UNIVERSITY OF KERALA

M.Sc. ZOOLOGY-Semester System

OUTCOME BASED EDUCATION(OBE) SYLLABUS

(2023 Admissions Onwards)

July 2023

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 Endocrinology, Entomology, Fish Biology and Fishery Science, Environmental Physiology 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 – Semester System Syllabus,
Course Structure & Mark Distribution

UNIVERSITY OF KERALA Course Structure and Mark Distribution										
Semester	**Course Code**	**Title of Course**		**Total hrs./ Sem**	**Instructional Hrs. per week**		**Duration of ESA**	**Maximum Marks**		
					Theory	**Practical**		**CA**	**ESA**	**Total**
1	ZO511	Systematics & Evolutionary Biology		100	5		3	25	75	100
	ZO512	Biochemistry		100	5		3	25	75	100
	ZO513	Biophysics, Instrumentation & Computer Science		100	5		3	25	75	100
	ZO514	Practical 1 -Systematics, Evolutionary Biology, Biochemistry, Biophysics, Instrumentation and Computer Science		120		10	4	25	75	100
	Total for Semester 1			**450 ***	**15**	**10**	**-**	**100**	**300**	**400**
2	ZO521	Advanced Physiology & Functional Anatomy		100	5		3	25	75	100
	ZO522	Genetics, Biostatistics & Research Methodology		100	5		3	25	75	100
	ZO523	Cell Biology, Molecular Biology& Bioinformatics		100	5		3	25	75	100
	ZO524	Practical 2 - Advanced Physiology, Functional Anatomy, Genetics, Biostatistics, Bioinformatics, Cell, and Molecular Biology		120		10	4	25	75	100
	Total for Semester 2			**450 ***	**15**	**10**	**-**	**100**	**300**	**400**
3	ZO531	Microbiology and Biotechnology		100	5		3	25	75	100
	ZO532	Ecology, Ethology & Biodiversity Conservation		100	5		3	25	75	100
	ZO533	Immunology & Developmental Biology		100	5		3	25	75	100
	ZO534	Practical 3 - Microbiology, Biotechnology, Ecology, Immunology & Developmental Biology		120		10	4	25	75	100
	Total for Semester 3			**450 ***	**15**	**10**	**-**	**100**	**300**	**400**
4	**Special Course: Endocrinology**									
	ZO541	Special Course 1^	Vertebrate Endocrinology	100	5		3	25	75	100
	ZO542	Special Course 2^	Physiology of Reproduction (With special reference to vertebrates)	100	5		3	25	75	100

	ZO543	Practical 4 (Special Course Practical 1) ^	Physiology of Reproduction (With special reference to vertebrates)-Practical 4	120		10	4	25	75	100
	ZO544	Practical 5 (Special Course Practical 2) ^	Endocrinology (Vertebrate Endocrinology)-Practical 5	120		10	4	25	75	100
	Special Course: Entomology									
	ZO541	Special Course 1^	General Entomology	100	5		3	25	75	100
	ZO542	Special Course 2^	Applied Entomology	100	5		3	25	75	100
	ZO543	Practical (Special Course Practical 1) ^	Taxonomy, Anatomy, Histology and Physiology Practical 4	120		10	4	25	75	100
	ZO544	Practical 5 (Special Course Practical 2) ^	Ecology, Economic Entomology and Experimental Entomology- Practical 5	120		10	4	25	75	100
	Special Course: Fish Biology and Fishery Science									
	ZO541	Special Course 1^	Ichthyology	100	5		3	25	75	100
	ZO542	Special Course 2^	Fisheries and Aquaculture	100	5		3	25	75	100
	ZO543	Practical 4 (Special Course Practical 1) ^	Ichthyology- Practical 4	120		10	4	25	75	100
	ZO544	Practical 5 (Special Course Practical 2) ^	Fisheries and Aquaculture - Practical 5	120		10	4	25	75	100
	Special Course: Environmental Physiology									
	ZO541	Special Course 1^	Pollution Biology & Environmental Physiology	100	5		3	25	75	100
	ZO542	Special Course 2^	Environmental Management	100	5		3	25	75	100
	ZO543	Practical 4 (Special Course Practical 1) ^	Pollution Biology & Environmental Physiology - Practical 4	120		10	4	25	75	100
	ZO544	Practical 5 (Special Course	Environmental Management - Practical 5	120		10	4	25	75	100

		Practical 2) ^								
	Total for Semester 4			**450 ***	**15**	**10**	**-**	**100**	**300**	**400**
	ZO501	Project Work/Dissertation						25	75	100
	ZO502	Comprehensive Viva Voce							100	100
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										
CA- Continues Assessment, ESA- End Semester Assessment, *Tutorial 30hours per week, ^Compulsory course										

SEMESTER 1 COURSE CODE ZO511 (100hrs.)

Name of the Course: Systematics and Evolutionary Biology

COURSE OUTCOMES

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

CO1: Understand the basic principles of taxonomy and systematics
CO2: Recognize the importance of Zoological nomenclature, International Code of Zoological Nomenclature
CO3: Understand and apply new trends in systematics especially chemo and cytotaxonomy, numerical taxonomy, cladistics, molecular systematics, and DNA bar coding
CO4: Acquire enhanced knowledge about the mechanism of natural selection
CO5: Describe the mechanism of natural selection and the evolutionary mechanisms
CO6: Assimilate knowledge regarding the process involved in the Gradualism and punctuated equilibrium along with anagenesis and cladogenesis
CO7: Comprehend concepts regarding Neutral theory of molecular evolution; molecular divergence; molecular drive, Molecular clocks

COURSE CONTENT

A. Systematics (50 hrs.)

Module 1. Definitions and basic concepts (10hrs.)

1.1. Taxonomy and systematics - Basic principles. Contributions of Aristotle, Carl Linnaeus, Darwin and Huxley in animal taxonomy.
1.2. Micro taxonomy and macro taxonomy. Stages of taxonomy - Alpha, beta and gamma taxonomy.
1.3. Hierarchy of categories and higher taxa. Species and types of species.
1.4. Different concepts of species - Typological, Nominalistic, Biological, Phylogenetic and evolutionary species concepts.
1.5. Importance and applications of taxonomy and systematics.

Module 2. Taxonomic tools and techniques (25hrs.)

2.1. Taxonomic characters (morphological, ecological, behavioural and embryological) and analysis of variation (qualitative and quantitative).
2.2. Taxonomic procedures - Collection (wet and dry collection), preservation, curetting and process of identification (brief and general account only).
2.3. Zoological type - Principles of typification, different kinds of type.
2.4. Different types of keys - Single access keys, diagnostic and synoptic keys, dichotomous and polytomous keys. Computer aided keys. Merits and demerits of keys.
2.5. Types of taxonomic publications - Atlas, catalogue, checklist, filed guide, field book, hand book, manual and monographs. Zoological records (brief and general account only).
2.6. International code of Zoological Nomenclature (ICZN) - Features, principles, and rules (brief and general account only). Zoological nomenclature, homonymy, synonymy, Phylocode, Zoobank.

Module 3. Modern trends and approaches in systematics (15 hrs.)

3.1. Modern methods - Cytotaxonomy, chemotaxonomy and molecular taxonomy.

3.2 Basics of DNA barcoding (general protocol) and molecular markers. Application of DNA barcoding in species identification. The Barcode of Life Data system (BOLD).
3.3. Cladistic analysis - Apomorphy, plesiomorphy, symplesiomorphy and synapomorphy.
3.4. Characteristic features of cladistics. Methodology of cladistics analysis - Construction of cladogram.
3.5. Different kinds - Cladogram, phenogram, phylogram, dendrogram, curvogram, eurogram, swoopogram and chronogram.
3.6 Significance of phylogenetic systematics. Phylogenetic trees.

EVOLUTIONARY BIOLOGY (50 hrs.)

Module 4. Concepts in Evolution (15 hrs.)

4.1. Concepts of variation, adaptation, struggle, fitness, and natural selection - Spontaneity of mutation and the evolutionary synthesis.
4.2. Origin of life. Concept of Haldane and Oparin, Miller experiment (1953). The RNA world, the first cell Evolution of prokaryote.
4.3. Origin of eukaryotes, anaerobic metabolism - Origin of photosynthesis and aerobic metabolism. Evolution of unicellular eukaryote. Contributions of Lynn Margulis (Endosymbiotic theory.).
4.4. Palaeontological evidences of vertebrate evolution - Important fossil evidences of fishes, amphibia, reptiles and birds (brief and general account only).

Module 5. Molecular Evolution and Natural Selection (25 hrs.)

5.1. Neutral theory of molecular evolution, molecular divergence, molecular drive.
5.2. Molecular clocks. Genetic equidistance. The C - value paradox.
5.3. Phylogenetic relationships – Homology, Homologous sequences of proteins and DNA - orthologous and paralogous. Parsimony analysis, nucleotide, and protein sequence analysis. Ancient DNA, DNA polymorphism.
5.4. Evolution of gene families. Factors influencing molecular evolution. Role of mutation and selection in molecular evolution, genome organization and evolution.
5.5. Natural selection and types. Selection on small continuous variation. Founder effect and Bottle neck phenomenon.
5.6. Phyletic gradualism and punctuated equilibrium by Eldredge and Gould.
5.7. Speciation - Types and mechanisms of speciation. Mass extinction (brief and general account only).

Module 6. Primate Evolution and Human Origin (10 hrs.)

6.1. Stages in primate evolution. Prosimii, Anthropoidea and Hominids
6.2. Factors in human origin - Morphological and anatomical. A general account of hominid fossils including the Contributions of Leakey family.
6.3. Cytogenetic and molecular basis of origin of man - Palaeogenomics - Contributions of Svante Paabo
6.4. African origin of modern man - Mitochondrial Eve, Y chromosomal Adam. Migration out of Africa.

Activities, Learning resources and Assessment

Suggested Activities

1. Written Examinations
2. Seminars
3. Assignments
4. Poster Presentations
5. PowerPoint presentations
6. Model preparations

7. Visit to laboratories and instrumentation facilities of Universities and Research institutes

Learning Resources
References

Systematics

1. Arora, M.P. and Arora, H. (2013). A text book of organic evolution. Himalaya publishing house, Pune, Maharashtra.
2. Ashok Verma (2017). Principles of Animal Taxonomy. Narosa. New Delhi.
3. David, M.H., Craig Moritz and K.M. Barbara (1996). Molecular Systematics. Sinauer Associates, Inc.
4. Kapoor, V.C. (2017). Theory and Practice of Animal Taxonomy. 8th edition, Oxford and IBH Publishing Co., Pvt. Ltd. New Delhi.
5. Mayer, E. (2014). Principles of Systematic Zoology. 2nd edition, McGraw Hill book company, Inc., NY.
6. Narendran, T.C. (2008). An introduction to taxonomy. Zoological survey of India.
7. Pandit, D.N. (2020). Animal taxonomy: Principles and practices. Narendra publishing house, India
8. Sanjib Ghoshal (2020). Taxonomy principle and problem. Techno world, Kolkata.
9. Simson, G.G. (2012). Principles of animal taxonomy. Scientific publishers, India.
10. Winston, J.E. (2000). Describing species: Practical taxonomic procedures for biologists. Columbia University Press, Columbia, USA.

Evolutionary Biology

1. Arthur, W. (2011). Evolution - A developmental approach. Wiley-Blackwell, Oxford, UK.
2. Barton, N.H., Briggs, D.E.G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007). Evolution. Cold Spring, Harbour Laboratory Press.
3. Camilo J. Cela - Conde and Francisco J. Ayala. (2007). Human evolution - Trails from the past. Oxford University Press. Oxford, UK.
4. Campbell. B.G. (2009). Human evolution. Transaction publishers, NJ, USA.
5. Chattopadhyay Sajib. (2002). Life, origin, evolution, and adaptation. Books and allied (P) Ltd. Kolkata, India.
6. Dan, G. and Li, W.H. (2000). Fundamentals of molecular evolution. (2^{nd} Edn.). Sinauer Associates Inc. MA, USA.
7. Darwin C.D. (1859). On the origin of species by means of natural selection. John Murray, London.
8. Elliott Sober (2008). Evidences and evolution: The logic behind the science. Cambridge University Press, UK.
9. Gould, S.J. (2002). The structure of evolutionary theory. Harvard University Press, MA, USA.
10. Hall, B.K. and Hallgrimsson, B. (2008). Evolution. 4^{th} Edition; Jones and Bartlett Publishers.
11. Hall, B.K. and Hallgrimsson, B. (2008). Strickberger's evolution (4^{th} Edn). Jones and Bartlett Pub. London, UK.
12. Hall, B.K. and Olsen, W.M., (Ed). (2007). Keywords and concepts in evolutionary developmental biology. Discovery publishing house, New Delhi.
13. Jha, A.P. (2000). Genes and evolution - Macmillan publishers, India.
14. Kimura, M. (1983). The neutral theory of molecular evolution. Cambridge University Press
15. Lindell Bromham (2016). An introduction to molecular evolution and phylogenetics, 3^{rd} edition, Oxford press.
16. Margulis, Lynn and M.J. Chapman (2001). Kingdoms and Domains: An Illustrated Guide to the Phyla of Life on Earth (4^{th} edn.). W.H. Freeman &Company, USA.

17. Niles E. (2000). Life on earth: an Encyclopaedia of Biodiversity, Ecology and Evolution (Vol.1&II). ABCCLIO, Inc.CA, USA.
18. Ridley, M. (2004), Evolution 3rd Edition. Blackwell Publishing.
19. Roderick Page, D.M. and Edward Holmes, C. (2009). Molecular Evolution: A phylogenetic approach, Willey Blackwell publisher.
20. Strickberger, M.W. (2000). Evolution. Jones and Bartlett, Boston.
21. Strickberger's Evolution (4th Edn.). (2008). Hall B.K. and Hallgrimsson B. Jones and Bartlett Pub. London, UK.
22. Veer Bala Rastogi (2018). Organic evolution (3rd revised Edn.). Medtech press. New Delhi.

Web Resources:
http://www.talkorigins.org
http://www.ucmp.berkely.edu

Assessment:
25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. written examination

SEMESTER 1 COURSE CODE ZO512 (100 hrs.)

Name of the Course: Biochemistry

COURSE OUTCOMES

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

CO1: Classify and compare the structure of carbohydrates, proteins, nucleic acids, and lipids
CO2: Understand the biological importance and metabolism of carbohydrates, proteins, nucleic acids, and lipids
CO3: Evaluate the clinical aspects of blood glucose level variations and metabolic disorders
CO4: Summarize the tissue protein diseases and inborn errors associated with protein metabolism
CO5: Differentiate the disorders associated with lipid metabolism
CO6: Understand energy metabolism
CO7: Summarize the concepts of enzyme kinetics

Module 1. Carbohydrates and Lipids - Classification and Structure (20 hrs.)

1.1 Classification and nomenclature of carbohydrates.
1.2 Monosaccharide: Structure of glucose, fructose, galactose, mannose and ribose. Glycosidic bond. Isomerism- Structural isomerism and stereoisomerism, optical isomerism, epimerism and anomerism. Biological importance of monosaccharides.
1.3 Disaccharides: Structure of sucrose, lactose, maltose, isomaltose, cellobiose and trehalose.
1.4 Polysaccharides: Homopolysaccharides - Structure of starch, glycogen, cellulose, chitin, dextran, inulin and pectin. Heteropolysaccharides - Structure of hyaluronic acid, heparin, chondroitin sulphate, keratan sulphate, dermatan sulphate and agar-agar. Glycoproteins and mucoproteins.
1.5 Classification of lipids: Simple, compound, and derived lipids.
1.6 Fatty acids: Classification and nomenclature.
1.7 Simple fats: Triacylglycerol (Triglycerides), saponification, rancidity and acid value.
1.8 Compound lipids: Phospholipids- Lecithin, phosphatidyl inositol, cephalins, plasmalogens, glycolipids and sphingolipids.
1.9 Steroids: Biologically important steroids - Cholesterol, Vitamin D, bile acids, ergosterol, terpenes. Prostaglandins- Structure, types, synthesis, and functions.
1.10 Lipoproteins.

Module 2. Proteins and Nucleic Acid - Classification and Structure (20 hrs.)

2.1 Amino acids: Structure, classification, and properties of amino acids. pKvalue and iso-electric point of amino acids, Henderson-Hasselbalch equation, peptide and peptide synthesis.
2.2 Primary structure of protein (eg. insulin).
2.3 Secondary structure - Alpha helix, collagen helix, beta pleated sheet, Ramachandran plot.
2.4 Fibrous proteins: Examples (keratin, collagen, elastin, resilin and fibrous muscle proteins).
2.5 Tertiary structure: Globular protein- eg. myoglobin.
2.6 Quaternary structure: eg. Haemoglobin.
2.7 Tissue protein diseases: eg. Osteogenesis imperfecta, Ehlers-danlos syndrome, Alport syndrome, Marfan's syndrome, Williams-Beuren syndrome, Prion diseases and Cataracts (Brief description only).
2.8 Structure of nucleosides and nucleotides.

2.9 Watson & Crick - Double helical structure.
2.10 Characteristic features of A, B, C and Z DNA.

Module 3. Carbohydrate Metabolism (12 hrs.)

3.1 Glycolysis, citric acid cycle, pentose phosphate pathway - Regulation and energetics.
3.2 Gluconeogenesis, Cori cycle.
3.3 Glycogen metabolism: Glycogenesis, glycogenolysis, regulation.
3.4 Factors maintaining blood glucose level, normal plasma glucose level, Oral Glucose Tolerance (OGTT).
3.5 Diabetes mellitus, inborn errors associated with carbohydrate metabolism, Glycogen storage disease, lactose intolerance, galactosuria and pentosuria.

Module 4. Metabolism of Lipids (12 hrs.)

4.1 Beta oxidation, alpha oxidation, and omega oxidation of fatty acids.
4.2 Formation of ketone bodies, ketosis, and keto acidosis.
4.3 *De novo* synthesis of fatty acids, mention fatty acid synthase as multienzyme complex.
4.4 Biosynthesis and regulation and transport of cholesterol.
4.5 Metabolism of triglycerides.
4.6 Disorders: Cholesterol and its clinical significance, hyperlipidemia and hyperlipoproteinemia

Module 5. Metabolism of Proteins, Amino acids and Nucleic acids (12 hrs.)

