

PG & RESEARCH DEPARTMENT OF ZOOLOGY

B. BOROOAH COLLEGE (Autonomous)

(Affiliated to Gauhati University)

GUWAHATI, ASSAM, 781007, INDIA

(Nationally reaccredited with 'A++' grade by NAAC with a CGPA of 3.62)



SYLLABUS FOR FYUGP IN ZOOLOGY (MAJOR)

GENERAL CURRICULAR STRUCTURE

1 MAJOR 1 MINOR

SEMESTER 1			SEMESTER 2		
Type	Course	Credit	Type	Course	Credit
Major	Core-1 (Major-1)	4	Major	Core-1 (Major-2)	4
Minor	Core-2 (Minor-1)	4	Minor	Core-2 (Minor-2)	4
SEC	SEC-1	3	SEC	SEC-2	3
MDC	MDC-1	3	MDC	MDC-2	3
AEC	AEC-1 (Language/Alt Eng)	4	AEC	AEC-2 (Comm English)	4
VAC	VAC-1	2	VAC	VAC-2	2
TOTAL		20	TOTAL		20
SEMESTER 3			SEMESTER 4		
Type	Course	Credit	Type	Course	Credit
Major	Core-1 (Major-3)	4	Major	Core-1 (Major-5)	4
Major	Core-1 (Major-4)	4	Major	Core-1 (Major-6)	4
Minor	Core-2 (Minor-3)	4	Major	Core-1 (Major-7)	4
SEC	SEC-3	3	Major	Core-1 (Major-8)	4
MDC	MDC-3	3	Minor	Core-2 (Minor-4)	4
VAC	VAC-3	2			
TOTAL		20	TOTAL		20
SEMESTER 5			SEMESTER 6		
Type	Course	Credit	Type	Course	Credit
Major	Core-1 (Major-9)	4	Major	Core-1 (Major-12)	4
	Core-1 (Major-10)	4		Core-1 (Major-13)	4
	Core-1 (Major-11)	4		Core-1 (Major-14)	4
Minor	Core-1 (Minor-5)	4		Core-1 (Major-15)	4
Internship		4	Minor	Core-2 (Minor-6)	4
TOTAL		20	TOTAL		20

Structure of Four Year Undergraduate Programme (FYUGP) in Zoology (Major)

Semester	Paper	Code	Credit
1	Non-chordates		3
	Practical		1
2	Chordates		3
	Practical		1
3	Genetics		3
	Practical		1
	Ecology and Evolution		3
	Practical		1
4	Comparative Anatomy		3
	Practical		1
	Taxonomy, Biosystematics and Biostatistics		3
	Practical		1
	Physiology and Endocrinology		3
	Practical		1
	Parasitology		3
	Practical		1
5	Entomology and Fisheries		3
	Practical		1
	Biochemistry		3
	Practical		1
	Cell Biology		3
	Practical		1
	Internship		4
6	Immunology		3
	Practical		1
	Molecular Biology		3
	Practical		1
	Developmental Biology		3
	Practical		1
	Bioinformatics (Optional)		3
	Practical		1
	Wildlife Biology (Optional)		3
Practical		1	

FYUGP 1st SEMESTER (MAJOR)**NON-CHORDATES****CODE:****CREDITS: 3 (T) + 1 (P) = 4****Total marks: 100 (End semester: 45; Internal assessment: 30; Practical: 25)**

Theory	Hours
Unit 1: Protista to Ctenophora Protista: General characteristics and classification upto classes, locomotion and reproduction. Metazoa: Evolution theories of symmetry and segmentation. Porifera: General characteristics and classification upto classes, canal system and spicules in sponges. Cnidaria: General characteristics and classification upto classes, polymorphism, corals and coral reef formation. Ctenophora: General characteristics and classification upto classes, affinities with other phylum.	17
Unit 2: Platyhelminthes to Annelida Platyhelminthes: General characteristics and classification upto classes, life cycle and adaptations of <i>Taenia solium</i> and <i>Fasciola hepatica</i> . Nematelminthes: General characteristics and classification upto classes, life cycle and adaptations of <i>Ascaris lumbricoides</i> and <i>Wuchereria bancrofti</i> . Annelida: General characteristics and classification upto classes, evolution of coelom and metamerism, excretion.	12
Unit 3: Arthropoda to Echinodermata Arthropoda: General characteristics and classification upto classes, larval forms of Crustacea, vision and respiration. Onychophora: General characters and affinities. Mollusca: General characteristics and classification upto classes, torsion and detorsion in Gastropoda, pearl culture, larval stages. Echinodermata: General characteristics and classification upto classes, water vascular system, larval stages.	16

Practical (30 hours)

1. Study of whole mount of *Euglena*, *Amoeba* and *Paramecium* collected from water bodies
2. Study of two representatives from each phylum of non-chordates (specimen/slide/model)
3. Study of larval forms of Arthropoda and Echinodermata from slides/photomicrographs
4. Study of TS of pharynx, gizzard and typhlosolar intestine of earthworm
5. Project report on life cycle of any helminth parasite

Reference books

1. EE Ruppert and RD Barnes. Invertebrate Zoology
2. K Jordan and PS Verma. Invertebrate Zoology
3. RL Kotpal. Modern textbook of Zoology, Invertebrates
4. B Schierwater and R DeSalle. Invertebrate Zoology: A tree of life approach

**FYUGP 2nd SEMESTER (MAJOR)
CHORDATES**

CODE:

CREDITS: 3 (T) + 1 (P) = 4

Total marks: 100 (End semester: 45; Internal assessment: 30; Practical: 25)

