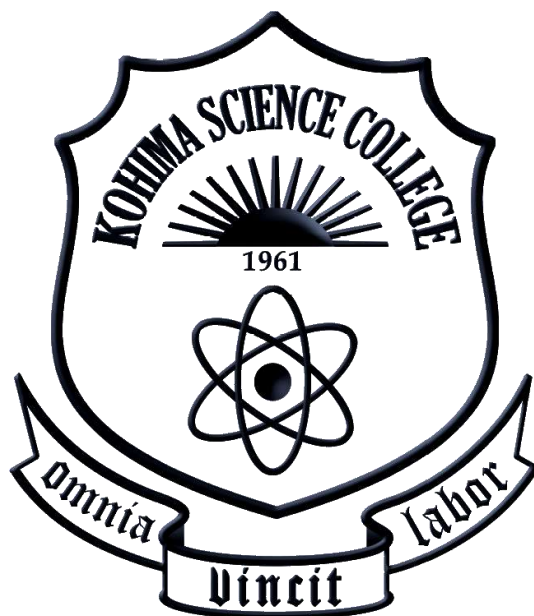


KOHIMA SCIENCE COLLEGE
(An Autonomous Government P.G. College)
JOTSOMA, NAGALAND



Revised
SYLLABUS OF M.SC. ZOOLOGY
Under UGC CBCS Guidelines

2023

SCHEME FOR CHOICE BASED CREDIT SYSTEM
&
Course Structure
M.Sc. (Zoology)

| SEMESTER | CORE COURSE | COURSE CODE | COURSE TITLE | CREDITS |
|--------------|-----------------------------|---|--------------------------------------|---------|
| I | Core 1 | MZOC 1.11 | Genetics & Cytogenetics (Theory) | 4 |
| | | MZOC 1.12 | Genetics & Cytogenetics (Practical) | 2 |
| | Core 2 | MZOC 1.21 | Biochemistry (Theory) | 4 |
| | | MZOC 1.22 | Biochemistry (Practical) | 2 |
| Core 3 | MZOC 1.31 | Biosystematics & Evolutionary Biology (Theory) | 4 | |
| | MZOC 1.32 | Biosystematics & Evolutionary Biology (Practical) | 2 | |
| Core 4 | MZOC 1.41 | Developmental Biology (Theory) | 4 | |
| | MZOC 1.42 | Developmental Biology (Practical) | 2 | |
| II | Core 5 | MZOC 2.11 | Cell & Molecular Biology (Theory) | 4 |
| | | MZOC 2.12 | Cell & Molecular Biology (Practical) | 2 |
| | Core 6 | MZOC 2.21 | Animal Physiology (Theory) | 4 |
| | | MZOC 2.22 | Animal Physiology (Practical) | 2 |
| Core 7 | MZOC 2.31 | Techniques in Biology (Theory) | 4 | |
| | MZOC 2.32 | Techniques in Biology (Practical) | 2 | |
| Core 8 | MZOC 2.41 | Immunology (Theory) | 4 | |
| | MZOC 2.42 | Immunology (Practical) | 2 | |
| III | Core 9 | MZOC 3.11 | Parasitology (Theory) | 4 |
| | | MZOC 3.12 | Parasitology (Practical) | 2 |
| | Core 10 | MZOC 3.21 | Proteomic & Enzymology (Theory) | 4 |
| | | MZOC 3.22 | Proteomic & Enzymology (Practical) | 2 |
| | DSE 2 | MZOD 3.21 | Research Methodology (Theory) | 4 |
| | | MZOD 3.22 | Research Methodology (Practical) | 2 |
| | DSE 1 | MZOD 3.11(A) | Fish Biology – I (Theory) | 4 |
| MZOD 3.12(A) | | Fish Biology – I (Practical) | 2 | |
| MZOD 3.11(B) | | Limnology – I (Theory) | 4 | |
| MZOD 3.12(B) | | Limnology – I (Practical) | 2 | |
| MZOD 3.11(C) | | Entomology – I (Theory) | 4 | |
| MZOD 3.12(C) | | Entomology – I (Practical) | 2 | |
| MZOD 3.11(D) | Endocrinology – I (Theory) | 4 | | |
| | MZOD 3.12(D) | Endocrinology – I (Practical) | 2 | |
| IV | Core 11 | MZOC 4.11 | Ecology & Environmental Biology | 4 |
| | | MZOC 4.12 | Ecology & Environmental Biology | 2 |
| | Core 12 | MZOC 4.21 | Animal Behaviour & Chronobiology | 4 |
| | | MZOC 4.22 | Animal Behaviour & Chronobiology | 2 |
| | DSE 3 | MZOD 4.11(A) | Fish Biology – II (Theory) | 4 |
| | | MZOD 4.12(A) | Fish Biology – II (Practical) | 2 |
| | | MZOD 4.11(B) | Limnology – II (Theory) | 4 |
| | | MZOD 4.12(B) | Limnology – II (Practical) | 2 |
| | | MZOD 4.11(C) | Entomology – II (Theory) | 4 |
| | | MZOD 4.12(C) | Entomology – II (Practical) | 2 |
| MZOD 4.11(D) | Endocrinology – II (Theory) | 4 | | |
| | MZOD 4.12(D) | Endocrinology – II (Practical) | 2 | |
| DSE 4 | MZOD 4.21 | Dissertation | 6 | |

SEMESTER – I

CORE 1 (THEORY): GENETICS AND CYTOGENETICS (MZOC 1.11)

Theory Credit: 4

- UNIT 1 Genome size and evolutionary complexity, C- value paradox; Organization of chromosomes; Unique and repetitive sequences in eukaryotic genome; Non- Mendelian genetics; maternal effects (pigmentation in *Ephestia*); Organelle heredity (mutations in *Chlamydomonas*, mitochondria- petite in *Saccharomyces*); Infections hereditary – Kappa in *Paramecium*); Mitochondrial diseases in man.
- UNIT 2 Linkage and chromosomal mapping: crossing over as physical basis of recombination, chiasmata and the time of crossing over, mapping distance, two- point test cross, three point test cross, gene order, recombination frequency and map distance, interference and coincidence, cytogenetic mapping; Somatic cell genetics: concept and applications; Transfection of cells: principles and method; Cell fusion; Hybridoma; Applications of embryonic stem cells.
- UNIT 3 Gene mutation: molecular basis of transition and transversion, missense, neutral, silent, frameshift and reverse mutation; Types of DNA damages: physical and chemical mutagen; DNA repair mechanisms (base excision repair system, nucleotide excision repair system, mismatch repair system, recombination repair system, SOS system); Diseases in man (sickle cell anaemia, thalassemia, cystic fibrosis; Structural and numerical alterations of chromosomes: deletion, duplication, inversion, translocation, polyploidy and their genetic implications; Transposable genetic elements in prokaryotes and eukaryotes: IS element, composite transposons, Tn3 element, mechanism of transposition, pelement and hybrid dysgenesis in *Drosophila*, retrotransposons.
- UNIT 4 Microbial genetics: methods of gene transfer- transposition, transduction, conjugation, sexduction); Sex determination in *Drosophila*, *C.elegans*, human and other animals; Dosage compensation of X-linked genes- hyperactivation of X-linked genes in male *Drosophila*, inactivation of X- linked genes in female mammals; Human cytogenetics: human chromosomes and karyotypes, autosomal and sex chromosomal anomalies; Human genome project; Prenatal diagnosis.
- UNIT 5 Oncogenes: tumour inducing retrovirus and viral oncogenes; Chromosome rearrangement and cancer; Tumour suppressor gene- cellular roles of tumour suppressor genes pRB, p53, APC, genetics pathways to cancer; Diseases (chronic myeloid leukaemia, Burkitts lymphoma, retinoblastoma, Wilm's tumour).