5.1 Amino acid metabolism: Deamination, transamination and trans-deamination, decarboxylation.
5.2 Urea cycle - Regulation and energetics.
5.3 Fate of carbon skeletons of amino acids: glucogenic, ketogenic, partly glucogenic and ketogenic with examples.
5.4 Synthesis of biologically significant compounds from different amino acids with special reference to glycine, glutamic acid, phenylalanine, tyrosine and tryptophan.
5.5 Catabolism of purines and pyrimidines. Mention disorders.
5.6 Heme structure and degradation, bilirubin metabolism, plasma bilirubin and jaundice.
5.7 Inborn errors of metabolism: Phenylketonuria, alkaptonuria, albinism, tyrosinosis, maple syrup urine disease, Lesch-Nyhan syndrome, sickle cell anaemia, histidinemia (brief description only).

Module 6. Energy Metabolism (12 hrs.)

6.1 Biological oxidation - Mitochondrial electron transport, major complexes, and inhibitors. Types of electron carriers, redox couples.
6.2 Oxidative phosphorylation, Chemi-Osmotic hypothesis, proton motive force. Mechanism of ATP synthesis, structure and function of ATP synthase, rotational catalysis, and binding change mechanism.

Module 7. Enzymes (12 hrs.)

7.1 Classification of enzymes: IUB system.
7.2 Enzyme specificity: Absolute specificity, bond specificity, stereo-specificity, reaction specificity, substrate specificity
7.3 Mechanism of enzyme action: Concept of activation energy. Catalytic strategies (acid base catalysis, substrate strain, covalent catalysis, metal ion catalysis). Theories (Michaelis Menten theory, Koshland induced fit theory, Fisher's template theory).
7.4 Enzyme Kinetics: Michaelis-Menten equation and its derivation, importance of Km value and Vmax, Lineweaver-Burk Plot of enzyme catalysed reaction.
7.5 Enzyme Inhibition: Irreversible, reversible, competitive, non-competitive, uncompetitive, suicide inhibition and feedback inhibition. Mention kinetics of enzyme inhibition.
7.6 Enzyme regulation: Allosteric regulation, regulatory enzymes, and covalent modification.
7.7 Vitamins as coenzymes.

Activities, Learning resources and Assessment

Suggested Activities

1. Written examinations
2. Seminars
3. Assignments
4. Poster presentations
5. PowerPoint presentations
6. Model preparations

References:

1. Nelson D. L., Cox M. W. H. (2021). Principles of Biochemistry, W. H. Freeman, ISBN-10 : 9781319108243.
2. Jermy M. Berg, John L Tymoczko, Lubert Stryer (2019). Biochemistry, W. H. Freeman, ISBN-13: 978-1319114657.
3. Donald Voet, Judith G. Voet Charlotte W. Pratt (2018). Voet's principles of biochemistry., Wiley, ISBN: 978-1-119-45513-4.
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9. Satyanarayana U. and U. Chakrapani (2021), Biochemistry, Elsevier Health Sciences, ISBN 9781319108243.

Assessment:

25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. written examination

SEMESTER 1 COURSE CODE ZO513 (100hrs.)

Name of the Course: Biophysics, Instrumentation & Computer Science

COURSE OUTCOMES

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

CO1: Understand the concept of energy and laws of thermodynamics
CO2: Follow the new trends in radiation biophysics and nanotechnology
CO3: Impart knowledge on microscopes and their application methods
CO4: Understand the principle, working and applications of centrifugation, electrophoretic and chromatographic methods
CO5: Acquire knowledge on the principle and components of instruments of biomedical research
CO6: Understand the basics of computer hardware, software, languages, networking and current trends in the field of computer science

COURSE CONTENT

A. Biophysics (25hrs.)

Module 1. Thermodynamics & Electromagnetic spectrum (13 hrs.)

1.1 Introduction: Concept of energy and laws of thermodynamics.
1.2 Matter and energy: Life as an energy system - order, disorder, entropy, enthalpy.
1.3 Photo bioenergetics: Photosynthesis - light and dark reactions, redox couple and redox potential.
1.4 Cosmic radiation: Gamma radiation, X-rays, UV-radiation, visible spectrum, infrared rays, microwaves and radio waves. Biological applications.

Module 2. Radiation Biophysics & Nanotechnology (12 hrs.)

2.1 Radioactivity; Detection and measurement of radiation, Ionizing radiation, and induced mutations.
2.2 Radio-labelling 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.
2.3 Nuclear medicine - Internally administered radioisotopes.
2.4 Radioiodine in thyroid function analysis. Renal, liver and lung function analysis.
2.5 Applications of nanotechnology in biology.
2.6 Nanosensors and nanomedicines.

B. Instrumentation (50 hrs.)

Module 3. Methodology and working of microscopes (18 hrs.)

3.1 Atomic Force Microscope (AFM).
3.2 Widefield Multi-photon Microscopy.
3.3 Total Internal Fluorescence Microscopy (TIRF).
3.4 Electron microscopes - TEM, SEM - Field emission SEM and Tungsten Filament SEM.
3.5 Environmental Scanning Electron Microscope (ESEM). Various types of SEM detectors- BSE detectors, EDS detector, and SED detector.
3.6 Confocal Laser Scanning Microscope (CLSM).
3.7 Photo Activated Localization Microscopy (PALM).

Module 4. Centrifugation, Electrophoresis and Chromatography (15 hrs.)

4.1 Refrigerated high speed centrifuge, density gradient centrifugation, ultracentrifugation, and dual Asymmetric Centrifugation (DAC).

4.2 PAGE Gel electrophoresis, SDS PAGE, agarose gel electrophoresis, high voltage electrophoresis, and immuno-electrophoresis.

4.3 Column chromatography, ion exchange chromatography, affinity chromatography, HPLC, UHPLC, gas chromatography, and LC-MS (principle, working and application only).

Module 5. Biophysical Methods (17 hrs.)

5.1 UV-VIS spectrophotometer, flame photometer.

5.2 Atomic Absorption Spectrophotometer (AAS), Infrared Spectrophotometer (IR).

5.4 NMR and EMR spectroscopy.

5.5 X-ray crystallography, Mass spectrometry.

5.6. Electro-physiological methods: simple neuron recording, patch clamp neuron recording, ECG, and brain activity recording (EEG).

5.7 Medical imaging Techniques: Positron Emission Tomography (PET), MRI, fMRI, ultrasound scanning, CT scanning, and fluoroscopy (principle, working and application only).

C. Computer Science (25 hrs.)

Module 6. Introduction to computers & Computer generations Computer programming, software, communication and networking (25 hrs.)

6.1 Fundamentals of computers: History, generations, memory devices. Advantages and limitations of computers. Comparison of different operating systems: DOS, Windows NT and XP.

6.2 Software: Relationship between hardware and software, system software and application software. Acquiring software: buying pre-written software, developing customized software. Concept of free software.

6.3 Programming language: (brief account only)- Compiling and linking, testing and debugging, low-level languages, high-level languages, programming languages, C^{++}, PYTHON, R-programming, Web programming.

6.4 Internet technologies: Web Services - WWW, URL, servers: client/server essentials, domain name server, FTP server, E-mail server, WEB servers, Web publishing - browsers, IP address.

6.5 Network basics: Communication technology, Networking elements - Networking hardware. Networking services: Types of networks - LAN, WAN and MAN. Intranet - Wireless communication, Internet services, Uses of internet.

6.6 New trends: (brief account only)- Artificial intelligence (AI), Cloud computing, Artificial neural networks, High Performance Computing (HPC), High Throughput Computing (HTC), Machine learning security in computing, Blockchain technology.

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Activities, Learning resources and Assessment

Suggested Activities

1. Written examinations
2. Seminars
3. Assignments
4. Poster presentations
5. PowerPoint presentations

6. Model preparations
7. Visit to laboratories and instrumentation facilities of Universities and Research institutes and hospitals

Learning Resources

References

1. Ackerman, E. (1962). Biophysical science. Prentice Hall Inc.
2. Alonso, A. and Arrondo, J. L. R. (2006). Advanced techniques in biophysics, Springer
3. Arora, M. P. (2007). Biophysics, Himalaya publishing house.
4. Baker, E. J. and Silverton R. E. (1978). Introduction to medical laboratory technology. ELBS.
5. Das, D. (1991). Biophysics and biophysical chemistry. Academic press, NY
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10. Lehninger, A. L. (1971). Bioenergetics. W. A. Benjamin, London
11. Narayanan, P. (2000). Essentials of Biophysics. New Age International, Ltd. Publishers, New Delhi.
12. Nicholls, D. G. and Ferguson S. J. (1992). Bioenergetics, Academic press New York
13. Pradeep, T. (2007). Nano: The essentials. Understanding nanoscience and nanotechnology. Tata McGraw Hill Education Pvt. Ltd., New Delhi.
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15. Sandhu, G. S. (1990). Research techniques in biological sciences. Anmol publications, New Delhi
16. Srivastava P. K. (2006). Elementary biophysics. An introduction. Narosa publishing, Delhi.
17. Varghese, T. and Balakrishna, K. M. (2012). Nanotechnology - An introduction to synthesis, properties and applications of nanomaterials, Atlantic publishers and distributors.
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Assessment:

25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. written examination

SEMESTER 1 COURSE CODE ZO514 (120hrs.)

Name of the Course: Systematics, Evolutionary Biology, Biochemistry, Biophysics, Instrumentation and Computer Science- Practical 1

COURSE OUTCOMES

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

CO 1: Understand the principle of volumetric titrations.
CO 2: Understand the significance of pKa and isoelectric point.
CO 3: Perform quantitative estimation of biomolecules in given samples.
CO 4: 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. Systematics and Evolutionary Biology

1. Collection and identification of the following using standard keys:
    A. Insects (5 nos.)
    B. Prawn (2 nos.)
    C. Crab (2 nos.)
    D. Fishes (5 nos.)
2. Study of preservation media and tools and materials for taxidermy.
3. Comparative study of prokaryotic and eukaryotic cells by staining and mounting (evolutionary significance).

B. Biochemistry

4. 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.
5. Estimation of DNA/RNA (colorimetric method, standard curve methods).
6. Quantitative estimation of moisture content of animal tissue samples (fish/shrimps/ molluscs/chicken) (direct method-weight loss).
7. Quantitative estimation of free amino acids (colorimetric method, standard curve methods).
8. Quantitative estimation of glycogen of a tissue (colorimetric method, standard curve methods).
9. Quantitative estimation of blood glucose (colorimetric method, standard curve methods).
10. Quantitative estimation of serum protein (colorimetric method, standard curve methods).
11. Determination of acid value of the given fat.
12. Determination of saponification value of the given fat.
13. Estimation of serum cholesterol using a standard protocol (colorimetric method, standard curve methods).

C. Biophysics, Instrumentation and Computer Science

14. Micrometry: Measurement of microscopic objects using micrometer.
15. Sketching of biological specimens using a Camera Lucida.
16. Preparation of tables, line and bar diagrams, histogram, frequency polygon and pie diagram using suitable software using appropriate software (eg. MS Excel) using the data provided.
17. Statistical analysis of the given data (descriptive statistics; One way ANOVA- single factor; t-test- paired two sample for means; correlation; regression analysis with graph and equation) of the given data using suitable software. e.g., PH Stat., MS Excel, SPSS, Vassarstats),

Activities, Learning resources and Assessment

Suggested Activities

1. Field visits
2. Field collections
3. Preparation of insect boards
4. Preservation and display of specimens
5. Preparation, analysis, and presentation of biological data
6. Scientific drawing of specimens
7. Skill in handling, calibration and operation of instruments and lab equipment
8. PowerPoint presentations
9. Model preparations
10. Visit to laboratories and instrumentation facilities of Universities and Research institutes
11. Submission of Records for Continuous Evaluation

Learning Resources

References

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3. Philip Bovier Hawk. (2016). Hawk's Practical Physiological Chemistry, Palala Press, ISBN-13: 978-1357428150.
4. Jayaraman, Practical Biochemistry. (2011). New Age International Private Limited, ISBN-13: 978-8122430493.
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Assessment:

25% Continuous Evaluation, 75% End Semester Evaluation: 4Hrs. Practical Examination

SEMESTER 2 COURSE CODE ZO521 (100hrs.)

Name of the Course: Advanced Physiology & Functional Anatomy

COURSE OUTCOMES

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

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 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 organisms.

COURSE CONTENT

Module 1. Homeostasis and Human Nutrition (10 hrs.)

1.1. Basic concept of homeostasis and control of internal environment.
1.2. Types of nutrition, functional anatomy of stomach and intestine.
1.3. Secretory functions of alimentary canal - hormones and enzymes.
1.4. Absorption mechanism of nutrients.
1.5. Obesity and gastro intestinal disorders.

Module 2. Fluid Circulation and Gas Transport (20 hrs.)

2.1. Production, differentiation and maturation of red blood cells. role of erythropoietin. anaemia - blood loss anaemia, aplastic anaemia, megaloblastic anaemia. Polycythemia - secondary polycythemia, erythremia. blood volume. Clinical abnormalities of fluid volume - hyponatremia and hypernatremia. Blood groups. haemostasis.

2.2 Physiology of Cardiac Muscle - Action Potentials in Cardiac Muscle. ECG - Its principle and significance. Cardiac cycle - Diastole and Systole. Blood pressure. Control of blood pressure and blood flow. Neural and chemical regulation.

2.3 Cardiac failure- Congenital heart defects and their causes, valvular lesions, myocardial infarction.

2.4 Comparison of respiration in different invertebrates and vertebrates- Anatomical considerations, transport of gases, exchange of gases, neural and chemical regulation of respiration.

2.5 Respiration in unusual environment: Foetal and neonatal respiration, respiratory adaptations in high altitude, respiratory adaptations in deep sea diving.

Module 3. Excretion and Osmoregulation (10 hrs.)

3.1 Comparative physiology of excretion in invertebrates and vertebrates.

3.2 Structural organisation of kidney, urine formation, urine concentration-hormonal regulation, micturition, regulation of water balance, electrolyte balance, acid-base balance, and blood volume regulation

3.3 Kidney diseases (brief and general account only) and haemodialysis.

3.4 Osmoregulation in fresh water and marine environment with special reference to vertebrate groups.

Module 4. Nerve and sensory Physiology (15 hrs.)

4.1. Organization of the Nervous System: Neuron, sensory receptors, effectors, processing, and storage of information. Major levels of central nervous system functions- Spinal cord level, subcortical level, and cortical level.

4.2. Synapse, types of synapses and synaptic transmission. Mechanism of excitatory and inhibitory pathway- Acetylcholine (ACh) and Gamma-aminobutyric acid (GABA). Special characteristics of synaptic transmission.

4.3. States of Brain Activity: Sleep, Brain Waves, Epilepsy, Psychoses. Parkinson's disease and Alzheimer's disease.

4.4. Structural and functional classification of somatic senses and somatic receptors. Mechanism of hearing and equilibrium, Physiology of vision, Tactile receptors.

Module 5. Movement, Support, and sports physiology (15 hrs.)

5.1. Cellular movements-Ciliary, flagellar, and amoeboid movements.

5.2 Hydrostatic skeleton- structure, advantages, and limitation

5.3. Ultrastructure of skeletal muscle, mechanism of muscle contraction and its energetics. Types of muscle contraction.

5.4. Muscles in exercise, physical fitness and its components. Dope test in sports.

Module 6. Endocrinology, Stress Adaptation and Reproduction (30 hrs.)

6.1. Classification of hormones and mechanisms of hormonal action.

6.2. Endocrine glands- Hormones and functions - Pituitary, Thyroid, Adrenal, Pineal and Pancreas. Diseases/disorders of hormonal hypo and hyper secretion.

6.3 Stress and Stress adaptation, acclimation and acclimatization, stress hormones and Hypothalamo-Pituitary - Adrenocortical (HPA) axis.

6.4. Hormonal control of male reproductive system.

6.5. Hormonal control of ovarian function, uterine changes during menstrual cycle. Effects of oestrogen, progesterone and androgen in women.

6.6. Movement of sperm and activation, ovum transport and implantation and placentation

6.7. Hormonal changes during pregnancy, parturition, and lactation.

6.8. Prenatal diagnostic tests- Amniocentesis, Ultrasonography, Chorionic villus sampling, Maternal Serum Alpha-Fetoprotein (MSAFP).

Activities, Learning resources and Assessment

Suggested Activities

1. Written examinations
2. Seminars
3. Assignments
4. Poster presentations
5. PowerPoint presentations
6. Model preparations

Learning Resources

References

1. Bray, J.J., Cragg, P. A, Macknight, A.D, Mills, R.S and Taylor, D.W. 1986. Lecture Notes on human Physiology. ELBS, New Delhi.
2. Brijlal Gupta and J.A.1977. Transport of Ions and Water in Animals. Ramsay Academic Press, New York
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15. Totora G. J. and S. R. Grabowski. 1996. Principles of Anatomy and Physiology Edition, 8, illustrated, reprint; Publisher, Harper Collins College, ISBN, 067399354X, 9780673993540.
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Assessment: 25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. written examination

SEMESTER 2 COURSE CODE ZO522 (100hrs.)

Name of the Course: Genetics, Biostatistics & Research Methodology

COURSE OUTCOMES

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

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 biostatistics 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 (70 hrs.)

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

1.1 Genetics and modern animal husbandry and fisheries.
1.2 Genetics and medicine Legal and ethical issues in genetics.
1.3 Gene mapping, Recombination frequency.
1.4 Chromosome banding, General effects of inbreeding and out breeding.
1.5 Hybrid vigour.
1.6 Expressivity.
1.7 Penetrance.

Module 2. Population Genetics & Human Genetics (30 hrs.)

2.1 Polymorphism.
2.2 Hardy-Weinberg equilibrium, Disequilibrium.
2.3 Factors disrupting gene equilibrium.
2.4 Pedigree analysis – Karyotype analysis.
2.5 X-Chromosome dosage.
2.6 Lyon hypothesis and mosaicism.
2.7 Genetics of ABO system.
2.8 Rh disease and its inheritance, Sickle haemoglobin and inheritance; thalassemias.
2.9 Genetic disorders – Patau, Edwards, Cri-du-chat syndromes, Philadelphia chromosome.

Module 3. Viral Genome, Microbial Genetics & Genetics in Medicine, and Forensics (20 hrs.)

3.1 Retrovirus.
3.2 HIV genome and multiplication.
3.3 Lambda Phages, Plasmids – Vector DNA – Insert DNA.
3.4 Microbes in genetic engineering.
3.5 Human Genome Project.
3.6 Human gene therapy.
3.7 DNA fingerprinting: and its application in forensic science and paternity testing.

Biostatistics **(15 hrs.)**

Module 4. Introduction to Biostatistics & Descriptive Statistics and Probability Distribution (7 hrs.)