Theory	Hours
Unit 1: Introduction to chordates Origin of chordates: Dipleurula concept and echinoderm theory, general characteristics and classification. Protochordates: General characteristics of hemichordata, urochordata and cephalochordate, larval forms	12
Unit 2: Pisces to Amphibians Advanced features of vertebrata over protochordate. Pisces: General characteristics and classification upto classes, migration. Cyclostomes: General characteristics and classification upto orders, affinities, phylogenetic status, differences between Lampreys and Hag fishes. Amphibia: Origin of Tetrapoda, general characteristics and classification upto orders, parental care.	17
Unit 3: Reptiles to Mammals Reptiles: General characteristics and classification upto orders, biting apparatus and mechanism, differences between poisonous and non-poisonous snakes. Aves: General characteristics and classification upto orders, <i>Archaeopteryx</i> as a connecting link, flight adaptations. Mammalia: General characteristics and classification upto orders, affinities in Prototheria.	16

Practical (30 hours)

1. Study of museum specimens/models of Protochordata (*Balanoglossus*, *Herdmania*, *Amphioxus*), Agnatha (*Petromyzon*, *Myxine*), fishes (*Scoliodon*, *Torpedo*, *Mystus*, *Heteropneustes*, *Labeo*, *Hippocampus*, *Tetradon*), Amphibia (*Ichthyophis*, *Necturus*, *Bufo*, *Hyla*), Reptilia (*Chelone*, *Hemidactylus*, *Varanus*, *Chameleon*, *Bungarus*, *Naja*), Aves (peacock, sparrow, crow, king fisher, common myna, pigeon), Mammalia (bat, common primates and ungulates, Gangetic river Dolphin)
2. Study of TS of *Amphioxus* through pharyngeal, intestinal and caudal regions
3. Identification key of venomous and non-venomous snakes
4. Presentation on study of any two vertebrates from two different class

Reference books

1. JZ Young. The life of Vertebrates
2. FH Pough and CM Janis. Vertebrate Life
3. PS Verma and EL Jordan. Chordate Zoology
4. RL Kotpal. Modern textbook of Zoology: Vertebrates

**FYUGP 3rd SEMESTER
GENETICS**

CODE:

CREDITS: 3 (T) + 1 (P) = 4

Total marks: 100 (End semester: 45; Internal assessment: 30; Practical: 25)

Theory	Hours
<p>Unit 1: Introduction to Genetics Principles of inheritance, incomplete dominance and co-dominance, multiple alleles, lethal alleles, penetrance and expressivity, epistasis, pleiotropy, sex-linked, sex-influenced and sex-limited characters, inheritance and concept of gene. Linkage and crossing over, Cytological basis of crossing over, recombination frequency as a measure of linkage intensity, two factor and three factor crosses, linkage map, coefficient of coincidence and interference, gene mapping by somatic cell hybridization.</p>	15
<p>Unit 2: Gene mutations Chromosomal aberrations: deletion, duplication, inversion, translocation, aneuploidy and polyploidy. Mutation: induced versus spontaneous mutations, backward and forward mutations, suppressor mutations, molecular basis of mutations in relation to UV light and chemical mutagens, detection of mutations in <i>Drosophila</i>: CLB method, attached X method.</p>	16
<p>Unit 3: Genetic phenomena Basis of sex determination: genetic and environmental, sex determination in <i>Drosophila</i> and human, mechanism of dosage compensation. Comparison of nuclear and extra nuclear inheritance, organelle inheritance, antibiotic resistance in <i>Chlamydomonas</i>, mitochondrial mutations in <i>Saccharomyces</i> and human disorders, infective heredity in <i>Paramecium</i>. Maternal effects: Shell coiling in <i>Limnaea</i>, pigmentations in <i>Ephestia</i>. Polygenic inheritance and transgressive variation. Bacterial genetics: conjugation, transformation, transduction.</p>	14

Practical (30 hours)

1. To study Mendelian laws and gene interactions and their verification by chi square analyses using seeds/beads/*Drosophila*
2. Study of linkage maps based on data from *Drosophila* crosses.
3. Identification of mutant types of *Drosophila* (through culture/photomicrograph)
4. Study of human karyotype (normal and abnormal) using photomicrograph
5. Preparation of polytene chromosomes from *Chironomus/Drosophila* larvae
6. Preparation of metaphase chromosome from fish/mammal
7. Preparation of permanent slides of meiosis from testis (grasshopper/cockroaches/mice/rat) and determination of chiasma frequency and coefficient of terminalization
8. Determination of mitotic index from mitotic preparations
9. Study of pedigree charts of genetic traits/blood groups of humans
10. Study of linkage maps based on data from conjugation, transformation, and transduction

Reference books

1. DP Snustad and MJ Simmons. Principles of Genetics
2. B Lewin. Genes XI
3. PJ Russell. Genetics – A Molecular Approach
4. RH Tamarin. Principles of Genetics

**FYUGP 3rd SEMESTER
ECOLOGY AND EVOLUTION**

CODE:

CREDITS: 3 (T) + 1 (P) = 4

Total marks: 100 (End semester: 45; Internal assessment: 30; Practical: 25)

Theory	Hours
<p>Unit 1: Introduction to Ecology and Ecosystem Basic concept of ecology and ecosystem, Autecology, Synecology, level of organization, study of physical factors, laws of limiting factors, structural components of ecosystem, functional attributes of ecosystem - trophic structure, food chain, food web, energy flow, ecological pyramids, ecological efficiencies. Types of ecosystems with examples.</p>	12
<p>Unit 2: Population and community Ecology Definition, unitary and modular populations, population attributes - abundance, density, natality and mortality, life table and survivorship curve, dispersion, dispersal, age distribution, sex ratio, biotic potential and environmental resistance, population growth form - exponential and logistic, population regulation - density dependent and independent factors. Population interactions, Gauss's principle, definition of community, community characteristics, community structure, ecological succession and types, theories pertaining to climax community, ecotone and edge effect.</p>	17
<p>Unit 3: Evolution Theories of origin of life – chemogenesis, biogenesis, experimental evidences. Evolutionary theories: Lamarckism, Darwinism, Neo-Darwinism. Palaeontological evidences of evolution, geological time scale. Natural selection: concept of fitness, selection coefficient, kin selection, sexual selection. Population genetics: Hardy-Weinberg law (statement and derivation), concept of gene flow, natural selection and survival of the fittest, sources of variations and role in evolution, genetic drift (Founder's and Bottleneck effect), role of migration and mutation in changing allelic frequencies, evolution of man.</p>	16

