE AND BUSINESS. 2004. John Wiley and Sons.
7. Orengo, C. A., Jones, D.T. and Thornton, J.M. BIOINFORMATICS: GENES, PROTEINS AND COMPUTERS (Advanced Text) 2003. Routledge.
8. <http://www.ncbi.nlm.nih.gov>
9. <http://www.ebi.ac.uk>
10. <http://foldoc.doc.ic.ac.uk/foldoc/index.html>
11. SPSS or any other data analysis software.

ZOO-603 FUNDAMENTALS OF ENDOCRINOLOGY Cr. Hours:3(2+1)

Aims and Objectives:

- a. General concepts and principles of chemical coordination.
- b. The details of the endocrine mechanisms in relation to various functions such as reproduction and lactation.
- c. Recent trends of endocrinology in relation to diversified function.
- d. 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 feed back, 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.

Calcitropic 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.

Books Recommended

1. Greenspan, F.S. and Stewler, 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.
6. Essentials of Endocrinology by William F. Kelly latest edition.

Practicals

Demonstration of endocrine glands and associated structures in dissections, transparencies, computer projections etc; Histological and ultra-structure features of endocrine glands; Experiments to demonstrate physiological roles of hormones of different endocrine glands; Experiments to demonstrate regulation of hormones' releases. Experiments to demonstrate functional diversity of hormones in different vertebrates. Experiments on endocrine mechanism in vertebrates. Slide preparation of endocrine glands.

Aims and Objectives:

This course aims to provide knowledge regarding different modes of transmission of parasites of medical and veterinary importance along with their pathology, host parasite relationship and control measure.

Course Contents:

Introduction to parasitology.

History and origin of parasitism. Classification of relationships between two individuals: symbiosis, commensalism, parasitisms, myiasis, zoonosis, infection and infestation.

Evolutionary aspects related to parasites, geographical distribution factors affecting the geographical and patterns of distribution. Habitat within the host. Epidemiology: incidences of occurrence and prevalence.

Classification of parasites: ectoparasites, endoparasites, temporary parasites, permanent parasites, facultative parasites, occasional or accidental parasites, wandering parasites or aberrant parasites (brief account and examples).

Protozoology: protozoan parasites of man and other animals, classification, life cycle, habitat, morphology, epidemiology and immunopathology of infections e.g. Entamoeba spp. Pathogenic amoeba, giardia spp, trichomonas, trypanosome, leishmania, coccidia, plasmodium and other protozoan parasites of medical and veterinary importance.

Practicals:

1. Study of prepared slides of protozoan parasites.
2. Study of various host tissues for morphological changes in hosts (prepared slides or diagrams showing comparison) could be used to study the difference.
3. Techniques of collection of parasite samples, preservation and preparation of slides for the study of the morphology.
4. Identification of vector hosts in various habitats and their morphology.
5. Identification of parasites and classification with particular reference to adaptations as parasitic mode of life.
6. Hematological studies of blood samples of infected/non infected hosts (sheep/ chicken and fish).

Books recommended:

1. Bush.A.O Fernandez, J.C., Esch, G.W. and Seed, J.R., 2001. Parasitism: the diversity and ecology of animal parasites. Cambridge university press, Cambridge, U.K.
2. Robert, L.S. and Janovy, J.Jr., 2001. Foundation of Parasitology, 5th edition, Wm Brown Publishers, Chicago, London, Tokyo, Toronto.
3. Smith, J.D. 1994. Introduction to animals Parasitology, Cambridge University Press.

ZOO-605

FISH BIOLOGY

Cr. Hours: 3(2+1)

Aims and Objectives:

The aim of this course is to enable students in obtaining complete understanding about freshwater as well as marine fishes in general and freshwater culturable fishes in particular. It comprises morphology, anatomy, classification and some understanding about various feeding groups found in different water bodies. After having complete knowledge of above, students will be able to practice independently.

Course Contents:

Fish morphology, Anatomy, scales, swim bladder, fins

Fish nutrition: Feeding habits and feeding adaptations, feed formulation

Respiration: Structure of gills in different groups of fishes, Gills; Lungs, Skin, Swim bladder,

Excretion: Osmoregulation in fresh water and marine fishes.