4.1 Concepts – population and sample, parameter, variables, sampling.
4.2 Descriptive and inferential statistics.
4.3 Primary and secondary data collection methods. Use of software in statistics.
4.4 Correlation and Regression.
4.5 Measures of Dispersion, Skewness and Kurtosis.
4.6 Probability Distribution, Definition, important terms and concepts.
4.7 Theorems in probability.
4.8 Important theoretical distributions- Binomial distribution, Poisson distribution, and normal probability distribution.

Module 5. Parametric and Non-Parametric Test (8 hrs.)

5.1 Basic idea – Hypothesis testing, types of errors.
5.2 Tests of significance for large and small samples - Z-test, Chi-Square Test, Student's 't' test, F-test – Problems. ANOVA. Characteristics, advantages, and disadvantages.
5.3 Types of non-parametric tests (brief account only) Examples: Sign tests, Kruskal Wallis tests, Mann-Whitney U test, Spearman's rank correlation test.

Module 6. Research Methodology **(15 hrs.)**

6.1 Introduction to research methodology: Definition, meaning, objectives, and significance of research, Types of research – Descriptives, Analytical, Applied vs. Fundamental, Quantitative vs Qualitative, Conceptual vs Empirical. Characteristics of good research. Steps of working of research.
6.2 Research problem formulation: Formulation and defining a research problem, techniques involved, literature survey, journals, conference proceedings, books, government reports, problem selection, formulation of hypothesis.
6.3 Research design meaning, need and features a good research design, different types of research designs (exploratory, descriptive, diagnostic, hypothesis- testing).
6.4 Execution of research plan: Data collection, Analysis of data, Interpretations.
6.5 Scientific documentation: Significance of report writing, types of reports, research report writing (thesis, dissertations, research articles, books, proceedings), characteristics and format, writing and preparation of articles for publication and for oral and poster presentation, project proposal writing.
6.6 Research, extension and ethics: Extension tools, impact factor, journal indexing, citation index. Research misconduct: Fabrication, falsification and plagiarism precaution, ESO standards for safety, IACUC, control of hazards, ethical norms, codes and policies for research ethic, laws in India.

Activities, Learning resources and Assessment

Suggested Activities

1. Written examinations
2. Seminars
3. Assignments
4. Poster presentations
5. PowerPoint presentations
6. Preparation of video

7. Sample project proposal preparation and presentation
8. Visit to zoo, sanctuaries, national parks
9. Survey
10. Flip classroom assignment

Learning Resources

REFERENCES

Genetics

1. Daniel Fairbanks and W.R Anderson (2000). Genetics – The Continuity of Life. Brooks/Cole Publishing Co., N.Y.
2. Herbert Tayleor J., (1960). Molecular Genetics Part I & II.
3. Eldon. J., (2006). Gardner Principles of Genetics.
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6. PKU Nair and K. Prabhakar Achar. (1990). A Text Book of Genetics and Evolution: Konark publishers.
7. Robert M Horton and Robert C. (1998). Tait, Genetics Engineering with PCR: Horizon Scientific Press, UK.
8. World R. and S.B. (1980). Primrose, Principles of Gene Manipulation: Black Well Scientific Publishers, Melbourne, Paris.
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15. Gunther S. Stent & Richard Calender. (1971). Molecular Genetics, CMS Publishers, 485 Jain Bhawan, Bholanath Nagar, Shahdra, Newdeli.
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Biostatistics

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2. Mather K. (1949). Biometrical Genetics –Dover Publication, New York.
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4. Agarwal, B.L. (1996) Basis Statistics. New Age International (P) Ltd. Publishers, New Delhi.
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6. Finney, D.J. (1980). Statistics for Biologists. Chapman and Hall, London.

7. Caswell, F. (1982). Success in Statistics. John Murray Publishers Ltd., London.
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13. Finney, D.J. (1980). Statistics for Biologists. Champman and Hall, London
14. Kothari C.R., (2009). Research Methodology: Methods and Techniques. New Age International Publishers, New Delhi.
15. Oliver, P. (2005). Writing Your thesis. Vistar Publications. New Delhi.

Assessment:
25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. written examination

SEMESTER 2 COURSE CODE ZO523 (100 hrs.)

Name of the Course: Cell Biology, Molecular Biology & Bioinformatics

COURSE OUTCOMES

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

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.

Cell Biology (25 hrs.)

Module 1. Cell interactions, membrane transport and chromatin structure (15 hrs.)

1.1 Interaction of cells with other cells: Selectins, Immunoglobulins, Cadherins, Adherens.

1.2 Cell Junctions: Tight junctions, Gap junctions, Desmosomes and Plasmodesmata.

1.3 Diffusion of small molecules across phospholipid bilayer, Uniporter – catalysed transport, Co-transport by symporters and antiporters.

1.4 Active transport by ATP powered pumps.

1.5 Membrane potential.

1.6 Chromatin structure: Types of Chromatins, Detailed structure of nucleosome; higher order structure of chromatin and the role of histones HI, scaffold proteins, and radial loop model.

Module 2. Cell growth, Cell Cycle, Cell-cell signalling and Cancer (20 hrs.)

2.1 Cell Growth & Cell Cycle: Cell cycle: Stages in cell cycle, Control of cell cycle: Cyclin and cyclin – dependent kinases, Regulation of CDK – Cyclin activity, Checkpoints in cell cycle. Control of cell division and cell growth. Regulation of cell cycle in malignant cells, Apoptosis-extrinsic and intrinsic pathways, significance of apoptosis.

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

2.3 Cancer: Basic properties of a cancer cell. Metastasis, interaction of cancer cells with normal cells, Types of cancer, Causes of cancer, Tumour suppressor gene, Oncogene. Therapeutic interventions for combating cancer: Immunotherapy, Gene therapy, inhibiting cancer promoting proteins, inhibiting formation of new blood vessels.

Molecular Biology (40 hrs.)

Module 3. Replication of DNA & DNA Repair (14 hrs.)

3.1 Models of DNA replication: Semi conservative mode (Messelson and Stahl experiment and Cairns experiment), rolling circle mode and D-loop mode of replication. Role of antisense RNA in replication initiation in plasmids.

3.2 Enzymes and accessory proteins involved in DNA replication.

3.3. Replication origin and replication fork, fidelity of replication and extra chromosomal replicons

3.4 DNA damage and repair mechanisms in bacteria and higher organisms. Base Excision repair, Nucleotide Excision repair. Mismatch repair and SOS response.

3.5 Importance of DNA repair and DNA repair associate disorders.

Module 4. RNA, protein synthesis and processing (14 hrs.)

RNA synthesis and processing

4.1Transcription factors and machinery, Formation of initiation complex, Transcription activators and repressors.

4.2 RNA polymerases, capping, elongation and termination, RNA processing, RNA editing, splicing, polyadenylation.

4.3 Structure and function of different types of RNA, RNA transport.

4.4 Translation – ribosome formation of initiation complex, Initiation factors and their regulation, Elongation and elongation factors, termination.

4.5 Aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, Translational proof-reading, translational inhibitors,

4.6 Post- translational modification of proteins and protein targeting.

Module 5. Regulation in gene expression in bacteria, phage, and eukaryotes (12hrs.)

5.1 The Operon model: Lac operon and its eukaryotes regulation.

5.2 Tryptophan operon and its regulation, Regulation of gene expression in phages

5.3 Interaction with RNA, DNA binding proteins, gene dosage, gene amplification, regulatory transcription factors, Histone acetylation and deacetylation, epigenetic effects.

5.4 Regulation at transcriptional level: Activation of transcription, Repression of transcription

5.5 Regulation at translational level, Regulation by alternate pathways of transcript splicing.

5.6 Anti - sense RNA strategies for regulating gene expression, si RNA, mi RNA, Gene editing

Bioinformatics (25 hrs.)

Module 6. Introduction to Bioinformatics, Genome, Sequencing the Genome, Biological sequence Analysis (10hrs.)

6.1 Introduction to Bioinformatics: Scope of Bioinformatics, Research areas of Bioinformatics. Bioinformatics industries and Institutions

6.2 Genome: Organization of genome: Single sequence DNA, GC content, Molecular markers of DNA Fingerprinting & DNA Foot printing, Genome mapping

6.3 Sequencing the Genome: History of sequencing, Sanger's sequencing (Automated whole Genome shotgun sequencing), Next generation sequencing techniques. Comparative genomics and its application.

6.4 Biological sequence analysis: Concept of sequence alignment, Scoring matrices: PAM & BLOSUM; homology sequences using BLAST & FASTA programs. Multiple Sequence Alignment Tools: CLUSTAL, T-Coffee, MEGA

Module 7. Biological Databases & Evolutionary Analysis and Molecular Phylogeny (15hrs.)

7.1 Biological Databases: Classification and importance of biological databases; Nucleic acid databases: GenBank, EMBL, DDBJ; Protein Sequence Databases - SwissProt, PIR; Structure Database - RCSB PDB, Cambridge Structural *Database* (CSD); Chemical Structure Database: Pubchem, Derived Databases: InterPro, Prosite Pfam, Specialized Databases: OMIM, KEGG, Genecard, Viral Databases, Drugbank
7.2 Evolutionary Analysis and Molecular Phylogeny: Concept of Molecular Phylogeny, Types of trees, Components of trees, Distance based methods, Character based methods, Boot strapping, Phylogenetic software (PHYLIP, PAUP, MEGA), Tree viewing software (NCBI Tree viewer, iTOL, Newick viewer)

Activities, Learning resources and Assessment
Suggested Activities

1. Written Examinations
2. Seminars
3. Assignments
4. Poster Presentations
5. PowerPoint presentations
6. Preparation of videos
7. Flip Classroom assignments
8. Quizzes using Mentimeter app
9. Model preparations
10. Online tools demonstrations

Learning Resources

REFERENCES

Cell and Molecular Biology

1. Harvey Lodish, Arnold Berk, Sipursky, Matsudaria, David Baltomore and Darnell, (2002). Molecular Cell Biology, W.W. Freman and Company.
2. Gerald Karp. (2005). Cell and Molecular Biology, John Wiley and Sons, Inc. USA
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25. Andrew Read and Dian Donnai. (2007). New Clinical Genetics. Scion Publishing Ltd.

Bioinformatics

1. Alberghina, L and H.V. Westerhoff (Eds). (2008). Systems Biology-Definitions & Perspectives. Springer-Verlag, Berlin.
2. Attwood T.K. and Parry Smith, D. (2006). Introduction to Bioinformatics. Pearson Education.
3. Bourne P. E and Weissig H. (2003). Structural Bioinformatics. Wiley - Liss. USA.
4. David W. M. (2004). Bioinformatics, Sequence and Genome Analysis (2ndedn). CSHP, New York
5. Krane, D. E and M.L. Raymer (2006). Fundamental concepts of Bioinformatics. Pearson Education, New Delhi.
6. Lesk A. M. (2005). Introduction to Bioinformatics. Oxford Press, New Delhi.
7. Pengcheng Fu and Sven Panke, (Eds.) (2009). Systems Biology and Synthetic Biology. John Wiley & Sons, Inc. NJ, USA.
8. Tisdall J. D. (2001). Beginning Perl for Bioinformatics. O"Reilly Media Inc. CA, USA
9. Masaru Tomita and Takaai Nishioka (2005). Metabolomics. The Frontier of Systems Biology. Springer Japan.

Assessment: 25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. written examination

SEMESTER 2 COURSE CODE ZO524 (120hrs.)

Name of the Course: Advanced Physiology, Functional Anatomy, Genetics, Biostatistics, Bioinformatics, Cell, and Molecular Biology - Practical 2

COURSE OUTCOMES

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

CO1: Quantify blood cells and the effect of tonicity on diameter of RBC.
CO2: Develop skills in biostatistical methods and tools in analyzing data and representation of data using appropriate software.
CO3: Prepare slides of giant chromosome.
CO4: Develop skills in mounting of mouth parts of insects and interpretation of its feeding preferences.
CO5: Learn methods and techniques of biochemical assays.
CO6: Gain skills in enzyme assays and estimate the effect of pH on enzyme activity.
CO7: Develop skills in histological localization of protein and glycogen in paraffin sections.

A. **Physiology and Functional Anatomy**

1. Effect of pH on salivary amylase on starch (colorimetric method).
2. Effect different concentrations of NaCl (0.1% to 2%) on the diameter of RBCs using micrometry.
3. Estimation of RBCs and WBCs in vertebrate blood.
4. Blood histology of earthworm and fish.
5. Studies on feeding-Mounting of mouth parts of housefly, honey bee and mosquito in relation to food and feeding.
6. Observation of mitochondria in yeast cells.
7. Observation on ciliary movement in bivalve gills in relation to temperature and pH.

B. Genetics and Biostatistics

8. Calculation of Mean, median, mode of the given biological data.
9. Calculate the Standard deviation, Standard error of the given data.
10. Hypothesis testing of the given biological data using Students' t-test.
11. Calculation of correlation coefficient & regression using the given biological data.
12. Non parametric tests: Sign Tests, Spearman's Rank Correlation test using the given biological data.

C. Cell and Molecular biology

13. Chromosome study - Squash preparation of Drosophila/Chironomus larvae
14. Study of meiosis - Squash preparation of grasshopper testis.
15. Histological localization of protein in paraffin sections.
16. Histological localization of glycogen in paraffin sections.
17. Estimation of DNA from tissue extract.

D. Bioinformatics

18. Familiarising the Databases-National Center for Biotechnology Information (NCBI), Protein Database (PDB), EMBL, DDBJ, OMIM, KEGG.
19. Visualize biomolecules (DNA, RNA, Protein) using software (Rasmol, PyMol)-Any one software
20. Sequence similarity search using NCBI- BLAST.
21. Pairwise and Multiple sequence alignment of DNA and protein sequences using BioEdit/ClustalW/ MEGA.
22. Construction of Phylogenetic tree using MEGA.
23. Downloading and visualisation of 3-D structure of Protein using PDB.

Activities, Learning resources and Assessment

Suggested Activities

1. Field visits
2. Field collections
3. Preparation of insect boards
4. Preservation and display of specimens
5. Preparation, analysis, and presentation of biological data
6. Scientific Drawing of specimens
7. Skill in handling, calibration and operation of instruments and lab equipment
8. PowerPoint presentations
9. Model preparations
10. Visit to laboratories and instrumentation facilities of Universities and Research institutes
11. Submission of Records for Continuous Evaluation

Learning Resources

References

Books

1. Hardd Varley. (2015). Practical clinical Biochemistry
2. Ranjana Chawla. (2014). Practical Clinical Biochemistry – Methods and interpretations.
3. Philip B. Hawk. (1907). Hawk's Practical Physiological Chemistry
4. Jayaraman (2020) , Practical Biochemistry. ISBN 9788122430493 New age Publishers p.166.
5. Brown T.A. (1998). Molecular biology Lab Fax. Vol. 1. Recombinant DNA. II Ed. Academic Press.
6. Brown, T.A. (2007). Essential Molecular Biology a practical approach Vol.2. II Ed. Oxford University press.
7. Don Anson (2007). Reporter Genes: A Practical Guide (Methods in Molecular Biology) Hardcover
8. Michael R. Green, Joseph Sambrook (2012). Molecular Cloning a l a b o r a t o r y m a n u a l fourth edition
9. Plummer, David T. (2007). An introduction to Practical Biochemistry, III Ed. Tata Mc Graw-Hill, New Delhi.
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11. Wilson Keith and Walker John (2006). Principles and Techniques of Biochemistry and Molecular Biology VI Ed., Cambridge University Press.

Links

1) https://www.ncbi.nlm.nih.gov
2) https://blast.ncbi.nlm.nih.gov/Blast.cgi
3) https://www.ddbj.nig.ac.jp/index-e.html
4) https://www.rcsb.org
5) https://www.omim.org
6) https://www.genome.jp/kegg
7) http://www.openrasmol.org
8) https://pymol.org
9) https://bioedit.software.informer.com
10) https://mega.io
11) https://www.genome.jp/tools-bin/clustalw
12) http://vassarstats.net

Assessment:

25% Continuous Evaluation, 75% End Semester Evaluation: 4Hrs. Practical Examination

SEMESTER 3 COURSE CODE ZO531

Name of the Course: Microbiology & Biotechnology

COURSE OUTCOME

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

CO1: Understand the ultra-structure of bacteria.
CO2: Understand nutrition, growth, and communication of microbes.
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.

Part A Microbiology (50 hrs.)

Module 1. Introduction, Bacterial Cell structure and function (15 hrs.)

1.1 Classification of bacteria, Bergey's Manual- Editions, and volumes (1 to 5)
1.2 Extremophiles.
1.3 Ultrastructure of bacteria-cell membrane, vacuoles, cytoplasmic inclusions,
1.4 Bacterial Cell Wall- structure, differences between gram, positive and negative cell wall, mechanism of gram staining.
1.5 External components & their functions – pili/fimbriae, flagella capsules, slime layers, mention mechanism of flagellar action.

Module 2. Microbial Nutrition, Growth and Communication (15 hrs.)

2.1 Common nutritional requirements of microorganisms- autotrophy and heterotrophy.
2.2 Types of culture media- Supportive (general purpose), Enriched, Selective, Differential, Culture methods.
2.3 Microbial growth – Lag, exponential, stationary, death phase, generation time, mention viable but nonculturable (VBNC), influence of environmental factors on growth, measurement of growth.
2.4 Cell to cell communication within microbial population, Quorum sensing and biofilm.

Module 3. Industrial & Environmental and Medical Microbiology (20 hrs.)

3.1 Concept of fermentation. Basis design and types of fermenters, types of fermentation-submerged, solid state.
3.2 Products of Industrial Microbiology – Alcohol, Antibiotics (e.g. Penicillin), Organic acids (e.g. Acetic acid, Lactic acid).
3.3 Microbiology of milk & foods. Preservation of milk, Pasteurization techniques. Probiotics.
3.4 Bioremediation- microbial treatment of waste water and solid wastes, microbial treatment of radioactive wastes and xenobiotics.
3.5 Host-microbe interaction-process of infection, pathogenicity, virulence & infection, microbial adherence, penetration of epithelial cell layers and events in infection. following penetration, Infection of blood, lymphatic system.
3.6 Control of Microorganisms –Physical & chemical methods.
3.7 Antibiotic resistance mechanisms, transmission of drug resistance, mention MDR, XDR, NDM and Pan-Drug resistance.

Part B: Biotechnology (50 hrs.)

Module 4. Recombinant DNA technology (20 hrs.)

4.1 Gene cloning – Construction of chimeric DNA (Blunt end ligation, cohesive end ligation, homopolymer tailing, use of adaptors, linkers), Selection of transformed cells –blue white selection method, colony hybridization, Plaque hybridization.

4.2 Vectors (map, general features and applications): Cloning vectors, Shuttle vectors and expression vectors: Plasmids (pBR322, pUC, Ti plasmids), Phage vectors (Lambda Phage, M13), Cosmids, Phagemids, Artificial chromosomes-BAC, YAC.