CORE 1 (PRACTICAL): GENETICS AND CYTOGENETICS (MZOC 1.12)

Practical Credit: 2

1. Meiosis from grasshopper testis and calculations of chiasma frequency and coefficient of terminalisation.
2. Preparation and mapping of polytene chromosomes (from salivary gland of *Chironomus*/ *Drosophila* larvae).
3. Preparation of human karyotypes (normal male and female); analysis of some common human chromosomal aberrations.
4. Demonstration of monohybrid and dihybrid crosses of *Drosophila*.
5. Study of mutant phenotypes of *Drosophila*.
6. Study of sex chromatin in buccal smear and hair bud cells (human).
7. *Drosophila* genetics: preparation of culture medium. (Study of wild type and mutant/ life cycle and morphology).
8. Mounting of sex comb of *Drosophila melanogaster*.

Recommended Books and References:

1. Snustad P and Simmons M.J. (2011) Principles of Genetics, 8th Ed.,. John Wiley & sons Inc., USA.
2. Russels P(2006) Fundamentals of Genetics, Addison Wesley Longman Inc.
3. Brooker RJ (2009) Genetics: analysis and Principles, McGraw Hill.
4. Griffiths A.J.F., Wesslers S.R., Lewontin R.C. and Carrol S.B. (2007) Introduction to Genetic Analysis.
5. Brookers RJ 1999 Benjamin/ Cummings Genetic Analysis and Principles. Longman Inc.
6. Garner BP, Simmons EJ and Snustad MJ 1991, Principles of genetics. John Wiley & sons Inc.
7. Lewin B 2003. Genes 2003. Genes VIII. Oxford Univ. Press.

CORE 2 (THEORY): BIOCHEMISTRY (MZOC 1.21)

Theory Credit: 4

- UNIT 1 Acids, bases, pH and buffer; Derivation of Henderson and Hasselbach equation; Simple calculations on pH and buffer; Bioenergetics: coupled reaction, group transfer, standard reduction potential; Gibbs free energy changes; mitochondrial electron transport chain complexes: oxidative photophosphorylation
- Unit 2: Metabolism: Steps, enzymes and inhibitors of Glycolysis and Citric acid cycle; Glycogenolysis, Glycogenesis and Gluconeogenesis; Pentose Phosphate pathway and its significance.
- Unit 3: Amino acids: chemical structure and classification based on structure, polarity, nutritional requirement and metabolic fate; Properties of amino acids; Derivatives of amino acids, non-transcribed amino acids as protein constituents, D-amino acids.
Metabolism of amino acids: amino acid pool, transamination, oxidation and non-oxidative deamination; Metabolism of branched chain amino acids; Fate of carbon skeleton of amino acids; Urea cycle.
- Unit 4: Organisation of protein structure: primary structure and peptide bond, secondary, tertiary and quaternary structure; Conjugate protein- haemoglobin, cytochromes, myoglobin; Bonds involved in protein organization; Biological functions of proteins; Biological importance of peptides: glutathione, octa-, nona-, and deca-peptides.
Metabolism of nucleic acids: synthesis of ribonucleotides- a brief idea of *de-nova* pathway and salvage pathway; Conversion of ribonucleotides to deoxyribonucleotides; Degradation of nucleotides.
- Unit 5: Integration of metabolism; Energy demand and supply; Integration of major metabolic pathways of energy metabolism; Intermediary metabolism. Organ specialization and metabolic integration: Liver, Kidney, Brain, Adipose tissue and Skeletal Muscles; Metabolism in starvation.

CORE 2 (PRACTICAL): BIOCHEMISTRY (MZOC 1.22)

Practical Credit: 2

1. Preparation of phosphate and acetate buffers with different pH.
2. Determination of pka for glycine and glutamic acid.
3. Estimation of protein using Bradford method.
4. Estimation of amino acids using Ninhydrin reagent.
5. Estimation of inorganic phosphate by Fiske-Subharao's method.
6. Preparation of standard acid and alkali and its standardization.
7. Study of osazone derivatives of sugar.
8. Estimation of tyrosine by folin phenol method and verification of beer's law.
9. To estimate the amount of α -amino nitrogen by formal titration.
10. To determine standard glucose curve by DNSA (3,5 dinitro salicylic acid method)
11. Estimation of cholesterol.
12. To separate amino acids by paper chromatography.

Recommended Books and References:

1. Nelson D.L Cox. M.M (2013) Lehninger Principle of Biochemistry, 6thEdn., Worth Publisher, New York.
2. Moran L.A et al. (2011) Principles of Biochemistry, 5thEdn., Prentice, 5thEdn. ASM, USA.
3. Cooper G.M and Hausman R.E (2009). The Cell: Molecular Approach, 5thEdn, ASM Press, USA.
4. Metzler D.E. (2005) Biochemistry, vol. 1 and 2, 3rdEdn., Academic Press, New Delhi.
5. Rawn J.D. (2004) Biochemistry, Panima Publishing Corporation, New Delhi.
6. Berg J.M., Tymocko J.L. and Stryer L. (2010) Biochemistry, 7thEdn., H. Freeman and Company, UA.
7. Muray R.K et al. (2010) Harpers Illustrated Biochemistry, 29thEdn., McGwat hill, London.
8. Alberts et al. (2008) Molecular Biology of the Cell, 5thEdn. Garand publishing.
9. Lewin B. (2011) Gene XI, John Cl, John Wiley & Sons.
10. Weaver R.F (2005) Molecular Biology, 3rdEdn., McGraw-Hill International.
11. Watson J.D., Baker T.A., Bell S.P., Gann A., Levin M. and R. (2007) Molecular Biology of the Gene, Benjamin Cummings, San Francisco, USA Losick.
12. Plummer L. (1989) Practical Biochemistry, Tata McGraw-Hill.
13. McPherson H.J. and Moller S.G (2006) PCR, 2ndEdn., Taylor & Francis.

CORE 3 (THEORY): BIOSYSTEMATICS & EVOLUTIONARY BIOLOGY (MZOC 1.31)

Theory Credit: 4

- UNIT 1 Definition, Importance of Biosystematics, Applications of Biosystematics in Biology; Cytotaxonomy: Chromosomal behavior – Karyotype test, Chromosome number, Chromosome morphology, Linkage, recombination frequency analysis; Banding pattern – G,C,R,Q Banding; Molecular Taxonomy: Source of variation, satellite DNA (Mini and micro DNA), Molecular markers – RFLP, RAPD, and AFLP, Ribotyping and DNA sequencing.
- UNIT 2 Principles - Principle of Binominal Nomenclature, Principle of Priority, Principle of Coordination, Principle of the First Reviser, Principle of Homonymy, Principle of Typification, Structure, Gender agreement, Commission. Species Indices – Shannon – Weiner Index, Dominance Index, Similarity & Dissimilarity, Association Index.
- UNIT 3 Evolutionary time scale: eras, periods and epoch; Major events in the evolutionary time scale; Stages in primate evolution including Homo; Concepts of neutral evolution, molecular divergence, and molecular clocks; Molecular tools in phylogeny, classification, and identification.
- UNIT 4 Darwin–concepts of variation, adaptation, struggle, fitness, and natural selection; Lamarck; Mendelism; Spontaneity of mutations; The evolutionary synthesis; Origin of basic biological molecules; Abiotic synthesis of organic monomers and polymers; Origins of unicellular and multicellular organisms.
- UNIT 5 Population genetics – Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; Concepts and rate of change in gene frequency through natural selection, migration, and random genetic drift; Adaptive radiation; Isolating mechanisms. Speciation; allopatricity and sympatricity; convergent evolution; sexual selection; co-evolution.

CORE 3 (PRACTICAL): BIOSYSTEMATICS & EVOLUTIONARY BIOLOGY (MZOC 1.32)

Practical Credit: 2

1. Identification and classification of aquatic micro-organism
2. Analysis of morphometric variations in selected natural populations.
3. Preparation of taxonomic keys for identification of the studied populations.
4. Karyotype test for species identification.
5. Identifying specimen samples of vertebrates and invertebrates by Taxonomic procedures (collection, preservation, curating).
6. Study of homologous and analogous organs in vertebrates with photos and pictures.
7. Study of fossils.
8. Study of Hardy- Weinberg equilibrium in human population by taking example of blood group system (ABO).