Systematics: Identification of fishes up to order.

Effects of different environmental factors on biology of fishes.

Books Recommended

1. Kestin, S. C. and Warris, P.D. (Editors). KESTIN FARMED FISH QUALITY, 2002, Blackwell Science, Oxford, UK.
2. Woo, P.T.K FISH DISEASES AND DISORDER. Vol 1. PROTOZOAN AND METAZOAN INFECTIONS. 1995. CABI Publisher.
3. Brenabe, G. AQUACULTURE, Vol. I. 1992. Blackwell Publishing, Oxford. UK.
4. Huet M. TEXT BOOK OF FISH CULTURE: BREEDING AND CULTIVATION. 1973. Blackwell Publishing Company.

Practicals

1. Fish dissection to expose different systems.
2. Microscopic study of gills.
3. Use of scales for age determination of fish.
4. Study of gut content of various groups of fishes.
5. Collection, preservation and identification of freshwater fish species
6. Study and survey of various fish collection present in museum like Natural History Museum at Islamabad, at G.C. Lahore & at P.U. Lahore.

Aims and Objectives:

The students will learn to identify the pest during damaging to the crop; Students will understand methods of population estimation of the pest and application of different control strategies.

Course Contents:

General characteristics of insects. Relationship with other Arthropods, splitting up into different evolutionary lines, Reasons for success of the insects in diverse environments.

Hard Parts: General segmentation, tagmatosis and organization.

Cuticle: Detailed structure along with its biochemistry. Epidermal layer; its structure and function. Basement membrane. Colors of insects. cuticular outgrowths and appendages sclerotization.

Head: cephalization, sclerites, modifications.

Antennae: Different modes of ingestion and types of mouth parts.

Neck: Sclerites.

Thorax: Sclerites: legs, their different modifications and functions.

Wings: Origin; Different regions. Development and basal attachments, main veins and their branches (generalized insects), wing coupling.

Abdomen: Secondary appendages and external genitalia, Flight; types of flight. Aerodynamics, fuels, endoskeleton; head, thorax and abdomen.

Soft Parts: Muscular system; basic structure, types of muscles; muscle contraction and its energetics, comparative structure of all the systems, e.g., digestive, excretory, respiratory, incubatory, and nervous system and their physiology.

Sense organs: sound and light producing organs, compound eyes.

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.

Ecology: Carrying capacity 'r' and k selection, Food chains, predation and competition, insect defenses and adaptations, diapause insect population and community studies, insect communication, forensic entomology.

Practicals

Preparation of permanent slides. All the hard parts (antennae, mouth parts, wings, legs, terminal segments and genitalia). Different systems, especially digestive, reproductive of the following insects. American cockroach, Gryllus, grasshopper, housefly, butterfly, mosquito, any common beetle. Red cotton bug. Wasp and honey bee. Sympathetic nervous system of cockroach and gryllus. Salivary glands of cockroach, red cotton bug and honey bee.

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. Chapman, R.F. THE INSECTS: STRUCTURE AND FUNCTION, 2000. Blackwell Science Inc., London.
3. Wigglesworth, V. B. INSECT PHYSIOLOGY 8th Edition. 1984. Springer Publisher.
4. Robert L. Patton. W. B. INSECT PHYSIOLOGY. 1963. Saunders Co., Philadelphia.
5. Price, W. INSECT ECOLOGY. 1997. John Wiley & Sons.
6. Krebs, C. J. ECOLOGY: THE EXPERIMENTAL ANALYSIS ABUNDANCE. 5th Edition. 2000. Benjamin-Cummings Publishing Company.
7. Tembhare, Db. MODERN ENTOMOLOGY. 2002. Himalaya Publishing House. India.
8. Southood, T.R.E. ECOLOGICAL METHODS. 1978. Chapman and Hall, London.
9. Yazdani, S.S., and Agarwal, M.L. ELEMENTS OF INSECT ECOLOGY. 1997. Narosa Publishing House. India

Zoo-607 RESEARCH METHODOLOGY (Cr.hr 2+ 0)

Course Contents:

What is Research? Research and Education. Scientific research and Common sense. Problem of research in Pakistan. What is a theory? The significance of theory. Pure and applied research. The modern scientist. The research problems. Guideline for selecting a research topic. The research proposal. Title, introduction and statement of the problem. Significance of the study and its Delimitation and limitation. Method and materials, presentation and analysis of data, summary,

conclusion and bibliography. Primary and secondary data. Methods of collecting data. The nature of data. Variables and types of variables. Independent and dependent variable. Analyzing and interpreting research data.