4.3 Enzymes used in rDNA technology -Restriction endonucleases, DNA modifying enzymes and Ligases

4.4 Methods of gene transfer – Electroporation, calcium chloride, calcium phosphate precipitation, dextran mediated transfer, microinjection, Gene gun, ultra sonication, Liposome, Agrobacterium mediated gene transfer.

Module 5. Biotechnology and Healthcare (15 hrs.)

5.1 Transgenic Animals and plants-Production and Application, molecular pharming, mention pros and cons of Genetically modified organisms (GMO's)

5.2 Useful products- Vaccines, Humulin, Erythropoietin, Growth Hormone/Somatostatin, tPA, Interferons

5.3 Biosensors and Biochip

5.4 Diagnosis of diseases

5.5 Gene therapy

5.6 Transplantation of bone marrow, artificial skin,

5.7 DNA finger printing

Module 6. Recent Trends in Biotechnology (15 hrs.)

6.1 Synthetic Biology– Genome designing, artificial cells, protein engineering, applications of synthetic biology

6.2 Real-Time PCR-Principle and applications

6.3 Stem cells and regenerative medicine-Induced pluripotent stem cells (iPS)

6.4 Next Generation sequencing –Methods, Principle, and applications

6.5 Gene silencing- Antisense RNA Technology, RNA interference, microRNA, DICER, RISC, Applications

6.6 Gene knockout technology: methods and applications

6.7 CRISPR-CAS9 system

6.8 Ethical, legal, and social issues of Biotechnology

Activities, Learning resources and Assessment

Suggested Activities

1. Written Examinations
2. Seminars
3. Assignments
4. Poster Presentations
5. PowerPoint presentations
6. Preparation of video
7. Debate
8. Model preparation

Learning Resources

References:

1. Prescott's Microbiology. 2017. Joanne Willey, Linda Sherwood. Christopher J.Woolverton. McGraw Hill, 10th edition
2. Microbiology. 2018. An Introduction. Tortora, Funke & Chase. 13th edition. Pearson; 13th edition
3. Microbiology. 2023. Pelczar, Reid and Chan. Assorted Editorial 5th Edition
4. Introductory Food Microbiology. H. A. Modi. 2007. Pointer Publishers; 1st edition.
5. Text Book of Microbiology. 2013. Ananthanarayanan, R. and Jayaram Panikar, C.K. University Press, Hyderabad.
6. Thomas J Montville, Karl R. Mathews. 2017. Food Microbiology - An Introduction
7. Jeffrey C. Pommerville Jones & Bartlett Learning 2013.Alcamo's Fundamentals of Microbiology.; Tenth edition
8. Casida L. E. J. R. 2019. Industrial Microbiology. New Age International Pvt Ltd Publishers
9. Dubey R.C. & Maheshwari D.K. S. Chand. 2023. A Textbook of Microbiology.
10. Arvind H. Patel. 2022.Industrial Microbiology. Laxmi Publications; Second edition

Biotechnology

1. Glick and Patten. 2017. Molecular Biotechnology: Principles and Applications of Recombinant DNA. Taylor & Francis; 5th edition.
2. Primrose S.B. 2014. Principles of Gene Manipulation and Genomics. John Wiley Blackwell.
3. Biotechnology. 2020. Sathyanarayana, U. Books and allied (p) Ltd.
4. Biotechnology 2015. Singh, B.D. Kalyani publishers.
5. Text book of Biotechnology 2007 Das, H.K. Wiley India Pvt. Ltd. New Delhi.
6. Molecular Biology and Biotechnology 2021. Ralph Rapley. Royal Society of Chemistry; 7th edition.
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.
9. Bernard R. Glick, Cheryl L. Patten, Terry L. Delovitch. 2013. Medical Biotechnology: Principles and Applications of Recombinant DNA ASM Press.
10. A Textbook of Biotechnology. 2022. Chand and Company Ltd.

Assessment:

25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. written examination

SEMESTER 3 COURSE CODE ZO532

Name of the Course: Ecology, Ethology and Biodiversity Conservation

COURSE OUTCOME

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

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: Generate interest in biodiversity among the learns and understand the conservation strategies in India
CO6: Analyze the importance of international conventions, treaties for the conservation of global biodiversity

COURSE CONTENT

Part A: Ecology (30 hrs.)

Module 1. Ecological Energetics, Transition and Stability in Communities (15 hrs.)

1.1 Solar energy. Solar irradiance – Chemosynthesis. Energy flow - Unidirectional model. Mention Y-shaped energy flow model.

1.2 Ecological succession: Types (Primary succession, Secondary succession), Causes of succession (Autogenic succession, Allogenic succession).

1.3 Mechanisms of succession - (Nudation, Migration, Ecesis, Competition, Reaction, Stabilisation). Seral communities. Changes in animal life. Micro-succession. Climax community – Characteristics, types of climax. Monoclimax and polyclimax theory. Examples of succession – (Succession in an aquatic ecosystem, succession in a terrestrial ecosystem)

Module 2. Concepts of Habitat, Niche, Guild and Species Interactions (15 hrs.)

2.1 Habitat, microhabitat and niche. Different types of niches: Grinnellian niche, Eltonian niche, Hutchinsonian niche. Contemporary niche theory. Niche overlap. Gaia hypothesis.

2.2 Competitive exclusion principle, resource partitioning, compression hypothesis, concept of guild, character displacement, ecological equivalents.

2.3 Intra and interspecific interactions: Types of Interspecific interactions – (Positive, Negative and Neutral), Positive interactions (commensalism, proto-cooperation, mutualism and pollination). Negative interactions (competition, parasitism, amensalism, predation, herbivory, carnivory).

2.4 Co-evolution: Mutualism (Insects and insect-pollinated flowers, Birds and bird-pollinated flowers, Acacia ants and Acacias, Hosts and parasites, Mention Antagonistic coevolution, Mention Geographic mosaic theory.

Part B: Ethology (30 hrs.)

Module 3. Learning , Behaviour and Nervous System Biological communications (20 hrs.)

3.1 Classification of learning: Imprinting, habituation, imitation, classical conditioning, instrumental/operant conditioning, cognitive learning, latent learning, insightful learning, Models on the organization of instinctive behaviour, Psycho-hydraulic model of Lorenz and Hierarchical Model of Tinbergen.

3.2 Neural basis of behaviour, Stimulus filtering and behaviour, Evolutionary and neurological basis of behaviour, sign stimulus, innate release mechanism and fixed action plans (FAPs).

3.3 Brain centres and learning, neural mechanism of learning and memory, Hormonal influence on behavior, Factors influencing effects of hormones on behaviour.

3.4. Biological communications: Means of communications in animals, physical, behavioural and chemical means of communication, pheromones or semiochemicals in animals, Lee Boot effect, Whitten effect, Parental care, Bruce effect, Coolidge effect, Vandenbergh effect, Anthropogenic impacts on animal behavior.

Module 4. Complex behaviour patterns, Environment, Genetics, and Evolution of behaviour (10 hrs.)

4.1 Orientation, Navigation and homing, Migration (Fishes and birds)

4.2 Biological rhythms – biological clock, circadian, circannual, lunar, tidal and seasonal periodicities, sleep and arousal, genetics of biological rhythms.

4.3 Habitat selection and territoriality.

4.4 The evolution of communication; Development of bird song., The evolution of reproductive behaviour and mating systems.

PART C: **Biodiversity Conservation (40hrs.)**

Module 5. Biodiversity & Conservation Biology (30hrs.)

5.1 Diversity indices: Alpha diversity, Beta diversity and Gamma diversity. Species diversity and ecosystem stability.

5.2 Biodiversity in India: Major biogeographic zones of India; India as a mega diversity nation; hot spots biodiversity – characteristics; an outline of the features and biodiversity of hot spots in India (Western Ghats and Eastern Himalaya). Terrestrial ecosystems of India: Forests- characteristic features, biodiversity, ecosystem services, degradation, and management strategies; Grasslands- characteristic features, biodiversity, ecosystem services, degradation, conservation; Deserts- characteristic features, climate, and biodiversity). Freshwater ecosystems - characteristic features, types-lentic and lotic, biodiversity, threats, climate change. Marine ecosystems - characteristic features, biodiversity, ecosystem services and threats and conservation strategies. Estuaries – types, salinity variation, biodiversity, human impact.

5.3 Depletion of biodiversity: Current estimates of species loss, causes of biodiversity loss, impacts of biodiversity loss, Strategic species concepts: keystone species, indicator species, umbrella species, flagship species.

5.4 Strategies of biodiversity conservation: *in situ* and *ex situ* conservation, Gene Banks, establishment of protected areas, habitat conservation, public awareness and other relevant measures. Restoration ecology, need and uses. Karanji lake restoration in India (Brief account only).

5.5 Project tiger, Project elephant. World Conservation Strategy (1980), National Biodiversity Action Plan 2008 (Brief account only).

Module 6. International Conventions & Treaties for conservation of Biodiversity (10hrs.)

6.1 Stockholm declaration on human Environment (1972), Earth summit (1992) Kyoto Protocol and Framework Convention on Climate Change (UNFCCC), Brundtland Report (1987). Rio Declaration on Environment and Development, Agenda 21, Forest Principles.

6.2 Convention on Biological diversity. Species based treaties: Migratory Bird Treaty Act (MBTA) of 1918, International Convention for the Regulation of Whaling (ICRW), Washington, 1946, Convention for the Conservation of Antarctic Seals,1972.

6.3 Convention on International Trade on Endangered Species (CITES,1975), Ecosystem based treaty: Ramsar Convention (1981) – Ramsar sites in India and Kerala.

Activities, Learning resources and Assessment

Suggested Activities

1. Written Examinations
2. Seminars
3. Assignments
4. Poster Presentations
5. PowerPoint presentations
6. Preparation of video
7. Debate
8. Visit to zoo, sanctuaries, national parks
9. Survey
10. Model preparation

Learning Resources

References

Ecology & Biodiversity

1. Beck, W.S., Liem, K.F. & Simpson, G.G. (1991). Life: An introduction to biology (third Ed.). Harper Collins Publishers, New York, pp 1361. ISBN: 0 06 500009 9.
2. Bharucha, E. (2005). Textbook of environmental studies. Universities Press (P) Ltd, India, pp 276. ISBN 81 7371 540 8.
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6. Donald Van De Veer and Christine Pierce (2003). The environmental ethics & policy book (third Ed.). Wadsworth-Thomson Learning, Canada. ISBN: 0 534 56188 8.
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11. Odum, E.P & Barrett, G.W. (2006). Fundamentals of ecology. Thomson/Brooks and Cole, India, pp 598. ISBN: 81 7648 552 7.
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0 03 096575 6.
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17. Eldon, D.E. & Bradley, F.S. (2006). Environmental science - A study of Interrelationships (12th Ed). McGraw-Hill Higher Edition. ISBN: 007252829x.
18. Manuel C. & Molles Jr. (2009) Ecology: Concepts and applications (fifth Ed). McGraw- Hill International Education. pp 604. ISBN-13: 9780070171688

Ethology

1. Alcock, J. (2001). Animal Behaviour- An evolutionary approach (7th Ed.) Sinaur Associates, Inc. ISBN-10: 0878930116
2. Bear, F.M., Connors, B.W. & Paradiso, M.A. (2001). Neuroscience, exploring the brain (2nd Ed). Lippincott Williams & Wilkins, Baltimore, pp 855. ISBN: 0 683 30596 4
3. Gleitman, H., Fridulund, A.J. & Reisberg, D. (1998). Psychology (2nd Ed.). W.W Norton & Company, Inc., New York, pp 849. ISBN: 0 393 97364 6.
4. Bradbury, J.W. & Vehrencamp, S.L. (1998). Principles of animal communication (second Ed). Sinauer Associates, Inc., Sunderland, Massachusetts, USA.
5. Clutton-Brock, T.H. (1991). The evolution of parental care. Princeton University Press, Princeton, NJ, USA. Pp 368. ISBN: 9780691025162.
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7. Gould, J.L. (1982). Ethology: The mechanisms and evolution of behaviour. W.W. Norton & Company, Inc., New York. ISBN-10: 0393014886
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Assessment:
25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. written examination

SEMESTER 3 COURSE CODE ZO533 (100 hrs.)

Name of the Course: Immunology & Developmental Biology

COURSE OUTCOMES

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

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.

Part A: Immunology (40 hrs.)

Module 1. Overview of the Immune System & Immunogenicity and Antigenicity (15 hrs.)

1.1. Cells, tissues, and organs involved in immune system.

1.2. Haematopoiesis- B-cell and T-cell maturation and differentiation and B- cell and T cell receptors. Properties of B-cell and T-cell epitopes.

1.3. Phagocytosis & inflammatory response.

1.4. Factors that influence immunogenicity.

1.5. Immunogens & Properties, Haptens, Adjuvants, Epitopes.

1.6. Immunoglobulins - Structure, classes and functions, Antigenic determinants of immunoglobulin - (a) Isotype (b) Allotype (c) Idiotype.

1.7. Immunoglobulin genes - Multigene organization.

1.8. Generation of antibody diversity.

1.9. Hybridoma technology, Monoclonal antibodies, and applications.

Module 2. Antigen –Antibody Interactions & Complement system (10 hrs.)

2.1 Antigen-antibody interaction- Primary and secondary immune response, Types of antigen-antibody reactions: Cross-reaction, Precipitation, Agglutination.

2.2 Clonal selection theory.

2.3 Antibody affinity and avidity.

2.4 The Complement System: Complement Activation - Classical, Alternate and Lectin Pathways, Terminal sequence of complement activation (MAC).

2.5 Regulation of complement system.

2.6 Biological consequences of complement activation.

2.7 Complement deficiencies.

Module 3. Hypersensitivity, Graft rejection & Defects in Immune mechanisms (15 hrs.)

3.1 Hypersensitivity: Types of Hypersensitivity- IgE- mediated (type- I) hypersensitivity. Antibody-mediated cytotoxic (type- II) hypersensitivity. Immune complex- mediated (type- III) hypersensitivity. Delayed type (type- IV) hypersensitivity. Stimulatory (type V) hypersensitivity.
3.2 Transplantation immunology.
3.3 Immunologic basis of graft rejection and Clinical manifestation of graft rejection.
3.4 General and specific immunosuppressive therapy.
3.5 Major Histocompatibility Complex: General organization and inheritance of MHC, MHC genes, HLA Complex in humans, MHC-peptide interaction, Expression of MHC molecules on different cell types.
3.6 Biological significance of MHC and HLA typing.
3.7 Antigen processing and presentation Immunity in health and disease.
3.8 Congenital immunodeficiency diseases (SCID, WAS, CGD, LAD, AIDS).
3.9 Autoimmunity: Organ-specific autoimmune diseases, Systemic auto-immune diseases.

Part B: Developmental Biology

Module 4. Concepts of Fertilization, Development & Embryonic induction (20 hrs.)

4.1 Events in fertilization, cytoplasmic changes, nuclear changes, Polyspermy and prevention of polyspermy.
4.2 Zygote formation, cleavage, blastula formation, gastrulation, and formation of germ layers in animal,
4.3 Significance of Orgniser and Nieuwkoop centre.
4.4 Induction and competence, reciprocal and sequential induction events (eye lens induction, regional specificity of induction).
4.5 Instructive and permissive interactions, epithelial- mesenchymal interaction, Genetic specificity of induction.
4.6 Potency, stem cells and commitment, specification.
4.7 Genomic equivalence and Differential gene expression.

Module 5. Developmental model systems (25 hrs.)

5.1 Early development and axis specification in *Caenorhabditis elegans.*
5.2 Early development and axis specification in Drosophila (cleavage, mid-blastula transition, gastrulation). Anterior posterior patterning in Drosophila (Maternal effect genes, zygotic genes, gap genes, pair rule genes, segment polarity genes; homeotic selector genes, realisator genes), Dorsal and ventral patterning and left right patterning, Dorsal protein gradient.
5.3 Mechanism of axis formation in Amphibians and Chick, Hox cluster genes, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development-larval formation, metamorphosis; environmental regulation of normal development.

Module 6. Assisted reproductive technology & Cloning (15 hrs.)

6.1 IVF-ET - General protocol – Patient selection, Controlled ovarian stimulation, superovulation, Oocyte retrieval, Sperm preparation, IVF and Embryo transfer.
6.2 Gametic Intra Fallopian Transfer (GIFT), Zygotic Intra Fallopian Transfer (ZIFT), Tubal Embryo Stage Transfer (TET), Intracytoplasmic Sperm Injection (ICSI), Intrauterine Insemination (IUI).
6.3 Amphibian cloning, Human cloning.
6.4 Prospects and demerits of human cloning.

Activities, Learning resources and Assessment

Suggested Activities

1. Written Examinations
2. Seminars
3. Assignments
4. Poster Presentations
5. PowerPoint presentations
6. Preparation of video
7. Debate
8. Model preparation

Learning Resources

References:

Immunology

1. Abbas, K. Abul and Lechtman H. Andrew (2003). Cellular and Molecular Immunology. V Edition, Saunders Publication
2. Akihiko Yoshimura, Tetsuji Naka and Masato Kubo, (2007). SOCS proteins, cytokine signalling and immune regulation, Nature Reviews, Immunology, 7:454-465.
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6. Christopher K. Garcia and Erin J. Adams, (2005). How the T Cell Receptor Sees Antigen—A Structural View, Cell, Vol. 122: 333– 336, Elsevier Inc.
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10. Kenneth Murphy and Casey Weaver. Janeway's Immunobiology. (2016). IX Edition, Garland Science.
11. Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J. (2006). Immunology, VI Edition, W.H. Freeman and Company.
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Developmental Biology

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7. Wolpert, L. (2002). Principles of Development. II Edition, Oxford University Press.

Assessment:

25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. written examination

SEMESTER 3 COURSE CODE ZO534 (120hrs.)

Name of the Course: Microbiology, Biotechnology, Ecology, Immunology & Developmental Biology- Practical 3

COURSE OUTCOMES

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

CO1: Develop skills in microbial enumeration and determination of quality of milk.
CO2: Develop knowledge on isolation DNA from tissues.
CO3: Identify blood cells and blood groups and able to detect pregnancy using test kits.
CO4: Develop skills in induced breeding in fishs and regeneration studies in planarians.
CO5: Develop expertise in vital staining of chick blastoderm and tracing the development.
CO6: Gain ability to identify the types of eggs and placenta of animals.
CO7: Estimate pyramid of numbers and biomass in an ecosystem.
CO8: Acquire estimate diversity indices using PAST software.

