UNIVERSITY OFKERALA
Thiruvananthapuram

M.Sc. ZOOLOGY PROGRAMME

with Specialization in Biosystematics and Biodiversity

(Innovative Programme)

Semester System

(2023 admissions onwards)

JULY 2023

UNIVERSITY OF KERALA

Programme Specific Outcomes

PSO 1: Acquire in-depth knowledge on different branches of Zoology and thereby develop inquisitiveness to explore advanced courses of learning and research.

PSO 2: Integrate biological knowledge to allied disciplines and to inculcate interest in biodiversity, various ecosystems, its interactions and laws governing their conservation.

PSO 3: Apply ethical principles and commit to professional ethics and responsibilities in research and teaching.

PSO4: Apply the scientific method to questions in biology by formulating testable hypotheses, gathering data and analysing those data to assess the degree to which their scientific work supports their hypotheses.

PSO5: Create empathy and care towards the ecosystem and biomes.

PSO6: Acquire necessary skills in the observation and study of nature, biological techniques, handle analytical equipments, research methodologies, with scientific temper and ethics leading to research.

PSO7: Achieve intellectual competency with innovative ideas and research aptitude enhanced with specialization in Biosystematics and Biodiversity to avail career opportunities in higher education, scientific research projects, environmental and industrial organizations that require postgraduation in Zoology.

PSO8: Coordinate and present appropriate applications of knowledge through effective written, verbal, graphical/ virtual communications and interact fruitfully with people from diverse background.

M.Sc. Zoology (with Specialization in Biosystematics and Biodiversity) – Semester System Syllabus, Course Structure & Mark Distribution

Semester	Paper Code	Title	Distribution of hours semester	Instructional hrs. per week		Duration of ESA (Hrs.)	Maximum Marks		
				L	P		CA	ESA	Total
1	ZOBB 511	Evolution and Zoogeography	100	5	-	3	25	75	100
	ZOBB 512	Biochemistry	100	5	-	3	25	75	100
	ZOBB 513	Biophysics, Instrumentation, Nanoscience and Nanotechnology	100	5	-	3	25	75	100
	ZOBB 514	Practical 1 - Biochemistry, Biophysics and Instrumentation, Evolution	120	-	10	4	25	75	100
	Total for Semester 1		**450***	**15**	**10**	**-**	**100**	**300**	**400**
2	ZOBB 521	Advanced Physiology& Functional Anatomy	100	5	-	3	25	75	100
	ZOBB 522	Genetics, Biostatistics &Research Methodology	100	5	-	3	25	75	100
	ZOBB 523	Cell Biology, Molecular Biology& Bioinformatics	100	5	-	3	25	75	100
	ZOBB 524	Practical 2- Advanced Physiology and Functional Anatomy	120	-	10	4	25	75	100
	Total for Semester 2		**450***	**15**	**10**	**-**	**100**	**300**	**400**
3	ZOBB 531	Microbiology & Biotechnology	100	5	-	3	25	75	100
	ZOBB 532	Ecology and Ethology	100	5	-	3	25	75	100
	ZOBB 533	Immunology & Developmental Biology	100	5	-	3	25	75	100
	ZOBB 534	Practical 3 - Microbiology, Biotechnology, Ecology, Immunology and Developmental Biology	120	-	10	4	25	75	100
	Total for Semester 3		**450***	**15**	**10**	**-**	**100**	**300**	**400**
4	ZOBB 541	Special Paper 1 Bio Systematics & Animal Diversity^	100	8	-	3	25	75	100
	ZOBB 542	Special Paper 2 Biodiversity Management^	100	7	-	3	25	75	100
	ZOBB 543	Special Paper Practical 4 Biosystematics and Animal Diversity^	120	-	5	3	25	75	100
	ZOBB 544	Special Paper Practical 5 Biodiversity Management ^	120	-	5	4	25	75	100
	Total for Semester 4		**450***	**15**	**10**	**-**	**100**	**300**	**400**
	ZOBB501	Project/Dissertation	-	-	-	-	25	75	100
	ZOBB502	Comprehensive Viva Voce						100	100
Grand Total			**-**	**-**	**-**	**-**	**400**	**1400**	**1800**

Field visits/Study tour/Nature study Camp must be carried out appropriately to get the real time information of the relevant topics included in the syllabus

L – Lecture, P – Practical; T – Tutorial; CA Continuous Assessment; ESA – End Semester Assessment * Tutorial 30 hours/week, ^Compulsory Course

Semester I

ZOBB 511 Evolution and Zoogeography 100 hrs.

COURSE OUTCOMES

CO 1: Develop a comprehensive knowledge on evolution and zoogeography
CO 2: Students will get basic knowledge of Darwin's concept, cosmic evolution, molecular and genomic evolution
CO 3: Gain an insight into the distribution of animals
CO 4: Create a thorough knowledge on remote sensing and GIS
CO 5: Understand the origin of higher categories
CO 6: Acquire knowledge on geographical distribution of animals

Evolution (70 hrs.)

Module1. Introduction to Evolution (18 hrs.)

1.1 Lamarckism; Darwin concepts of variation, Contribution of A.R. Wallace in Evolutionary Biology, adaptation, struggle, fitness and natural selection, Mendelism, the evolutionary synthesis, Evolution as the development of Individual, different species and relation, similarity and pattern of evolution.

1.2 Earth Changing Atmosphere, structure, movement of continents,Possible site for the origin of early molecules, Origin of basic biological molecules, abioticsynthesis of organic monomers and polymers; Concepts of Oparin and Haldane; experiment ofMiller; the first cell; the evolution of prokaryotes; the origin of eukaryotic cells; the evolution ofunicellular eukaryotes; anaerobic metabolism; photosynthesis and aerobic metabolism

1.3 Cosmic evolution and the Origin of life: Cosmic evolution: Origin of the Universe, matter-time-space continuum. Theory of oscillating universe. Origin of galaxies, stellar systems, planets –earth. Origin of Life- Physical basis of life,extra-terrestrial life.

Module 2. Palaeontology and Evolutionary history (8 hrs.)

2.1 The evolutionary time scale, Eras, Periods and Epoch, Major events in evolutionary time scale, Mass Extinction and adaptive radiation, Origin of unicellular and multicellular organisms, Major groups of plants and animals.

2.2 Human Influences of Evolution, Cultural and Religion Evolution.

Module3. Natural Selection and Molecular Evolution (32 hrs.)

3.1 Evolution by natural selection, Artificial and Natural selection, Selection on small continuous variation, Types of Natural selection, Stabilizing selection, Sexual Selection, Group Selection, Directional Selection, Disruptive Selection, Natural Selection, Phenotype and Genotypes.

3.2 Concepts of neutral evolution. Gene evolution, Evolution of gene families, molecular drive, Amino acid sequence divergence inproteins. Nucleotide sequence divergence in DNA, Molecular

clocks, Ancient DNA.

3.3 Biochemical and genomic evolution
The evolutionary history of proteins and concept of molecular clock. Outline of origin ofprokaryotic and eukaryotic genomes, The "C-Value paradox". Evolutionary history of neural integration Evolution of the endocrine systems, Hormones and evolution.

Module 4. Origin of Higher Categories (12hrs.)

4.1 Origin of Metazoa, Origin& Evolution and extinction of Trilobites, Origin and evolution of vertebrate groups- Pisces, Amphibia, Reptilia, Aves and mammals, Phylogenetic gradualism and punctuated equilibrium; Micro and Macroevolution, Stages in Primate Evolution- Prosimii, Anthropoidea and Hominids. Factors in human origin-Hominid fossils.

4.2 Cytogenetic and Molecular basis of origin of man-African origin of modern man- Mitochondrial Eve, Y chromosomal Adam - early migration, hunter-gatherer societies. Evolution of human brain-communication, speech and language. Evolution of culture.

Zoogeography (30 hrs.)

Module 5. Introduction, Distribution, dispersal and migration (24 hrs.)

5.1 Introduction to Biogeography, Origin and development of the Earth, Geological time scale and development of life. Origin of continents- Plate tectonics and continental drift.

5.2 Geographical distribution of animals – Oriental, Palaearctic, Nearctic, Neotropical, Ethiopian and Australian Regions. Zoogeographical realms; Biogeography of India fauna. Island Biogeography: Continental Island, British Isles, Madagascar, Oceanic Islands, Galapagos. Mr. Sclater's regions, Mr. Huxley's regions, other suggested regions, Wallace. Patterns and types of distributions, theories of distribution, affinities of organisms, Application of biogeography – Remote Sensing & Geographical Information System (GIS). Centres of dispersals and pattern of dispersal, Mobility and migration, Geographical checks or barriers to dispersal / movement. Routes of dispersal, Vicariance, Adaptation and competition, Species range, territoriality.

Module 6. Speciation, Island Biogeography (6 hrs.)

6.1 Meaning and scope, types of speciation. Variety of Island habitats, Problems of isolation, Hazards of island life, effects of inbreeding, dispersal, Opportunities for adaptive radiation.

6.2 Case studies – Real Island, functional island, Island biodiversity models.

References

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Brooks/Cole, Belmont, CA,
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Web Resources
32. http://www.talkorigins.org
33. http://www.ucmp.berkely.edu
34. http://www.academicearth.org

Semester I

ZOBB 512 Biochemistry (100 hrs.)

