

**COURSE  
CONTENTS  
FOR  
MSc (2-Years)  
ZOOLOGY**

### Courses M.Sc. Zoology 5<sup>th</sup> Board of Studies

Year I			
Semester-I			
Course Category	Course Code	Course Title	Credits
Foundation-I	BST-551	Biostatistics	3(3+0)
Foundation-II	ZOO-552	Biochemistry	4(3+1)
Major-I	ZOO-553	Cell & Molecular Biology	4(3+1)
Major-II	ZOO-554	Zoogeography and Palaeontology	3(2+1)
Major-III	ZOO-555	Animal Behavior	3(2+1)
		Total Credits	17
Semester-II			
Course Category	Course Code	Course Title	Credits
General - I	ZOO-561	Biological Techniques	3(1+2)
Foundation-III	ZOO-562	Evolution & Principles of Systematics	3(2+1)
Major-IV	ZOO-563	Developmental Biology	4(3+1)
Major-V	ZOO-564	Genetics	4(3+1)
Major-VI	ZOO-565	Synopsis & Research Methodology	2(2+0)
		Total Credits	16
Year -II			
Semester-III			
Course Category	Course Code	Course Title	Credits
Major-VII	ZOO-671	Environmental Biology	4(3+1)
Major-VIII	ZOO-672	Animal Physiology	4(3+1)
Major-IX	ZOO-673	Parasitology I	4(3+1)
Major-X	ZOO-674	Wildlife	2(2+0)

Elective-I	ZOO-675	Entomology	3(2+1)
		Total Credits	17
Semester-IV			
<b>Course Category</b>	<b>Course Code</b>	<b>Course Title</b>	<b>Credits</b>
Major-XI	ZOO-681	Bioinformatics	3(2+1)
Major-XII	ZOO-682	Thesis/ Research Project/Internship or Special Paper	4(0+4) or 4(3+1)
Elective-II	ZOO-683	Applied Fisheries	4(3+1)
Elective-III	ZOO-684	Applied Entomology and Pest Management	3(2+1)
Elective-IV	ZOO-685	Parasitology II	3(2+1)
		Total Credits	17

17+16+17+17=67

Year I		
Semester-I		
Course Code	Course Title	Credits
BST-551	Biostatistics	3(3+0)
ZOO-552	Biochemistry	4(3+1)
ZOO-553	Cell & Molecular Biology	4(3+1)
ZOO-554	Zoogeography and Palaeontology	3(2+1)
ZOO-555	Animal Behavior	3(2+1)
	Total Credits	17

BST-551	Biostatistics	3(3+0)
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#### Course Contents

**Introduction and scope:** use of statistics in biology. Population and sample: Stages of research,

**Types of data:** 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,

**Handling of multiple samples:** Analysis of variance and LSD.

Correlation and regression: Experimental designing, planning of an experiment, replication and randomization.

ZOO-552	Biochemistry	4(3+1)
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#### Course Contents

**Amino acids, peptides and proteins:** standard amino acids, their structure and classification; acid/base properties of amino acids and their titration curves; peptides, their ionic behavior and amino acid composition, cytochrome c; Proteins: level of structural organization, example of structural and functional proteins.

**Enzymes:** Introduction; important characteristics of enzymes; immobilized enzymes; how enzymes work; example of enzymatic reaction; enzyme kinetics, enzyme rate of reaction and substrate concentration, how pH and temperature effect on enzyme activity.

**Carbohydrates:** Classification, types, important characteristics and structure of carbohydrates; cyclic structure of 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 B complex group.

**Metabolism:** detailed description of glycolysis and catabolism of other hexoses; regulation and bioenergetics of glycolysis. Anabolic role of glycolysis; fate of pyruvate under aerobic and anaerobic conditions, lactate, acetyl CoA and ethanol formation; alcoholic fermentation; gluconeogenesis, its regulation and significance in the tissues; feeder pathways in glycolysis;

utilization of other carbohydrates in glycolysis phosphorolysis and starch; regulation of glycogen metabolism. Citric acid (TCA) cycle: conversion of pyruvate to acetyl CoA, pyruvate dehydrogenase, a multi-enzyme complex; detailed description of citric acid cycle; bioenergetics and conservation of energy produced in the cycle. Anabolic or biosynthetic role of citric acid cycle intermediates; replenishing or anaplerotic reactions and their role; regulation of citric acid cycle; Electron transport and its components, oxidative phosphorylation, chemiosmotic theory, ATP synthesis, uncouple electron transport and heat generation.