A. Microbiology and Biotechnology

1. Enumeration of bacteria from water sample (Serial dilution and pour plate method, Demonstration only)
2. Motility Testing – hanging drop method.
3. Gram staining of bacteria.
4. Determination of quality of milk-methylene blue reductase test.
5. Isolation of DNA from plant/animal tissue.
6. Culturing of paramecium to observe ciliary movement.

B. Immunology

7. Antigen-antibody interaction in vitro and identification of blood groups.
8. Blood film preparation and identification of cells.
9. Detection of pregnancy using kits.

C. Developmental Biology

10. Induced ovulation and artificial fertilization.
11. Induced breeding of fishes using OVAPRIM.
12. Regeneration studies in planarians.
13. Vital staining of chick blastoderm and tracing the development of stained parts (window method).
14. Study of different types of eggs: insect egg, frog's egg, hen's egg, mammalian egg- models/charts
15. Morphological and histological studies of different placental types of mammals (3 Nos.).
16. Identification of cross sections of chick embryo through heart, eye, and ear.

D. Ecology

17. Estimation of pyramid of numbers and biomass in a small ecosystem.
18. Estimation of Primary productivity using dark and light bottles.
19. Description of ecological adaptations of any 10 organisms.
20. Habituation in Pila/Alarm response in fishes/Maize learning in rats.
21. Study of following biodiversity indices and estimation using PAST (PAleontological STatistics) programme: Shannon-Wiener index, Dominance index, Margalef index, Simson index, Evenness

index.

22. Assessment of Invertebrate and Vertebrate diversity in your locality (e.g. campus, wetland, pond).
23. Quantitative estimation of plankton.
24. Poster Presentation on a relevant topics (e.g. International conventions and treaties, species interactions, biodiversity loss, etc.).

Activities, Learning resources and Assessment

Suggested Activities

1. Field visits to ecologically important places
2. Assessment of invertebrate and vertebrate diversity in your locality
3. Plankton collection from freshwater pond ecosystem and analysis
4. Scientific Drawing of specimens
5. Skill in handling, calibration and operation of instruments and lab equipment
6. PowerPoint presentations
7. Models and chart preparations
8. Visit to laboratories and instrumentation facilities of Universities and Research Institutes
9. Setting up of fish breeding and spawning tanks
10. Submission of Records for Continuous Evaluation

Learning Resources

References

Microbiology and Biotechnology

1. Cappuccino, J.G. and Sherman, N. (2007). Microbiology: A Laboratory Manual Published by Benjamin-Cummings Publishing Company, USA.
2. Kannan, N. (2002). Lab Manual in General Microbiology Panima Publishing Company, India.
3. Talwar, G.P. and Gupta, S.K. (2002). A handbook of practical and clinical immunobiology (2nd Edition) CBS Publishers, India.
4. Wilson, K. and Walker, J. (Eds.) (1995). Practical biochemistry - Principles and Techniques. Cambridge University Press.
5. Bauerfeind R., A. Von Graevenitz, P. Kimmig, H. G. Schiefer, T. Schwarz, W. Slenczka, and H. Zahner (2015). Zoonoses: Infectious Diseases Transmissible from Animals to Humans, ASM Press
6. Chakraborty, P. A. (2009). Text Book of Microbiology. New Central Book Agency, New Delhi
7. Childs JE., Mackenzie J. S., Richt, J. A. (2007). Wildlife and Emerging Zoonotic Diseases: The Biology, Circumstances and Consequences of Cross-Species Transmission, Springer
8. Claus, W.G. (1989). Understanding microbes: A laboratory text book for Microbiology. W.H. Freeman & Company,
9. Ausubel, F. M., Brebt, R., Kingston, R. E., Moore, D.D., Seidman, J. G., Smith, J. A. and Struht, K. (2002). Short Protocols in Molecular Biology. John Wiley and Sons Inc.
10. Sambrook, J. and Russell, D.W. (2001). Molecular cloning: A laboratory Manual. CSHL Press, New York.
11. Wilson Keith and Walker John (2006). Principles and Techniques of Biochemistry and Molecular Biology, Sixth Ed., Cambridge University Press, New York.

Immunology

1. Balakrishnan, S., Kaliaperumal, K. and Duraisamy, S. (2017). Practical Immunology - A Laboratory Manual. Lap Lambert Academic Publishing
2. Detrick, B., Robert G. Hamilton, R. G. and, James D. Folds, J. D. (2006). Manual of Molecular and Clinical Laboratory Immunology, 7th Edition. ASM Press, Washington DC
3. Hay F. C. and Westwood O. M. R. (2002). Practical Immunology. Wiley- Blackwell
4. Talwar, G. P. and Gupta, S. K. (2006). A handbook of practical and clinical immunobiology (2nd Edition) CBS Publishers, India.
5. Wilson, K. and Walker, J. (Eds.) (1995). Practical Biochemistry - Principles and Techniques. Cambridge University Press

Developmental Biology

1. Charles F. Lytle and John R. Meyer (2005). Laboratory Manual: Required: "General Zoology Laboratory Guide" (14^{th} ed.)
2. Dounersberger, Anne B., Lesak, Anne C. and Timmons, Maichael, J. (1992). A Laboratory Text Book of Anatomy and Physiology. 5 th Ed. D. C. Heath and Co.
3. Hill R. W., Wyse, G. A. (1989). Animal Physiology, 2^{nd} Ed. Harper Collins Publishers Inc. New York. 88-91 pp.
4. Schmidt-Nielsen, K. (1997). Animal Physiology, Adaptation and Environment, 5^{th} Ed. Cambridge University Press, New York. 174- 175 pp.
5. Arvy, L. (1971). Histoenzymology of the endocrine glands. Pergamon Press, Oxford,

Ecology

1. Rice, E. W., Baird, R.B, Eaton, A.D., Clesceri, L.S. (edited). (2017). Standard methods for the examination of water and wastewater. 22^{nd} editions. American Public Health Association, American water, Water environment federation. APHA 22^{nd} Edition
2. Michael, P. (1984). Ecological methods for field and laboratory investigations. Tata –McGraw –Hill Publ. Company.
3. Grainer, J. M. and Lynch, J. M. (1984). Microbial methods for Environmental Biotechnology. Academic Press
4. Manual on Sewerage and Sewage Treatment (1980). Ministry of Works and Housing, New Delhi
5. George, T., Franklin, L. Burton and David, S. H. (2002). Waste Water Engineering, Metcalf and Eddy. 4 th Ed. INC Tata McGraw Hill.
6. Webber, W. J. (1972). Physicochemical Processes: For Water Quality Control. Wiley inter-science
7. Arceivala, S. J. and Asolaker, S. R. (2007). Waste Water Treatment for Pollution Control and Reuse. Tata McGraw Hill Education.
8. Indian Standard for Drinking Water. (2012). Bureau of Indian Standards, New Delhi

Assessment:
25% Continuous Evaluation, 75% End Semester Evaluation: 4Hrs. Practical Examination

SEMESTER 4 SPECIAL COURSES (100hrs.)

Special Course: Endocrinology

Special Course 1 ZO 541: Vertebrate Endocrinology

COURSE OUTCOMES

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

CO1: Understand the morphology and anatomy of endocrine glands
CO2: Acquire knowledge about the mechanism of hormone action
CO3: Understand the types of growth factors, mechanism, and its functional role in cellular activities
CO4: Understand the relationship of hormones to carcinogens and development of cancers
CO5: Impart knowledge on functional role of hormones in animal behaviour
CO6: Acquire knowledge the methods and techniques in endocrine research.

Module 1. Introduction (5 hrs.)

1.1 Historical perspective

1.2 General classes of chemical messengers, Peptide hormones, steroid hormones, bioamines, eicosanoids, chalones, neurotransmitters, neuropeptides, neurosteroids, neurohormones, lumones, phytohormones, synthetic hormones.

Module 2.. Vertebrate endocrine glands (30 hrs.)

2.1 Morphology and anatomy of endocrine glands.

2.2 Biosynthesis of hormones (Mention key enzymes).

2.3 Functions of hormones.

2.4 Disorders of hormonal imbalance.

2.5 Hypothalamus and its secretions.

2.6 Hypothalamo-hypophysical interaction.

2.7 Eicosanoids-Biochemistry and biological action, Prostaglandins, prostacyclins, thromboxanes, leukotrienes.

2.8 Evolution of endocrine glands-a brief account.

Module 3. Mechanism of hormone action (30 hrs.)

3.1 General and Molecular mechanism of action of amines, Polypeptide, and steroid hormones.

3.2 Hormone receptors, Receptors as mediators of endocrine signals, Classification of endocrine receptors, Measurement of receptor ligand interaction.

3.3 Cell surface receptors (Mode of action of peptide hormones), Receptor structure, Regulation of receptor number.

3.4 Second messengers of hormonal action, Cyclic nucleotides, Inositol triphosphate, Diacyl glycerol; Genomic action of cAMP.

3.5 Signal transduction, G proteins and dual control of adenylate cyclase, receptor crosstalk.

3.6 Receptor with tyrosine kinase activity, serine and threonine kinase activity, Receptors that are protein phosphatases, Receptors coupled with ligand gated ion channels.

3.7 Direct membrane action of steroid hormones-non genomic action.

Module 4. Cell growth factors **(5 hrs.)**

4.1 Types of growth factors-mechanism and its functional role in cellular activities: Somatomedins-IGC; Epidermal Growth factor (EGF) family; Transforming Growth factor β family (TGF β); Platelet derived growth factor (PDGF); Fibroblast growth factor (FGF).

4.2 Nerve Growth factor (NGF); Hepatocyte Growth factor (HGF).

Module 5. Hormones and Cancer **(10 hrs.)**

5.1 Relationship of hormones to carcinogens and development of cancers from inappropriate hormonal treatment.

5.2 Hormone related treatment of cancer.

5.3 Oncogenes and hormonal function.

5.4 Hormone receptor status of breast cancer.

5.5 Ectopic production of hormones by tumour cells.

Module 6. Functional Endocrinology **(10 hrs.)**

6.1 Role of hormones in behaviour of animals.

6.2 Hormonal control of reproduction.

6.3 Hormonal involvement in evolution.

6.4 Influence of hormones in developmental process.

Module 7. Endocrine methodology **(10 hrs.)**

7.1 Methods and techniques in endocrine research.

7.2 Histological and cytological methods; Surgical methods; Bioassays.

7.4 Radio isotopic studies-RIA, ELISA, EIA.

7.5 Nucleic acid approaches in endocrinology.

7.6 Recombinant DNA techniques and genetic engineering.

Activities, Learning resources and Assessment

Suggested Activities

1. Written Examinations
2. Seminars
3. Assignments
4. Poster Presentations
5. PowerPoint presentations
6. Model preparations
7. Visits to laboratories

Learning Resources

References

1) Mac. E. Hadley, 2000.Endocrinology- Prentice Hall. International
2) Jean D. Wilson and Daniel W.Foster. 1992.Williams Text Book of Endocrinology edited by, Saunders Company 8th Edn.
3) Elby-Elienne-Erulie Bautieu and Paul A. Kelly 1990. Hormones from Molecular to disease
4) Endocrinology-Basic and Clinical Principle- P. Michael Corn and Shlomo Mel Med.

Humana Press The Totowa. 1997.
5) Daniel O. Norris. 1997.Vertebrate Endocrinology- Academic Press. 3rd Edn.
6) Turner and Bangara. 2012. General and Comparative Endocrinology, Saunders Company
7) Bentley, P.J. 1997.Comparative Endocrinology-
8) Barrington, 1979. Hormones and Evolution
9) Anthony-W. Norman and Gerald Litwark. 1997. Hormones- -Academic Press.

Assessment:
25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. Written Examination

SEMESTER 4 SPECIAL COURSES (100hrs.)

Special Course: Endocrinology

Special Course 2 ZO 542: Physiology of Reproduction (With special reference to vertebrates)

COURSE OUTCOMES

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

CO1: Understand the structure of foetal and embryonic gonads and genital ducts basics and causes of different types of pollution.
CO2: Understand the physiology of female reproduction.
CO3: Understand the physiology of male reproduction.
CO4: Acquire knowledge about the human reproductive behaviour and health.
CO5: Understand the disorders of male and female reproductive systems.
CO6: Acquire knowledge about the application and uses of birth control devises and fertility regulation.

Module 1. Foetal and Embryonic Gonads and Genital Ducts (20 hrs.)

1. 1. Comparative anatomy of genital system in vertebrates.
1. 2. Origin of primordial germ cells.
1.3. Differentiation of the testis: Germinal epithelium, interstitial tissue, Foetal androgens and role.
1.4. Differentiation of ovary: Foetal estrogens and role.
1.5. Origin and differentiation of the genital ducts: Wolffian duct, mullerian duct.
1.6. Hormonal basis of sex differentiation.
1.7. Histology, cytology and endocrinology of the foetal gonads.
1.8. Disorders of sexual differentiation development: True hermaphroditism, Pseudohermaphroditism, Chromosomal errors and sex determination – Penile agenesis, Double Penis, Bifid Penis, Micropenis, Arcuate uterus, Double uterus.

Module 2. Physiology of female reproduction–I. Ovary & Reproductive cycles (12 hrs.)

2.1 Anatomy of female reproductive system- Gross anatomy and histology of ovary.
2.2 Ovarian hormones.
2.3 Folliculogenesis and oogenesis and their hormonal control.
2.4 Ovulation- Luteinization, Atresia.
2.5 Reproductive cycles- Oestrus and menstrual cycles- structural changes and hormonal control.

Module 3. Physiology of female reproduction– II. Implantation, Pregnancy, Parturition and Lactation

(18 hrs.)

3.1 Nidation, Desidualization.
3.2 Placentation- Types, Placental hormones and their regulation.
3.3 Physiology of pregnancy - Endocrine basis.
3.4 Development of foetal membranes- Amnion, chorion, allantois and yolk sac.

3.5 Physiology of parturition and endocrine control.
3.6 Infantile mammary gland, Pubertal changes in mammary gland, Structure of adult mammary gland.
3.7 Synthesis, composition and secretion of milk- galactopoesis- Milk let down.
3.8 Hormonal regulation of lactation.

Module 4. Physiology of Male reproduction: I. Testis, Reproductive tract and Accessory Reproductive Glands (15 hrs.)

4.1 Anatomy of male reproductive system- Testis, Vasa efferentia, Epididymis, Vas Deferens, Ejaculatory ducts, Urethra, Penis.
4.2 Accessory sex glands- Seminal vesicles, Prostate gland and Cowper's glands- Structure, cytology and functions.
4.3 Histology of testis- Sertoli cells, Leydig cells and rete testis – structure and functions.
4.4 Male sex act.
4.5 Temperature regulation of testicular function.
4.6 Testicular hormones- Androgens.

Module 5. Physiology of Male Reproduction - Spermatology (10 hrs.)

5.1 Spermatogenesis and its hormonal control.
5.2 Structure of a typical mammalian sperm, comparative morphology of sperms of mammals.
5.3 Physiological maturation of sperm – initiation of motility and capacitation.
5.4 Sperm motility and energetic- Factors affecting sperm motility.
5.5 Biochemistry of semen.

Module 6. Reproductive Behaviour & Health (17 hrs.)

6.1 Concept of puberty.
6.2 Adolescence- Somatic changes, psychological changes and hormonal changes.
6.3 Senescence.
6.4 Menopause.
6.5 Sex Education and its importance.
6.6 Adolescent sexual activity and adolescent stress management.
6.7 Sexual harassment and its impacts.
6.8 Sexually transmitted diseases.

Module 7. Fertility regulation and reproductive toxicology (8 hrs.)

7.1 Disorders of male and female reproductive systems- Sexual dysfunction.
7.2 Infertility in males and females – causes and curative measures.
7.3 Birth control devices.
7.4 Reproductive toxicology – effects of chemicals, drugs and alcohol on reproduction.
7.5 Fertility regulation in farm animals.

Activities, Learning resources and Assessment

Suggested Activities

1. Written Examinations
2. Seminars
3. Assignments
4. Poster Presentations
5. PowerPoint presentations
6. Model preparations
7. Visits to laboratories

Learning Resources

References

1. Leonard R. Johnson (Ed.) 2003.Essentials of Medical Physiology, , Academic Press.
2. Physiology of reproduction – Vol. I & II. Edited by E. Knobi & J.D. Neill. Raven Press, New York. 1994.
3. Human Reproductive Biology – R.E. Jones, Academic Press, London. 1997.
4. Comparative Endocrinology and Reproduction – Joy KP. Krishna A, Haldar L, Narosa Publishing House, New Delhi. 1999.
5. Male infertility and Sexual Dysfunction – W.J.G. Hellstrom, Springer-Verlag, New York. 1997.
6. Reproduction in Mammals. Vol. I and II. Edited by C.R. Austine & R.V. Short Cambridge University Press, London. 1986.
7. Principles of Vertebrate Reproductive Biology – HBD Sarkar, Himalaya Publishing House. 1993.
8. Current Concepts in Fertility Regulation. Edited by C.P. Puri and P.F. A. Van Look. Wiley Eastern Ltd. 1994.
9. Principles of Anatomy and Physiology 15th Edn ; G.I. Tortora and B.H. Derrickson, John Wiley & Sons Inc.2016.

Assessment:

25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. Written Examination

SEMESTER 4 SPECIAL COURSES (120hrs.)

Special Course: Endocrinology

(Special Course Practical 1)

Practical 4 ZO543: Physiology of Reproduction (With special reference to vertebrates)- Practical 4

COURSE OUTCOMES

At the end of the course the students will be able to:
CO1: Understand the histology of testes and ovary of fish
CO2: Develop skills in dissecting the male and female reproductive systems of vertebrates
CO3: Expertise in smear preparation of sperm and vagina of rats
CO4: Understand induced ovulation of vertebrate

1) Histology of testes of fish.
2) Histology of ovary of fish.
3) Dissection of male and female reproductive system of fish/ calottes/chick/ rat.
4) Vaginal smear of rat.
5) Sperm smear of any one vertebrate.
6) Demonstration of induced ovulation in any one vertebrate.

Activities, Learning resources and Assessment

Suggested Activities

1. Field visits for vertebrate specimen collection.
2. Handling, calibration and operation of instruments and lab equipment.
3. PowerPoint presentations.
4. Models and chart preparations.
5. Visit to laboratories in Universities and Research Institutes.
6. Submission of Records for Continuous Evaluation.

Learning Resources
References

1. Charles F. Lytle and John R. Meyer. (2005). Laboratory Manual: Required: "General Zoology Laboratory Guide" (14th ed.)

2. Dounersberger, Anne B., Lesak, Anne C. and Timmons, Maichael, J. (1992). A Laboratory Text Book of Anatomy and Physiology. 5th Ed. D. C. Heath and Co.