COURSE OUTCOMES

CO 1: Understand various biochemical molecules and pathways in life processes.
CO 2: Understand the molecular machinery of living cells.
CO 3: Understand the principles behind the structures of macromolecules.
CO 4: Acquire knowledge on the role of macromolecules in molecular recognition.
CO 5: Understand the principles and basic mechanisms of metabolic control
CO 6: Demonstrate the principle of molecular signaling.

Module 1: Introduction (6hrs.)

Atoms and molecules, intermolecular and intramolecular interactions. Bonds- covalent and electrovalent bonds, ionic bond, hydrogen bond. Water: Biological importance, pH and Acid – base balance. Buffers: Biological importance. Unique solvent properties; electrolytic dissociation into cations and anions, Henderson– Hasselbalch equation.

Module 2: Micro molecules and Macro molecules (50 hrs.)

2.1 Carbohydrates (12hrs.)

Classification and nomenclature, Monosaccharides: Biological importance, glucose, fructose, galactose, mannose and ribose. Isomerism – Structural isomerism and stereoisomerism, opticalisomerism, Epimerism and anomerism. Reactions of monosaccharidees: Oxidation, reduction, ester formation, Osazone formation. Glycosidic bond. Disaccharides: Sucrose, Lactose, Maltose, Isomaltose, Cellobiose and Trehalose. Polysacchacides– Homopolysaccharides – Starch, glycogen, cellulose, Chitin, Dextrans, Inulin, Pectin. Heteropolysaccharides- Hyaluronic acid, Heparin, Chondroitin sulphate, Keratansulphate, Dermatan sulphate and Agar-agar. Glycoproteins and Mucoproteins.

2.2 Proteins (10hrs.)

Amino acids: Structure, classification and properties of amino acids. pK value and iso-electric point of amino acids. Peptide and peptide synthesis. Reactions (due to carboxyl group, amino group and side chains). Colour reactions of amino acids and proteins. Proteins–structure and classification-primary structure of protein (eg. Insulin). Secondary structure- Alpha helix, Collagen helix, Beta pleated sheet, Ramachandran angles and Ramachandran map. Fibrous proteins-examples (Keratin Collagen, Elastin, Resilin, Fibrous muscle proteins). Chaperons. Tertiary structure-Globular protein- eg: Myoglobin. Quaternary structure-eg: Haemoglobin. Tissue protein in health and diseases, collagen-structure and synthesis, abnormal collagens, elastin, keratins, muscle proteins, lens proteins and cataract.

2.3 Lipids (10 hrs.)

Biological importance of lipids. Fatty acids: classification, nomenclature. Simple fats: Triacylglycerol (Triglycerides) – Physical properties. Reactions – Hydrolysis, Saponification, Rancidity. Acid number, Saponification number, Iodine number oxidation, Ketosis, Reichert- Meissl-Wollny value. Compound lipids: Phospholipids- Lecithin,

Phosphatidyl inositol, Cephalins, plasmologens, Glycolipids, Sphingolipids Steroids: Biologically important steroids-cholesterol, Vitamin D, Bile acids, Ergosterol, Terpenes. Prostaglandins- Structure, types, synthesis and functions. Lipoproteins.

2.4 Nucleic Acids (8hrs.)

Structure of nucleic acids and nucleotides: Structural organization of DNA (Watson-Crick model) Characteristic features of A,B,C and Z DNA. Structural organization of tRNA and micro- R N A stability of proteins and nucleic acids. Protein-nucleic acid interactions. Electrostatic interaction, hydrogen bonding stacking interactions. DNA binding proteins-DNA regulatory proteins, folding motifs, finger motifs, Zipper motifs, conformation flexibilities. Biological roles of nucleotides and nucleic acids.

2.5 Enzymes (10hrs.)

Classification- (I.U.B. system) co-enzymes, iso-enzymes, ribozyme. Enzyme specificity. Mechanism of action of enzymes. Formation of enzyme substrate complex. Various theories. Enzyme kinetics: Michaelis-Menten equation. Km value and its significance. Enzyme velocity and factors influencing enzyme velocity. Enzyme inhibition- suicide inhibition and feedback inhibition. Enzyme regulation: Types of regulation, Allosteric Regulations-Key enzymes, Covalent modification.

Module 3. Metabolism (32 hrs.)

3.1 Carbohydrate Metabolism (8 hrs.)

Major metabolic pathways: Glycolysis – Fate of pyruvate. Citric acid cycle and its significance Oxidative & substrate level phosphorylation. Pentose phosphate pathway Gluconeogenesis, Cori cycle Glycogen metabolism: Glycogenesis, Glycogenolysis, adenylate cascade system Ca+2 Calmodulin-sensitive phosphorylase kinase. Regulation of glycogen synthesis. Inborn errors associated with carbohydrate metabolism. Glycogen storage disease, Lactose intolerance, Galactosuria. Factors maintaining blood glucose, Normal plasma glucose level, OGTT oral glucose tolerance test.

3.2 Metabolism of Proteins, Amino acids and nucleic acids (10 hrs.)

Amino acid metabolism: Deamination, Transamination and Trans- deamination, decarboxylation. Formation and disposal of ammonia. Urea cycle. Fate of carbon skeletons of amino acids: glucogenic, ketogenic, partly glucogenic and ketogenic with examples. Synthesis of biologically significant compounds from different amino acids with special reference to glycine, glutamic acid, phenylalanine, tyrosine, and tryptophan. Catabolism of purines and pyrimidines. Haeme synthesis and break down – Structure, biosynthesis, porphyrins, bilirubin metabolism, plasma bilirubin, jaundice.

3.3 Metabolism of Lipids (6 hrs.)

Beta oxidation, alpha oxidation and omega oxidation of fatty acids. Formation of ketone bodies, ketosis and ketoacidosis. De novo synthesis of fatty acids and fatty acid metabolism. Biosynthesis and regulation of cholesterol, Metabolism of cholesterol. Metabolism of Triglycerides.

3.4 Energy Metabolism (8hrs.)

Energy rich compounds and their biological significance. Biological oxidation- Mitochondrial electron transport, oxidative phosphorylation, ATP synthesis, Chemi-osmotic theory.

Module 4. Detoxification, Free radicals and antioxidants. (6 hrs.)

4.1 Detoxification (3hrs.) Formation of toxic compounds in the body. Detoxification- oxidation, reduction, hydrolysis and conjugation

4.2 Free radicals and antioxidants (3 hrs.) Free radicals and antioxidants, Generation of free radicals. Reactive oxygen species. Damage produced by free radicals, free radical scavenger systems. Lipid peroxidation. Preventive antioxidants.

Module 5. Biochemistry of aging (3 hrs.)
Cellular aging. Diseases associated with aging – e.g. Alzheimer's disease. Prions. Apoptosis

Module 6. Clinical biochemistry (3 hrs.)
Introduction to clinical biochemistry. Analysis of diseases (Diabetes etc.)

References:

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Semester I

ZOBB 513 Biophysics, Instrumentation, Nanoscience and Nanotechnology (100 hrs.)

COURSE OUTCOMES

CO1: Understand the concept of energy, laws of thermodynamics, new trends in radiation biophysics and nuclear medicine
CO2: Understanding the principle, structural parts and application of various centrifugation, electrophoretic and chromatographic methods.
CO3: Acquire knowledge about the working principle and application of various instruments used in the research laboratories and medical field.
CO4: Acquire new knowledge in the areas of nano biotechnology and nano toxicology
CO5: Students will get an idea on nano medicine and its therapeutic applications

Module 1. Introduction to Thermodynamics, Electromagnetic spectrum and Radiation Physics (25 hrs.)

1.1 Introduction-Concept of energy and laws of Thermodynamics. Matter and energy-Life as an energy system-order, disorder, Entropy, Enthalpy. Photo bioenergetics:

1.2 Photosynthesis – light and dark reactions, Redox couple and redox potential. Chemo-bioenergetics: electron transport and oxidative phosphorylation, Chemi- osmotic theory and binding change mechanism of ATP synthesis. Life as an autocatalytic system.

1.3 Electromagnetic spectrum Cosmic radiation – Gamma radiation, X-rays, UV – radiation, visible spectrum, infrared rays,microwaves and radio waves. Biological applications.

1.4 Radiation Biophysics: Radioactivity; Detection and measurement of radiation. Radio-labeling methods, detection and measurement of different types of radioisotopes and their applications in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material and safety guidelines. Ionizing radiation and induced mutations. Fluorescence.

1.5 Nuclear Medicine-Internally administered radioisotopes. Radio iodine in thyroid function analysis. Renal, liver and lung function analysis.

Module 2. Centrifugation, Electrophoresis and Chromatography (11hrs.)

2.1 Ordinary, high-speed centrifuge, Density gradient centrifugation, Ultracentrifugation

2.2 Principle, Gel electrophoresis – SDS PAGE, Agarose Gel Electrophoresis. High voltage electrophoresis, Immuno electrophoresis- principle and application

2.3 Principle of chromatography, Column chromatography, Ion exchange chromatography HPLC, Gas chromatography

Module 3. Biophysical methods& Instrumentation (39hrs.)