Practical (30 hours)

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided
2. Determination of population density by quadrat method and calculation of Shannon-Weiner diversity index in a natural/hypothetical community.
3. Measurement of temperature, pH, and turbidity of aquatic ecosystem
4. Estimation of dissolved oxygen content (Winkler's method) and free CO₂ of water sample
5. Estimation of phosphate, nitrate, and organic content of soil sample
6. Estimation of primary productivity (light and dark water bottle method) in aquatic ecosystem
7. Study of fossil from models/pictures
8. Study and verification of Hardy-Weinberg law by chi-square analysis
9. Preparation and submission of report on a visit to National Park/Biodiversity Park/Wildlife sanctuary/any other important ecosystems

Reference books

1. EP Odum. Fundamentals of Ecology
2. PA Colinvaux. Ecology
3. M Ridely. Evolution
4. BL Hall and B Hallgrimsson. Strickberger's Evolution

FYUGP 4th SEMESTER (MAJOR)
COMPARATIVE ANATOMY OF VERTEBRATES

CODE:

CREDITS: 3 (T) + 1 (P) = 4

Total marks: 100 (End semester: 45; Internal assessment: 30; Practical: 25)

Theory	Hours
Unit1: Skeletal and Digestive tract Integumentary system – structure, functions and derivatives. Skeletal system – Overview of axial and appendicular skeleton, jaw suspensorium, visceral arches. Digestive tract – alimentary canals and associated glands in vertebrates, dentition in mammals.	15
Unit 2: Respiratory, Circulatory and Urinogenital system Respiratory System – skin, gills, lungs and air sacs; accessory respiratory organs in vertebrates. Circulatory system – general plan of circulation, comparative anatomy of heart and aortic arches. Urinogenital system – succession of kidney, evolution of urinogenital duct.	15
Unit 3: Nervous system Nervous system – comparative account of brain, autonomic nervous system, spinal cord, cranial nerves in mammals. Sense organs – classification of receptors, brief account of visual and auditory receptors in man.	15

Practical (30 hours)

1. Study of placoid, cycloid and ctenoid scales through permanent slides
2. Study of disarticulated skeleton of frog/fowl/rabbit
3. Study of human skeleton
4. Study of carapace and plastron of turtle/tortoise
5. Study of mammalian skulls: herbivorous and carnivorous animal
6. Study of variations in a natural population
7. Study of permanent slides of neuron, bone, skin, cartilage, spinal cord and types of muscles
8. Project on comparative structure of any two organs (heart, lung, kidney, brain, eye, and ear)

Reference books

1. KV Kardong. Vertebrates' Comparative Anatomy, Function and Evolution
2. GC Kent and RK Carr. Comparative Anatomy of the Vertebrates
3. M Hilderbrand and GE Gaslow. Analysis of Vertebrate Structure
4. HE Walter and LP Sayles. Biology of Vertebrates

FYUGP 4th SEMESTER (MAJOR)
TAXONOMY, BIOSYSTEMATICS AND BIOSTATISTICS

CODE:

CREDITS: 3 (T) + 1 (P) = 4

Total marks: 100 (End semester: 45; Internal assessment: 30; Practical: 25)

Theory	Hours
<p>Unit 1: Animal Taxonomy Taxon and phenon, chemotaxonomy and cytotoxonomy, molecular taxonomy, taxonomic categories, concepts of species – typological, nominalistic, biological and evolutionary. Taxonomic keys – various types, dichotomous nature of keys. Taxonomic characters – morphological, behavioral, ecological, and geographical.</p>	12
<p>Unit 2: Biosystematics International Code of Zoological Nomenclature, principles, functions, and importance, principle of priority, homonymy and synonymy, principle of typification and use of types for specimens. Characters (ancestral vs. derived), homology and analogy, parallelism and convergence, monophyly, polyphyly, paraphyly; representing phylogenies – rooted and unrooted phylogenetic trees, clades, cladograms and phenograms.</p>	13
<p>Unit 3: Biostatistics Concept, collection and classification of statistical data, frequency, distribution, types of presentation of statistical data. Probability, measures of central tendency - Mathematical average, average of position. Measures of partition values. Measures of dispersion - range, quartile deviation, mean deviation, standard deviation, co-efficient of variation, standard error and regression. Parametric and non-parametric tests, testing of hypothesis, confidence intervals, chi-square test, student's t- test, analysis of variance. Introduction to R.</p>	20

Practical (30 hours)

1. To identify and distinguish species of insects/ fishes/ amphibians/ reptiles/ birds of NE India using appropriate taxonomic keys
2. Analysis of morphometric and meristic variations in common Indian major/minor carps and insect species
3. Analysis of length-weight relationship and condition factor/ponderal index in a commonly available fish
4. Preparation and study of skeleton of fish following Alizarin test
5. Collection procedures and identification of phytoplankton and zooplankton
6. Comparison of community similarities between natural populations
7. Preservation and mounting of Lepidoptera
8. Graphical representation of statistical data with the help of computer (MS-Excel/R)
9. Calculation of t-test for a given set of data
10. Calculation of F value (ANOVA) for a given set of data
11. Calculation of coefficient and regression analysis

Reference books

1. VC Kapoor. Theory and Practice of Animal Taxonomy
2. GG Simpson. Principles of Animal Taxonomy
3. E Mayr. Principles of Systematic Biology
4. B Rosner. Fundamentals of Biostatistics

**FYUGP 4th SEMESTER (MAJOR)
PHYSIOLOGY AND ENDOCRINOLOGY**

CODE:

CREDITS: 3 (T) + 1 (P) = 4

Total marks: 100 (End semester: 45; Internal assessment: 30; Practical: 25)