Recommended Books and References:

1. Principles of Animal Taxonomy – G.G Simpson- Oxford & IBH Publication.
2. Elements of Taxonomy – E. Mayer – Tata Mcgraw Hill Co.
3. Biosystematics and Taxonomy – R.C. Tripathi- University Book House.
4. Biodiversity, Taxonomy and Ecology – G K Singh- Alp Books.
5. Theory and Practices of Animal Taxonomy- VC Kapoor – Oxford and Ibh Co.
6. Fundamentals of Biodiversity and Taxonomy (HB) – J.Juneja- Cubertech Publications.

CORE 4 (THEORY): DEVELOPMENT BIOLOGY (MZOC 1.41)

Theory Credit: 4

- UNIT 1 Cell fate and Commitment; Mechanism of Developmental Commitment; Totipotency and pluripotency; Stem cells, genomic equivalence and the cytoplasmic determinants; Cell hybridization and nuclear transplantation experiment; Organizer-induction; Competence.
- UNIT 2 Spermatogenesis- formation of spermatids and spermiogenesis; Oogenesis- oocyte growth, maturation and vitellogenesis; Fertilization (**internal and external**): Cleavage: characteristics, planes and patterns of cleavage; Gastrulation and formation of germ layers in **chick** and amphibia.
- UNIT 3 Axis pattern formation in *Drosophila* and Chick; Neurulation in Zebra fish; Vulva formation in *Caenorhaptidis elegans*. Organogenesis: Development of vertebrate brain and the dynamics of optic Development- the vertebrate eye; Regeneration: Epimorphic regeneration of Salamander limbs, Morphallactic regeneration in *Hydra*, Compensatory regeneration in Mammalian Liver.
- UNIT 4 Reproductive cycles in animals and human: Estrous and menstrual cycle; Seasonal and Continuous breeders; Photoperiodic regulation of breeding cycle of vertebrates; Puberty and Adolescence, role of hormones; Origin, cause and treatment of male and female sterility.
- UNIT 5 Contraceptive methods for male and Female; Surgical Sterilisation with reference to Tubectomy and vasectomy; Assisted Reproductive Techniques: IVF-ET; Stem cells-concepts, types and significance; Teratogenesis: Teratogenic agents- malformations and disruptions.

CORE 4 (PRACTICAL): DEVELOPMENT BIOLOGY (MZOC 1.42)

Practical Credit: 2

1. Study of developmental stages of frog from permanent slides/models/charts.
2. Study of different types of invertebrate and vertebrate eggs from permanent slides/models/charts.
3. Study of regeneration in Planaria/Hydra.
4. Study of regeneration in the tail of tadpoles.
5. Study of developmental stages of chick from permanent slides/models/charts
6. Preparation of whole mount of chick embryo of 13-18, 24-33, 36-48 and 48-72 hours and identification of the developmental stages

Recommended Books and References:

1. Developmental Biology, Gilbert, (8th Ed,2006), Sinaur Associates Inc, Massachusetts, USA.
2. Principles of Development, Wolpert, Beddington, Brockes, Jessell, Lawrence, Meyerowitz,(3rd Ed,2006),Oxford University Press, New Delhi.
3. Analysis of Biological Development, Kalthoff, (2nd Ed,2000), McGraw-Hill Science, New Delhi.
4. Reproductive Endocrinology, Physiology, Pathophysiology and Clinical management, Samuei S.C Yen, Robert B. Jaffe, Robert. L. Barbieri (ed) Saunders Publishers, USA.
5. The Physiology of Reproduction, Vol.1 and 2, Ernst Knobil and Jimmy D. Neil (ed), Raven.

SEMESTER – II

CORE 5 (THEORY): CELL AND MOLECULAR BIOLOGY (MZOC 2.11)

Theory Credit: 4

- UNIT 1 Plasma membrane: fluid mosaic model, chemical constituents (membrane lipids, proteins and carbohydrates) and their organization and functional features; General features of cytoskeleton: microtubules, microfilaments and intermediate filaments- structural and functional dynamics; Secretory pathway: receptor mediated endocytic pathway, protein sorting and transport to the cell organelles
- UNIT 2 Chromatin: chemical composition, histones, molecular organization of nucleosomes, nucleoplasm, chromatin to chromosomes, histone modifications, chromatin remodeling complex .
Cell cycle- features and phases; cyclins and cyclin dependent kinases, regulation of CDK- cyclin activity, cell cycle check points.
Cell death: types ,significance, salient features; mechanism: extrinsic and intrinsic pathways.
- UNIT 3 Structure and properties of DNA and RNA.
DNA replication: mechanism of DNA replication in prokaryotes and eukaryotes; structure and properties of DNA polymerases; enzymes and factors involved in DNA replication.
Transcription: mechanism- initiation, elongation and termination steps. Sense and antisense strand, structure and properties of RNA polymerases in prokaryotes and eukaryotes; RNA processing.
- UNIT 4 Protein synthesis; Genetic code; Differences between prokaryotic and eukaryotic protein synthesis; Inhibitors of protein synthesis; posttranslational modifications of proteins.
Prokaryotic gene expression: positive and negative control of gene expression, lac operon and tryptophan operon in *E.coli*; Repression and attenuation.
- UNIT 5 History of recombinant; Tools of RDT; Tools-restriction enzymes, cloning vectors, plasmids, phages, viruses; Methods of introduction – transformation, transduction, transfection, electroporation, microinjection, liposome fusion; applications: transgenic animals.

CORE 5 (PRACTICAL): CELL AND MOLECULAR BIOLOGY (MZOC 2.12)

Practical Credit: 2

1. Study of metaphase plate in red corneal/ root tip
2. Study of meiosis in grasshopper testis
3. Study of sex- chromatin in human buccal cavity cells
4. Isolation and staining of mitochondria from mice/ rat.
5. Estimation of DNA by diphenylamine reagent.
6. Estimation of RNA by orcinol reagent.
7. Subcellular fractionation of functional mitochondria
 - i. Isolation of mitochondria from mouse liver by differential centrifugation
 - ii. Determination of protein yield in the fractions by Lowry method
 - iii. Identification of mitochondrial fraction by assay of marker enzyme
8. Microtubules in vesicle transport in fish chromatophores
9. Mammalian cell culture
10. Assessment of proliferation in cultural cells by MTT assay
11. Over- expression and affinity purification of SH3- GCT recombinant protein from bacterial cells
12. Observation of DNA fragmentation in apoptotic cells.
13. Study of different stages of mitosis with the help of onion root tip.

Recommended Books and References:

1. Molecular Cell Biology, Lodish et al., (2007), W.H. Freeman & Company, Ner York, USA.
2. Molecular Biology of the Cell, Alberts et al.,(2008), Garland Science, Taylor & Francis Group, New York, USA.
3. Karp G (2007) Cell Biology, 7th Edn). Wiley Publ., New York.
4. De Robertis E.D.P. and De Robertis E.M.F.,(2008) 8th Edn, Wolters Kluwer Pobl., New York.
5. Verma P.S., Cell Biology, S.Chand Pvt. Ltd.
6. Co Kleinsmith L.J and Kish V.M (1995) Principles of Cell & Molecular Biology. Harper Collins Publishers, New York.
7. Lewin B. (2011) Gene XI, John Cl, John Wiley & Sons.
8. Weaver R.F (2005) Molecular Biology, 3rdEdn., McGraw-Hill International.
9. Watson J.D., Baker T.A., Bell S.P., Gann A., Levin M. and R. (2007) Molecular Biology of the Gene, Benjamin Cummings, San Francisco, USA Losick.