3.1 Colorimetry & Spectrophotometry: UV-VIS spectrophotometer, flame photometer, Atomic absorption spectrophotometer, Infrared spectrophotometer NMR and EMR spectrophotometry: Principle and Application

3.2 Mass spectrometry: Principles of mass spectrometer, Different types of mass spectrophotometers, Applications of Mass spectrochemistry in biological research. GC-MS

3.3 X-ray crystallography: X-ray crystallography in Molecular structure determination Principles of X ray diffraction. Application of X-ray crystallography in proteomics and biological research

3.4 Electrophysiological methods: Simple neuron recording, patch clamp recording, Brain activity recording using EEG, ECG, Tread Mill Test, Applications of Deep Brain Stimulator & Pacemaker

3.5 Radio-Ultrasound Imaging Techniques: PET (Positron emission tomography), MRI, FMRI, CAT scanning methods, Ultrasound Scanning methods, Eco cardiogram.

3.6 Nanobio-Analytics: Luminescent Quantum Dots for Biological Labeling – Nanoparticle Molecular Labels.

3.7 Surface Biology: Analysis of Biomolecular Structure by Atomic Force Microscopy and Molecular Pulling – Force Spectroscopy, Surface Plasmon Resonance &Antibody Microarrays SurfacePlasmon Resonance Spectroscopy

3.8 Instruments in Molecular Biology: (Brief study only): PCR – Thermal cyclers, Real timePCR, DNA sequencers, High throughput screening, Gel documentation systems, Nanodrop, Sonicators, Micro array reader, Pulse field gel electrophoresis system, laminar flow systems.

Part III Nanoscience and Nanobiology (25 hrs.)

Module 4. (13 hrs.)

4.1 Background to nanoscience Nanobiology and nanotechnology-scientific revolutions - nanosized effects. Natural nanocomposite systems; spider silk, bones, shell, Biomimetics. Definition of a nano system.

4.2 Quantum dots, Nanowires and Nanotubes, Carbon based nanomaterials – CNT- Organic-Inorganic Hybrids- ZnO- Silicon - DNA- RNA- Nanoproducts.

4.3 Nanobiotechnology: Application of nanotechnology in food and Agriculture industry: fisheries and livestock sectors.

4.4 Nanotoxicology: toxicological effect of Nanoparticles. Nano sensors: Enzyme Biosensors and Diagnostics - DNA-Based Biosensors and Diagnostics

Module 5. **(7 hrs.)**

5.1 Nanomedicine**:** Nano carriers for gene delivery: basic concept of nanotechnology-based systems for gene delivery, Biochips- DNA based biosensors and diagnostics-Nanomaterials in bone substitutes and dentistry,

5.2 Neuro-electronic Interfaces -Nanorobotics– Photodynamic Therapy - Nano sensors in Diagnosis–Drug delivery – Cancer therapy and other therapeutic applications

Module 6. **(5 hrs.)**

6.1 Nanotechnology for environmental safety: Pollution control, gas sensing, waste water treatment.

6.2 Impact of nanotechnology on the health, safety and environmental risks/hazards;

6.3 Social and ethical impacts.

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33. Application of Nanotechnology in Drug Delivery: Edited by Ali DemirSezer, ISBN 978-953-51-1628-8, 552 pages, Publisher: In-Tech 2014.
34. Introduction to Novel Drug Delivery Systems By N.K. Jain. 2017.
35. Understanding Nanomedicine: An Introductory Textbook by Rob Burgess. 2012 CRC Press
36. Nanomedicine for Drug Delivery and Therapeutics, Editor(s): Ajay Kumar Mishra, 2013, Wiley
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Semester I

ZOBB 514 Biochemistry, Biophysics and Instrumentation, Evolution- Practical 1 (120hrs.)

COURSE OUTCOMES

CO1: Understand the principle of volumetric titrations.
CO 2: Understand the significance of isoelectric point.
CO 3: Can perform quantitative estimation of given samples.
CO4: Develop skill to measure micro-objects using micrometry.
CO 5: Perform statistical analysis of given data.
CO 6: Develop skill to sketch objects using camera lucida.

A. Biochemistry

1. Titration curve of acetic acid. Titration of a measured volume of acetic acid with sodium hydroxide (NaOH) to determine the amount of acid in the given solution and pKa of acetic acid.
2. Determination of the isoelectric pH of the given amino acid by titration method.
3. Estimation of DNA/RNA
4. Quantitative estimation of glycogen of a tissue.
5. Quantitative estimation of blood glucose.
6. Quantitative estimation of serum protein.
7. Determination of acid value of the given fat.
8. Determination of saponification value of the given fat.
9. Estimation of serum cholesterol using a standard protocol
10. Determination of the Michaelis constant (Km value) for the digestion of casein by trypsin.
11. Estimation of serum cholesterol using a standard protocol.
12. Estimation of acetylcholine content in tissue sample.

B. Biophysics and Instrumentation

1. Micrometry: Measurement of microscopic objects using micrometer.
2. Separation of haemolymph of serum protein by gelelectrophoresis.
3. Sketching of biological specimens using a camera Lucida.
4. Quantification estimation of Na, K, Ca of the given sample with the help of flame photometer/ spectrophotometer preparing standard curve.
5. Preparation of tables and bar diagrams using suitable software, from the data provided.
6. Statistical Analysis (Chi-square, t-test, correlation, regression, standard deviation and standard error, one way ANOVA) of the given data using suitable software. e.g. MS Excel and Vassar Stats.

C. Evolution

1. Comparative study of prokaryotic and eukaryotic cells by staining and mounting (evolutionary significance).

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Semester II

ZOBB 521: ADVANCED PHYSIOLOGY and FUNCTIONAL ANATOMY (100 hrs.)

COURSE OUTCOMES

CO1: Understand the various physiological process and associated systems in the body.
CO2: Differentiate the structure and functions of various organs in the human body.
CO3: Understand the optimum role of nutrition in health.
CO4: Describe the cardiac cycle and mechanisms of respiration.
CO5: Understand neuro-anatomical structures and neurological disorders
CO6: Differentiate types of excretory organs in different animal groups
CO7: Understand the environment's influence on the physiological function and performance of living organisms.

Module 1. Movements (10 hrs.)

1.1 Introduction to Physiology and Anatomy, A brief history of Physiology and Anatomy, Cell as a living module of the body, Fluids in the cell environment, Resistance of the cell to acidity and alkalinity

1.2 Support and Movement Cellular movements, Cytoskeleton, Hydrostatic skeleton Terrestrial, aquatic and aerial locomotion

1.3 Musculo skeletal system – Bones and muscles –structure and its role in locomotion with reference to humans, Theories of molecular basis of muscle contraction. Catch muscle and Fibrillar muscle, Clinical implications

Module 2. Nutrition, Circulation and Respiration (31 hrs.)

2.1 Feeding mechanism in animals: General principles of Gastro-intestinal function. Factors that regulate quantity of food. Secretory function of the alimentary canal- hormones and enzymes. Absorption mechanism of digested nutrients. Obesity-causes and consequences. Gastro- intestinal disorders

2.2 Body fluids in invertebrates and vertebrates, types of heart, anatomy of heart (human) and Haemopoiesis.Coronary circulation, Heart valves and Heart sounds. Circulatory Shock, Cardiac failure. Control of blood pressure and blood flow

2.3 Respiratory organs of invertebrates and vertebrates and its functions. Mechanism of Pulmonary ventilation. Respiration of unusual environment – Aviation, High-altitude, Deep-Sea diving, Foetal respiration. Regulation of respiration. Respiratory disturbance: Oxygen therapy, Artificial respiration

Module 3. Excretion, Osmoregulation and Nervous coordination (20 hrs.)

3.1. Osmoregulation in fresh water, marine and terrestrial animals. Regulation of sodium and water balance, Primary sodium reabsorption, Urine concentration. Diuretics and kidney diseases.

Creatine clearance – Plasma creatine. Haemodialysis, Peritoneal dialysis and transplantation. Regulation of acid-base balance, blood volume and extra cellular volume. Respiratory regulation of acid base balance

3.2 Nervous Coordination: Giant nerve fibres in invertebrates, Development of neurons and neuronal functionality, Factors leading to neuronal death, Neuro transmitters, neuro modulators and mechanism of neurotransmitter release. Neuronal disorders- strokes, excitotoxicity and NMDA receptors

Module 4. Endocrinology and Reproduction (20 hrs.)

4.1 Classification of Hormones and natureof hormonal action. Structure and function of different hormones. Neuro-endocrine feedback and response to various stimuli. Measurement of Hormone concentration in blood.

4.2 Male reproductive system- Hormonal control of male reproductive function. Female reproductive system – Anatomy, Ovarian function. Control of ovarian function. Uterine changes in menstrual cycle, effects of estrogen and progesterone. Androgen in women. Pregnancy – Ovum transport, sperm activation, implantation and placentation. Hormonal and other changes during pregnancy – Parturition, Lactation. Birth control measures pre-natal diagnostic tests. Adjustments of the infants to extra uterine life.

Module 5. Somatic and Special senses (10 hrs.)

5.1 Structure of Invertebrate and Vertebrate eye. Tactile, Position, Pain, Thermal and taste Senses. Visual pathways organization of visual cortex. Analysis of visual information, detection of colour.