Theory	Hours
<p>Unit 1: Connective tissue and Digestion Structure and function of epithelial, connective, muscular tissues, characteristics of muscles, mechanism of muscle stimulation and contraction. Neuron and its structure, nerve impulse, physiology of nerve impulse, conduction and propagation, neuro - muscular junction and neurotransmitters in smooth muscle and cardiac muscle. Anatomy of the digestive system in mammals, digestive enzymes, digestion, and absorption of food.</p>	15
<p>Unit 2: Respiration and Circulation Respiratory organs in different animals, transport of oxygen and carbon dioxide, respiratory pigments, types and structure of heart, concepts of neurogenic and myogenic hearts, cardiac cycle, ECG patterns in mammals, homeostasis and blood clot formation, functions of kidney, types of nitrogenous wastes in different animal groups and their excretion urea production – Hans Krebs and Kurt Henseleit cycle, urine formation.</p>	15
<p>Unit 3: Endocrinology Endocrine glands of invertebrates and vertebrates, structure and function of insects' neuroendocrine glands, hypothalamus and pituitary structures, hormones and its functions. Hypothalamus-hypophyseal blood vessel. Thyroid and parathyroid gland structure in mammals. Endocrine pancreas structure and function, structural organizations of adrenals, functions of cortical and medullary hormones and mechanism of action. Male and female gonads in mammals, structure and function.</p>	15

Practical (30 hours)

1. Total RBC count
2. Total WBC count
3. Estimation of haemoglobin content in blood
4. Estimation of amount of casein from cow's milk
5. Estimation of oxygen consumed by aquatic animal using Winkler's method
6. Study of absorption of glucose and aminoacid by chicken intestine
7. Proteolytic study of pepsin and trypsin
8. Dissection and display of endocrine glands of rat (Demonstration)
9. Dissection of insect neuroendocrine system in cockroach
10. Dissection and display of pituitary gland and gonad of fish
11. Extraction and estimation of glycogen from chicken/fish liver using Anthrone reagent
12. Study of permanent slides of endocrine glands: ovary, testis, thyroid, adrenal, pituitary, parathyroid, pancreas, pineal, and thymus

Reference books

1. AC Guyton and JE Hill. Textbook of Medical Physiology
2. KS Saladin. Anatomy and Physiology
3. MA Hadley and JE Levine. Endocrinology
4. RE Jones and KH Lopez. Human Reproductive Biology

**FYUGP 4th SEMESTER (MAJOR)
PARASITOLOGY**

CODE:

CREDITS: 3 (T) + 1 (P) = 4

Total marks: 100 (End semester: 45; Internal assessment: 30; Practical: 25)

Theory	Hours
Unit 1: Introduction to Parasitology Parasitism, parasite, parasitoid and vectors, host-parasite relationship; types of parasites and hosts; evolution of parasitism and parasitic adaptations. Zoonotic diseases.	08
Unit 2: Protozoan parasites Study of morphology, life cycle, prevalence, epidemiology, pathogenicity, diagnosis, prophylaxis and treatment of <i>Entamoeba histolytica</i> , <i>Trypanosoma gambiense</i> , <i>Leishmania donovani</i> , <i>Giardia intestinalis</i> , and <i>Plasmodium</i> .	10
Unit 2: Helminthology Study of morphology, life cycle, prevalence, epidemiology, pathogenicity, diagnosis, prophylaxis and treatment of <i>Schistosoma haematobium</i> , <i>Paragonimus westermanni</i> , <i>Hymenolepis nana</i> , <i>Ancylostoma duodenale</i> , <i>Trichinella spiralis</i> , <i>Dracunculus medinensis</i> , <i>Trichuris trichiura</i> , <i>Enterobius vermicularis</i> , and <i>Necator americanus</i> .	14
Unit 3: Ectoparasites External parasites in domesticated animals with examples (cattle, goat, sheep, buffalo and dogs), Study and control of ticks, mites, <i>Pediculus humanus</i> (head and body louse), <i>Xenopsylla cheopis</i> and <i>Cimex lectularius</i> . Parasitic vertebrates – Candiru and vampire bat.	13

Practical (30 hours)

1. To study and prepare protozoan parasite *Monocystis* from seminal vesicle of earthworm
2. To prepare and study protozoan parasites (ciliates and flagellates) in frog rectum
3. Study of helminth parasites from snail
4. To flatten, fix and study amphistomes from goat
5. To recover and study helminth parasites from fowl and preparation of slides
6. Study of protozoan permanent slides: *Entamoeba histolytica*, *Plasmodium vivax*, *Trypanosoma gambiense*, *Giardia intestinalis*, and *Leishmania donovani*
7. Study of helminth specimens: *Schistosoma haematobium*, *Paragonimus westermanni*, *Hymenolepis nana*, *Trichuris trichiura*, *Enterobius vermicularis*, *Ancylostoma duodenale*, *Necator americanus*, *Dracunculus medinensis*, *Trichinella spiralis*.
8. Study of trematode larval parasites from permanent slides: sporocyst larva, miracidium larva, redia larva, cercaria larva, and metacercaria larva

Reference books

1. JD Smyth. Introduction to Animal Parasitology
2. KD Chatterjee. Parasitology
3. MA Taylor, RL Coop, and RL Wall. Veterinary Parasitology
4. ES Loker and BV Hofkin. Parasitology – A Conceptual Approach

**FYUGP 5th SEMESTER (MAJOR)
ENTOMOLOGY AND FISHERIES**

CODE:

CREDITS: 3 (T) + 1 (P) = 4

Total marks: 100 (End semester: 45; Internal assessment: 30; Practical: 25)