CORE 6 (THEORY): ANIMAL PHYSIOLOGY (MZOC 2.21)

Theory Credit: 4

- UNIT 1 Gastrointestinal hormones and digestive enzymes in vertebrates; secretion and regulation in mammal; mechanism of digestion and absorption of different component of food materials. The enteric nervous system.
- UNIT 2 Neuroanatomy of the brain and spinal cord; Membrane potential, ions as current carriers (calcium, potassium), structure of cation permeable channels and chloride channels. Synaptic transmission: Electric transmission, chemical transmission, chemical transmitter-Neuropeptide, FMRF – amide family.
- UNIT 3 Respiration: Regulation of respiration, Respiratory function of blood; respiratory pigments, respiratory acidosis and alkalosis, Alkali reserve, control and co – ordination of respiration, respiratory adjustment, Dyspnea, periodic breathing, respiratory buffering. Transport of oxygen and carbon dioxide; oxygen dissociation curve; Bohr effect and Root effect.
- UNIT 4 Structure of vertebrate kidney and nephron; formation of urine ; counter current mechanism of urine formation; renal control mechanism ; acid-base balance ; homeostasis; Osmoregulation in aquatic and terrestrial animals –mechanism and regulation. Thermoregulation – heat balance in animals; body temperature – physical, chemical and neural regulation.
- UNIT 5 Cardiac cycle events, regulation of cardiac amplitude and frequency in mammals. Composition and functions of blood volume; haemopoiesis; blood pressure; blood groups; blood coagulation; haemostasis. Ultra-structure and chemical composition of skeletal muscle; neuromuscular junction, molecular mechanism and regulation of muscle contraction; energetics of muscle contraction.

CORE 6 (PRACTICAL): ANIMAL PHYSIOLOGY (MZOC 2.22)

Practical Credit: 2

1. RBC count in blood.
2. Hb concentration in the blood.
3. Measurement of blood pressure under different physiological conditions.
4. Estimation of casein in milk.
5. Estimation of glycogen content in liver of fish/goat.
6. Estimation of ascorbic acid in tomato, lemon and milk.
7. Determination of the rates of oxygen consumption by an aquatic animal
8. Determination of respiratory quotient of an air breathing animal.
9. Absorption of glucose by the gut in laboratory bred animal.

Recommended Books and References:

1. Hill R.W., Wyse G.A and Anderson M. (2008) Animal Physiology, 2ndEdn. Sinauer Associates, Inc USA.
2. William B., M.D. (2008) Carpenter Animal Physiology, New Rev Edn. Kessinger Pub. Co.
3. Moyes C.D., Schulte P.M. (2006) principles of Animal Physiology, Pearson Benjamin Cummings (USA)
4. Willmer P. Stone G. and Johnston I. (2000) Environmental Physiology of Animals, Blackwell Science Ltd. USA.
5. Prosser, C.L. (1991) Comparative Animal physiology, Saunders, Philadelphia, USA.
6. Eckert, R and Randall, d. (2005) Anima Physiology, Mechanism & Adaptations, 2ndEdn., CBS publishers & Distributors, New Delhi.
7. Schmidt-Nielsen K. (2005) Animal Physiology, Harper & Row, NY.
8. Withcrspoon J.D. (2001) Human Physiology: Adaptation and Environment, Cambridge Press.
9. Hoar W.S. (1993) General and Comparative Physiology, Pentice Hall of India Pvt. Ltd.
10. Hainsworth F.R (1999) Animal Physiology: Adaptations' in function, Addison Wesley Longman Publishing Co., USA.
11. Publishing Co., USA.

CORE 7 (THEORY): TECHNIQUES IN BIOLOGY (MZOC 2.31)

Theory Credit: 4

- UNIT 1 Microscopy: Light, phase-contrast, fluorescent and electron microscopy.
Methods in Cell Biology: Cell and tissue culture.
Principle and application of tracer techniques: Autoradiography, radioimmunoassay.
Immunological techniques: Immuno-diffusion, immuno-electrophoresis, Enzyme linked
Immunosorbant assay (ELISA).
Spectrophotometry: Spectrofluorometry; spectroscopy.
Tissue processing and separation of various sub-cellular organelles by centrifugation.
- UNIT 2 Chromatography: Adsorption, ion-exchange, gel filtration, affinity and high performance liquid
chromatography (HPLC).
Electrophoresis: Iso-electrophoresis and pulse field electrophoresis.
Blotting Technique: Southern, Northern and Western blotting.
Sequencing of nucleic acids; Polymerase Chain Reaction (PCR).
- UNIT 3 Statistics and its applications in biology; Sampling and Variables.
Frequency distribution: Simple and Grouped.
Measure of central tendency: mean, median and mode.
Measure of variation: Range, quartile deviation, mean deviation, Standard deviation, Coefficient
of variation.
- UNIT 4 Distribution: Normal, Binomial and Poisson distribution.
Tests of statistical significance: t-test, Chi-square test, Introduction to one and two ways ANOVA,
F- test.
Correlation and Regression: Types of correlation, Coefficient of correlation, Linear regression,
Coefficient of regression.
- UNIT 5 Introduction to bioinformatics, Database concepts and biological databases (NCBI, EBI and DDBJ).
Needleman-Wunsch and Smith-Waterman methods of local and global alignment; Pairwise
alignment and Multiple sequence alignment; BLAST and FASTA; Database submission; Information
retrieval.

CORE 7 (PRACTICAL): TECHNIQUES IN BIOLOGY (MZOC 2.32)

Practical Credit: 2

1. Use of different types of microscope: phase contrast, fluorescent and electron microscope.
2. Demonstration of ELISA/radioimmunoassay techniques.
3. Estimation of certain biomolecules using spectrophotometry
4. Amplification of a target gene by PCR
5. Determination of molecular size by agarose gel electrophoresis.
6. Computation of average, variances, standard deviation.
7. Regression analysis and fitting straight line for a bivariate data.
8. Students' 't' test, chi-square test and computation of ANOVA for one-way.
9. Retrieval of DNA sequences and alignment.
10. Construction of phylogenetic tree and interpretation of result using DNA/Protein databases

Recommended Books and References:

1. Norman G. R and Striner D.L (2014) Biostatistics: The bare essentials, 4thEdn., PMPH-USA Limited.
2. Wilson K. and Walker J. (2010) Principles and Techniques of Practical Biochemistry, Cambridge University Press.
3. Nelson and Cox (2013) Lehninger Principles of Biochemistry, 6thEdn.
4. Marc M. Triola M.D and Tiola (2009) Biostatistics for the biological and health sciences: Books a La Carte Edn. Prentice Hall College Div.
5. Plummer D.T. (2008) Introduction to Practical Biochemistry, 3rdEdn., Tata McGraw Hill.
6. Baxevanis A.D. and Ovellette B.F.F (2002) Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Willey-Interscience.
7. Hayat M.A (2000) Principal and Techniques of Electron Microscopy: Biological Application, 4thEdn. Maniatis T. et al. (1982) Molecular Cloning. A Laboratory Manual. Cold Spring.
8. Rodney F. Boyer (2000) Modern Experimental Biochemistry 3rdEdn., Prentice Hall.
9. Elston R.C. and Johnson W.D. (1994) Essential Biostatistics 3rdEdn., Prentice Hall.
10. Elston R.C and Johnson W.D. (1994) Essential Biostatistics, 2ndEdn. F.A Davis Company, USA.
11. Switzer R.L. and Garrity L.F (1999) Experimental Biochemistry. 3rdEdn.
12. Stiles et al. (1991) basic and clinical Immunology, Prentice- Hall international inc.
13. Murad H. and Antique M.V.A. (1991). Biological Techniques in electron Microscopy, CBS publication.
14. Rao C.D.R., Mitra S.K., Mathai A. and Ramamurthy, K. G. (1985) Formulae and Tables for statistical Work, Statistical Publishing Society, Calcutta.
15. Fisher R.A (1970) Statistical Methods for Research Workers. Hafner Press, New York.

CORE 8 (THEORY): IMMUNOLOGY (MZOC 2.41)

Theory Credit: 4

- UNIT 1 Innate and acquired immunity – components and characteristic features.
Lymphoid organ – primary and secondary lymphoid organ and their functions.
Humoral and cell mediated immune response.
Immunogen – antigenicity and immunogenicity. Factors influencing immunogenicity.
Adjuvant, Epitopes and Haptens.
- UNIT 2 Immunoglobulin – structure, classes and function; Antibody mediated effector function; Antigen – antibody reaction; Activation and differentiation of B and T cell; B and T cell receptor – structure and function. Cytotoxin.
- UNIT 3 Antigen presenting cell; Endogenous and exogenous pathways of antigen processing and presentation; Cytokines – property, types and functions.
- UNIT 4 MHC – structure and function of class I and class II.
Complement system – characteristic features, classical and alternate pathway of complement activation.
Hypersensitivity – types and features, mechanism of immediate hypersensitivity reaction.
- UNIT 5 Immunodeficiency – types and diseases.
Immune response to bacterial (Tuberculosis), parasite (Malaria) and viral (HIV) infection.
Immunological techniques – radio-immuno assay (RIA) and Enzyme-linked immunosorbent assay (ELISA).