**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; betaoxidation; 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; Ketone bodies their biosynthesis, utilization and role in the tissues; cholesterol metabolism: 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.

### **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

ZOO-553	Cell & Molecular Biology	4(3+1)
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### Course Contents

**Introduction to prokaryotic and eukaryotic cells:** Plasma membrane, its chemical composition structure and functions of plasma membranes, 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 and their role in protein synthesis and drug metabolism, Golgi apparatus its role in synthesis of glycoprotein, Mitochondrial respiration and its significance as semi-autonomous organelle; Lysosome, its diverse roles due to hydrolytic activity of enzymes, Peroxisome, its role in metabolism of hydrogen peroxide, Glyoxysome with reference to glyoxylic acid cycle.

**Nucleus:** chromatin, heterochromatin, euchromatin, chromosome structure, 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 emphasis on 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:** Specific role of Ribosomes, various factors, and posttranslational processing, control of gene expression in Prokaryotes.

### Practicals

1. Identification of cell organelles
2. Preparation of temporary whole mount.
3. Preparation of permanent whole mount (demonstration)
4. Preparation of human blood smear and identification of Leucocytes.
5. Tissues (permanent slides of epithelial tissues, striated muscle, smooth muscle, cartilage, bone).
6. Squash preparation of onion root tip for mitotic stages.
7. Mounting of polytene chromosome (Drosophila/Chironomous.) Demonstration.
8. Detection and quantitative determination of chromosomal DNA and RNA.
9. Cultural and staining of bacteria and yeast.
10. Separation of different sized DNA fragments on agarose gel.
11. Isolation and characterization of proteins on polyacrylamide gel electrophoresis (native and sub-unit molecular weights).

ZOO-554	Zoogeography and Palaeontology	3(2+1)
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### Course Contents

**(i) Zoogeography:** Branches of zoogeography: descriptive, chorology, faunistics, systematic, biocoenotic, causal, ecological, historical, experimental and applied zoogeography.

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

Zoogeographical regions: zoogeographic division and boundaries, geographic ranges, physical features, climates, faunas and affinities of Palaearctic, Nearctic regions, Oriental, Ethiopian, Australian, and Neotropical Regions, insular fauna

Palaeogeography: Theories of continental drift and plate tectonics; Pangea.

Zoogeography of Pakistan:

### **(ii). Paleontology**

The Planet Earth: History, age, shells of earth; atmosphere, hydrosphere, biosphere and lithosphere.

Rocks: types; Igneous 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, methods, index fossils; evolutionary history of man, elephant, horse and camel, Paleoecology, Paleomagnetism.

Practicals

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, ammonite, 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.

ZOO-555	Animal Behavior	3(2+1)
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### Course Contents

**Foundations of animal behavior:** ethology, classical ethology Development of behavior: innate mechanisms, imprinting

**Kinds of behavior:** innate, conditioned, complex behaviour 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 behaviour, reproduction and fitness, parental care, social system.

**Animal Communication:** chemical attraction, in moths, honey bees, communication displays, pheromones etc.

**Practicals**

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

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Semester-II		
Course Code	Course Title	Credits
ZOO-561	Biological Techniques	3(1+2)
ZOO-562	Evolution & Principles of Systematics	3(2+1)
ZOO-563	Developmental Biology	4(3+1)
ZOO-564	Genetics	4(3+1)
ZOO-565	Synopsis & Research Methodology	2(2+0)
	Total Credits	16

ZOO-561	Biological Techniques	3(1+2)
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### 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.

**Micrometry 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.

Practicals

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

ZOO-562	Evolution & Principles of Systematics	3(2+1)
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(Note: Evolution and Principles of Systematic Zoology 60% and 40% weightage, respectively. Three questions from Evolution and two questions from Systematic will be attempted by the students).