5.2 Auditory pathways – Functions of cerebral cortex in hearing. Neuronal mechanism of sound detection and direction.

Module 6. Physiological adaptation, stress and sports physiology (9hrs.)

6.1 Physiological adaptation, acclimation, acclimatization. Concept of stress- definition, stressor, stress response, eustress, distress, acute and chronic stress, stress acclimation. Concept of ease, recovery response, stress hormones, neuroendocrine control of stress response, role of hypothalamo-pituitary-adrenal axis.

6.2 Sports Physiology: Muscles in exercise, cardiac reserve, cardiovascular fitness, fascia training, neurobiological effects of physical exercise, physical fitness and its components. Dope test, drugs and athletes.Fitness test. Bio energetic fuel for muscle work

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Semester II

ZOBB 522- Genetics, Biostatistics and Research Methodology(100 hrs.)

COURSE OUTCOMES

CO1: Understand the principles of mendelian genetics and its application
CO2: Acquire knowledge about concepts of population genetics and human genetics
CO3: Explore the application of genetics in the field of microbiology, medicine and forensics
CO4: Understand the application of statistics in biology
CO5: Apply parametric and non-parametric tests in biological research problems
CO6: Acquire knowledge in research methodology, research problem formulation, research design and scientific documentation

Genetics (70hrs.)

Module 1. Introduction, Mendelian Genetics and its Application (20 hrs.)

1.1 Genetics and modern agriculture, Genetics and medicine. Legal and ethical issues in genetics.

1.2 Gene mapping, Recombination frequency, Chromosome banding, Genetics in animal breeding, General effects of inbreeding and out breeding; hybrid vigor. Expressivity, penetrance. Modern concept of Mendelism

Module 2. Population, Human, Microbial Genetics (50 hrs.)

2.1 Population Genetics

Genetic variations, Polymorphism Gene pool. Gene frequency. Distribution patterns Hardy Weinberg equilibrium. Disequilibrium. Factors disrupting gene equilibrium

2.2 Human Genetics

Pedigree analysis – Karyotype analysis. X-Chromosome dosage. Lyon hypothesis and mosaicism. Genetics of ABO system. Rh disease and its inheritance. Sickle haemoglobin and inheritance; thalassemia. Genetic disorders – Patau, Edwards, Cri-du-chat syndromes, Philadelphia chromosome.

2.3 Microbial Genetics and Genetics in Medicine and Forensics

Retrovirus. Viral genome and multiplication – HIV genome and multiplication. Reproductive cycle of RNA viruses. Plasmids – Vector DNA – Insert DNA. Lambda Phages. Microbes in genetic engineering

2. 4 Human Genome Project: Human gene therapy. DNA fingerprinting: Applications in forensic science. Applications in paternity testing

Biostatistics (15 hrs.)

Module 3. Introduction (2hrs.)

3.1 Application of statistics in biology. Descriptive and inferential statistics. Preliminary concepts – population and sample, statistic and parameter, variables, sampling.

3.2 Collection of data – primary and secondary data, methods. Use of software in statistics.

3.3 Descriptive Statistics (2 hrs.)

Measures of Dispersion-problems, Skewness and Kurtosis. Correlation and Regression, problems

3.4 Probability Distribution (3 hrs.)
Definition, important terms and concepts. Theorems in probability. Important theoretical distributions- Binomial, Poisson, and Normal probability distributions.
3.5 Parametric test (4 hrs.)
Basic idea – Hypothesis testing, types of errors. Tests of significance for large and small samples- Z-test, Chi-Square Test, Student's 't' test, F-test – problems – and ANOVA

3.6 Non-parametric test(2 hrs.)
Characteristics, advantages and disadvantages. Types (Brief account only)
3.7 Vital statistics (2 hrs.)
Introduction, uses, methods of collections. Measures of vital Statistics, life tables

Research Methodology (15 Hrs.)

Module 4. Introduction (2hrs.)
4.1 Definition, meaning, objectives, and significance of research, research methods vs Methodology.
4.2 Types of research – Descriptive. Analytical, Applied vs. Fundamental, Quantitative vs Qualitative, Conceptual vs Empirical. Characteristics of good research, steps of working of research

Module 5. Research Formulation (2 hrs.)
5.1 Formulation and defining a research problem, techniques involved. Literature survey- Journals, conference proceedings, books, government reports etc. Problem selection, formulation of working hypothesis
5.2 Research design (2 hrs.)
Meaning need and features a good research design. Different types of research design (exploratory, descriptive, diagnostic and hypothesis-testing research studies) Developing a research plan
5.4 Execution of research plan (2 hrs.)
Data collection methods-primary and secondary, sampling design, measurements etc. LC 50 & Dose Response. Analysis of data Interpretations-advantages and techniques-and generalizations of the findings
5.6 Scientific documentation (3 hrs.)
Significance of report writing, types of reports. Research report writing (thesis, dissertations, research articles, etc) characteristics and format. Writing and preparation of articles for publication and for oral and poster presentation. Project proposal and report writing.

Module 6. Research, extension and ethics(4hrs.)
6.1 Publications-abstracting and indexing journals, books, conference/seminar proceedings, periodicals, reference sources, reviews, monographs. Extension tools, impact factor, citation.
6.2 Online libraries, e-journals, e-books, e-encyclopedia, institutional websites, TED Talk. Intellectual property Rights-copy right, patents, trademarks, geographical indications, industrial design.
6.3 Research misconduct: fabrication, falsification and plagiarism. Precaution – ESOstandards for safety, lab protocols, lab animal uses, IACUC, control of hazards. Ethical norms, codes and policies for research ethic, laws in India

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Semester II

ZOBB - 523: Cell Biology, Molecular Biology and Bioinformatics (100 hrs.)

COURSE OUTCOMES

CO1: Understand the fundamental aspects of structure of plasma membrane, cell interactions, membrane transport and chromatin structure.
CO2: Acquire knowledge about process of cell growth, cell cycle, cell-cell signalling and molecular biology of cancer.
CO3: Understand the mechanism and significance of DNA replication
CO4: Understand the mechanism of transcription, translation, post transcriptional and translational modifications.
CO5: Differentiate the regulation of gene expression in Phages, Bacteria, and in Eukaryotes
CO6: Acquire basic knowledge about the Genome, methods of genome sequencing, biological sequence analyzing tools and the scope of Bioinformatics.
CO7: Understand the significance and application of Biological Databases, Evolutionary Analysis and Molecular Phylogeny and familiarizing with the phylogenetic software.

A. Cell Biology

Module 1. Membrane structure, models, and membrane transport (10 hrs.)

1.1 Diffusion of small molecules across phospholipids bilayer. Uniporter – catalyzed transport. Membrane potential. Active transport by ATP powered pumps. Co-transport by symporters and antiporters

1.2 Cell-cell signaling (5hrs.)

Cell surface receptors. Signal transduction pathways (cyclic AMP, cyclic GMP, Ras, Raf and kinase pathways). Second messenger system, MAP

1.3 Cell cycle (6 hrs.)

Cyclin and cyclin – dependent kinases, Regulation of CDK – cyclin activity, Check points in the cell cycle, Regulation of cell cycle in malignant cells

1.4 Chromatin structure (6 hrs.)

Types of Chromatin, Detailed structure of nucleosome; higher order structure of chromatinand the role of histones HI, scaffold proteins, and radial loop model

B. Molecular Biology

Module 2. Topology of Nucleic Acids (5 hrs.)

2.1 Liking number and writhing number, DNA Super coiling, Super coiling in prokaryotes, Supercoiling in eukaryotes, Role of topoisomerases

2.2 Organization of the eukaryotic genome (12 hrs.)

Genomic size and genetic content. Complexity of eukaryotic genome: Intragenic sequences - exons, introns; split gene organization; regulatory sequences; Intergenic sequences; Unique sequences; Repetitive sequences: Highly repeated sequences–satellite, minisatellite and microsatellite DNAs Moderately repeated sequences (e.g. SINEs and LINEs).

2.3 DNA denaturation-renaturation kinetics and genome complexity; in situ hybridization. Organelle genomes- mitochondrial and plastid DNAs

Module 3. DNA Replication, repair and recombination (14 hrs.)

3.1 Prokaryotic and Eukaryotic DNA replication. DNA replication machinery. Enzymes and accessory proteins involved in replication. DNA damage and repair. Direct reversal: photo reactivation, adaptive response.

3.2 Excision repair. Mismatch repair. SOS repair and mutagenesis. ERecombination repair; Rec A and other recombinases. Damage signaling and checkpoints. DNArepair-associated disorders

Module 4. Transcription and RNA processing (8 hrs.)

4.1 Prokaryotic and eukaryotic transcription. Binding the transcription complex-promoters, factors and RNA polymerases. Regulation of transcription. Sigma factor and its role in prokaryotic transcription. Post-transcriptional processing of RNA precursors, spliceosomes.

4.2 Translation-gene expression (15 hrs.)

Prokaryotic and Eukaryotic translation. The translation machinery. Mechanism of initiation, elongation and termination. Co-and post translational modifications of proteins. Hormonal regulation of protein synthesis.

Module 5. Gene Regulation Mechanisms (7 hrs.)

5.1 Gene regulation in eukaryotes at various levels. Transcription factors and DNA-binding domains (Zinc-finger motif and Helix- loop-helix motif).