Theory	Hours
Unit I: Insect Taxonomy and Morphology General features of insects, classification upto orders, general habits and characters, role of insects in pollination, collection, preservation and culture techniques, identification, structure of compound eyes, types of antennae and legs, mouth parts with respect to feeding habits, wings and wing articulation, structure of integument, moulting, metamorphosis.	12
Unit II: Economic importance of insects Bees and termites, and their social life. Theory of co-evolution, role of allelochemicals in host plant mediation, common insect vectors (<i>Aedes</i> , <i>Culex</i> , <i>Anopheles</i> , <i>Phlebotomus</i> , <i>Musca domestica</i>), insects as plant pests.	10
Unit III: Fish Morphology and Physiology Freshwater fish groups, Weberian ossicles, types of fins and their modifications, types of scales, Accessory respiratory organs in fish, swim bladder - types, role in respiration and buoyancy, osmoregulation in Elasmobranchs. Fish endocrinology – pituitary, thyroid, pancreas	11
Unit IV: Capture and culture Fisheries Concept of marine and brackish water fisheries, inland fisheries, fishing crafts and gears, application of remote sensing and GIS in fisheries, extensive, semi-intensive and intensive culture of fish, pen and cage culture, integrated composite fish farming, induced breeding of Indian major carps. Fish in research - transgenic fish, zebrafish as model organism.	12

Practical (30 hours)

1. Preparation of whole mount of antenna, wings, legs, and genitalia of grasshopper, cockroach, housefly, and honey bee
2. Preparation of permanent slide of mouth parts of cockroach, mosquito, butterfly, and honey bee
3. Identification of insects belonging to different orders
4. Identification and study of insect vectors: *Aedes*, *Culex*, *Anopheles*, *Pediculus*, *Cimex*, *Phlebotomus*, *Musca domestica*
5. Study of common insect pest of paddy, tea, stored grain, citrus and sugarcane
6. Study of head and sclerites of cockroach
7. Identification of commercially important food and ornamental fishes of NE India
8. Estimation of phosphate, nitrate, sulphate, and chloride content of water sample
9. Estimation of total alkalinity, total hardness, calcium and magnesium hardness, total suspended solids and total dissolved solids of water sample
10. Dissection of Weberian ossicles of fish
11. Dissection of accessory respiratory organ of *Channa*

Reference books

1. RF Chapman. The Insects: Structure and Function
2. DB Tembhare. Modern Entomology
3. Q Bone and RH Moore. Biology of Fishes
4. SS Khanna and HR Singh. Textbook of Fish Biology and Fisheries

**FYUGP 5th SEMESTER (MAJOR)
BIOCHEMISTRY**

CODE:

CREDITS: 3 (T) + 1 (P) = 4

Total marks: 100 (End semester: 45; Internal assessment: 30; Practical: 25)

Theory	Hours
<p>Unit 1: Carbohydrates and Lipids Carbohydrates - structure and biological importance, monosaccharides, disaccharides, polysaccharides and glycoconjugates, glycolysis, citric acid cycle, phosphate pentose pathway, gluconeogenesis, glycogenolysis and glycogenesis. Lipids - structure and significance, physiologically important saturated and unsaturated fatty acids, triacylglycerols, phospholipids, glycolipids, steroids. β-oxidation and omega-oxidation of saturated fatty acids with even and odd number of carbon atoms, ketogenesis.</p>	14
<p>Unit 2: Proteins Amino acids - structure, classification and general properties of α- amino acids, physiological importance of essential and non-essential α- amino acids. Proteins – bonds stabilizing protein structure, levels of organization, denaturation, introduction to simple and conjugate proteins. Catabolism of amino acids, urea cycle, fate of C-skeleton of glucogenic and ketogenic amino acids.</p>	13
<p>Unit 3: Enzymes and oxidative phosphorylation Nomenclature and classification of enzymes, cofactors, isozymes. Specificity, regulation and mechanism of enzyme action, enzyme kinetics, factors affecting the rate of enzyme catalysed reactions, derivation of Michaelis-Menten equation, concept of K_m and V_{max}, types of enzyme inhibition. Catabolism vs anabolism, stages of compartmentalization of metabolic pathways, shuttle systems and membrane transporters, ATP as "energy currency of cell", coupled reactions, use of reducing equivalents and cofactors, intermediary metabolism and regulatory mechanisms. Redox systems, review of mitochondrial respiratory chain, inhibitors and un-couplers of electron transport system.</p>	18

Practical (30 hours)

1. Study of activity of salivary amylase and determination of amylase number
2. Separation of standard amino acids by paper chromatography method and TLC
3. Extraction and estimation of protein from chicken/fish liver using Lowry's/Bradford's reagent
4. Estimation of amino acid using Ninhydrin reagent
5. Estimation of inorganic phosphate using Fiske-Subbarow reagent
6. Study of effect of time on urease/amylase activity and enzyme concentration in a reaction
7. Study of the effect of substrate concentration and to determine V_{max} and K_m for the substrate of urease enzyme by Michaelis-Menten and Lineweaver-Burk plot
8. To determine the iodine number of given oil/fat
9. To find the pKa value of acetic acid
10. Detection of SGOT and SGPT in serum/tissue
11. To study the enzymatic activity of Trypsin and Lipase
12. To perform the Acid and Alkaline phosphatase assay from serum/tissue

Reference books

1. MM Cox and DL Nelson. Lehninger's Principles of Biochemistry
2. D Voet, JG Voet and CW Pratt. Principles of Biochemistry
3. JM Berg, JL Tymoczko, and L Stryer. Biochemistry
4. RK Murray, DK Granner, PA Mayes, and VW. Rodwell. Harper's Illustrated Biochemistry

**FYUGP 5th SEMESTER (MAJOR)
CELL BIOLOGY**

CODE:

CREDITS: 3 (T) + 1 (P) = 4

Total marks: 100 (End semester: 45; Internal assessment: 30; Practical: 25)