### Course Contents

#### (i). Evolution

The nature and origin to life: Evidences of evolution (molecular, embryological & paleontological).

Theories of Evolution: 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.

#### (ii). Systematic Zoology

**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, microtaxonomy, taxonomic categories: specific category, infraspecific category, higher categories; Species concept.

**Typological species concept:** Nominalistic 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.

**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.

**Practicals**

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.

ZOO-563	Developmental Biology	4(3+1)
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**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.

**Practicals**

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.
5. Preparation and staining of histological slides.

ZOO-564	Genetics	4(3+1)
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**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 crisscross inheritance. Polygenic traits-Cleft lip and cleft palate, Sex-linked Chromosomal anomalies: Klinefelters 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.

### 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. X<sup>2</sup> test
9. Study of transformed bacteria on the basis of antibiotic resistance.

ZOO-565	Synopsis & Research Methodology	2(2+0)
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### Course Contents

**Significance:** objectives of research, Types of research, Research approaches,

**Research process:** steps involved in research process, (Survey, Observation, case study, experimental, historical and comparative methods)

**Data:** Types of Data, Data collection, processing, analysis, Review of literature, Research problem, Hypothesis.

**Bioethics:** Ethical, legal, social and scientific issues in Biological Research.

**Plagiarism:**

**Funding Sources:** A brief idea about the funding agencies such as HEC, PSF, USAID etc.

**Writing of Research Proposal:** Thesis/Report and Research Paper: Footnotes and Bibliography.

Year -II		
Semester-III		
Course Code	Course Title	Credits
ZOO-671	Environmental Biology	4(3+1)
ZOO-672	Animal Physiology	4(3+1)
ZOO-673	Parasitology I (Protozoology, Pathology and Immunology)	4(3+1)
ZOO-674	Wildlife	2(2+0)
ZOO-675	Entomology	3(2+1)
	Total Credits	17

ZOO-671	Environmental Biology	4(3+1)
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**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, sulphur, 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 (sulphur 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).

**Practicals**

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

ZOO-672	Animal Physiology	4(3+1)
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**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; tetany; Muscles: Structure, types, components, muscle proteins, molecular basis of muscle contraction: sarcoplasmic reticulum and role of calcium, muscle action potentials, isometric and isotonic contraction, leverage factor, muscle fatigue.

**Receptors Physiology:** Receptor types: Mechanoreceptors, Olfactory and taste receptors, Photoreceptors, Photochemistry and Phototransduction; acoustico-lateralis system, Cutaneous receptors, electro-receptors. Sensory transduction, coding and adaptations. Range fractionation.

**Endocrine Physiology:** Gland types; Hypothalamus, Pituitary, Thyroid, Parathyroid, Pineal, Pancreatic Islets, Gastric glands, Adrenal, Ovary, Testis and Placenta; Overview of hormones; types, peptide and steroid hormones, chemistry, synthesis and roles. Hormone receptors and signal transduction. Feedback mechanisms.

**Cardiovascular Physiology:** Electrical activity of heart: Autorythmicity, Electrocardiography, Kymography; Hemodynamics, Relationship between blood flow, pressure and resistance. Control of cardiac activity, cardiac output and peripheral circulation.

**Respiratory Physiology:** Respiratory epithelia, gas exchange in gills and lungs; Transport of O<sub>2</sub> and CO<sub>2</sub>, Structure of alveoli, lung volumes and capacities, surfactants, control of breathing; hypoxia; Hypercapnia etc., air breathing in divers.

**Renal Physiology:** Osmoregulation: Osmoregulation in aquatic and terrestrial animals; Kidney and Vertebrate nephron as osmoregulatory and excretory organ: Glomerular

filtration, Tubular absorption and secretion; Nitrogenous waste products; Patterns of nitrogenous excretion and their phylogenetic significance.

**Physiology of Digestion:** Physiologic anatomy of digestive tract (mammalian model), Regulation of digestive secretions; Absorption of water, ions and nutrients; Potential and Movements in gastrointestinal tract; Control of motility. 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; Costs and benefits of ectothermy; Temperature relations of heterotherms and endotherms; Dormancy: Sleep, Torpor, Hibernation and Estivation.