3. Hill R. W., Wyse, G. A. (1989). Animal Physiology, 2nd Ed. Harper Collins Publishers Inc. New York. 88-91 pp.

4. Schmidt-Nielsen, K. (1997). Animal Physiology, Adaptation and Environment, 5th Ed. Cambridge University Press, New York. 174-175 pp.

5. Arvy, L. (1971). Histoenzymology of the endocrine glands. Pergamon Press, Oxford, New York.

Assessment:
25% Continuous Evaluation, 75% End Semester Evaluation: 4Hrs. Practical Examination

SEMESTER 4 SPECIAL COURSES (120hrs.)

Special Course: Endocrinology
(Special Course Practical 2)

Practical 5 ZO 544: Endocrinology (Vertebrate Endocrinology)-Practical 5

COURSE OUTCOMES

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

CO1: Develop anatomical investigations on the endocrine glands of vertebrates.
CO2: Develop expertise in demonstration of glandectomy experiments vertebrate.
CO3: Demonstrate the effect of thyroxine, insulin and cortisol on blood glucose/total protein in fish.
CO3: Learn histology of endocrine gland vertebrate.
CO4: Understand the disorders of vertebrate endocrine glands.

1) Dissection of endocrine glands in fish/calotes/chick/rat.
2) Demonstration of glandectomy experiments in any vertebrate.
3) Simple experiment to study the effect of thyroxine, insulin and cortisol on blood glucose/total protein in fish.
4) Preparation of single cell suspension of any one tissue for *in vitro* study.
5) Histological study of endocrine gland using haematoxylin eosin stain any vertebrates.
6) Disorders of endocrine glands (5 numbers for short notes).

Activities, Learning resources and Assessment

Suggested Activities

1. Field visits for vertebrate specimen collection.
2. Handling, calibration and operation of instruments and lab equipment.
3. PowerPoint presentations.
4. Models and chart preparations.
5. Visit to laboratories in Universities and Research Institutes.
6. Submission of Records for Continuous Evaluation.

Learning Resources

References

1. Charles F. Lytle and John R. Meyer (2005). Laboratory Manual: Required: "General Zoology Laboratory Guide" (14th ed.)
2. Dounersberger, Anne B., Lesak, Anne C. and Timmons, Maichael, J. (1992). A Laboratory Text Book of Anatomy and Physiology. 5th Ed. D. C. Heath and Co.
3. Hill R. W., Wyse, G. A. (1989). Animal Physiology, 2nd Ed. Harper Collins Publishers Inc. New York. 88-91 pp.
4. Schmidt-Nielsen, K. (1997). Animal Physiology, Adaptation and Environment, 5th Ed. Cambridge University Press, New York. 174-175 pp.
5. Arvy, L. (1971). Histoenzymology of the endocrine glands. Pergamon Press, Oxford, New York.

Assessment:

25% Continuous Evaluation, 75% End Semester Evaluation: 4Hrs. Practical Examination

SEMESTER 4 SPECIAL COURSES (100hrs.)

Special Course: Entomology
Special Course 1 ZO 541: General Entomology

COURSE OUTCOMES

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

CO1: Acquire knowledge on the origin and evolution of insects and fossil insects.
CO2: Understand the scope and importance of insect anatomy.
CO3: Analyse embryogenic processes in insect development.
CO4: Develop a thorough understanding of insect classification.
CO5: Acquire detailed understanding of insect physiology and able to deliver scientific information related insect nutrition, respiration, circulation, excretion, nervous system, endocrine and exocrine glands, reproduction, and sense organs.
CO6 : Understand insect communication and social organization.

Module 1. Introduction to Entomology (5 hrs.)

1.1 Insect characters, Origin of insect, Evolution of Insect.
1.2 Fossil insects.
1.3 Insect-plant interdependence (Co-evolution).

Module 2. Insect Anatomy (20 hrs.)

2.1. Integument- Structure, physiology and functions of integument.
2.2. Head- Origin, structure and modifications; General morphology of head (Opisthognathus, Prognathus, Hypognathus), Mouth parts- modifications based on feeding mechanisms. Antennae- Structure, functions, and types.
2.3. Thorax- Segmentation- Structure and modifications.
2.4. Abdomen- Segmentation and appendages. Adaptive radiation of legs.
2.5. Wings- Structure and modifications, venation.

Module 3. Embryogenesis (20 hrs.)

3.1. Types of eggs, formation of blastoderm and germ layers, formation of germ band and extra embryonic membranes.
3.2. Differentiation of germ layers.
3.3. Segmentation, Appendage formation and blastokinesis, organogenesis, polyembryony, control of embryogenesis, Oviparity, Viviparity, Oviposition, eclosion, post embryonic morphogenesis.
3.4. Growth, metamorphosis, endocrine mechanism in metamorphosis.

Module 4. Insect Classification (15 hrs.)

4.1. Biology and habit of the different orders of insects- classification up to families.
4.2. Biology and habits of gall forming and leaf mining insects.
4.3. Aquatic insects - Aquatic adaptations including respiratory adaptations.
4.4. Adaptation of parasitic and predatory insects.
4.5. Seasonal adaptations- Dormancy- Diapause.

Module 5. Insect Physiology (30 hrs.)

5.1. Insect Nutrition- Basic structure of alimentary canal, Histology of foregut, midgut and hind gut, Salivary glands, Mechanism of digestion and gut microflora.

5.2. Respiratory system- Organisation and structure of tracheal system, Mechanism of gaseous exchange, Respiration in aquatic and parasitic insects.
5.3. Circulatory system- The dorsal vessel and accessory pumping sinuses. Haemolymph composition and function, haemocytes types and functions.
5.4. Excretion – Malpighian tubules and other excretory structures, Physiology of excretion, Salt and water balance, Nitrogenous excretion, Insect Urine.
5.5. Nervous system- Structure and function of nervous system, Nervous integration. Exocrine and endocrine glands and their functions. Skeletal muscle, visceral muscle, muscle development and maintenance.
5.6. Sense organs- Morphology of sense organs, sensory mechanisms, light and sound production. Mechanoreception-the tactile sense, proprioceptive sense and sound perception. Photoreception- compound eyes and dorsal ocelli, Chemoreception, Thermoreceptors and Hygroreceptors.
5.7. Reproduction and morphogenesis- Reproductive system and gametogenesis in male and female, Fertilization, Sex determination, Parthenogenesis. Different types of insect larvae and pupae.

Module 6. Insect Communication (10 hrs.)
6.1**.** Acoustic, visual, tactile, and chemical methods.
6.2. Role of hormones in communication- Pheromones, Kairomones and Allomones.
6.3. Social organization, communication and behaviour of termites, ants, and honey bees.
6.4. Insect Immunity.

Activities, Learning resources and Assessment
Suggested Activities

1. Written Examinations
2. Seminars
3. Assignments
4. Poster Presentations
5. PowerPoint presentations
6. Model preparations

Learning Resources

References

1. Ross, H.H., Ross C.A. & Ross J.R.P. (1982). Text book of Entomology, Ed. 4. John Willey & Bons, New York.
2. Nayar, K.K. & Ananthkrishnan, T.N. and David. B.V. (1976). General and Applied Entomology, Tata McGraw Hill Co Ltd., Bombay.
3. Mani. M.S. (1988). General Entomology 3rd Edn., Oxford & IBH Publishing Co., New Delhi.
4. Chapman, R.F. (1988). The Insects Structure & Function, English University Press, London.
5. Kerkut, G.A. & Gillbert, L.I. (1985). Comprehensive Insect. Physiology, Biochemistry and Pharmacology. Vol. 1 to 13. Pergamon Press, Oxford & New York.
6. Sondgrass, R.E. (2004). Principles of Insect Morphology, Tata McGraw Hill, Rutl. Co. Ltd., Bombay, New Delhi.
7. Tembhare, D.B. (1984). A Text Book of Insect morphology, Physiology and Endocrinology. II End. S. Chand & Co., New Delhi.

8. Wigglesworth, V.B. (1972). The Principles of Insects Physiology. Vlbs & Methuten & Co.Ltd., London.
9. Beament, J.W.L. Tieherne, J.E. & Wigglesworth, V.B. (1968). Advances in Insect Physiology, Academic Press, New York.
10. Nova. V.J.A. (1966). Insect hormones Methuten & Co. Ltd., London.
11. Tembhare (1984). – Insect Endocrinology and Physiology
12. Wigglesworth. (1971). V.B.- Insects Hormones.
13. Resh, V. H. (2009). Encyclopaedia of Insects, 2nd edition, Elsevier Science.
14. Daly,H. V., Doyen J. T. and Purcell A. H. (1998) Introduction to Insect Biology and Diversity, 2nd edition, Oxford University Press.
15. Gullan, P. J. and Cranston P. (2010). The Insects: An Outline of Entomology, 4th edition, Wiley-Blackwell Press.

Assessment:
25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. Written Examination

SEMESTER 4 SPECIAL COURSES (100hrs.)

Special Course: Entomology

Special Course 2 ZO542: Applied Entomology

COURSE OUTCOMES

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

CO1: Gain knowledge on the insect pests, its types and familiarize with the concepts of pest out breaks.

CO2: Acquaint with insect pests of agriculturally and economically important crops and their control measures.

CO3: Understand the scope and significance of sericulture, apiculture, and lac culture.

CO4: Gain familiarity with the chemical control, classification of insecticides, fumigation, and pest appliances.

CO5: Understand and analyze the concepts of pest management.

CO6: Understand the concepts of insecticide resistance, insecticide pollution and its impact on biosphere.

Module 1. Introduction to Insect Pests (15 hrs.)

1.1 Kinds of insect pests- Major pests, minor pests, sporadic pests, endemic pests, exotic pests, seasonal pests, occasional pests, regular pests, persistent pests.

1. 2. Causes of pest outbreak- deforestation, destruction of natural enemies, pest resurgence

1.3. Secondary pest outbreak, intensive and extensive cultivation, introduction to new crops, hybrid varieties, introduction to new pests.

1.4. Forecasting pest outbreaks and surveillance, short term, and long-term forecasting.

Module 2. Biology and Control of Pests and Principles of Insect Control (35 hrs.)

2.1. Biology, nature of damage and control of major pests of major crops- paddy, coconut, cotton, mango, vegetable, pulses, coffee, tea, sugarcane, banana, cashew, pepper, turmeric, ginger, and cardamom.

2.2. Insect pest of domestic animals, biology, and control.

2.3. Biology and control of major arthropod vectors of human diseases belonging to diptera and anoplura.

2.4. Biology and control of house hold pest insects.

2.5. History, principles, and scope of biological control. Important groups of parasitoids, predators, and pathogens. Principles of classical biological control- importation, augmentation, and conservation.

2.6. Microbial control- bacteria, fungi, and virus.

2.7. Importance of biological control products undertaken in India against insect pest.

2.8. Significance and relevance of biological control in the present regime.

Module 3. Industrial Entomology and Forensic Entomology (15 hrs.)

3.1. Sericulture, Apiculture, Lac culture.

3.2. Insect as human food and as scavengers.

3.3. Forensic entomology- introduction, insects of forensic importance, insects as tools in forensic science.

Module 4. Insect Toxicology (15 hrs.)

4.1. Chemical control – classification and evolution of insecticides, types, mode of action. Insecticide formulation and application.
4.2. Synthetic organic insecticides- DDT, BHC, Endosulphan, Heptachlor, Dieldrin.
4.3. Organophosphorous insecticides- Monocrotophos, Parathion.
4.4. Carbamates- Carbaryl, Carbofuran.
4.5. Botanical insecticides- Nicotine, Rotenone, Pyrethrum and neem.
4.6. Synthetic pyrethroid- Pyrethrin, Allethrin.
4.7. Fumigation and fumigants.
4.8. Insecticide residues, biological magnification, Pesticide appliances.

Module 5. Pest Management (15 hrs.)

5.1. Concepts of pest management, Pest management strategies and techniques.
5.2. Integrated Pest Management- IPM in agro-ecosystem, preventive practices, therapeutic practices, selection of tactics.
5.3. Principles of behavioural control- Communication pheromones, sex pheromones, aggregation, orientation theories, repellents- plant allomones, antifeedants.
5.4. Autocidal control- Chemosterilants, sterile male technique and other genetic tactics.
5.5. Pest management tactics- Reduce and disrupt pest habitat in and around crop, Adjust crop planting to disrupt pest habitat and nutrition requirements, Diverting pest population away from crop, Reducing the impact of insect injury.
5.6. Ecological back lash and its management.

Module 6. Insecticide Resistance and Insect Diversity Conservation (5 hrs.)

6.1. Genetic, physiological, and biochemical mechanisms.
6.2. Insecticide metabolism- microsomal and extra microsomal.
6.3. Dynamics of environmental pollution by insecticides and its impacts in biosphere.
6.4. Insect and the climate change- process, patterns, and implications for conservation.

Activities, Learning resources and Assessment

Suggested Activities

1. Written Examinations
2. Seminars
3. Assignments
4. Poster Presentations
5. PowerPoint presentations
6. Model preparations

Learning Resources

References

1. Chapman, R. F. (1998). The Insects: Structure and Function, 4th edition [paperback] Cambridge University Press.
2. Metcalf, C.L., Flint. W.P. & Metcalf. R.L. (1962). Destructive and Useful Insects – Their habits & control. Ed. 4, Ms Graw Hill, New York
3. Gullan, P. J. and Cranston P. (2010). The Insects: An Outline of Entomology, 4th edition, Wiley-Blackwell Press.
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17. Khare BP. (1994). Stored Grain Pests and Their Management. Kalyani Publ., New Delhi.
18. Aruga H. (1994). Principles of Sericulture. Oxford & IBH, New Delhi.
19. Atwal AS. (2006). The World of the Honey Bee. Kalyani Publ., New Delhi.
20. Smith CM, Khan ZR & Pathak MD. (1994). Techniques for Evaluating Insect Resistance in Crop Plants. CRC Press, Boca Raton, Florida.

Assessment:
25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. Written Examination

SEMESTER 4 SPECIAL COURSES (120hrs.)

Special Course: Entomology
(Special Course Practical 1)

Practical 4 ZO543: Taxonomy, Anatomy, Histology and Physiology- Practical 4

COURSE OUTCOMES

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

CO1: Develop skills in the procedures of collection, preservation, and presentation of insects for taxonomic studies.
CO2: Expertise in the anatomy of insects through dissections.
CO3 Analyse the insect specimens following standard histological techniques
CO4: Expertise in estimation of the biochemical parameters of insects through laboratory experiments.

A. Taxonomy

1. Identification and preparation of taxonomic key of 10 insects belonging to 10 families and 4 orders.
2. Collection, preservation, and presentation of insects belonging to 30 families.
3. Mounting, sketching, and labelling of taxonomic features of the following:
    a) Wings in insect of order 5
    b) Antennae in insects of 5 orders
    c) Mouth parts in insects – 4 types
    d) Leg- 4 types
    e) Whole mount of 54 insects/ life stages of taxonomic importance.

B. Anatomy

4. Alimentary canal and associated glands of 4 groups of insects with different feeding habits.
5. Reproductive systems of any 2 female insects.
6. Nervous system in any two groups.
7. Stomatogastric nervous system (Oesophageal, sympathetic, single recurrent nerve and paired recurrent nervous).
8. Endocrine system.
9. Identification of sensilla employing a suitable technique.

C. Histology

10. Preparation of paraffin sections of insect midgut epithelium and ovary using Haematoxylin-eosin staining technique to demonstrate histological details.
11. Whole mount staining preparation of insect brain to demonstrate neurosecretory cells by PAVB example.

D. Physiology

12. Quantification of proteins in fat/haemolymph.
13. Quantification of glycogen in fat body.
14. Estimation of any one transaminase in insect fat body/haemolymph.
15. Identification of at least two free amino acids in haemolymph by paper chromatography.
16. Quantitative estimation of any two digestive enzymes (protease, amylase/invertase).
17. Haemolymph protein profile employing PAGE (Demonstration).

NOTE: Candidates shall submit a collection consisting of 30 families of insect from different orders. (It shall include dry collection, wet collection and slides including life stages). The collection shall be submitted at the time of practical examination along with the practical record.

Activities, Learning resources and Assessment

Suggested Activities

1. Field visits to collect insects
2. Visit to Research institutions and establishments practicing Integrated pest management system
3. Preservation of specimens and presentation in insect boxes
4. Standardisation of laboratory equipment and familiarisation of instruments in the laboratory
5. Poster Presentations
6. PowerPoint presentations
7. Model preparations
8. Submission of Records for Continuous Evaluation

Learning Resources

References

1. Borror, D.J.& D.M. Delong. (1964). An Introduction to the Study of Insects. 7 th Edn. Holt Reineheart & Winston, New York.
2. Pedigo, L. P (2009). Entomology & Pest Management Practice. 6 th Edn. Hall India Pvt. Ltd., New Delhi.
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4. Mani, M.S. (1974). Modern Classification of Insects. Satish Book Enterprise, Agra.
5. Nayar,K. K., Ananthakrishnan T.N. &. David B.V. (1976). General and Applied Entomology, Tata Mac Grew Hill, New Delhi.
6. Richards, O.W. &. Davies R.G.G (1977). Imm's General Text Book of Entomology. Chapman & Hall, London.
7. Romoser, W.S. and Stoffolano, J.G. (1994). The Science of Entomology. 3rd Edition. WCB Publishers, Oxford, England.

Assessment:

25% Continuous Evaluation, 75% End Semester Evaluation: 4Hrs. Practical Examination

SEMESTER 4 SPECIAL COURSE(120hrs..)

Special Course: Entomology
(Special Course Practical 2)

Practical 5 ZO544: Ecology, Economic Entomology and Experimental Entomology- Practical 5

COURSE OUTCOMES

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

CO1: Explore diversity of insects in their natural habitat by field visits.
CO2 Identify and classify insect pests, damages caused by them, and control measures.
CO3: Hands-on experience in methods of insect pest management.
CO4: Explore experimental entomology through laboratory experiments.

A. Ecology

1. Methods of collection and identification of soil insects (any 10 numbers)
2. Field work: A field study shall be conducted to observe the insects in their natural habitat.
   A detailed field report shall be submitted by each student which includes the observation of insects in areas such as forests, grass land, aquatic insects, sandy areas etc. The field report duly certified shall be submitted at the time of practical exam along with practical record.
3. Estimation of LC 50 value and LD 50 value of any two brands of insecticides for some aquatic/ terrestrial organisms.