Books Recommended:

Diebold B. Van Dole, Understanding of Educational Research. New York: McGraw-Hill Book Company Inc.1962.

Osula E.C. Introduction to Research Methodology. Africana-FEP Publishers limited.1982.

BS Semester VIII / M.Sc IV

Course #	Name of Subject	Cr. Hours
ZOO-651	Zoogeography and Paleontology	3 (2+1)
ZOO-652	Economic Zoology	2 (2+0)
ZOO-653	Basic immunology	3 (2+1)
ZOO-654/ZOO-655 /ZOO-656	Parasitology B/Applied Fisheries / Applied Entomology	3 (2+1)
ZOO-657	Wild Life of Pakistan	2 (2+0)
ZOO-658	Research/Special paper	3
Total		17

ZOO-651 ZOOGEOGRAPHY AND PALEONTOLOGY Cr. Hours:4(4+0)

Course Contents

Zoogeography: Introduction to zoogeography, Animal distribution (cosmopolitan distribution, discontinuous distribution, isolation distribution, bipolar distribution and endemic distribution) Barriers and dispersal. Zoogeographical regions (division, geographic ranges, physical features, climates, faunas and affinities of Holarctic (Palearctic, Nearctic regions), Oriental, Ethiopian, Australian, and New tropical Regions

Paleontology

Principles of Paleontology,Importance of paleontology, big bang theory and evolution of earth, Shells of earth; (atmosphere, hydrosphere, biosphere and lithosphere). Rock, types of rocks (Igneous rocks, sedimentary rocks and metamorphic rocks) Fossil, types and uses of fossils,

nature of fossils. Processes of fossilization. Geological time scale. Pre-Cambrian life. Post Cambrian life (Palaeozoic life, Mesozoic life, Cenozoic life). Geochronometry (Uranium/Lead dating, radiocarbon dating, methods), evolutionary history of man, elephant, horse and camel, Paleocology, Paleomagnetism. . Paleogeography (Theories of Continental drift and Plate tectonics).

Books Recommended Paleontology:

1. Dunbar C.O. HISTORICAL GEOLOGY, 1969. John Wiley and Sons Inc. New York.
2. Brouwer, A. GENERAL PALAEOLOGY, 1977. Oliver and Boyed, London.
3. Gilbert, L. I. and Colbert, E.H. EVOLUTION OF VERTEBRATES, 1980. John Wiley and Sons Inc. New York.
4. Ali, S.S. PALAEOLOGY, ZOOGEOGRAPHY AND WILDLIFE MANAGEMENT. 1999. Nasim Book Depot, Hyderabad, India.

ZOO-652 ECONOMIC ZOOLOGY Cr. Hours:2 (2+0)

Course Contents:

Diseases of animal origin. Shell fishery. Animal product and byproducts. Apiculture. Sericulture. Aquaculture. Game animal and animal resources of Pakistan. Brief description of poultry farming and dairy farming

Book Recommended:

1. Theobald F.V. (1999). Economic Zoology. Printwell Publishers, Jaipur, India
2. Kellogg VL (2012) Elementary Textbook of Economic Zoology and Entomology: HardPress.
3. Upadhyaya SD (2009) Economic Zoology: Rastogi Publications.
4. Shukla M (2009) Economic Zoology Biostatistics And Animal Behaviour: Rastogi Puglications

ZOO-653 BASIC IMMUNOLOGY Cr. Hours: 3 (2+1)

COURSE CONTENTS:

Overview of the immune system, Historical perspective, innate and acquired immunity. Cells and organs of immune systems Hematopoiesis, lymphoid cells, Mononuclear cells Dendritic cells,

primary lymphoid organs, leukocyte recrudescences. Antigens; immunologic properties of Antigens factors affecting antigenicity, epitopes, Haptens, and study of antigenicity, viral and bacterial antigens, mitogens. Immunoglobulins structure and function basics structure, sequencing studies, fine structure, receptor complex, Antigenic determinants, Isotype and super family. Major histocompatibility complex (MHC). General organization and inheritance of MHC. Class I MHC molecules and genes. Polymorphism of class I and II MHC genes, class III MHC molecules, mapping of MHC and its expression. Antigen processing and presentation; self MHC restriction of T-cells role of Ag presenting cells. Cytokines, generation of humoral immune responses. Kinetics, experimental systems, identification of cells required for induction of humoral immunity. Cell mediated immunity. Direct and delayed type cytotoxic and hypersensitivity responses. Transplantation immunology graft rejection. Immunodeficiency diseases. Classification, phagocytic humoral, cell mediated and combined humoral and cell mediated deficiencies, complement mediated deficiencies.

PRACTICALS

Detection of Antibody. Primary immune response. Secondary immune response. Demonstration of Ab specificity. Estimation of antibodies. Microscopic study of various organs of immune system. Demonstration of enzyme linked immunosorbent assay. Demonstration of radioimmuno assays.

BOOKS RECOMMENDED

1. KUBY'S IMMUNOLOGY, 2002. 4th ed. Richard, A., Goldsby, Thomas, J. Kindt and Barbara, A. Osborn. W.H. Freeman & Company, New York.
2. CELLULAR AND MOLECULAR IMMUNOLOGY, 1994. 2nd ed. Abbas Lichtman & Pober, W.B. Saunders Co.

Aims and Objectives:

The students will learn to classify parasites, immunological responses of hosts and helminthology.

Course Contents:

Classification of hosts: definitive hosts, intermediate hosts, paratenic hosts.

Host susceptibility and specificity. Various types of susceptibilities. Host-parasite relationships. Morphology and physiology of parasites: adaptations to parasitic mode of life. Effects of parasitism on parasites.

Effect of parasites on hosts: influence of parasites on host populations. Pathological responses, immuno-parasitology: immunity and immune responses of host.

Diagnosis, prevention, control treatment, common drugs and anthelmintics, vector control methods.

Helminthology: helminth parasites of man and other animals, general account, classification, biology, life cycle, pathology and symptomology, immunology. Platyhelminthes e.g. polystoma, trematodes, fasciola, diphylobothrium, acanthocephalus, nematodes, trichuris, trichinella, strongyloides, ancylostoma, trichostrongylus, haematobium, toxocara, filarial worms etc.

Practical:

1. Study of the prepared slides and preserved specimens of parasites: helminth parasites and arthropod parasites.
2. Epidemiology of parasitic infections. Survey of incidences of occurrence and prevalence using soil, water (canal drain water samples) and animal population (chicken, goat/sheep, rat, fish etc). Fecal egg count techniques. Survey and study of vectors/intermediate host (population etc).
3. Preparation of slides for the study of structure of egg larvae of various helminth parasites and staining of cross-section through body regions. Preparation of protozoan parasites slides with various staining techniques. Study and preparation of slides/ preservation of arthropod parasites.

Books Recommended:

1. Noble & Noble, 1982, Parasitology. The Biology of Animal Parasites, 5th edition. Lea & Febriger.
2. Cheeseberugh, M., 1987. Medical Laboratory Manual for Tropical Medicines, Vol-1. University Press Cambridge.
3. Robert, L.S. and Janovy, J.Jr., 2001. Foundation of Parasitology, 5th edition, Wm Brown Publishers, Chicago, London, Tokyo, Toronto.
4. Smith, J.D. 1994. Introduction to animals Parasitology, Cambridge University Press.

ZOO-655 APPLIED FISHERIES Cr. Hours: 3(2+1)

Aims and Objectives:

The aim of this course is to provide sufficient knowledge about all physiological phenomena in fishes. The subject provides practicals information to obtain better growth by following physiological aspects during extensive or semi-intensive culture. It also emphasizes thoroughly in breeding of most culturable freshwater fish by manipulating reproductive and endocrinological aspects during natural season as well as off seasons.