**Practicals**

1. Determination of haemoglobin content, haematocrit and cell counting.
2. Preparation of blood smears.
3. 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.
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 estrous cycle.

ZOO-673	Parasitology I (Protozoology, Pathology and Immunology)	4(3+1)
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**Course Contents:**

**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.

**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**

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

ZOO-674	Wildlife	2(2+0)
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### Course Contents

Wildlife: Animal occurrence, protection, needs of animals, maintenance, and the habitat.

Techniques: Ground and aerial tracking, GPS, radiotelemetry, maps etc.

Wildlife Conservation: Philosophy and significance, Biodiversity and sustainability of wildlife.

Wildlife Agencies: National and International agencies involved in conservation and management of wildlife. International conventions, agreements.

Wildlife of Pakistan: identification, distribution, status, conservation and management (population estimate technology) of fishes, reptiles, birds and mammals of major importance in Pakistan.

Wildlife rules and regulations in Pakistan: Sanctuaries, Game Reserves and National Parks in Pakistan. Endangered species of Pakistan.

*(Note: The teacher is suggested to provide blank maps of Pakistan in the theory class to the students to indicate the distribution of the animals. Similar blanks maps should be attached with the question paper, if distribution of animals is asked from the student in the theory paper).*

ZOO-675	Entomology	3(2+1)
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### Morphology and Physiology:

An introduction of Entomology with a brief description of different classes of Arthropods. Complete morphology of an insect. Anatomy and Physiology of various systems with special reference to digestive, nervous, circulatory, respiratory, excretory and reproductive system. Development and metamorphosis. Hibernation and diapause.

### Taxonomy and Ecology

Classification of insects up to orders. Insect ecology with special reference to factors effecting the population, population estimations. Insect societies.

### Practicals

1. Dissection of various insects, to expose their internal anatomy.
2. Preparation of mouth parts, antennae, wings, legs and genitalia of different insects.
3. To study the whole mounts of Collembola, silverfish, aphids, lice and fleas.
4. Preparation of killing bottles, preservation, pinning and setting of insects.
5. Study of metamorphosis and different types of insects' larvae and pupae, life history of an insect.
6. Classification and identification of insects.

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Semester-IV		
Course Code	Course Title	Credits
ZOO-681	Bioinformatics	3(2+1)
ZOO-682	Thesis/ Research Project/Internship or Special Paper	4(0+4) or 4(3+1)
ZOO-683	Applied Fisheries	4(3+1)
ZOO-684	Applied Entomology and Pest Management	3(2+1)
ZOO-685	Parasitology II	3(2+1)
	Total Credits	17

ZOO-681	Bioinformatics	3(2+1)
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### 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

Short introduction to DNA, RNA and protein: amino acids, sequence; analyzing Protein sequence using BI tools; sequence-structure function.

Retrieving protein sequences from database (FASTA): Alignment of protein\ nucleotide sequences (BLAST, CLUSTALW); Computing physicochemical parameters of proteins (eg. PROTPARAM); Predicting elements of secondary structure of proteins (eg. PSSP); Retrieval, understanding and predicting 3D structure of protein from sequence; PTMs (eg NETPHOS etc.)

Enzyme classification: retrieval databases

Short introduction to DNA/RNA: structure, genetic code; analyzing the DNA/RNA sequence by the use of BI tools 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, OLIGO-CALC etc.)

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

### Practicals

- Retrieval of FASTA sequence
- Determination of proteins physical and chemical parameters
- Finding similar sequences for protein and DNA

- Multiple alignment
- Predicting proteins secondary structure
- Predicting RNA secondary structure
- Predicting protein PTM
- Finding protein families
- Determination of gene location on chromosome
- SNPs
- Primer design