Theory	Hours
<p>Unit 1: Introduction to cell Overview of cells: Prokaryotic and eukaryotic cells, virus, viroids, mycoplasma, prions. Plasma Membrane: Various models of plasma membrane structure, transport across membranes: Active and passive transport, facilitated transport, types of transporters. Cell junctions: Structure and functions of tight junctions, desmosomes, gap junctions.</p>	15
<p>Unit 2: Organisation of cell Endomembrane system: Structure and functions of endoplasmic reticulum, Golgi apparatus and lysosomes. Mitochondria: structure, semi-autonomous nature, endosymbiotic hypothesis, mitochondrial respiratory chain, chemi-osmotic hypothesis. Peroxisomes: structure and functions, Cytoskeleton: structure and functions of microtubules, microfilaments and intermediate filaments, cilia and flagella. Nucleus (structure of nucleus, nuclear envelope, nuclear pore complex, nucleolus).</p>	15
<p>Unit 3: Chromosomes and Cell division Chromosomes: Giant chromosome (Polytene and Lampbrush), types of eukaryotic chromosomes based on centromeres, euchromatin and heterochromatin, DNA packaging within the nucleus (nucleosome model). Cell division: mitosis, meiosis, cell cycle and its regulation. Cell to cell communications: types of signalling molecules, cell surface receptors and its types, second messengers, mechanism of signal transductions of peptide and steroid hormones. Cell deaths: necrosis and apoptosis, mechanism of apoptosis. Cancer: basic concept of cancer and its types, development and causes, oncogenes and tumor suppressor genes.</p>	15

Practical (30 hours)

1. Study of types of epithelial cells from permanent slides
2. Preparation of temporary slides of nerve and squamous epithelial cells and skeletal muscle fibre
3. Preparation of temporary stained squash of onion root tip to study various stages of mitosis
4. Preparation of temporary squash of grasshopper/cockroach/mice/rat testis to study various stages of meiosis
5. Preparation of permanent slide to show the presence of Barr body in human female buccal mucosa cells
6. Preparation and study of histological slides of liver, lung, stomach, intestine, and kidney
7. Preparation of permanent slide for cytochemical demonstration of DNA by Feulgen reaction; Mucopolysaccharides and Glycogen by PAS reaction; Proteins by Mercurio bromophenol blue/Fast Green; Lipid by Sudan black B
8. Isolation of mitochondria from mammalian liver

Reference books

1. GM Cooper. The Cell: A Molecular Approach
2. B Alberts et al. Molecular Biology of the Cell
3. J Hardin, GP Bertoni, LJ Kleinsmith, and WM Becker. The World of the Cell
4. G Karp. Cell and Molecular Biology

**FYUGP 6th SEMESTER (MAJOR)
IMMUNOLOGY**

CODE:

CREDITS: 3 (T) + 1 (P) = 4

Total marks: 100 (End semester: 45; Internal assessment: 30; Practical: 25)

Theory	Hours
<p>Unit 1: Introduction to Immunology Basic concepts of immunology, components of immune system, Innate and adaptive immune systems, Active and passive immunity (Artificial and natural immunity), Haematopoiesis and role of haematopoietic factors; cells of the immune system; primary and secondary lymphoid organs; lymphatic system.</p>	15
<p>Unit 2: Antigens and Antibodies Antigens and their properties, antigenicity and immunogenicity, B and T cells and their epitopes, immunogens, adjuvants and haptens. Immunoglobulins and their structure, properties and functions, antigenic determinants, monoclonal and polyclonal antibodies, myeloma protein, principle of antigen-antibody interactions, types of antigen-antibody interactions in research and diagnosis.</p>	15
<p>Unit 3: Immune response MHC and its classes, structure and functions. Pathways of antigen presentation and processing, properties and functions of cytokines, complement system and its pathways and components, immune responsiveness. Immunodeficiency disorders, auto immune diseases, hypersensitivity reactions, transplantation immunology and graft rejection. Cancer: tumor antigen, host response to tumors, tumor immunity, immunotherapy in cancer. General introduction to vaccines, various types of vaccines.</p>	15

Practical (30 hours)

1. Study of permanent slides of spleen, thymus, lymph nodes, and tonsil
2. Preparation of blood smear to study and identify WBCs
3. ABO blood grouping and Rh factor determination
4. Demonstration of ELISA and immunoelectrophoresis
5. Antigen quantifications using single radial immunodiffusion
6. Antigen and antibody interaction by Ouchterlony double diffusion
7. Separation of T and B lymphocytes from human peripheral blood
8. Dissection and display of lymphoid organs in rat (Demonstration)

Reference books

1. J Punt, S Stranford, P Jones, and JA Owen. Kuby Immunology
2. DP Stites, AI Terr, and TG Parslow. Basic and Clinical Immunology
3. M David, B Jonathan, RB David, and R Ivan. Immunology
4. KA Abbas and AH Lichtman. Cellular and Molecular Immunology

FYUGP 6th SEMESTER (MAJOR)**MOLECULAR BIOLOGY****CODE:****CREDITS: 3 (T) + 1 (P) = 4****Total marks: 100 (End semester: 45; Internal assessment: 30; Practical: 25)**

Theory	Hours
Unit 1: Nucleic acids and Replication Nucleic Acids (DNA, RNA), structure and types, purines and pyrimidines, nucleosides and nucleotides, Watson and Crick model of DNA, Cot curves – base pairing, denaturation and renaturation. DNA replication in prokaryotes and eukaryotes, enzymes in DNA replication, semiconservative, bidirectional and semi-discontinuous replication, telomere and replication of telomeres.	13
Unit 2: Transcription and Translation Transcription: RNA polymerase structure and transcriptional unit, mechanism of transcription in prokaryotes and eukaryotes, post transcriptional modifications and processing of eukaryotic RNA, split genes: concept of introns and exons, splicing mechanism and alternative splicing. Translation: Genetic code, degeneracy of the genetic code and Wobble hypothesis, aminoacyl tRNA synthetases and charging of tRNA, proteins involved in initiation, elongation and termination of polypeptide chain, mechanism of translation, inhibitors of protein synthesis.	18
Unit 3: Gene regulation Operon concept and models, Transcription regulation in prokaryotes (lac operon and tryptophan operon) Transcription regulation in eukaryotes: Activators, repressors, enhancers, silencer, inducers elements, gene silencing and genetic imprinting. DNA damage and repair mechanisms, RNA interference.	14

Practical (30 hours)

1. Isolation of DNA and RNA from chicken liver
2. Estimation of DNA using Diphenylamine reagent
3. Estimation of RNA using Orcinol reagent
4. Study of electron micrographs/ photograph showing: DNA replication, transcription, translation and split genes
5. Primer designing
6. Demonstration of PCR
7. Demonstration of Agarose gel electrophoresis for DNA