B. Economic Entomology

4. Collection, preservation, identification, and presentation of the following categories of pests.
   a. Agricultural pests of different crops 10 numbers.
   b. Stored- product pests- 3 numbers.
   c. Vectors and veterinary pests- 4 numbers.
   d. Household pests- 5 numbers.
   e. Beneficial insects – 6numbers
5. Collected and identified insect specimens and pests of crops shall be submitted at the time of practical examination. Candidates shall submit a minimum of 10 wet collections.
6. Field study to collect/ observe insect species of pollinators, parasitoids, predators, scavengers and weed killers.
7. Field study of various methods of pest management.
   Pesticide formulation, Pesticide application. Safety, hazards and first aid.
8. Identification of egg rafts of mosquitos.

C. Experimental Entomology

9. Malpighian tubule activity using suitable dyes.
10. Rearing of any two insects in the laboratory.
11. Identification of larval instars using Dyar's rule.
12. Sexing of insects- larva pupa and adults of *Oryctes rhinoceros*
13. Effect of starvation on glycogen/ protein on insect fat body/haemolymph.
14. Effect of starvation on transaminase activity in insects.

NOTE: Candidates shall submit a minimum of 10 numbers of different categories of pests at the time of practical examination along with the practical record. A duly certified field report also shall be submitted at the time of practical examination.

Activities, Learning resources and Assessment

Suggested Activities

1. Field visits to collect insects.
2. Visit to Research institutions and establishments practicing Integrated pest management system.
3. Preservation of specimens and presentation in insect boxes.
4. Standardisation of laboratory equipment and familiarisation of instruments in the laboratory.
5. Poster Presentations.
6. PowerPoint presentations.
7. Model preparations.
8. Submission of Records for Continuous Evaluation.

Learning Resources

References

1. Atwal. A.S. (1986). Agricultural Pests of India and South East Asia. Kalyani Publishers, Ludhiana.
2. Banerjee, B. (1988). An introduction to Agricultural Acarology - Biology and control of mite pests in the tropics. S.K. Dutta Associated Publishing Co., 8798/7, Shidipura, Karolbagh, New Delhi.
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5. Lephroy, H.M. (1971) Indian Insect Life – Today and Tomorrow's Printers.
6. Metcalf. G.L. and W.P. Flint. (1962). Destructive and Useful Insects, their Habits and Control. Tata McGraw Hill Publ. Co.Ltd., New York.
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16. Thacker, J.R.M. (2002). An introduction to Arthropod pest control. Cambridge University Press, U.K.
17. Tonapi, G.T. (1994). Experimental Entomology- An aid to field and laboratory, New Delhi.

18. Trigunayat, M.M. (2002). A Manual of practical Entomology. Scientific Pulbl.

Assessment:

25% Continuous Evaluation, 75% End Semester Evaluation: 4Hrs. Practical Examination

SEMESTER 4 SPECIAL COURSES (100hrs..)

Special Course: Fish Biology and Fishery Science
Special Course 1 ZO 541: Ichthyology

COURSE OUTCOMES

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

CO1: Understand the classification and geographical distribution of fishes, significance of barcoding in fish taxonomy.

CO2: Acquire knowledge on the adaptations of fishes and types of larvicidal fishes.

CO3: Differentiate the diversity in the functional morphology and the mechanisms of locomotion.

CO4: Conceptual understanding on the food and feeding, digestion and growth in fishes.

CO5: Understand and differentiate the structure and types of excretory, sensory organs and endocrine glands in fishes.

CO6: Understand the reproductive system and types of reproductive strategies and behaviours in fishes.

Module 1. Taxonomy and distribution of fishes (13 hrs.)

1.1 Scope and history of Ichthyology.
1.2 Geographical distribution of fishes in marine and freshwater habitats.
1.3 Distribution of fishes in marine and freshwater habitats in India and Kerala.
1.4 Classification of fishes up to family - distinguishing characters with examples.
1.5 Barcoding in fish taxonomy.

Module 2. Adaptations of fishes (7 hrs.)

2.1 Deep Sea fishes
2.2 Cave dwelling fishes
2.3 Hill stream fishes
2.4 Air breathing fishes
2.5 Venomous fishes
2.6 Larvicidal fishes
2.7 Schooling in fishes

Module 3. Functional morphology and locomotion (25 hrs.)

3.1 External anatomy of fishes and diversity of body form in relation to locomotion.
3.2. Fin – types, structure, function, and modifications; fins and locomotion – swimming and non-swimming.
3.3 Skin- Structure and function; Scalation - types of scale, structure, development, and modifications.
3.4 Colouration - types of chromatophores, mechanism and biological significance.
3.5 Swim bladder – structure, types, and functions.
3.6 Weberian ossicles and its significance.

Module 4. Feeding, digestion and growth in fishes (10 hrs.)

4.1 Basic anatomy of digestive system of a cartilaginous and a bony fish.

4.2 Food and feeding habits- natural food, feeding habits and adaptations; feeding in relation to season, growth, sex and breeding; gastro-somatic index.
4.3 Digestion, absorption, and utilization of food.
4.4 Growth in fishes- length and weight relationship, growth curve and growth studies using scales, condition factor.

Module 5. Excretion, Sensory organs, and Endocrine glands in fishes (25 hrs.)
5.1 Structure and function of kidneys; hormonal control of excretion and osmoregulation.
5.2 Sensory System - Lateral line sense organs, Ampullae of Lorenzini, Chemo, mechano, thermo and electro receptors; structure of eye and vision.
5.3 Endocrine system - Structure and function of Pituitary gland, ultimobranchial gland, caudal neurosecretory system, corpuscles of Stannius, inter renal tissue and chromaffin tissue, islets of Langerhans, thyroid gland, gonads and pineal organ.

Module 6. Reproduction and fish genetics (20 hrs.)
6.1 Reproduction – types – bisexual, hermaphroditic, parthenogenetic.
6.2 Male and female reproductive system; Gonads- phases of maturity, length at first maturity, gonado-somatic index, fecundity.
6.3 Reproductive behaviour- sexual dimorphism, reproductive strategies – Non-guarders, guarders and bearers; mating system – promiscuity, polygamy, monogamy; courtship, parental care, nest building.
6.4 Sex determination in fishes.
6.5 Recent trends and techniques in hybridization.
6.6 Chromosome manipulation in fishes.
6.7 Genetic engineering and production of transgenic fishes.

Activities, Learning resources and Assessment
Suggested Activities
1. Written Examinations
2. Seminars
3. Assignments
4. Poster Presentations
5. PowerPoint presentations
6. Model preparations

Learning Resources

References

1.Ali, M. (1980). Environmental Physiology of fishes. NATO advanced Study Institute series. Series A. Life sciences, vol. 35, Plenum Press, New York.
2.Fundamentals of aquatic ecosystems. Blackwell Scientific Publications, Oxford and London
3.Beavan R. (1990). Freshwater fishes of India Low price Publications, Delhi.
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23. Santhosh Kumar and Manju Tembhre, (1998). Anatomy and physiology of fishes, Vikas publishing house Pvt. Ltd, New Delhi.
24. www.fish.biol.org
25. http://mail.nbfgr.res.in/fbis/

Assessment:

25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. Written Examination

SEMESTER 4 SPECIAL COURSES (100hrs..)

Special Course: Fish Biology and Fishery Science

Special Course 2 ZO542: Fisheries and Aquaculture

COURSE OUTCOMES

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

CO1: Understand the types of fishing crafts, gears used in capture fisheries and assess the level of exploitation of fishery resources in India.

CO2 Impart knowledge on post-harvest technology, export and extension, biochemical composition, and nutritional value of fish.

CO3 Expand knowledge domain on the modern aquaculture techniques.

CO4: Understand the principles and methods of induced breeding and seed production in finfishes and shell fishes.

CO5: Impart knowledge on different types of aquaculture practices.

CO6: Understand the principles and methods of mariculture.

A. FISHERIES

Module1. Capture fisheries and harvest technology (25 hrs.)

1.1. Importance of Fishery Science- Inland fisheries, Marine fisheries, capture fisheries and culture fisheries.

1.2. Inland capture fisheries- Riverine fisheries, reservoir fisheries, cold water fisheries and estuarine fisheries.

1.3. Marine capture fisheries in India- pelagic, demersal, offshore and deep sea fisheries; finfish and shell fish fishery (crustacean and molluscan).

1.4 Indigenous fishing crafts of India- Sea fishing crafts- Catamaran, Masula boat, caravel boats, Dinghi, Dugout canoes, plank-built canoes, out trigger canoes, built up boats; Inland fishing crafts; Mechanized fishing crafts- stages of mechanization, fishing vessel characteristics.

1.5. Indigenous fishing gears in India: Traditional and conventional; sea fishing gears and inland fishing gears.

Module 2. Post-harvest technology, Export and Extension (25 hrs.)

2.1 Precautions observed during handling, sorting, and grading the catch.

2.2 Nutritive value of fish and biochemical composition of fish flesh.

2.3 Fish spoilage.

2.4 Fish preservation and processing - Icing and freezing, canning, salting, drying, curing, smoking.

2.5 Fish products and byproducts- Liver oil, meal, manure, glue, isinglass, leather, chitosan, fish maws, fish protein concentrate, fish fins and value-added fish products.

2.6 Fish food poisoning.

2.7 Status of global trade in fish and fishery products; Overview of export from India.

2.8. Fisheries Extension - philosophy and methodology; status of co-operative movement and fish farmer's development agencies.

B. AQUACULTURE

Module 3. Aquaculture (20hrs.)

3.1 Definition, scope, and objectives of aquaculture; status in India.

3.2 Culture systems- pond, bheries, salt pans, tanks, raceways, cage, pens, RAS.
3.3 Criteria for space and site selection and design and construction of aqua farms.
3.4 Paddy cum fish culture; Integrated farming methods- fish and livestock farming.
3.5 Sewage fed fish farming.
3.6 Nutritional requirement of culture fishes.
3.7 Feed types -live and formulated, Procedure for feed formulation.
3.8 Hatcheries- different types.

Module 4. Breeding and Seed production (10hrs.)

4.1. Bionomics of cultivable species of fish and shell fish (*Mugil cephalus*, *Chanos chanos, E. suratensis*, Indian Major Carps, *Fenneropenaeus indicus*, *Penaeus monodon*, *Macrobrachium spp*.).

4.2 Breeding of fishes with special reference to Indian major carps- wet and dry bundh technique for breeding; Induced breeding in carps - Principle, techniques and advantages of hypophysation, selective breeding and seed production; Induced breeding in Shrimp- Techniques involved in shrimp breeding and seed production- eye stalk ablation.
4.3 Transport of live fishes- fingerlings and brooders.
4.4 Cryopreservation of gametes.
4.5 Common fish diseases - viral, fungal, bacterial and parasitic infections.

Module 5. Aquaculture practices (10 hrs.)

5.1 Ornamental fish culture- exotic and indigenous species, breeding and culture of common ornamental fishes.
5.2 Monoculture - Indian major carps (Catla, Rohu, Mrigal), exotic species, Tilapia, Etroplus, Biofloc farming.
5.3 Composite culture.
5.4 Freshwater prawn culture.
5.5 Culture of air-breathing fishes- ecology of swamps and use in culturing air-breathing fishes
5.6 Shrimp culture: Brackish water shrimp culture practices in India with special reference to Kerala.

Module 6. Mariculture (10 hours)

6.1 Pearl culture and culture of edible molluscs.
6.2 Seaweed cultivation and utilization.
6.3. Sea ranching.
6.4. Mariculture of fishes with special reference to India.

Activities, Learning resources and Assessment

Suggested Activities

1. Written Examinations
2. Seminars
3. Assignments
4. Poster Presentations
5. PowerPoint presentations
6. Model preparations

Learning Resources

References

1 Bal, D V and Rao, K V. (1989). Marine Fisheries. Tata Mac Graw Hill Publishing Co., Delhi

2. Biwas, K.P. (1996). A text book of fish, fisheries and technology. Narendra Publishing house , Delhi
3 Balakrishnan N and Thampy D. M. (1990). A text book of marine ecology. Macmillan House Delhi.
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5. Beavan R. (1990). Freshwater fishes of India Low price Publications, Delhi.
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15. Madhusoodana Kurup, B. (Ed) (2008). Ornamental fish - Breeding, farming, and trade. Department of Fisheries, Govt. of Kerala.
16. Paul, J. B. and John d. Reynold (Eds.) (2002). Handbook of fish biology and fisheries. Blackwell Science Ltd., UK.
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Assessment:
25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. Written Examination

SEMESTER 4 SPECIAL COURSES (120hrs..)

Special Course: Fish Biology and Fishery Science
(Special Course Practical 1)

Practical 4 ZO 543: Ichthyology- Practical 4

COURSE OUTCOMES

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

CO1: Identify and classify the marine and freshwater fishes, and prawns.
CO2: Expertise in anatomical studies of fishes.
CO3: Gain practical experience in fish biology.
CO4: Determination of the sex, karyotype analysis and hands on experience in hybridization techniques in fishes.

A. Taxonomy

1. Identification and classification of 5 local fishes (Marine/freshwater) down to species level.
2. Identification and classification of 3 prawns down to species level.

B. Dissection and Mounting

3. Brain
4. Scales- placoid, cycloid, ctenoid
5. Digestive system of a bony fish
6. Urinogenital system of a teleostean fish
7. Pituitary gland

C. Fish Physiology

8. Effect of NaCI /KCl on fish chromatophores.
9. Determination of the rate of oxygen consumption of a fish at room temperature.
10. Determination of gonado-somatic index.
11. Measurement of fecundity rate in a fish.
12. Qualitative and quantitative analysis of gut content in herbivorous and carnivorous fish.
13. Determination of gastro somatic index.
14. Smear preparation of fish blood to study the morphology of different cellular elements.
15. Differential count of fish WBC.

D. Fish genetics

16. Sex determination in fishes.
17. Hybridization techniques in fishes
18. Karyotyping in fishes.

Activities, Learning resources and Assessment

Suggested Activities

1. Field visits
2. Visit to Research institutions and Fish farms
3. Preservation of specimens and presentation
4. Standardisation of laboratory equipment and familiarisation of instruments in the laboratory
5. Poster Presentations
6. PowerPoint presentations
7. Model preparations
8. Submission of Records for Continuous Evaluation

Learning Resources

References

1. Beavan, R. (1990). Freshwater fishes of India Low price Publications, Delhi.
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8. Gerhard Brunner, (1973). Aquarium plants, TFH. Publications, Inc. Ltd., Hong Kong
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12. Jhingran, V.G. (1991). Fish and fisheries of India. Hindustan Publishing Corporation (India) , New Delhi. 45
13. Lagler, K.F., Bardach, J.E., Miller, R.R. and D.R. May Passino (2003). Ichthyology. John Wiley and sons (Asia) Pvt. Ltd., Singapore.

Assessment: 25% Continuous Evaluation, 75% End Semester Evaluation: 4Hrs. Practical Examination

SEMESTER 4 SPECIAL COURSES (120hrs.)
Special Course: Fish Biology and Fishery Science
(Special Course Practical 2)

Practical 5 ZO544: Fisheries and Aquaculture - Practical 5

COURSE OUTCOMES

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

CO1: Acquire knowledge to estimate water and soil quality parameters of fish and shrimp farms.
CO2: Expertise in identification of fish pathogens, parasites, and fish extent of fish spoilage
CO3: Gain practical experience in fish breeding
CO4: Expertise in preparation of fish byproducts and its quality estimation
CO5: Identification of fishing crafts and gears
CO6: Obtain hands on experience in fishing operations, fish preservation, fish processing, boat building and net making

A. Fish farm ecology

1. Determination of pH, turbidity, salinity and hardness in pond water.
2. Determination of free calcium carbonate in the soil sample from freshwater and brackish water ponds.

B. Fish Pathology

3. Identification of common external fish parasites (at least 5 numbers).
4. Estimation of spoilage in fish by pH method.

C. Breeding Techniques

5. Mounting of pituitary gland.
6. Preparation of pituitary gland extract.
7. Demonstration of hypophysation technique.
8. Demonstration of artificial insemination.

D. Fish byproducts

9. Identification and study of fish byproducts.
10. Estimation of muscle protein.
11. Estimation of muscle glycogen.

E. Fishing crafts and gears

12. Identification and study of different types of fishing crafts (Minimum 5 numbers).
13. Identification and study of different types of fishing gears (Minimum 5 numbers).

F. Field study & Field work.

1. Visit to freshwater or brackish water fish farms.
2. Collection of water and soil samples of fish ponds for analysing hydrographical parameters.
3. Visit to a fisheries institute and fishing harbours to study the following:
    a. Freshwater and brackish water aquaculture
    b. Fishing operations
    c. Fish preservation and processing
    d. Boat building and net making
    e. Fisheries research, survey, education and examination

Activities, Learning resources and Assessment

Suggested Activities

1. Field visits to freshwater or brackish water fish farms
2. Visit to Fisheries Research institutions, fish and shrimp processing plants, boat building yards and net making factories and fishing harbours.
3. Interview with traditional people who construct fishing crafts and gears .
4. Preservation of specimens and presentation.
5. Standardisation of laboratory equipment and familiarisation of instruments in the laboratory.
6. Poster Presentations.
7. PowerPoint presentations.
8. Model preparations.
9. Submission of Records for Continuous Evaluation.

Learning Resources

References

1. Ali, M. (1980). Environmental-Physiology of fishes advanced Study Institute series. Series A: Life sciences, vol. 35, Plenum Press, New York.
2. Bal, D.V. and Rao, K.V. (1989). Marine Fisheries. Tata Mac Graw Hill Publishing Co., Delhi.
3. Biswas, K.P. (1996). A text book of fish, fisheries and technology. Narendra Publishing House, Delhi.
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5. Barnes, R.S.K. and Mann, K.H. (1980). Fundamentals of aquatic ecosystems. Blackwell Scientific Publications, Oxford and London.
6. Boyd, C.E. (1982). Water quality management for pond fish culture: developments in aquaculture and fisheries sciences, Elsevier, Amsterdam.
7. Charles, T. Cutting (1996). Fish processing and preservation. Agro Botanical Publishers, Bikaner. Claude E. Boyd, (1984). Water quality management in aquaculture, CMFRI special Publication, No.22
8. Cushing, D.H. 1980 Marine ecology, and fisheries. Cambridge University Press
9. Halver J. E. (1977). Fish nutrition. Academic press, London.
10. Harvey, B.J. and Hoar W.S. (1979). Theory and practice of induced breeding in fish international Development Research Centre, Ottawa.
11. John, S. Lucas and Paul C. Southgate (2000). Farming aquatic animals and Plants. Fishing News Books, Blackwell publishing co.,
12. Jorgen Hansen. (1979). Making your own aquarium, Bell and Hyman Ltd. London

Assessment: 25% Continuous Evaluation, 75% End Semester Evaluation: 4Hrs. Practical Examination

SEMESTER 4 SPECIAL COURSES (100hrs.)