ZOO-683	Applied Fisheries	4(3+1)
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History and significance of aquaculture; Study of management techniques and habitat improvement; Designing, construction, fertilization, manuring, stocking and harvesting of a fish pond; Study of native and exotic fishes of Pakistan; Shellfish and fin fish; Fishing gears and crafts/nets used in Pakistan; Fish ways; construction and importance. Bye products of fish industry; Methods of processing fish such as drying, salting smoking, curing, freezing etc; Study of fish parasites, common diseases and enemies of fishes. Pollution and its effect on fish population; Methods of population estimation by direct count, catch effort, mark re-capture method, tagging of fish; Artificial propagation induced spawning techniques; Marketing strategies; transport of fish and seed; Major problems of fishermen in Pakistan;

**Practical**

- Collection and identification of common zooplanktons
- Study of gut contents of fish
- Statistical analysis of fish growth, length-weight relationship
- Study of farm fishes of KPK
- Visit to a fish farm/hatchery to study installations/methods of breeding
- Prepared slides of fish parasites
- Analysis of physical properties (temperature, light, colour, turbidity, conductivity etc.) and chemical properties (pH, oxygen, carbon dioxide, salinity, dissolved solids/salts) of water;
- General methods of age growth studies; reading of age from scales, opercula, otolith and back calculation from bones;
- Study of larvae, fry and fingerlings of a common fish, regulation of fishing, enactment of fishery legislation.

ZOO-684	Applied Entomology and Pest Management	3(2+1)
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**Course Contents:**

**Applied Entomology:**

Principles of apiculture, sericulture and lac culture. Study and identification of pests of agriculture, stored grain and households. General characteristics, life cycles and habits of insects of medical and veterinary importance. Study of various insect-borne diseases.

## Pest management

The principles of pest control/management viz., physical, mechanical, culture, legislative biological, genetic, chemical and integrated control. Relative merits of various types of insect control. Pest's management practices in Pakistan- oriental review.

## Practical: Applied Entomology

Collection, identification and preservation of different pests and other insects of medical and veterinary importance. Study of sericulture and apiculture. Operation of various types of sprayers. Dusters, fumigation emulsions. Preparation of insecticide emulsions in different concentration. The record of laboratory and fieldwork will be maintained and presented at the time of examination.

ZOO-685	Parasitology II (Helminthology)	3(2+1)
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**Course contents:** Basic principles and concepts in Parasitology, Taxonomy, etiology, biology, epidemiology, pathology and pathogenesis, diagnosis, life cycle, control and treatment of **Digenetic Trematodes:** *Schistosoma mansoni*, *S.japonicum*, *S.haematobium*, *Fasciola hepatica*, *Fasciolopsis buski*, *Paragonimus westermani*, *Colonorchis sinensis*, *Heterophyes heterophyes*, **Monogenetic trematodes:** *Dactylogyrus vastator*, *Gyrodactylus*, **Cestodes:** *Diphyllobothrium latum*, *Taenia saginata*, *T.solium*, *Echinococcus granulosus*, *Hymenolepis nana*, *Dipylidium caninum*, **Nematodes:** *Trichuris trichiura*, *Trichenella spiralis*, *Strongyloides stercoralis*, *Ancylostoma duodenale*, *Necator americanus*, *Ascaris lumbricoides*, *Toxocara canis*, *Enterobius vermicularis*, *Wuchereria bancrofti*, *Brugia malayi*, *Onchocerca volvulus*, *Loa loa* and *Dracunculus medinensis*.

## Practicals

- 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.
- 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

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**List of Optional /  
Special Subjects  
for  
BS and MSc  
Zoology**

**List of Optional/Elective/Special papers for BS 8<sup>th</sup> semester and MSc 4<sup>th</sup> semester students**

Course Category	Course Title	Credits
Special Paper I	Ichthyology	4(3+1)
Special Paper II	Ornithology	4(3+1)
Special Paper III	Immunology	4(3+1)
Special Paper IV	Fish Farming	4(3+1)
Special Paper V	Mammalogy	4(3+1)
Special Paper VI	Endocrinology	4(3+1)
Special Paper VII	General Microbiology	4(3+1)
Special Paper VIII	Herpetology	4(3+1)
Special Paper IX	Reproductive Biology	4(3+1)
Special Paper X	Biotechnology	4(3+1)

Ichthyology	4(3+1)
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**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.