Course Contents:

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, Courtship behaviour

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), introduction to other culture system and integrated fish farming.

Fish health: Water quality; Hygiene of fish culture facilities; Hygiene of equipments 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 behavior: Aquarium fish culture.

Fish pond construction and management

Fish gears, fish marking and tagging for study of fish population dynamics.

Books Recommended

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

Practicals

Study of water quality parameters (DO, NH₃, hardness, alkalinity, turbidity, transparency, temperature, salinity), Study of various forms of swimbladder as hydrostatic organ, Study fecundity of various fish species, Study the effects of reproductive hormone (GnRH) on fish maturation, Study of blood cells and their counts in normal and diseased fish, Diagnosis of infection in infected fish, Study of fish parasites, Visit to various fish seed hatcheries during breeding seasons.

ZOO-656 APPLIED ENTOMOLOGY Cr. Hours: 3(2+1)

Aims and Objectives:

The students will learn to identify the pest during damaging to the crop; Students will understand methods of population estimation of the pest and application of different control strategies.

Course Contents:

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, Insects of economic importance. Brief account of biological control, chemical control and integrated pest management: 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. Knowledge of Pests of cotton, rice, sugarcane.

Books Recommended

1. Pedigo, L.P. ENTOMOLOGY AND PEST MANAGEMENT. 1991. Maxwell MacMillan.
2. Richards, O.W. and Davies, R.J. IMM'S General textbook of Entomology. 1977.Vol-2. Chapman & Hall, London.
3. Metcalf, C.L. and Flint, W.P. Destructive and useful insects. 1962. McGraw Hill.
4. Hashmi, A.A. 1994. Insect Pest Management. Vols. I, II and III. Pakistan Agriculture Research Council, Islamabad, Pakistan.

Practicals

1. Collection, preservation and identification of insects upto order (except for the identification upto species of a few pests of great economic importance), with the help of keys/literature.

ZOO-657 WILDLIFE OF PAKISTAN Cr. Hours: 2(2+0)

Course Contents:

Wildlife of Pakistan, identification, distribution, status, conservation and management (population estimate technology) of fishes, reptiles, birds and mammals of major importance in Pakistan, Philosophy and significance of wildlife conservation, Biodiversity and sustainability of wildlife, Wildlife rules and regulations in Pakistan, National and International agencies involved in conservation and management of wildlife, Sanctuaries, Game Reserves and National Parks in Pakistan, Ramsar convention, wetlands, endangered species of Pakistan.

Books Recommended

Zoogeography:

1. Darlington, P. J. Jr. ZOOGEOGRAPHY, 1963. John Wiley and Sons.
2. DeBeaufort, L. F. ZOOGEOGRAPHY OF THE LAND AND INLAND WATERS. 1951. Sidgwick and Jackson.
3. Ali, S.S. PALAEONTOLOGY, ZOOGEOGRAPHY AND WILDLIFE MANAGEMENT. 1999. Nasim Book Depot, Hyderabad, India
4. Bailey, J.A. PRINCIPLES OF WILDLIFE MANAGEMENT, 1986. John Wiley and Sons..
5. Ali S. and Ripley S.D. A HANDBOOK OF BIRDS OF INDIA & PAKISTAN, 1973. Oxford University Press, London.
6. Roberts, T. J. THE BIRDS OF PAKISTAN, (Vol. I). 1992. Oxford University Press.
7. Roberts, T. J. THE BIRDS OF PAKISTAN, (Vol. II), 1998. Oxford University Press.
8. Roberts, T.J. MAMMALS OF PAKISTAN. 1977. Ernest Benon Ltd, London.
9. Robinson, W.L. and Bolen, E.G. WILDLIFE ECOLOGY AND MANAGEMENT. 1984. McMillan, Cambridge.
10. Magon, C.F. BIOLOGY OF FRESHWATER POLLUTION. 1988. Longman and Scientific Publication.
11. Boyd, C.E. and Tucker, C. S. POND AQUACULTURE AND WATER QUALITY MANAGEMENT. 1998. Boston, Kluwer Publishers Alabama.