5.2 Transcription signals – TATA BOX, CAAT BOX., Enhancers.

C. Bioinformatics

Module 6. (12hrs.)

6.1 Introduction to bioinformatics, brief history and its role and importance in modern biology, internet, internet, portals, servers and search engines.

6.2 Biological databases, their purpose, primary, secondary, curated and curated databases types of databases (DNA, protein, RNA, functional and structural databases), Uploading and downloading of data, FASTA format, data retrieval from databases, analyses tools and software's and their applications, pairwise and multiple sequence analyses.

6.3 Construction of rooted and un-rooted phylogenetic trees, their interpretation and use in analyzing evolutionary trends, steps in phylogenetic analyses.

6.4 Brief overview of computational biology, computation, prediction a nd modulation of biological pathways, (ex. Kegg pathways, E- cell, human Cyc) computational analyses of genomes and proteomes

References

1. Harvey Lodish, Arnold Berk, Sipursky, Matsudaria, David Baltomore and Darnell, (2002) Molecular Cell Biology, W.W. Freman and Company.
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Semester 2

ZOBB- 524: Advanced Physiology and Functional Anatomy- Practical 2 (120hrs.)

COURSE OUTCOMES

CO1**:** Experience various experimental techniques related to physiology
CO2: Analyze the biological data using biostatistics methods
CO3: Developing skill in doing chromosome preparations

Please use software such as **Physio Ex.9.0** where ever applicable

1. Effect of salivary amylase on starch (colorimetric)
    a) Influence of temperature and calculation ofQ10
    b) Influence of pH
2. Transport of glucose through intestinal wall (everted gut sac) of a suitable animal
3. Recording of heart beat and the effect of drugs (acetylcholine and adrenaline) in fowl.
4. Effect pH different concentrations of NaCl (0.1% to 2%) on the diameter ofRBCs using micrometry.
5. Estimation of RBCs and WBCs in vertebrate blood
6. Blood histology of earthworm/cockroach/fish and chick.
7. Studies on feeding-Mounting of mouth parts of housefly, honey bee and mosquitoin relation to food and feeding.
8. Observation of mitochondria in yeast cells.
9. Observation on ciliary movement in bivalve gills in relation to temperature and pH. Genetics and Quantitative analysis
10. Chromosome study – Squash preparation of Drosophila/Chironomous larvae
11. Calculation of Mean, Standard deviation, Standard Error, and Student's-test.
12. Calculation of correlation coefficient & Test of significance.
13. Preparation of histogram, frequency polygon and pie diagram using appropriatesoftware. Cell and molecular biology
14. Study of meiosis- Squash preparation of grasshopper testis.
15. Histological localization of protein and glycogen in paraffin sections.
16. Estimation of DNA from tissue extract.

Semester III

ZOBB -531 Microbiology and Biotechnology (100 Hours)

COURSE OUTCOMES

CO1: Understand the ultra-structure of bacteria
CO2: To understand nutrition, growth, and communication of
CO3: Explain the concept of fermentation and differentiate the types of fermenters
CO4: Understand recombinant DNA technology
CO5: Understand and explain application of biotechnology in healthcare
CO6: Critically evaluate the Ethical, legal, and social issues of Biotechnology and acquire knowledge in the recent trends in biotechnology

A. Microbiology (50hours)

Module1. Introduction to Microbiology (15 hrs.)

1.1 Scope and history of microbiology – mention the contributions of important Scientists who developed Microbiology as a major disciple (e.g. Pasteur, Koch etc). Microbial diversity including Extremophiles – brief account.

1.2 Characteristic features of microorganisms –Bacteria, Virus, Fungi & Protozoa. Mention Microalgae. Classification of Bacteria, Virus, Fungi &Protozoa. Classification of bacteria, Bergey's Manual.

1.3 Bacterial Cell structure and function
Ultra structure of bacteria – cell membrane, cytoplasmic inclusions, nucleotide etc.
Bacterial Cell Wall- structure; differences between gram positive and negative cells, gram staining. External components & their functions – pili, flagella, fimbriae, capsules, slime layers etc.

Module 2. Microbial Nutrition and Growth (10 hrs.)

2.1 Common nutritional requirements of microorganisms- autotrophy and heterotrophy. Types of culture media.
2.2 Microbial growth – overview of cell growth, generation time, measurement ofgrowth. Typical growth curve, continuous culture, effect of environmental factors on growth.Stress response.

Module 3. Industrial, Environmental and Medical Microbiology (25hrs.)

3.1 Industrial Microbiology
Concept of fermentation. Types of fermentation – submerged, solid state – mention briefly.Basis design and types of fermenters. Products of Industrial Microbiology such as Alcohol, Antibiotics (e.g. Penicillin), Organic acids (e.g. Acetic acid, Lactic acid).Microbiology of mild& foods. Preservation of milk–Pasteurization techniques. Probiotics. Microbial spoilage of different types of foods& Food borne diseases Beneficial activities of microbes in food Microbial quality control and safety of food

3.2 Environmental Microbiology

Introduction to terrestrial and aquatic microbiology. Principles of Microbial Ecology. Biogeochemical cycles – nitrogen cycle, sulphur cycle& carbon cycle. Role of microorganisms in the biogeochemical cycles. Microbiology of waste treatment. Brief account of microbial treatment of waste water and solid wastes. Bioremediation – microbial treatment of radioactive wastes and xenobiotics. Microbes in decomposition and recycling process Symbiotic and asymbiotic N2 – fixation

3.4 Medical Microbiology

Host-microbe interaction-process of infection, pathogenecity, virulence & infection, microbial adherence, penetration of epithelial cell layers and events in infection following penetration, Infection of blood, lymphatic system. Exotoxins – classification, mechanism ofaction of exotoxins e.g. Diphtheria, Botulinum, Tetanus, and Choleratoxins. Control of Microorganisms – various physical & chemical methods. Use of antibiotics and other antimicrobial drugs. Drug resistance and emergence of multiple drug resistance – recent cases of TB (XDR, TDR); NDMetc.A survey of harmful and beneficial microbes.

PART B. Biotechnology (50hrs.)

Module 4. Introduction to Biotechnology (10hrs.)

4.1. Board areas of Biotechnology – traditional and modern; types – plantbiotechnology, animal biotechnology and microbial biotechnology. Techniques in Biotechnology– brief description of common techniques such as tissue culture, genetic engineering, cloning etc.

Module 5. Molecular Cloning (15hrs.)

5.1 Gene cloning – basic steps in gene cloning. Isolation of donor DNA. Vectors – types and characteristics e.g. plasmids, phages, hybrid vectors, artificial chromosomes.

5.2 Enzymes used in gene cloning – exonuclease, endonuclease, ligase, reverse transcriptase, polymerase, terminal transferase etc. Techniques of gene transfer – calcium chloride transformation, microinjection, electroporation, shotgun cloning, Agrobacterium mediated transfer etc.

5.3 Practical application of genetic engineering – useful products. Application in Medicine, Agriculture, Agriculture and Animal Husbandry, Environment etc. Biotechnology Industry.

Module 6. Recent Trends in Biotechnology (25 hrs.)

6.1 Synthetic Biology – description and developments in the area. Artificial life – concept and achievement. DNA Barcoding – concept and experimental details with examples. GMOs and GM Foods – pros and cons. Microbial warfare – bio-weapons and bioterrorism

6.2 Bioethics Ethical, legal and social issues of Biotechnology**.**

6.3 Biotechnology in India

History of biotechnology research in India. India's Biotechnology Policy. Biotechnology Regulatory Agencies in India. Comparison with developed countries

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Microbiology

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7. Microbiology by Edward Alcamo Wiley publishing inc ISBN0-8220-5333-0
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5. Text book of Biotechnology 2007 Das, H.K. Wiley India Pvt. Ltd. New Delhi.
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7. Molecular Cell Biology 2021. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher. W H Freeman & Co; 9th edition.
8. Molecular Biology of The Cell. 2022. Bruce Alberts, Rebecca Heald, Alexander Johnson, David Morgan, Martin Raff, Keith Roberts, Peter Walter. WW Norton & Co; Seventh edition.
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10. A Textbook of Biotechnology. 2022. Chand and Company Ltd.

Semester III

ZOBB 532: Ecology and Ethology (100 hrs.)

COURSE OUTCOMES

CO1: Understand the components of ecosystem, concepts of ecosystem energetics, and types of succession
CO2: Acquire in depth knowledge in the concepts of habitat, niche, guild, and species interactions
CO3: Analyze the complex animal behavior patterns, fundamentals and different factors regulating the animal behavior
CO4: Understand the types of learning process and the neural mechanism of learning and memory
CO5: Understand the types of natural calamities and its management.
CO6: Acquire more knowledge about the social and stress behaviour

Part1: Ecology (50hrs.)

Module 1. Ecological Energetics (12hrs.)

1.1 Solar energy and photosynthetic production, efficiency of energy capturing, chemosynthesis, Energy flow – features of energy flow (unidirectional flow and loss of energy as heat) and pathways of energy flow.

1.2 Productivity – primary production and production efficiency, secondary production, standing crop, Food chain (grazing, detritus and auxiliary food chains), food, webs, trophic levels and ecological pyramids (pyramid of numbers, pyramid of biomass and pyramid of energy. Classification of ecosystems based on energy input (natural unsubsidized, and subsidized solar powered ecosystems, human subsidized solar powered ecosystem and fuel powered urban and industrial systems).