**Practicals**

1. Study of classification of fishes and some selected fish species

2. Study of Fish anatomy, physiology and adaptations, fish dissections
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

<b>Ornithology</b>	<b>4 (3+1)</b>
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**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, neornithes; 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.

**Practicals**

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 egg shells, beak and claw structures
8. Study of bird songs, recording bird songs, fundamental experimentation to understand bird songs in sensitive and sensorimotor phases
9. Bird watching and preparation of ethograms
10. Study of Predator-prey relationship among birds
11. Study of Brood parasitism
12. Study of flying mechanics through models

<b>Immunology</b>	<b>4 (3+1)</b>
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### **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.

### **Practicals**

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.

<b>Fish Culture or Farming</b>	<b>4 (3+1)</b>
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### **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: Organic 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.

### **Practicals**

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

<b>Mammalogy</b>	<b>4 (3+1)</b>
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### **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.

## Practicals

1. General survey of mammalian species (Visits to zoological museums and zoos 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

<b>General and Comparative Endocrinology</b>	4 (3+1)
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### 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. Calcitrophic 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.

## Practicals

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.

<b>General Microbiology</b>	<b>4(3+1)</b>
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#### 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 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, 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.

### Practicals

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 staining and microscopic observations of protozoa
4. Cultivation methods of fungi
5. Isolation of bacteriophages

Reproductive Biology	4(3+1)
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**Introduction:** Overview of structure, at different levels, of reproductive systems and developments in gametes formation.

**Sex Determination and Differentiation:** Molecular aspects and chemical messengers in differentiation.

**Hypothalamic-Hypophysical-Gonadal axis in Reproduction:** Hormonal and neuronal factors and their interactions in ovarian, testicular and other reproductive targets functions. The interactions in developments in estrous and menstrual cycles. The interactions in transitions from childhood to reproductive and post-reproductive states.

**Reproductive Behaviors:** Endocrine basis of communication in reproduction and aggression; Pheromones in mammalian reproduction; Rhythms in Reproduction.

**Pregnancy:** Hormonal mechanism in fertilization, zygote transport and implantation. Placental steroid and polypeptide hormones; Recognition and maintenance of pregnancy; Maternal metabolism in gestation, Hormonal mechanism in parturition.

**Lactation:** Hormonal mechanism in lactation; Lactogenesis, Galactopoeisis, Milk ejection.

**Reproductive Senescence:** Hormonal and metabolic aspects in menopause; Mechanisms in males.

**Fertility Control Mechanisms:** Hormonal contraceptives; Rhythmic methods, Immunologic techniques and other fertility control procedures in women; complications in their uses; Fertility control in men and search for male contraceptive.

### **Practicals**

Study of male and female reproductive tract. Histology of segments of male and female reproductive tracts. Recognition of spermatogonial cells, ovarian follicles and corpus luteum in gonads. Study of hormonal mechanisms in super ovulation and implantation; Tests for pregnancy recognition; Experiments on role of gonads in maintenance of accessory sex gland in males and target structures in females. Study of fertility control procedures in populations.

<b>Biotechnology</b>	<b>3-1</b>
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### **Introduction to Biotechnology**

History, importance and application of Biotechnology

### **Introduction to recombinant DNA technology**

Restriction of endonucleases, classification of restriction enzymes, restriction and modification systems. Nomenclature of restriction enzymes, cutting and joining of DNA, recombinant DNA and gene cloning, restriction mapping.

### **Animal Biotechnology**

Stem cells concepts and applications, Transgenic Animals, Gene therapy, Vaccine production

### **Microbial Biotechnology**

Plants Biotechnology: Transgenic Plants, Vaccine production in plants. Bioethics

### **Techniques in Biotechnology**

Gel electrophoresis, Hybridization techniques (southern blotting, northern blotting, western blotting), polymerase chain reaction (PCR), sequencing techniques and cDNA libraries construction.

### **Practicals**

Bacterial cell culture, pure culture isolation and selection. DNA/ RNA extraction from animal tissues. Plasmid DNA isolation from Bacterial cell. Polymerase Chain Reaction (PCR). Gel electrophoresis.