CORE 8 (PRACTICAL): IMMUNOLOGY (MZOC 2.42)

Practical Credit: 2

1. Dissection and histology of lymphoid organ in laboratory bred animal.
2. Determination of blood group in human.
3. Study of different cell in blood smear from laboratory bred animal.
4. Enumeration of total count of WBC.
5. Identification of WBC cells
6. Antigen-antibody interaction in vitro-Double immunodiffusion.
7. Demonstration of:
8. Immuno-electrophoresis
9. ELISA.

Recommended Books and References:

1. An introduction to immunology by C.V.Rao.
2. Kuby Immunology, Richard Thomas, Barbara, Janis (5th Ed. 2003), W.H. Freeman and Company, New York, USA.
3. Immuno Biology- The immune system in health and disease, Janeway, Travers, Walport and Shlomchik, (6thEd, 2005), Garland Science Publishing, New York, USA.
4. Immunology, David, Brostoff and Roitt, (7th Ed, 2006), Mosby and Elsevier Publishing, Canada, USA.

SEMESTER – III

CORE 9 (THEORY): PARASITOLOGY (MZOC 3.11)

Theory Credit: 4

- UNIT 1 Introduction to parasites of man, scope and definition of parasites/parasitology; Animal associations; Parasitic adaptations - morphological, anatomical, physiological, biochemical; Types of parasites and types of hosts; Interrelationship between host and parasites responses, and hosts to parasitic infection; anthroponoses and zoonoses.
- UNIT 2 Morphology, life cycle, mode of infection, pathogenicity, treatment and prophylaxis of *Plasmodium*; Molecular biology of plasmodium- drug targets, mechanism of drug resistance, vaccine strategies and proteomic approaches.
Morphology, life cycle, mode of infection, pathogenicity, treatment and prophylaxis of protozoan parasite, *Leishmania*.
Morphology, life cycle, mode of infection, pathogenicity, treatment and prophylaxis of intestinal flagellates, *Giardia*;
Morphology, life cycle, mode of infection, pathogenicity, treatment and prophylaxis of cestodes, *Taenia*.
- UNIT 3 Trematodes: Morphology, life cycle, modes of entry, pathogenicity, treatment and prophylaxis of *Schistosoma*, *Fasciola*, *echinococcus*.
Nematodes: Morphology, Life-cycle, Transmission, Pathogenicity, Treatment and Prophylaxis of *Wuchereria*, *Ancylostoma*, and *Dracanculus*;
Vaccine strategies; Plant & Soil nematodes: Cyst nematode, citrus nematode.
- UNIT 4 Trypanosoma: Diploid & Sexual stage, Molecular characteristics of surface coat, Variable surface glycoprotein (VSG) and VSG gene expression.
Platyhelminthes: Inseminative behaviour, parthenogenesis and polyspermy, sex determination and sex linked inheritance in Schistosomes.
Nematoda: chromosome germ line limited DNA & chromatin diminution in *Ascaris*.
- UNIT 5 Microbial products: Industrial, agricultural and biotechnology; food microbiology: Microbial spoilage of food; Food borne animal parasites – *Entamoeba*, *Diphyllobothrium* and *Ascaris*.
Bio-control; biological weapons; wastewater treatment.

CORE 9 (PRACTICAL): PARASITOLOGY (MZOC 3.12)

Practical Credit: 2

1. Study of prepared slides and museum specimens of selected parasites of representatives groups of protozoans, parasites, helminthes and arthropods.
2. Culturing an insect parasitoid and studying their infection on an insect host.
3. Demonstration of in vitro culture of plasmodium, infection of mice with Plasmodium, chasing the process of infection by histopathology and immune reactions.
4. Studying the infection of tomato plant by root knot nematode.
5. Study of life cycle, role as vector & control measures of: a) Ticks (Argas, Boophilus) b) Mosquito - anyone from- Anopheles/ Aedes/ Culex c) Any two flies: Tabanus/ Phlebotomus/ Sarcophaga. Cyclops
6. Temporary mount of Ectoparasites & Endoparasites of wild rat, cattle, dog and chick.
7. Spotters based on theory.

Recommended Books and References:

1. Foundations of Parasitology, Roberts L.S. and Janovy J., McGraw-Hill Publishers, New York, USA.
2. Modern Parasitology: A Textbook of Parasitology, FEG Cox., Wiley-Blackwll. U.K.
3. Human parasitology-Burton J Bogtish
4. Introduction to Environmental Engineering & Science Gilbert M. Masters.
5. Parasitoses and Zoonoses, Bose,M., New central book agency (P) Ltd.
6. Parasitology (Protozoology and Helminthology) in relation to clinical medicine. Chatterjee, K. (2009). 13th Edn. CRC publisher New Delhi.
7. Genome sequence of the human malaria parasite Plasmodium falciparum nature 419:498-511. Gardner M.J. et al (2002) Practical exercises in Parasitology: Edited by D. W. Halton, Queen's University Belfast, J. M. Behnke, University of Nottingham I. Marshall, Liverpool School of Tropical Medicine.
8. Helminthes, Arthropods and Protozoa of domesticated animals. Soulsby, E.J.L. (1983). 7th Edn, Lea & Febiger, Philadelphia.
9. Parasitology by Chandler and Chands.
10. Parasitology, medical Publisher Calcutta, 1987, K.D. Chaterjee.
11. Parasitology – by Ramnik Sood, C.B.S., Publisher, New Delhi – 1993.

CORE 10 (THEORY): PROTEOMIC AND ENZYMOLOGY (MZOC 3.21)

Theory Credit: 4

- UNIT 1 Secondary structure: H-bonding scheme, diversity in alpha-helices, Helix capping, Beta-strand and sheet, turns and loops, importance of loops.
Super secondary structure: domains and motifs.
Tertiary structure: concept of subunits and protomers and their association.
Quaternary structure: importance of quaternary structure, various examples.
- UNIT 2 Anfinsen's classical experiment; folding curves; types of protein folding and enzymes involved in protein folding pathway; models of protein folding; assisted protein folding (chaperones); Post-translational processing, targeting and turnover.
- UNIT 3 Absorbance, fluorescence and circular dichroism.
Structural methods: NMR, X-ray Crystallography, Microarray, 2D- electrophoresis, protein sequencing, mass spectrometry.
- UNIT 4 An introduction to enzyme, enzyme properties, active sites, specificity and enzyme classification; cofactors and coenzyme; Inhibition of enzyme activity: reversible, irreversible, and allosteric inhibition; isoenzymes and ribozyme.
Transition state, binding energy; Effect of different physico-chemical factors on enzyme activity.
- UNIT 5 Mechanism of enzyme action: Fischer's lock and key theory, Koshland's Induced fit model; mechanism of enzyme catalysis.
Enzyme kinetic-Michaelis-Menten equation and its derivation, Lineweaver-Burk Plot, energetic of enzyme-catalyzed reaction, significance of K_m .
Isoenzymes; Ribozyme.

CORE 10 (PRACTICAL): PROTEOMIC AND ENZYMOLOGY (MZOC 3.22)

Practical Credit: 2

1. To study the effect of time on enzyme activity.
2. To study the effect of enzyme concentration on enzyme activity.
3. To study the effect of substrate concentration on enzyme activity and determination of K_m and V_{max} by Michaelis-Menten and Lineweaver-Burk plots.
4. Effect on activator and inhibitor on enzyme activity.
5. SDS-PAGE analysis of protein.
6. Separation of isoenzymes of malate dehydrogenase (MDH)/ lactate dehydrogenase (LDH) starch gel electrophoresis.