Module 2. Transition and Stability in Communities (16hrs.)

2.1 Succession- Basic types (Primary succession, Secondary succession, Auogenic succession, allogeneic succession, Autotrophic succession, Heterotrophic succession). Trends in succession Stages of succession – (Nudation, Invasion, Competition and co-action, Reaction, Climax), pulse stability. Examples of succession – (Succession in aquatic and terrestrial ecosystems). Relevance of ecosystem development theory to human ecology, prospects for detritus agriculture, the compartment model.

2.2 Concepts of Habitant, Niche and Guild Habitat, microhabitat and niche. different types of niches: spatial niche, trophic niche, species niche, multidimensional niche, fundamental and realized niche. Niche overlap, gause's principle, resource partitioning, compression hypothesis, concept of Guild, character displacement,ecological equivalents.

Module 3. Population Ecology (16 hrs.)

3.1 Characteristics of a population; population growth curves; population dynamics, life history pattern, fertility rate and age structure. Population regulation; life history strategies (R and K selection); concept of meta population-demes and dispersal, extinctions, age structured populations.

Competition and coexistence and other ecological interactions.
3.2 Species Interactions: Intra and inter specific interactions, Types of Interspecific interactions– (Positive Negative and Neutral), Positive interactions (commensalism, proto-cooperation, mutualism and pollination), Negative interactions (competition, parasitism, commensalism, predation, herbivory, carnivory), Co-evolution

Module 4. Natural calamities (6 hrs.)
4.1 Natural hazards, flood, volcanoes, coastal hazards, earth quakes, cyclones, landslides, El Nino, La Nina, Avalanche, Tsunami, and Tornado. Epidemics, pandemics and their management.
4.2 Remote Sensing as a tool for the study and the management of environment and calamities.

Part 2: Ethology (50hrs.)

Module 5. Introduction. (34 hrs.)
5.1 Historical background, Stimulus-Response, Causal factors, Quantitative aspects – Duration, interval frequency. Behaviour bouts. Darwinian Perspective on Animal behaviour, Scope of ethology.

5.2 Learning: Classification of learning: Imprinting, habituation, imitation, classical conditioning,instrumental/operant conditioning, cognitive learning, latent learning, insightful learning.

5.3 Communication: Evolution of communication, Sensory mechanisms: Electrical, Chemical, Olfactory, Auditory andVisual. Dance language of honey bees, Pheromonal communication (Ants and mammals).

5.4 Nervous System and Behaviour: Stimulus filtering, sign stimulus, innate release mechanism and fixed action plans (FAPs). Brain centres and learning, neural mechanism of learning and memory.

5.5 Complex Behaviour patterns: Orientation, Navigation and homing, Migration (Fishes and birds), Biological rhythms – biologicalclock, circadian, circannual, lunar, tidal and seasonal periodicities, sleep and arousal, genetics of biological rhythms.

Module 6. Environment, genetics and Evolution of behaviour (16hrs.)
6.1 Habitat selection and territoriality. The Evolution of communication; Development of birdsong. The evolution of reproductive behavior and mating systems.

6.2 Social Behaviour: Sociobiology (Brief account only) Aggregations – schooling in fishes, herding in mammals, Group selection, Kin selection, altruism, reciprocal altruism, inclusive fitness, co-operation, territoriality, alarm call, social organization in insects and primates.

6.4 Stress and Behaviour: Adaptations to stress- basic concept of environmental stress, acclimation, acclimatization, avoidance, and tolerance.

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18. Manuel C. & Molles Jr. (2009) *Ecology: Concepts and Applications* (5thEd). McGraw-Hill International Education. pp 604. ISBN-13:9780070171688

19. <u>Ethology</u>

20. Alcock, J. (2001): *Animal Behaviour- An Evolutionary Approach*(7thEd.) Sinaur Associates, Inc. ISBN-10:0878930116
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(2nd Ed). Lippincott Williams & Wilkins, Baltimore, pp 855.ISBN: 0 683 30596 4

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Semester III

ZOBB 533: Immunology and Developmental Biology (100 hrs.)

COURSE OUTCOMES

CO1: Understand the basis of immunogenicity and antigenicity, including the factors determining immune response and antigen interactions with immune cells.
CO2: Acquire a comprehensive knowledge in intricate mechanisms involved in antigen-antibody binding, complement system and its role in enhancing immune responses.
CO3: Understand immunological basis of hypersensitivity and different types of graft rejection reactions and their underlying mechanisms.
CO4: Acquire a comprehensive knowledge in the processes involved in fertilization, embryonic development, and the fascinating phenomenon of embryonic induction and differential gene expression.
CO5: Explain the principles and mechanisms underlying developmental processes and develop skills in experimental techniques employed in developmental biology research.
CO6: Understand the assisted reproductive technology, methods of cloning and the merits and demerits of cloning.

Immunology (40hrs.)

Module 1. Introduction to Immune System (25 hrs.)

1.1 Types of immunity, innate and acquired immunity; passive and active immunity; humoral and cell-mediated immunity. Organs of immune system: Primary and Secondary lymphoid organs. Brief account on immune cells: types and production.
1.2 Immunogens (Antigens)
General properties, Structure and function, variability and diversity. Factors affecting antigenicity. Epitopes and Haptens. Adjuvants and their role in enhancing immunogenicity.
1.3 Immunoglobulins (antibodies)
General Properties-Structure and functions Different classes of immune globulins (1gA, 1gD,1gE,1gG and1gM) Genetic basis of antibody diversity: Immunoglobulin gene organization; Gene rearrangement and expression. Somatic recombination: V (D) J recombination and functional diversity. Somatic hypermutation. Class witching. Polyclonal and Monoclonal antibodies. Hybridoma technology –technique and applications
1.4 Antigen-antibody interactions
Primary and secondary immune responses. Theories of antibody formation (Directive theory, clonal selection theory etc.)

Module 2. Complement System (4hrs.)
Complement systems-General features. Classical pathway and alternate pathway complement receptors, biological effect of complements.

Module 3. Transplantation (11hrs.)
3.1 Classification of grafts. Major Histocompatibility Complex (MHC) and MHC proteins role in

tissue transplantation; Mechanism of graft retention and rejection. General immune suppressive therapy.

3.2 Defects in Immune Mechanisms

Defective innate immune mechanisms. Auto immune diseases

Developmental Biology (60 Hrs.)

Module 4. Introduction (12hrs.)

4.1 The evolution of developmental patterns in unicellular protest; origin of sexual reproduction. Developmental patterns among animals (asexual means; parthenogenesis; sexual means; gonochorism, hermaphroditism, metamorphosis, uterine development in mammals)

4.2 Fertilization

Events in fertilization. Cytoplasmic change. Nuclear changes. Prevention of polyspermy. Significance of fertilization

Module 5. Developmental Model Systems (38 hrs.)

5.1 Early development of Drosophila-Egg, gastrulation cleavage, mid-blastula transition, Early development of *Caenorhabditis elegans*-Egg, cleavage and gastrulation. Genetic control of development and embryonic axis formation. Gene action in development of Drosophila:- Maternal effect genes; Segmental genes (gap genes, pair-rule gene and segment polarity gene) and Homeotic genes (homeobox and homeodomains). Hox cluster genes in vertebrates

5.2 Embryonic Induction

Types of embryonic induction – Primary, Secondary and Tertiary Induction (Experiments of Spemann and Mangold). Mechanism of axis formation in amphibians; Nieuwkoop centre. The functions of organizer; the diffusible proteins of the organizer1; the BMP inhibitors.

5.3 Medically assisted human reproductive technologies

Conventional in vitro fertilization and embryo transfer (IVF-ET)–general protocol (Patient selection, manipulation of menstrual cycle, superovulation, oocyte retrieval, preparationof semen sample, IVF treatment, embryo transfer. Gametic Intra fallopian Transfer (GIFT). ZygoticIntra fallopian Transfer (ZIFT). Tubal Embryo stage Transfer (TET). Intra-cytoplasmic sperminjection (ICSI). Intra Uterine Insemination (IUI).

Module 6. Cloning experiments in animals (10 hrs.)

Genomic equivalence; differential gene expression. Stem cells, totipotency, pluripotency multiple potencies, unipotency. Amphibian cloning, cloning mammals, human cloning-prospects and demerits.

References

Immunology

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Developmental Biology

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3. Carlson, B.M. (2007). Foundations of Embryology. VI Edition, Tata McGraw-Hill Publishers.
4. Gilbert, S. F. (2010). Developmental Biology. IX Edition, Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, USA.
5. Kalthoff, K. (2001). Analysis of Biological Development. II Edition, McGraw Hill Publishers.
6. Slack, J.M.W. (2013). Essential Developmental Biology. III Edition, Wiley- Blackwell.
7. Wolpert, L. (2002). Principles of Development. II Edition, Oxford University Press.