Reference books

1. GM Cooper. The cell: A Molecular approach
2. G Karp. Cell and Molecular Biology
3. H Lodish et al. Molecular Cell Biology
4. B Alberts et al. Molecular Biology of the Cell

**FYUGP 6th SEMESTER (MAJOR)
DEVELOPMENTAL BIOLOGY**

CODE:

CREDITS: 3 (T) + 1 (P) = 4

Total marks: 100 (End semester: 45; Internal assessment: 30; Practical: 25)

Theory	Hours
<p>Unit 1: Introduction to Developmental Biology Gametes (sperm and egg), types of eggs and membranes, spermatogenesis and oogenesis. External and internal fertilization, sperm-egg interactions, biochemical events, mono and polyspermy, post fertilization events. Parthenogenesis, natural, haploid, diploid, and cyclic parthenogenesis, artificial stimulus for parthenogenesis and its significance.</p>	15
<p>Unit 2: Early embryonic development Early development in chick (cleavage, blastulation, gastrulation), cleavage and its types, planes and patterns, types of blastula, embryonic induction and organisers, fate maps and their construction in frog and chick. Organogenesis: Development of heart and eye in vertebrates.</p>	15
<p>Unit 3: Later embryonic development Differentiation of germ layers in chick embryo, formation of neural tube, skin, notochord, somites, coelom and digestive tubes (upto rudiments). Extra embryonic membranes in birds and mammals (human), implantation of embryo, placentation, its structure, types and physiology. Regeneration in invertebrates and vertebrates. Metamorphosis, its types, changes, and hormonal regulations in insects and amphibians. Teratogenesis, teratogenic agents and their effects on embryonic development. In vitro fertilization, embryonic stem cells and amniocentesis.</p>	15

Practical (30 hours)

1. Collection and study of different types of eggs
2. Study of prepared slides of egg and sperm of rat
3. Study of prepared slides of developmental stages of frog: cleavage, blastula, gastrula, neurula, tail bud stage, tadpole (external and internal gill stages)
4. Study of developmental stages showing primitive streak of chick embryo through permanent slides (Hamburger and Hamilton stages): stage 3 (13 h, intermediate streak), stage 4 (18 h, definitive streak), stage 5 (21 h, head process), stage 7 (24 h), stage 8 (28 h), stage 10 (33 h), stage 11 (40 h), stage 13 (48 h), stage 19 (72 h), stage 24 (96 h)
5. Study of different types of placenta through permanent slides of photomicrographs
6. Study of regeneration in tadpole/planaria
7. Preparation of sperm smear from rat/frog
8. Permanent slide preparation of whole mount of chick embryo (any stage)

Reference books

1. SF Gilbert. Developmental Biology
2. JMS Slack. Essential Developmental Biology
3. L Wolpert. Principles of Development
4. K Kalthoff. Analysis of Biological Development

FYUGP 6th SEMESTER (MAJOR)
BIOINFORMATICS (TO BE ADOPTED FROM MOOCS)

CODE:

CREDITS: 3 (T) + 1 (P) = 4

Total marks: 100 (End semester: 45; Internal assessment: 30; Practical: 25)

Theory	Hours
<p>Unit 1: Introduction to Bioinformatics Definition, importance, goal, scope. Genomics, Transcriptomics, Systems Biology, Functional Genomics, Metabolomics, Molecular Phylogeny. Applications and limitations of Bioinformatics. Biological databases: Primary, secondary and composite databases, nucleic acid databases (GenBank, DDBJ, EMBL and NDB), protein databases (PIR, SWISS-PROT, TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc, and MetaCyc), small molecule databases (PubChem, Drug Bank, ZINC, CSD).</p>	15
<p>Unit 2: Bioinformatics tools Sequence submission tools (BankIt, Sequin, Webin), sequence file format (flat file, FASTA, GCG, EMBL, Clustal, Phylip, Swiss-Prot), sequence annotation, data retrieval systems (SRS, Entrez), structural Bioinformatics (3-D protein, PDB), drug discovery method (Basic concepts).</p>	15
<p>Unit 3: Sequence analysis Basic concepts of sequence alignment, applications of Bioinformatics, scoring matrices (PAM, BLOSUM), methods of alignment (Dot matrix, Dynamic Programming, BLAST and FASTA). Local and global alignment, pair wise and multiple sequence alignments, similarity, identity and homology of sequences.</p>	15

Practical (30 hours)

1. Sequence retrieval from NCBI, ENA, and DDBJ
2. Retrieval of sequence data from Entrez, gene expression from GEO, structural data of protein using PDB, motif information of protein using Prosite
3. Pair-wise alignment of sequences (BLAST) and interpretation of the output
4. Multiple sequence alignment using MEGA
5. Phylogenetic analysis using PHYLIP (rooted and unrooted)
6. Prediction of protein structure from its sequence and Ramachandran plot generation

Reference books

1. DW Mount. Bioinformatics
2. AM Lesk. Introduction to Bioinformatics
3. J Pevsner. Bioinformatics and Functional Genomics
4. M Zvelebil and OJ Baum. Understanding Bioinformatics