Special Course: Environmental Physiology

Special Course 1 ZO541 : Pollution Biology & Environmental Physiology

COURSE OUTCOMES

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

CO1: Understand the basics and causes of different types of pollution.
CO2: Acquire new knowledge regarding air and noise pollution and its abatement technologies.
CO3: Understand the causes, effects of water pollution and its abatement technologies.
CO4: Understand the causes, and effects of terrestrial, industrial, and radioactive pollution.
CO5: Impart knowledge on morphological and physiological adaptations about temperature and pressure variation.
CO6: Understand the eco-physiological and osmoregulatory adaptations of freshwater, marine, estuarine and terrestrial animals.

A. Pollution Biology

Module 1. Introduction to pollution (5hrs.)

Environmental pollution – Concepts and definitions, Organic pollutants, Heavy metals, industrial effluents, Pesticides, Radioactive pollutants, Oil, food additives and contaminants.

Module 2. Air and noise pollution (20 hrs.)

Chief air pollutants, occurrence, sources, and effects. Interaction of air pollutants in the atmosphere – Photochemical reactions- Formation and effects of secondary pollutants and photochemical smog, Effects of air pollutants on materials, building metals, vegetation, and human health; a brief survey of air pollution episodes. Air pollution abatement technologies- Design and working of bag filters, electrostatic.

Noise pollution: Sources, Effect of noise pollution on materials, animals and humans, Sonic boom, Abatement strategies.

Module 3. Water pollution & Abatement technology (25 hrs.)

Effects of pollution on aquatic ecosystems- sources of aquatic pollution, Significance of monitoring the water quality parameters for pollution, Importance and method of estimation COD and BOD, Eutrophication- Sources and effects, Biocides Sources and effects, Biomagnification: Toxic effects on non-target organisms and hazards to man.

Waste water treatment -Primary, secondary, and tertiary treatment systems, Design and operations of screens, frit chambers, sedimentation tanks and oxidation ponds. Design and operations of biological treatment systems -aerated lagoons, activated sludge process, trickling filters and sludge digestion.

Module 4. Terrestrial, Industrial and Radioactive pollution (20 hrs.)

Solid wastes and disposal Strategies of control of solid waste pollution.

Effects of various heavy metals (e.g. Hg, Pb, Cd, As Cr), Fluoride pollution on human life, Thermal and Oil spills- sources, effects, and control. Sources of nuclear radiation., Biological effects of ionizing radiations and non-ionizing radiations, nuclear waste disposal.

B. Environmental Physiology (30 hrs.)

Module 5. Temperature and pressure adaptation (15 hrs.)

Temperature: Morphological and physiological adaptations: Relation between body size and metabolic rate. Temperature and metabolic rate: Thermal acclimation; Enzymatic acclimation, Temperature: Homeotherms and Poikilotherms, Thermal migration. Implications of global warming on animals.

Pressure adaptations: Adaptations to hyperbaric stress with reference to deep sea organisms (hyperbaria). Biochemical mechanisms of animals to high altitudes (hypobaria and hypoxia).

Module 6. Osmoregulatory and eco-physiological adaptations (15 hrs.)

Osmoregulation and ionic regulation: Osmoregulation in freshwater, marine, estuarine and terrestrial animals. Sodium pump Na^+ and H^+-ATPase in relation to salinity adaptations.

Eco-physiological adaptations: Mimicry and coloration, Echolocation, Bio-luminescence, Electric organs.

Activities, Learning resources and Assessment

Suggested Activities

1. Written Examinations
2. Seminars
3. Assignments
4. Poster Presentations
5. PowerPoint presentations
6. Model preparations
7. Industrial visit and visits to laboratories

Learning Resources

References

1. Enger E.D. and Smith B.F. (2004). Environmental Science. Mc Graw Hill Higher Education.
2. J.L. Chapman and M.J. Resis. (1999), Ecology- Principles and Applications. Cambridge University Press.
3. Abbasi, S.A. and Ramaswamy, E.V. (1999). Biotechnological methods of pollution control. Oxford University Press, Hyderabad.
4. Atchia, M. and Tropp. S. (1995). Environmental Management, John Wiley and Sons.
5. Barthlott, W and Winiger, M. (1998), Biodiversity. Springer Verlag, Berlin.
6. Bishop, P.L. (2000). Pollution Prevention: Fundamentals and Practice, Mc Graw Hill Pub.
7. Aneja K.R. (2000). Experiments in microbiology, plant pathology, tissue culture, and mushroom cultivation. Wishwa Prakashan, New Delhi.
8. Cutter, S.L. (1999). Environmental risks and hazards. Prentice Hall of India Pvt. Ltd., New Delhi.
9. Hary, M.F. (1990). Standard hand book of hazardous waste treatment and disposal. McGraw Hill.
10. Houghton, J. (1999). Global Warming. Cambridge University Press.
11. Lamboj, N.S. (1999). Control of noise pollution. Deep and Deep Publishers.
12. Kluge, H. Bittner, A and Hohnholz. J.H. (1995). Environment management, Institute of scientific Co-operation, Tubinlen, Germany.
13. Morris and Therivel, R. (1995). Methods of Environmental Impact Assessment. UCL

Press. London.
14. Owen, K.L and Unwin, T. (1997). Environment Management, Blackwell Publishers.
15. Park, C (1997). The environment- principles and applications Routledge, London.
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18. Scragg. A. (1999). Environmental Biotechnology, ELBS.
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23. Siva, V. (1992). Biotechnology and Environment, Third World Network, Malaysis.
24. Trivedi, P.R. (2000). Global Biodiversity, Authors Press.
25. Wentz (1998). Hazardous waste management (2nd Edition) Mc Graw Hill Pub.
26. Wood, C. (1997). Environmental Impact Assessment, Longman.
27. Yogendra,N. and Srivasantha (1995). Environmental Pollution. Ashish Publishing House, New Delhi.
28. S.Charles Kendeigh (1980). Ecology with special reference to animals and man, Prentice Hall of India Pvt. Ltd.
29. Uberoi, N.K. (1999). Environmental Management., Excel Books.
30. Biswarup Mukherjee, 1997. Environmental Biology, Tata Mc Graw Hill.
31. Abbasi, S.A. (1998). Environmental Pollution and its control. Cognent International, Pondicherry.

Assessment: 25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. Written Examination

SEMESTER 4 SPECIAL COURSES (100hrs.)

Special Course: Environmental Physiology
Special Course 2 ZO542: Environmental Management

COURSE OUTCOMES

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

CO1: Understand the potential resources of earth.
CO2: Evaluate the extent of human exploitation of earth resources and its effects.
CO3: Understand and evaluate the strategies of biological conservation and its management.
CO4: Acquire current knowledge about the environmental policies and the significance environmental education.
CO5: Impart knowledge on the principles and concepts environmental impact assessment and sustainable development.
CO6: Application of pollution abatement technologies using microbes.

Module 1. Resources of Earth (15 hrs.)

Renewable and non-renewable resources: Forests, wild life, fossil fuels, minerals, and their over exploitation for domestic, agricultural, and industrial purposes. Exploitation of endangered species. Water resources - Protection of water shed, rain water harvesting sewage and waste and water management. Conservation of natural resources, Remote sensing of resource management.

Module 2. Human exploitation of earth's resources (15 hrs.)

Human interferences in ecosystems - consequences of over-exploitation. Brief account of weather modifications, desalination, artificial rain making, acid rain, green house effects and its consequences, destruction of ozone umbrella.

Module 3. Biological conservation and management (20 hrs.)

Principles of conservation, Conservation and economic use of energy, Ecological problems due to intensive aquaculture- importance of trawling ban, Conservation of wild life- present status and strategies of conservation, Deforestation, and its consequences- need for scientific management and conservation of forests, Biodiversity in India, Biodiversity registering, Biodiversity management committee (BMC), Peoples Biodiversity Register (PBR), Biopiracy and patenting of biodiversity.

Module 4. Environmental policy and Education (15 hrs.)

Environmental policy - Social, economic and legal aspects. Environmental laws and their enforcement. Environmental awareness- role of Government, media, and non-Governmental organizations.

Module 5. Environmental Impact Assessment and Sustainable Development (15 hrs.)

Environmental Impact Assessment (EIA) - Definition, aim, principles. Concepts of EIA. Elements of environmental impacts. Methods for preparing EIA - Check list method, Werner-Prestroit study. EIA Process making inventories, sampling and data processing, impact prediction and stimulation. Sustainable Development. Concepts and dimensions. Basic needs, Unavoidable impacts and imperatives relating to sustainable development, Alternative strategies.

Module 6. Environmental Biotechnology (20 hrs.)

Pollution abatement using microbes: Sewage treatment, Solid waste treatment - Composting & significance of Carbon/Nitrogen ratio. Soil enrichment by using microbes. Genetic engineering of nitrogenous gene ('*nif*' genes) and nodulation genes. Microbial insecticides *Bacillus thuringiensis*, Baculoviruses as biocontrol agents and their genetic engineering for improved biocontrol.

Activities, Learning resources and Assessment

Suggested Activities

1. Written Examinations
2. Seminars
3. Assignments
4. Poster Presentations
5. PowerPoint presentations
6. Model preparations
7. Field visits to sanctuaries and bioreserves
8. Visits to laboratories and research institutes

Learning Resources

References.

1. Chapman J.L. and M.J. Resis. (1999). Ecology- Principles and Applications. Cambridge University Press.
2. Abbasi, S.A. and Ramaswamy, E.V. (1999). Biotechnological methods of pollution control. Oxford University Press, Hyderabad.
3. Atchia, M. and Tropp. S. (1995). Environmental Management, John Wiley and Sons.
4. Barthlott, W and Winiger, M. (1998), Biodiversity. Springer Verlag, Berlin.
5. Bishop, P.L. (2000). Pollution Prevention: Fundamentals and Practice, Mc Graw Hill Pub.
6. Aneja K.R. (2000). Experiments in microbiology, plant pathology, tissue culture, and mushroom cultivation. Wishwa Prakashan, New Delhi.
7. Cutter, S.L. (1999). Environmental risks and hazards. Prentice Hall of India Pvt. Ltd., New Delhi.
8. Hary, M.F. (1990). Standard hand book of hazardous waste treatment and disposal. McGraw Hill.
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10. Kamboj, N.S. (1999). Control of noise pollution. Deep and Deep Publishers.
11. Kluge, H. Bittner, A and Hohnholz. J.H. (1995). Environment management, Institute of scientific Co-operation, Tubinlen, Germany.
12. Morris and Therivel, R. (1995). Methods of Environmental Impact Assessment. UCL Press. London.
13. Owen, K.L and Unwin, T. (1997). Environment Management, Blackwell Publishers.
14. Park, C (1997). The environment- principles and applications Routledge, London.
15. Rao, M.N. and Rao, N.V.N. (1997). Air Pollution. Tata Mc Graw Hill Pub. Co. Ltd.
16. Schwab, G.O. Gangmeirr, D.D. and Elliot, W.J. (1996). Soil and water management systems. John Wiley and sons.
17. Scragg.A. (1999). Environmental Biotechnology, ELBS.
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21. Sharma, B.K and Kaur, H. (1994). Environmental pollution. GOEL Publishing House, Meerut.
22. Singh B.P. et al., (1988). Environment and Biotechnology. Today and Tomorrow Printers. New Delhi.
23. Siva, V. (1992). Biotechnology and Environment, Third World Network, Malaysis.
24. Trivedi, P.R. (2000). Global Biodiversity, Authors Press.
25. Wentz. (1998). Hazardous waste management (2nd Edition) Mc Graw Hill Pub.
26. Wood, C. (1997). Environmental Impact Assessment, Longman.
27. Yogendra, N. and Srivasantha. (1995). Environmental Pollution. Ashish Publishing House, New Delhi.
28. Glick B.R. and Pasternak, J.J. (2000). Molecular Biotechnology ASM Press, Washington, DC.
29. Charles Kendeigh S. (1980). Ecology with special reference to animals and man, Prentice Hall of India Pvt. Ltd.
30. Uberoi N.K., (1999). Environmental Management., Excel Books.
31. Biswarup Mukherjee, (1997). Environmental Biology, Tata Mc Graw Hill.
32. Abbasi, S.A. (1998). Environmental Pollution and its control. Cognent International, Pondicherry.

Assessment: 25% Continuous Evaluation, 75% End Semester Evaluation: 3Hrs. Written Examination

SEMESTER 4 SPECIAL COURSES (120hrs.)

Special Course: Environmental Physiology
(Special Course Practical 1)

Practical 4 ZO543: Pollution Biology & Environmental Physiology - Practical 4

COURSE OUTCOMES

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

CO 1: Determination of soil quality parameters.
CO 2: Estimation of water quality parameters.
CO 3: Conduct short term bioassay and determination of LC_{50} of fish exposed to a given pollutant.
CO 4: Develop skill to identify indicator organism from an ecosystem.
CO 5: Estimate the effect of polluting agents on the oxygen consumption of fishes.
CO 6: Determine the temperature and pH preferences of fishes.

(10 practical must be carried out).

1. Determination of moisture content of soil.
2. Determination of organic carbon.
3. Determination of porosity/water retaining capacity of soil.
4. Determination of chlorine in water.
5. Determination of alkalinity in water.
6. Determination of Total Ammonia Nitrogen (TAN) in water.
7. Short term bioassays and determination of LC_{50} of fish exposed to a given pollutant (Demo only).
8. Effect of soil pollution on the population of earth worms.
9. Study of indicator organisms.
10. Effect of pollution on the oxygen consumption of fishes.
11. Temperature preferences of fishes.
12. pH preferences of fishes.
13. Estimation of nitrites in water sample.
14. Estimation of soluble reactive phosphates in water sample.

Field work- Students are expected to make a field study on the problem of environmental pollution in their locality.
Note: The students should submit the field study report at the time of examination.

Activities, Learning resources and Assessment

Suggested Activities

1. Field visits to ecologically important places.
2. Assessment of water and soil quality parameters and make a report.
3. Survey of indicator species from polluted ecosystem and record.
4. Skill in handling, calibration and operation of instruments and lab equipment.
5. PowerPoint presentations.
6. Models and chart preparations.
7. Visit to laboratories and instrumentation facilities of Universities and Research Institutes.
8. Setting up of aquarium tanks for bioassay studies.
9. Submission of Records and for Continuous Evaluation.
10. Submission of field study report during practical examination.

Learning Resources
References

1. Rice, E. W., Baird, R.B, Eaton, A.D., Clesceri, L.S. (2012). Standard methods for the examination of water and wastewater. 22nd edition. American Public Health Association, American water, Water environment federation.
2. Michael, P. (1984). Ecological methods for field and laboratory investigations. Tata McGraw, Hill Publication Company.
3. Grainer, J. M. and Lynch, J. M. (1984). Microbial methods for environmental biotechnology. Academic Press.
4. Manual on sewerage and sewage treatment. (1980). Ministry of works and housing, New Delhi.
5. George, T., Franklin, L. Burton and David, S. H. (2002). Waste water engineering, Metcalf and Eddy. 4th Ed. INC Tata McGraw Hill.
6. Webber, W. J. (1972). Physicochemical processes: for water quality control. Wiley inter-science.
7. Arceivala, S. J. and Asolaker, S. R. (2007). Waste water treatment for pollution control and reuse. Tata McGraw Hill Education.
8. Indian Standard for Drinking Water. (2012). Bureau of Indian Standards, New Delhi.

Assessment:
25% Continuous Evaluation, 75% End Semester Evaluation: 4Hrs. Practical Examination

SEMESTER 4 SPECIAL COURSES (120hrs.)

Special Course: Environmental Physiology
(Special Course Practical 2)

Practical 5 ZO544: Environmental Management - Practical 5

COURSE OUTCOMES

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

CO 1: Gain expertise in the determination of BOD and COD of polluted water.
CO 2: Estimation of water quality parameters.
CO 3: Construction of pyramid of numbers and biomass.
CO 4: Develop skill to identify indicator organisms from an ecosystem.
CO 5: Estimation of species diversity of local aquatic and terrestrial habitats.
CO 6: Determine the pH and texture of soil samples.
CO 7: Working with the laboratory instruments water and soil quality estimation.

(10 practical must be carried out)

1) Determination of pH of water using pH paper, Universal indicator solution and pH meter.
2) Determination of electrical conductivity of water.
3) Determination of turbidity of water.
4) Determination of salinity of water.
5) Determination of hardness of water.
6) Determination of COD of polluted water.
7) Estimation of BOD of polluted water.
8) Instrumentation (any three): Principles, use and working of the following instruments: pH meter, Electrical conductivity meter, Flame photometer, Dissolved oxygen meter, and Hygroscopic soil thermometer.
9) Construction of pyramids of numbers and biomass from a pond collection.
10) Species diversity estimation with reference to a freshwater pond/soil samples from leaves of mulched areas.
11) Determination of soil pH (using different soil samples).
12) Analysis of soil texture using micrometry.

Activities, Learning resources and Assessment

Suggested Activities

1. Field visit to polluted aquatic and terrestrial ecosystems and make report.
2. Visit to waste water treatment plants and make a report.
3. Estimation of water and soil quality parameters and make a report.
4. Handling, calibration and operation of instruments and lab equipment.
5. Make PowerPoint presentations.
6. Models and chart preparations.
7. Visit to laboratories and instrumentation facilities of Universities and Research Institutes.
8. Submission of Records and Records for Continuous Evaluation.

Learning Resources
References

1. Rice, E. W., Baird, R.B, Eaton, A.D., Clesceri, L.S. (2012). Standard methods for the examination of water and wastewater. 22nd edition. American Public Health Association, American water, Water environment federation.
2. Michael, P. (1984). Ecological methods for field and laboratory investigations. Tata – McGraw –Hill Publ. Company.
3. Grainer, J. M. and Lynch, J. M. (1984). Microbial methods for environmental biotechnology. Academic Press.
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5. George, T., Franklin, L. Burton and David, S. H. (2002). Waste water engineering, Metcalf and Eddy. 4th Ed. INC. Tata McGraw Hill.
6. Webber, W. J. (1972). Physicochemical Processes: For water quality control. Wiley inter-science.
7. Arceivala, S. J. and Asolaker, S. R. (2007). Waste Water Treatment for Pollution Control and Reuse. Tata McGraw Hill Education.
8. Indian Standard for Drinking Water (2012). Bureau of Indian Standards, New Delhi.

Assessment:
25% Continuous Evaluation, 75% End Semester Evaluation: 4Hrs. Practical Examination

SEMESTER 4 COURSE CODE ZO501

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: Standardise 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 COURSE CODE ZO502

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