Recommended Books and References:

1. Nelson D.L Cox. M.M (2013) Lehninger Principle of Biochemistry, 6thEdn., Worth Publisher, New York
2. Principles Of Proteomics (2004) Publisher: CBS publishers & distributors- New Delhi.
3. Tanner Perry (2017) Proteomics: A Comprehensive Study of Proteins. Larsen and keller publisher.
4. Charles Malkoff (2016) Functional Genomics and Proteomics. Syrawood publishing house.
5. Daniel C. Liebler & john R. Yates. (2002) Introduction to proteomics. Springer science+ Business media, LLC
6. P L Bonner and Trevor Palmer (2001) Enzymes: Biochemistry, Biotechnology, Clinical Chemistry
7. Nicholas C. Price & Lewis Stevens (1999) Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins. Publisher: Oxford University Press.

CORE 11 (THEORY): RESEARCH METHODOLOGY (MZOC 3.31)

Theory Credit: 4

- Unit 1 Research meaning, objectives and significance. Types of research – Descriptive vs Analytical, Applied vs. Fundamental, Quantitative vs Qualitative, Conceptual vs Empirical; Research methods vs Methodology; Characteristics of good research; Steps of working of research.
- Unit 2: Definition and selection of research problem; Technique involved in defining a problem; Meaning and need of research design; Important concepts relating to research design; Different research designs – exploratory research studies, descriptive and diagnostic research studies, and hypothesis-testing research studies; Steps in sample design; Types of sampling designs – non-probability sampling and probability sampling.
- Unit 3: Collection of primary data – Observation method and Interview method; Collection of data through questionnaires; Collection of secondary data; Difference between survey and experiment; Falsification and fabrication of data.
- Unit 4: Plagiarism – concept, software, legal aspects; Intellectual property rights (IPR) – patents, copyrights and related issues; Interpretation – definition, technique and precautions; Report writing – significance and steps; Research report – layout, types and precautions; Basic idea about the impact factor of a journal.
- Unit 5: Concept of standard error; Definition and characteristics of hypothesis; Basic concepts concerning testing of hypothesis – null hypothesis and alternative hypothesis, the level of significance, two-tailed and one-tailed tests; Procedure for hypothesis testing.

CORE 11 (PRACTICAL): RESEARCH METHODOLOGY (MZOC 3.32)

Practical Credit: 2

1. Computation of standard error through statistical software.
2. Writing of literature review.
3. Similarity check through plagiarism software.
4. Writing of project proposal.
5. Preparation of primary and secondary data.
6. Data analysis through SPSS.
7. Visit to research centre and report writing.

Recommended Books and References:

1. Anthony, M, Graziano, A.M. and Raulin, M.L. 2009. Research Methods: A Process of Inquiry, Allyn and Bacon.
2. Walliman, N. 2011. Research Methods- The Basics. Taylor and Francis, London, New York.
3. Wadhera, B.L.: Law Relating to Patents, Trade Marks, Copyright Designs and Geographical Indications, 2002, Universal Law publishing
4. C.R.Kothari: Research Methodology, New Age International, 2009
5. Coley, S.M. and Scheinberg, C.A. 1990, "Proposal writing". Stage Publications.

DSE 1 (THEORY): FISH BIOLOGY - I [MZOD 3.11(A)]

Theory Credit: 4

- UNIT 1 Taxonomic characterization; taxonomic keys; taxonomic methods for identification of fresh water fishes. Methods employed for phylogenetic studies and fish identification; Modern trends in fish taxonomy; fish barcoding, Biogeographic units of freshwater biodiversity; status and distribution of freshwater fish diversity of northeast India.
- UNIT 2 Study of growth curve; absolute and relative growth, length – weight relationship, condition factor, relative condition factor. Hepatosomatic index, gonadosomatic index, index of fitness, ponderal index, fecundity. Growth rate and ageing. Stock assessment and management.
- UNIT 3 Digestive system; anatomical differentiation and modification; feeding behaviour and feeding adaptation in fishes. Respiratory system in fishes: gill structure; mechanism of respiration; counter current principle; exchange of gases; accessory respiratory organs. Forms and function of swim bladder and weberian ossicles in tissues.
- UNIT 4 Types of excretion and regulation; Osmotic regulation: Salt and water balance in freshwater, marine and brackish water fishes; acid-base balance.
Endocrine system in fish: hypothalamo - hypophysial system; neurosecretory system and neuro – hypophysial hormones; functional morphology of Pituitary gland.
- UNIT 5 Reproductive system in teleosts; sexual maturation and breeding cycle; spermatogenesis, oogenesis and vitellogenesis; genetic structure of random mating populations. Test of equilibrium, application and properties of equilibrium population; Scope, application, role of genetics in fish selection and breeding; Sex reversal, hybridization, gynogenesis, polyploidy, hybrid vigour.

DSE 1 (PRACTICAL): FISH BIOLOGY - I [MZOD 3.12(A)]

Practical Credit: 2

1. Identification of important freshwater fish species.
2. Analysis of morphometric variations in teleosts.
3. Analysis of meristic variations in teleosts.
4. Length-weight relationship and K-factor.
5. Gonadosomatic index, absolute and relative fecundity.
6. Gut content analysis of locally available fish species.
7. Estimation of protein in fish tissues.
8. Estimation of phospholipid in fish tissues.
9. Histology of gut, liver and kidney.

Recommended Books and References:

1. Kumar S. and Tembhire M. (2011) fish and Fisheries, New Central book Agency (P) Ltd. (NCBA).
2. Ahmad S.H and Singh A.K (2011) freshwater Aquaculture, Days Publishing, House, New Delhi India.
3. Jhingran V.G (2007) Fish and fisheries of India, 3rd edn. Hindustan Publishing Corporation, India.
4. Evan D. H. (2006) The Physiology of Fishes, CRC Press, Boca Raton, U.S.A.
5. Dhalakia A.D. (2004) Fisheries and Aquatic Resources of India, Daya Publishing House, Delhi.
6. Arratia G., Kapoor B.G., Chardon M. And Diago R. (2003) Catfishes (Vol.1 & II), Science Pub. Inc., USA.
7. Hart P. and Reynold J.D. (2002) Handbook of Fish Biology and Fisheries (Volumn I & II) Blackwell Publishing, USA.
8. Wright P. and Anderson P. (200) Nitrogen Excretion (In Fish Physiology, Vol. 21) Academic Press, USA.
9. Wootton R.J. (1994) Ecology of Teleost Fishes, Chaman and Hall. London.
10. Moyle P. B. And Cech J.J. Jr. (1988) Fishes: An Introduction of Ichthyology, Prentice Hall, New Jersey, USA.
11. Datta-Munshi J.S. and Hughes G.M) (1992) Air-breathing Fishes of India, Oxford and IBH Publ. Co., New Delhi.
12. Matty A.J. (1995) Fish Endocrinology, Croom Helm Ltd. Australia.
13. Lagler K.F., Bardach J.E., Miller R.R and passion D.M (1977) Ichthyology, John Wiley and Sons.

DSE 1 (THEORY): LIMNOLOGY –I [MZOD 3.11(B)]

Theory Credit: 4

- UNIT 1 Introduction to Limnology, objectives, status and scope; concept of applied Limnology and Palaeolimnology; development of limnology in India; Inland aquatic environment- diversity of ecosystems, salient features of wetlands, lentic and lotic ecosystem.
- UNIT 2 Limnological methods and equipments; techniques for quantitative and qualitative sampling for analysis of communities in water bodies; Keys for identification of plankton and other aquatic organisms- periphyton, benthos, nekton.
- UNIT 3 Environmental factors I- Abiotic -light, temperature, thermal stratification, current of water, wind, turbidity, pressure, density.
- UNIT 4 Environmental factors II- Biotic communities- micro-organisms and macro- organisms; energy flow- food chain and food web.
- UNIT 5 Water chemistry- sources of water, pH, alkalinity, Carbonate, nitrate, phosphorus, chloride, dissolved Oxygen and Free Carbon dioxide, dissolved inorganic solid nutrient cycles- nitrogen, phosphorus movement of water.