FYUGP 6th SEMESTER (MAJOR)
FUNDAMENTALS OF BIOINFORMATICS
CODE: ZOO-MJ-06-B-04-04

FROM SWAYAM: By Dr. VIVEK P J; Sree Neelakanta Govt. Sanskrit College, Pattambi

Week 1

Day 1 Module 1: Origin, History, and Scope of Bioinformatics

Day 2 Module 2: Importance and Use of Bioinformatics

Day 3 Module 3: Applications of Bioinformatics

Day 4 Interaction based on the three modules covered

Week 2

Day 1 Module 4: IT in teaching, Learning and Research

Day 2 Module 5: Open Access Bibliographic Resources

Day 3 Module 6: Basic Concepts of Copyrights and Patents

Day 4 Interaction based on the three modules covered

Week 3

Day 1 Module 7: Central Dogma and Emergence of Omics Technologies

Day 2 Module 8: Genomics and Transcriptomics

Day 3 Module 9: Proteomics and Metabolomics

Day 4 Interaction based on the three modules covered

Day 5 Deadline for submitting assignments

Week 4

Day 1 Module 10: Introduction to Biological Databases

Day 2 Module 11: Sequence and Structural Databases

Day 3 Module 12: Functional and Other Databases

Day 4 Interaction based on the three modules covered

Day 5 Deadline for submitting assignments

Week 5

Day 1 Module 13: Basic Concepts of Sequence Similarity and Identity

Day 2 Module 14: File Formats for Sequences

Day 3 Module 15: Sequence – Patterns and Profiles

Day 4 Interaction based on the three modules covered

Day 5 Deadline for submitting assignments

Week 6

Day 1 Module 16: Scoring Matrices

Day 2 Module 17: Sequence – Pairwise alignments

Day 3 Module 18: Multiple Sequence Alignments

Day 4 Interaction based on the three modules covered

Day 5 Deadline for submitting assignments

Week 7

Day 1 Module 19: GenBank

Day 2 Module 20: BLAST

Day 3 Module 21: Protein Data Bank (PDB)

Day 4 Interaction based on the three modules covered

Day 5 Deadline for submitting assignments

Week 8

Day 1 Module 22: Taxonomy and Phylogeny

Day 2 Module 23: Phylogenetics – Methods
Day 3 Module 24: Phylogenetics – Tools
Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 9

Day 1 Module 25: Molecular Modelling
Day 2 Module 26: Molecular visualization – Rasmol and Pymol
Day 3 Module 27: Molecular docking
Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 10

Day 1 Module 28: Definition of Drugs and its Advances
Day 2 Module 29: Pharmacophore Identification and Novel Drug Design
Day 3 Module 30: Structure based drug design
Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 11

Day 1 Module 31: DNA sequencing – Basic methods
Day 2 Module 32: Next Generation Sequencing (NGS)
Day 3 Module 33: Human Genome Project
Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 12

Day 1 Module 34: Protein structure – Primary
Day 2 Module 35: Protein structure - Secondary
Day 3 Module 36: Protein structure - Tertiary and Quaternary
Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 13

Day 1 Module 37: Protein Structure Prediction
Day 2 Module 38: Protein Interaction analysis
Day 3 Module 39: Gene Prediction
Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 14

Day 1 Module 40: Mapping Populations
Day 2 Interaction based on the module covered
Day 3 Revision
Day 4 End term assessment

Practical (30 hours)

1. Retrieval of sequence data from Entrez, gene expression from GEO, structural data of protein using PDB, motif information of protein using Prosite
2. Primer Designing
3. Perform pair-wise alignment of sequences (BLAST) and interpret the output
4. Perform multiple sequence alignment using MEGA
5. Phylogenetic analysis using PHYLIP (rooted and unrooted)

Reference books

1. Ghosh Z and Mallick B. (2008). Bioinformatics:
2. Principles and Applications, Oxford University Press.
3. Pevsner J. (2009). Bioinformatics and Functional Genomics, II Edition, Wiley Blackwell.
4. Zvelebil, Marketa and Baum O. Jeremy (2008). Understanding Bioinformatics, Garland Science, Taylor and Francis Group, USA.
5. An Introduction to Computational Systems Biology, By Karthik Raman.
6. An Introduction to Systems Biology, By Uri Alon.

**FYUGP 6th SEMESTER (MAJOR)
WILDLIFE BIOLOGY**

CODE:

CREDITS: 3 (T) + 1 (P) = 4

Total marks: 100 (End semester: 45; Internal assessment: 30; Practical: 25)

Theory	Hours
<p>Unit 1: Introduction to Wildlife Concepts of wildlife, definition, conservation, history, and conservation ethics. Values and importance of wildlife, drivers of wildlife decline in India and Northeast, wildlife habitat ecology and its management, biological and ecological basis of wildlife management. Conservation vs. preservation, wildlife population survey.</p>	10
<p>Unit 2: Wildlife Ecology and Techniques Concepts pertaining to wildlife population, density, types of density, natality, mortality, sex ratio and age structure, population growth patterns and concept of carrying capacity, habitat management of wildlife in a grassland ecosystem, definition of wildlife cover and cover characteristics. Wildlife habitat succession and management, restoration of degraded habitats, concepts of GPS, GIS and remote sensing and their utility in wildlife habitat management.</p>	15
<p>Unit 3: Wildlife protected areas Protected areas (NP, WLS, Conservation reserve, Community reserve, Tiger reserve). Conservation of wildlife outside protected areas (elephant reserve, sacred grooves, community conserved areas, Ramsar sites), Biosphere reserve. Wildlife rescue and rehabilitation, human wildlife interactions.</p>	12
<p>Unit 4: Legal instrument of Wildlife conservation Wildlife (Protection) Act (1972), Forest Conservation Act (1980), Biodiversity Act (2002), CITES. Status of Wildlife crime.</p>	08

Practical (30 hours)

1. Identification of flora (Common plant species associated with wildlife) and fauna (butterflies, herpetofauna, mammals, and birds)
2. Demonstration and applicability of basic equipment needed for wildlife studies (binoculars, compass, range finder, GPS, camera traps)
3. Demonstrations of field study techniques: line transect, quadrat sampling, Point Centred Quarter
4. Indirect evidences in wildlife survey and its identification [animal footprints (pug mark and hoof mark), animal droppings (scat, dung, pellet), other animal signs, antlers, nests of birds], use of plaster of Paris for wildlife survey
5. Behavioural observation of any mammal
6. Estimation of population size of unknown sample by *Tribolium* mark recapture method
7. Observation of tree phenology
8. Project on diversity of animals in a particular area

Reference books

1. G Caughly and ARE Sinclair. Wildlife Ecology and Management
2. SK Shekhar. A field guide to tracks and signs of Indian Wildlife
3. M Raj. Wildlife Ecology and Management
4. TA Bookhout. Research and Management techniques for Wildlife and Habitats