Semester III

ZOBB 534 Microbiology, Biotechnology, Ecology, Immunology and Developmental Biology-Practical 3

COURSE OUTCOMES

CO1: Skills in microbial enumeration and determination of quality of milk
CO2: Isolation DNA from tissues
CO3: Identification of blood cells and blood groups, detection of pregnancy using test kits.
CO4: Skills in induced breeding in fishes and regeneration studies in planarians
CO5: Expertise in vital staining of chick blastoderm and tracing the development
CO6: Gain ability to identify the types of eggs and placenta of animals

Microbiology and Biotechnology

1. Techniques for Isolation of bacteria-serial dilution, pour plate, spread platetechniques.
2. Enumeration of bacteria from water and soil
3. Motility Testing – hanging drop method.
4. Gram staining of bacteria
5. Determination of quality of milk-methylene blue reductase test.
6. Biochemical tests – catalase test, Kovac's oxidase test, gas production etc.
7. Isolation of DNA from plant/animal tissue.
8. Plasmid isolation
9. Detection of coliform bacteria by H2S paper strip method for monitoring water quality.
10. Culturing of paramecium to observe ciliary movement.

Immunology

1. Antigen-antibody interaction in vitro and identification of blood groups.
2. Blood film preparation and identification of cells.
3. Detection of pregnancy using kits.
4. Immunodiffusion and Immuno-electrophoresis
5. Demonstration of phagocytes in insect hemocytes.

Developmental Biology

1. Induced ovulation and artificial fertilization
2. Preparation of temporary whole mounts of chick blastoderm
3. Vital staining of chick blastoderm and tracing the development of stained parts(window method)
4. Effect of drugs on heartbeat of chick embryo.
5. Study of different types of eggs: insect egg, frog's egg, hen's egg, mammalian egg-models/charts
6. Morphological and histological studies of different placental types of mammals (3numbers)
7. Identification of cross sections of chick embryo through heart, eye and ear.

Ecology

1. Estimation of pyramid of numbers and biomass in a small ecosystem.
2. Estimation of Primary productivity using dark and light bottles.
3. Description of ecological adaptations of any 10organisms.
4. Habituation in pila/ Alarm response in fishes / Maize learning in rats.
5. Quantitative estimation of planktons.
6. Poster Presentation on a relevant topic (e.g. International conventions and treaties,species interactions, biodiversity loss etc.).
7. Mounting cercaria of flukes in aquatic birds.

Semester IV

Special Paper 1

ZOBB 541: Bio Systematics & Animal Diversity (100 hrs.)

COURSE OUTCOMES

CO 1: Understand animal taxonomy and taxonomic characters
CO 2: Acquire knowledge on taxonomic keys and identify species
CO 3: Understand the importance of molecular taxonomy and related tools
CO 4: Develop interest in the field taxonomy of animals
CO 5: Understand the importance of molecular tools in taxonomy
Co 6: Acquire in-depth knowledge on fauna and its ancestral relationships

Bio Systematics (60hrs.)

Module 1. Introduction to Bio Systematics (12hrs.)

1.1 Basic concept of Biosystematics and animal taxonomy, Scope and significance of biosystematics, Procedures, and methods in Biosystematics. Classical taxonomy to systematics: A historical review; Relationship between experimental, phylogenetical and classical taxonomy taxonomic terms; taxonomy; classification and nomenclature; phenon, taxon and category; α, β and γ taxonomy, experimental category- Turreson categories. Modern concepts and recent trends: chemotaxonomy, cytotaxonomy, sero taxonomy and molecular taxonomy, Importance of application of Systematics in biology, Taxonomy vis-a-vis biodiversity conservation.

Module 2. Micro and Macro taxonomy (22 hrs.)

2.1 Micro taxonomy: species concepts; typological species concept, nominalistic species concept, biological species concept and evolutionary species concept. Polytypic and monotypic species; species category; subspecies, other infra-specific categories and intra-population variants. Origin of reproductive isolation and mechanism of speciation.

2.2 Macro taxonomy: Theories and practice of biological classification: basic principles of classification: The three schools of macro taxonomy: Phenetics, cladistics and phylogenetics and their comparison. Variations and their importance in Systematics.

Module 3. (14hrs.)

3.1 Taxonomic characters: Kinds and functions of taxonomic characters; plasmorphic and apomorphic characters. Taxonomic procedures – collection, preservation and process of identification of species.

3.2 Taxonomic keys – different kinds of taxonomic keys, their merits and demerits, preparation of taxonomic keys, Systematic publication – different kinds of publication. Process of typification of different zoological types. International Code of Zoological Nomenclature (ICZN), its operative principles; history of rules of Zoological nomenclature. Formation of scientific names of different taxa. Regulations governing this code and code

of ethics.

Module 4: (6hrs.)

4.1 Interpretation and application of important rules. Criteria of publication, criteria of availability of names, principles of priority, homonymy, synonymy, type concept. Taxonomy, the present scenario and the global taxonomic initiatives.

Module 5. (6hrs.)

5.1 Molecular techniques as taxonomic tools: DNA Profile making, DNA Finger Printing; Multiple Arbitrary Amplicon Profiling (MAAP), RAPD. Popular Molecular-evolutionary software & tools:- Molecular evolutionary Genetic analysis (MEGA), Phylip, Clustal W, BLAST. Molecular evolutionary Genetic analysis (MEGA), Phylip, Clustal W

Module 6. Animal Diversity (40hrs.)

6.1 Animal Diversity: Invertebrates (20hrs.)

Origin of metazoa; Brief accounts of mode of infection and pathogenicity of the following Pathogenic protozoans: Trypanosoma, Leishmania and Plasmodium; Modern concept of Flagellar and Ciliary movement in protozoa; Parasitic adaptation in helminths. Polymorphism in cnidarians;Larval forms and their significance, Cnidarians; Polymorphism in Cnidarians, Coral reefs and its formation, Affinities of Ctenophora; Auriferous and skeleton system in Porifera; Adaptive radiation in polychaeta, Characters and Affinities of Phoronida and Rotifera; Larval forms in Crustacea, Arachnida. Organization and taxonomic importance of Onychophora; Larval forms in molluscans, Torsion and distortion in gastropods; Echinodermata: Water vascular system, Larval forms and affinities.

General topics: Ancestral molluscs and arthropods, and derivation of modern classes; Invertebratelarval forms and their evolutionary significance.

6.2 Animal Diversity: Vertebrates (20hrs.)

Urochordata Cephalochordata and Hemichordata- affinities. Characters and affinities of Cyclostomata. Fish diversity- major classes, Origin and evolution of Amphibia, Parental care in Amphibia; Origin and evolution of Reptilia; Adaptive radiation in Reptilia. Characters and affinities of Chelonia and Rhynchocephalia; Origin and ancestry of birds, Characters and affinities of Ratitae. Primitive mammals: Characters and affinities of Prototheria, Metatheria and Eutheria. Adaptive radiation in mammals.

General topic: Geological time scale and fossils. Dentition in mammals, Aquatic and flying adaptations in mammals.

Books Recommended

1. Boolootian, R. A. and Stiles, K. A., College Zoology, 10th edition, Macmillan Publishing Co., Inc. New York, 1981.
2. Colbert, E. H., Morales, M. and Minkoff, E. C. Colbert's Evolution of the Vertebrates: A history of the backboned animals through time, 5th edition, John Wiley - Liss, Inc., New York, 2002.

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20. Mayr, E. 1969. Principles of Systematic Zoology. McGraw Hill Book Company, Inc.,NY.
21. Mayr, E.1997. this is Biology: The Science of Living world. Universities Press Ltd.
22. Narendran, T.C. 2008. An introduction to Taxonomy. Zoological survey of India.
23. Pat Willmer. 1996. Invertebrate Relationships-patterns in animal evolution. CambridgeUniversity Press
24. Rupert E. Edward., R.S. Fox and R.D. Barnes. 2006. Invertebrate Zoology: A Functional Evolutionary Approach. Thomson/Cole, Singapore
25. Waterman, A.J.1971. Chordate Structure and Function. Macmillan Co. London
26. Winston, J.E.2000. Describing species: Practical taxonomic procedure for biologists.Columbia University Press, Columbia
27. Young, J.Z.1950. Life of Vertebrates. Clarendon Press, Oxford, UK

Semester IV

Special Paper 2

ZOBB 542 - Biodiversity Management (100 hrs.)

COURSE OUTCOMES

CO 1: Understand the importance of biodiversity conservation and biodiversity hotspots
CO 2: Acquire knowledge on threats to sustainable biodiversity
CO 3: Understand the significance of biodiversity conservation organizations
CO 4: Expertise in different biodiversity quantifying methods
CO 5: Understand the importance of wildlife management methods and biodiversity conservation laws
CO 6: Understand the biodiversity of India with special reference to the Western Ghats and its the management

Module 1. (12 hrs.)

1.1 Introduction to Biodiversity Definition, History, and present status. Biodiversity documentation and species identification. Relevance of Systematics and molecular taxonomy to biodiversity and conservation. Genetic diversity, Species diversity and ecosystem diversity. Distribution of biodiversity, Mega diverse countries, Global hotspots, and criteria. Agro-biodiversity and food security.

Module 2 . (20 hrs.)

2.1 Quantifying Biodiversity: Assessing, Inventory, Monitoring, Faunal assessment and sampling techniques. Distribution and gradients of biodiversity, species area relation, Depth gradients,marine realms and freshwater regions. Latitudinal and Altitudinal gradients of biodiversity, Zonation in seas and mountains. Endemism and Biodiversity. Ecological relations, keystone species, umbrella species, flagship species and endangered animals, Red data list, Global biodiversity information system. GPS and various tracking methods.