DSE 1 (PRACTICAL): LIMNOLOGY –I [MZOD 3.12(B)]

Practical Credit: 2

1. Study of different equipment in limnological field works
2. Quantitative analysis of aquatic plankton in different water samples
3. Qualitative analysis of aquatic plankton in different water samples
4. Study of physical factors of water bodies- temperature, current, water movement
5. Determination of light penetration with Secchi's disk
6. Identification of food habit of aquatic organisms- herbivorous, carnivorous, omnivorous
7. Determination of dissolved O₂ content in water samples
8. Determination of free CO₂ content in water samples
9. Determination of pH and alkalinity of water samples
10. Determination of carbonate, nitrate, phosphorous and chloride in water samples

Recommended Books and References:

1. Allan J.A. (1995) Stream Ecology; Structure and function of running waters. Chapman & Hall.
2. Jefferies M. And Mills D. (1992) Freshwater-ecology, CBS Publishers.
3. Kalff (2002). Limnology, Prentice-Hall.
4. Goldman C.R. and Horne A.J (1983). Limnology, McGraw-Hill International
5. Moss B. (1988) Ecology of Freshwaters, Blackwell Scientific Publications.
6. Payne A.I (1986) The Ecology of Tropical Lakes and Rivers, John Wiley & Sons.
7. Wetzel R.G (2001). Limnology: Lakes and River ecosystems, Academic Press.
8. Wetzel R.G and Likens, G.E (2000) Limnological Analysis, Springer-Verlag.
9. Wetzel R.G (1983) Limnology, Saunders College Publishing.

DSE 1 (THEORY): ENTOMOLOGY – I [MZOD 3.11(C)]

Theory Credit: 4

- UNIT 1 Origin and evolution of insects; Classification of insects (up to orders with characters and examples); Mouthparts - structure and variations; Antennae - structure and variations; Wings - structural variations and venation. Leg - structure and variations; Genitalia - structure and variations.
- UNIT 2 Insect alimentary tract; Process of digestion and absorption; water and electrolyte absorption. Tracheal system: Structure, ventilation and diffusion of gases; mechanism of respiration in terrestrial and aquatic insects. Malpighian tubules: Structure and function; cryptonephridial system; biosynthesis of ammonia and uric acid; excretion of nitrogenous waste with special reference to uric acid excretion.
- UNIT 3 Structure of insect eye; mechanism of vision; Basic components of nervous system; Endocrine centres; Neurosecretory cells; corpora cardiac; corpora allata; prothoracic glands. Juvenile hormones: Major types: biosynthesis and degradation: mode of action. Male and female reproductive systems; types of ovarioles; vitellogenesis; hormonal control of reproduction; juvenile hormones as gonadotropins.
- UNIT 4 Structure of insect integument; chemistry and functions of various components of cuticle: Sclerotization in cuticle. Muscular system: types and structure of muscles, flight mechanism. Innate immunity in insects: Types functions and role of hemocytes; chemistry and function of hemolymph; Antimicrobial peptides in insects. Glycerol-3-phosphate shuttle in flight muscles; proline metabolism; trehalose metabolism.
- UNIT 5 Ecdysteroids: Biosynthesis and mode of action. Embryonic development; three patterns of insect development; types of insect metamorphosis; molting process and the formation of new cuticle; hormonal control of moltings and metamorphosis. Diapause and its hormonal control.

DSE 1 (PRACTICAL): ENTOMOLOGY – I [MZOD 3.12(C)]

Practical Credit: 2

1. Techniques of insect collection, data recording; preservation and display of insects.
2. Study of museum specimens representing major insect's orders.
3. Study of morphology of grasshopper to show various organs.
4. Study of different mouth parts, legs, antennae and wings
5. Preparation of external genitalia of grasshopper, cockroach and housefly.
6. Dissection of alimental canal of cockroach/grasshopper/honeybee.
7. Study of male and female reproductive systems in cockroach.
8. Dissection of nervous system of adult grasshopper/cockroach.
9. Assay of amylase from salivary gland of cockroach.
10. Estimation of total proteins in hemolymph.

Recommended Books and References:

1. Klowden M.J (2013) Physiological systems in insects, 3rdEdn., Academic Press.
2. Gilbert L.I (2011) Insect Endocrinology, 1stEdn. Academic Press.
3. Nation J.L (2008) insect Physiology and Biochemistry, 2ndEdn., CRC Press
4. Latou, K. Gil,S.S. and Gilbert L.I (2005) Comprehensive molecular insect Science, Vol. 1-7, Pergamon Press.
5. Chapman R.F. (2000) The Insects: Structure and Function, 4thEdn. Cambridge univ. Press.
6. Gullan P.J and Cranston P.S (1994) The insects, an outline of Entomology, Chapman & Hall.
7. Kerkut G.A and Gilbert L.I (1985) Comprehensive insect Physiology, Biochemistry and Pharmacology, Vols. 1-12 Ed. Pergamon Press, oxford.
8. Blum M.S (1985) Fundamentals of insects Physiology, Biochemistry and Pharmacology, (1970) The Physiology of insect Physiology. John Willey Sons, New York, Chicester, Brisbane, Toronto and Singapore.
9. Englemann F. (1970) The Physiology of Insect Reproduction, academic Press, New York.
10. Imms. A.D. (1964) The Text book of Entomology. Methuen Co., London.
11. Wigglesworth, V.B. (1984) The Principles of Insect Physiology, 8thEdn. Chapman and Hall.

DSE 1 (THEORY): ENDOCRINOLOGY - I [MZOD 3.11(D)]

Theory Credit: 4

- UNIT 1 Concept of hormones as chemical messengers: endocrine, paracrine and autocrine hormones; endocrine glands and the structural features of endocrine glands; classification of endocrine hormones; basic concept of hormonal effects and its regulation; biosynthesis and secretion of pancreas, adrenal, ovary, testis and thyroid hormones;
- UNIT 2 Hormone and target organs: hormone receptors and their characteristics; hormonal transduction. Hypothalamus: hypothalamic neurosecretory centres; hypothalamic hormones; hormonal feedbacks. Pituitary: pituitary hormones and their functions.
- UNIT 3 The thyroid gland: thyroid hormone biosynthesis and their functions; regulation of thyroid hormone secretion; feedback mechanism to control thyroid stimulating hormone or thyrotropin. Mechanism of action of thyroid hormones.
- UNIT 4 Comparative anatomy of adrenal glands in vertebrates: biosynthesis of adrenal hormones and their functions; adrenal medulla: catecholamine biosynthesis; release and its physiological functions. Parathyroid: calcitonin and vitamin D in calcitonin Homeostasis. Endocrine pancreas: glucose homeostasis and physiological functions of insulin and glucagon.
- UNIT 5 Peptide hormones and steroid hormones; biosynthesis, transport and metabolism of steroid hormones; mechanism of action of peptide and steroid hormones; factors influencing secretion of hormones in animals.

DSE 1 (PRACTICAL): ENDOCRINOLOGY - I [MZOD 3.12(D)]

Practical Credit: 2

1. Dissect and display of adrenal gland in laboratory bred rat*
2. Pituitary gland of laboratory bred mouse-dissection, display and permanent slide preparation using metachromatic stains.
3. Histological study of endocrine glands of vertebrates.
4. Compensatory ovarian/ adrenal hypertrophy in vivo bioassay in laboratory bred rat*
5. Demonstration of Castration/ ovariectomy in laboratory bred rat*

** Subjected to permission*

Recommended Books and References:

1. Barington (1979) hormones and evolution volume I and II. Academic press, New York.
2. General endocrinology. Bagrara and Tumer, W.B. Saunders.
3. John F-Laycock and Peter H.Wise, Essential of Endocrinology.
4. Williams R.H. (1974). Textbook of Endocrinology V.Ed. Saunders Press, London.
5. Bentley P.J. (1998) comparative vertebrate endocrinology, Cambridge university press.
6. General Endocrinology C. Donnell Turner Pub- Saunders Toppan
7. Endocrinology: An Integrated Approach; Stephen Nussey and Saffron Whitehead.
8. Oxford: BIOS Scientific Publishers; 2001.
9. Hadley, M.E. and Levine J.E. 2007. Endocrinology, 6th Edition. Pearson Prentice-Hall, Pearson Education Inc., New Jersey.
10. Vertebrate Endocrinology by David O. Norris,

SEMESTER - IV

CORE 12 (THEORY): ECOLOGY AND ENVIRONMENTAL BIOLOGY (MZOC 4.11)