Module 3. (26hrs.)

3.1 Threats to biodiversity: Extinction- past mass extinction, current human caused extinction, extinction rates in islands, local extinctions, vulnerability to extinction, endemic species and extinction, habitat destruction, fragmentation, Overexploitation, Invasive species and diseases, human population growth and its impact. Overview and causes of recent extinctions. Genetic erosion and degradation of aquatic ecosystems and pollution. Species extinction, metapopulation, Genetic consequences of fragmented population and minimum viable population. Effects of global warming to biodiversity.

3.2 Values and uses of Biodiversity: Natural capital, Direct and indirect values- economic, ecological, evolutionary, aesthetic, emotional and ethical, Economic evaluation of biodiversity, Ecosystem services and its importance. Intellectual Property Rights (IPR) and Sovereignty rights. Important days related with biodiversity.

5.3 Conservation of Biodiversity: Ex-situ and in-situ methods of conservation strategies, Captive breeding, zoo and captive breeding, Botanical gardens and gene banks. Evaluation of priorities for species and habitats**:** Choosing species to protect, Hotspots for conservation, Major tropical wilderness areas and Eco regions, UNESCO Man and Biosphere Programme, World heritage sites.Application of genetics in Conservation of biodiversity. Indigenous and Traditional Ecological knowledge (TEK), Biodiversity and sustainable development.

Module 4 . (10hrs.)

Conservation Organizations and laws: International and national conventions for the conservation of biodiversity: CBD, Ramsar Convention, CITES, UNFCC; IUCN, WWF, Conservation International (CI), TRAFIC, UNEP, WCMC etc. Earth summit, World summit, Biological Diversity Act 2002 and Rules 2004, National Action Plan and Strategy for biodiversity conservation, National Biodiversity Authority, State Biodiversity Boards, State Action Plan, Biodiversity Management Committees (BMCs); People's participation in the conservation of biodiversity, Peoples biodiversity register (PBR).

Module 5 . (17hrs.)

Wildlife Management: Principles and practices of wildlife management. Management of special habitats; riparian zones. Grasslands etc. Analysis and need for wildlife management, problems in plantations and exploited forests; Indian and Kerala scenario, Species conservation projects - tiger, lion, rhino, and elephant. Role of Biology in management. Management plan for Protected Areas: Forest working plans and wildlife management plans. Landscape approach and use of modern technology - GIS/GPS/Imagery, camera trapping/Drones etc) in wild life management. Human wildlife conflicts. Principles of planning, objectives, resource surveys, analysis of surrounding region, management zones, theme plans, communications, staff and visitor amenities, monitoring. Financing protected areas.

Module 6. Biodiversity of India with special reference to the Western Ghats

(15hrs.)

Eco regions of India, Distribution of biodiversity, hotspots, endangered species, National parks, biosphere reserves, world natural heritage sites and Wild life sanctuaries. Origin of the Western Ghats**,** Geology and geographical Features, Rivers, Environment, biodiversity, Protected Areas of the Western Ghats. Threats to Bio Diversity of the Western Ghats: The Paradigm Changes -Habitat Fragmentation, Degradation and Loss, Shrinking Genetic Diversity- Declining Natural Resource Base and Overexploitation of Resources, Invasive Alien Species, Climate Change and Desertification, Impact of Development Projects, Madhav Gadgil committee and Kasturirangan committee reports, Biodiversity of Kerala, protected areas, conservation initiatives and challenges. Local issues, sacred groves, mangrove protection and Traditional farming practices. India's

Biodiversity Act 2002 and its role in conservation.

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Semester IV
Special Paper

ZOBB 543 Practical 4 Biosystematics and Animal Diversity (120 hrs.)

COURSE OUTCOMES

CO 1: Providing field experience in collection and preservation of animals in wet and dry methods

CO 2: Acquire a thorough knowledge on conventional taxonomic keys

CO 3: Understand the tools used in collection of animals

CO 4: Hands on experience in identification of parasites

CO 5: Hands on training in tools and techniques involved in museum preservation of specimens

(10 Practicals to be carried out)

1. Collection, identification, and submission of the following:
    a) Insects (10nos)
    b) Prawn (2nos)
    c) Crab (2nos)
    d) Fishes (5nos)
2. Collection of planktons from freshwater, brackish/marine water ecosystems & identification of atleast 5 planktons from each ecosystem
3. Collection of specimens of bivalves and identification of any 5 species
4. Collection of Macro-benthos from any aquatic/wetland ecosystem and identification of at least 5specimens up to order
5. Identification of various parasites of fishes
6. Taxonomy of economically important agricultural pests (at least five specimens)
7. Collection and separation of soil organism using Bearman's and Berlese apparatus andIdentification (at least five specimens)
8. Keying out families of organisms of different major orders such as: Odonata, Orthoptera, Blattodea, Mantodea, Isoptera, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera,Diptera, Lepidoptera, Hymenoptera, Arachnida, Crustacea.
9. Study of Orders of vertebrates and their identification using taxonomic keys.
10. Study of tools &instruments and standard methods used in collection of different organisms from the field.
11. Tools and techniques involved in museum preservation of specimens.
12. Demonstration of BLAST for sequence comparison and MEGA for phylogenetic analysis andphylogenic tree construction
13. **Compulsory field visits:** Minimum 3days (Prepare field study reports and submit for evaluation-**10 marks**
    a) Visit to fish market/ fish landing center, specimen collection morphometry data collectionidentification
    b) Visit to forests/wetland ecosystems for studying birds, butterfly, mammalian diversity.
    c) Field visits to collect insects of different orders.
    d) Field key characters of any amphibians and reptiles reported during field visits

14. OR

Compulsory 15 days On Job Training (Govt./Central Govt/NGO's/ Registered Private organizations) (Produce certificate from the training agency/ organization. Prepare reports and submit for evaluation-**10 marks)**

Semester IV
Special Paper

ZOBB 544: Practical 5 Biodiversity Management - (120hrs.)

COURSE OUTCOMES

CO 1: Explore diversity of animals in their natural habitat by field visits
CO 2: Analysis of field data using various statistical tools
CO 3: Acquire thorough knowledge on microhabitat and biodiversity indices
CO 4: Hands on training in different bird census methods and field level identification of birds
CO 5: Hands on field experience in nature camp, natural history museums
CO 6: Field experience in analysis flora using vegetation sampling methods

(10 practicals to be carried out) specimen/ charts/ photos and data and viva for practical examination

1. Study and calculation of the following biodiversity indices based on field data using Excel or other software:
    a. Shannon-Wiener Index
    b. Richness index
    c. Evenness index
    d. Simpson's Diversity Index

2. Composition assessment of the taxonomic diversity/biodiversity in a habitat (eg. Grassland, arid land, wetland)
3. Population studies - Estimation of Abundance, Population Density, Relative density, Frequency and Relative frequency
4. Field study and survey methods for various animal groups.
5. Assessment of Invertebrate and Vertebrate diversity in your locality (e.g. campus, ecologicallyimportant spots near to the institution).
6. Analysis of species diversity in field such as aquatic/grassland/forest/terrestrial/wetlandecosystem.
7. Study on the micro-habitats
8. Analysis of vegetation types in a specific area/ecosystem.
9. Preparation of Posters- Locate and mark the National Parks/Wildlife Sanctuaries/Biosphere Reserves in India.
10. Quantification of flora using vegetation sampling methods (Estimation of species dominance,frequency, density using quadrate / plot methods).
11. Bird watching and identification of resident and migratory birds (minimum30 species) with theirsalient characteristics and use of different bird census techniques.
12. Visit to museums/repositories and make a report and submit for evaluation- 5 marks)
13. Compulsory attendance and production of participatory certificate and a report with of a Nature camp conducted byDepartment of Wildlife and Forests, Govt. of Kerala (5marks).

SEMESTER 4 CORSE CODE ZOBB 501

Name of the Course: Project work/Dissertation

COURSE OUTCOMES

At the end of the course the students will be able to:

CO1: Able to conduct a literature survey and identify their research area
CO2: Identify a research hypothesis and prepare a research plan
CO3: Standardize research methodology
CO4: Organised data collection will be done
CO5: Data will be analysed and interpreted
CO6: Dissertation will be prepared

COURSE CONTENT: Students shall undertake an independent time-bound research project under the supervision of a faculty in their concerned departments of the college. The periodic progress of the project shall be monitored by the supervising teacher. The project planning may be initiated from the beginning of the third semester onwards. A project wok/dissertation of about 60-70 pages may be submitted at the end of fourth semester. Candidate may, however, in certain cases be permitted to work on the project in other research institutes/industry/ research organizations on the recommendation of the supervising teacher.

Assessment: There shall be external assessment for the project work (75 marks). The project work shall be evaluated based on the presentation of the project work done by the student, the hard copy of the dissertation submitted and the viva-voce on the project (25 marks).

SEMESTER 4 CORSE CODE ZOBB 502

Comprehensive Viva-Voce

Comprehensive Viva-voce will be conducted at the end of fourth semester of the programme and its evaluation shall be conducted by the external examiners. Comprehensive Viva voce cover questions from all courses in the programme.

Assessment: External Evaluation for 100 marks