Theory Credit: 4

- UNIT 1 Concept of ecology; environmental concept: laws and limiting factors; Concept of habitat and niche; niche width and overlap; niche breadth; fundamental and realized niche; resource partition; Environmental factors and their effects- light, water, temperature, humidity.
- UNIT 2 Species richness, frequency, density, relative abundance, species diversity, dominance, equitability, carrying capacity; Population ecology: concept and characteristics- natality, mortality, growth patterns, density dependent and density independent; population dispersal; population interaction: prey-predator relationships, competition, mutualism, commensalism, symbiosis, parasitism; Life history strategies- K and r selection, Population age distribution.
- UNIT 3 Mode of ecological succession in terrestrial and aquatic ecosystems; types of change of communities; concept of climax and ecological stability; trophic dynamic- energy flow and Lindeman's trophic dynamics concept; Productivity- concepts of production, measurement of primary productivity.
- UNIT 4 Environmental stresses and their management, global warming, atmospheric ozone, acid and nitrogen deposition; Pollutants- pesticides and other chemicals in agriculture, industry; Bioindicators and biomarkers of environmental health; Biodegradation and bioremediation of chemicals.
- UNIT 5 Assessment, conservation and management of wild animals; Values of wild life- ecological, ethical and cultural, scientific, aesthetic and recreational; Wildlife corridors; Biodiversity management approaches – Wildlife Protection Act 1972 in India; Biodiversity Act related international convention; Major drivers of biodiversity changes in environment; Anthropogenic impact on environment.

CORE 12 (PRACTICAL): ECOLOGY AND ENVIRONMENTAL BIOLOGY (MZOC 4.12)

Practical Credit: 2

1. Study of ecological niches of soil organisms- litters, underground
2. Study of population density of terrestrial plants with quadrat method
3. Study of frequency of species of terrestrial plants with quadrat method
4. Case study of ecological succession in locality
5. Identification of bioindicators of any water body
Collection of literatures relating to wildlife conservation in NE region with special reference to Nagaland.
6. Case study of anthropogenic impact on environment in the locality
7. Observation of animal association- intra and inter relationship among animals.
8. Observation of population growth pattern of *Drosophila* in the laboratory.
9. Insect diversity in soil.

Recommended Books and References:

1. Krishnamurthy V.K (2003) Text Book of Biodiversity, Science publisher, Chennai
2. Rana S.V.S (2005) Essentials of Ecology and Animal science, Prentice Hall of India, Pvt Ltd
3. Botkin D and Keller E (2014) Environment Science, John Willey and Sons. Inc New York
4. Handbook on Convention on Biodiversity (2006) UNEP, Viva Books Pvt Ltd
5. Hill D, Fasham M.Graham T, Shewary M, and Saw P (2005) Handbook of Biodiversity methods: survey, evaluation and monitoring, Cambridge, University Press
6. Handbook on convention on biodiversity (2006), UNEP, Viva Books Pvt Ltd, Kolkata
7. Silvy N.J. (2012) the wildlife Technique Manual, vol-2 Management, 7th edition Edn John Hopkins Univ. Press
8. Sharma BD (1999) Indian Wildlife Resource, Ecology and Development, Daya Publishing House, Delhi
9. Hudson PJ, Rizzoli A., Grenfell B.t., Heesterbeek H. and Dobson A.P. (2002) The Ecology of Wildlife Disease, Oxford Uni. Press Oxford
10. Kotwal PC., Banerjee S. (1998) Biodiversity Conservation in Manage and Protected Area, Agro- bios India
11. Singh K. (1998) Handbook of Environment, Forest, and Wildlife Protection Laws in India Natraj Publishers, Dehradun
12. Jim C. (2007) The Temple Tiger, Oxford Uni. Press, New Delhi

CORE 13 (THEORY): ANIMAL BEHAVIOUR AND CHRONOBIOLOGY (MZOC 4.21)

Theory Credit: 4

- UNIT 1 Types of reflexes, Characteristics of Reflexes and Complex Behaviour. Orientation: Primary and Secondary Orientation, Sun-Compass Orientation. Kinesis: Orthokinesis and Klinokinesis. Taxis: Different kind of Taxis.
- UNIT 2 Learning: Types of Learning, Neural Mechanism of Learning. Communication: Types of Communication, Auditory Communication, Infrasound Communication among Elephants and Whales. Sonar- Navigation and Communications, Echolocation in Bat.
- UNIT 3 Reproductive strategies: sexual selection, intrasexual selection (male rivalry), intersexual selection (female choice), infanticide, mate guarding.
Parental behaviour: care before birth, care after birth, types of parental care, parent offspring conflict, monogamous versus polygamous sexual conflict.
- UNIT 4 Adaptive functional significance of biological clocks; Biological rhythms in Tidal, Lunar, Circadian and Circannual Rhythms (Migration in bird and fish); Centres of Biological Rhythms- Supra Chiasmatic nuclei, pineal gland, Optic Lobes; Factors influencing biological Rhythms- Environmental, Photoperiod, Temperature.
- UNIT 5 Methods of Measurement: Entrainment, Re-entrainment, Phase Angle difference, Free run, Phase Shift, Phase Response Curve, Arrhythmia.
Molecular Clockworks in Drosophila and Mammals (Clock Genes).
Applied Chronobiology: Human circadian rhythms, Application of circadian rhythms and principles, jet-lag\shift work, Depression and sleep disorders. Chronopharmacology and Chronotherapy.

CORE 13 (PRACTICAL): ANIMAL BEHAVIOUR AND CHRONOBIOLOGY (MZOC 4.22)

Practical Credit: 2

1. Photo tactic response in earthworms/grain or pulse pests
2. Chemo tactic response in earthworms/grain or pulse pests.
3. Geostatic response of earthworm or pest.
4. Effect of toxicants on opercular movement and surfacing in fish.
5. Effect of toxicants on movement of fish.
6. Communication in earthworm by pheromones.
7. Learning by trial and error in rat with the help of Hebb-William Maze.
8. Food preference in tribolium or any other grain/pulse pest.
9. Movement and exploratory behavior of rats.
10. Food preference in catfish.
11. Geotaxis in snails/slugs.

Recommended Books and References:

1. Mechanism of Animal Behaviour, Peter Maler and J. Hamilton: John Wiley & Sons, USA.
2. Animal Behaviour, David McFarland, Pitman Publishing Limited, London, UK.
3. Animal Behaviour, John Alcock, Sinauer Associate Inc. USA.
4. Perspective on Animal Behaviour, Goodenough, McGuire and Wallace, John Wiley & Son, USA.
5. Exploring Animal Behaviour, Paul W. Sherman & John Alcock, Sinauer Associates Inc. Massachusetts, USA.
6. An Introduction to Animal Behaviour, A. Manning and M.S. Dawkins, Cambridge University Press, UK.
7. Gadagkar: Survival Strategies-Cooperation and Conflict in Animal Societies. Universities Press, 1998.
8. Chadrashekar, M.K (1985). Biological rhythms. Madras science foundation, Chennai.
9. Binkley, S. (1990). The clockwork sparrow: time, clocks and calendars in biological organisms.
10. Chronobiology Biological timekeeping: Jay. C. Dunlap, Jennifer. J.Loros.
11. Insect Clocks D.S. Saunders, C.G.H Steel, X. Afopoulou R.D. Lewis (3rd Ed),2002 Barends and Noble Inc NewYork, USA.
12. Biological Rhythms: Vinod Kumar (ed 2002) Narosa Publishing House, New Delhi/ Springer- Verlag, Germany.

DSE 2 (THEORY): FISH BIOLOGY - II [MZOD 4.11(A)]

Theory Credit: 4

- UNIT 1 Fishery resources of the major river system of India; Types of capture fishery resources; Cold water fish and fisheries of India; Floodplain (wetland) fisheries; Coastal fisheries of India (Sardines & Mackerel fisheries); Estuarine fisheries.
- UNIT 2 Principle of preservation, handling and packaging of fish for marketing; Importance and methods of fish preservation(refrigeration and freezing, drying, salting, smoking, canning, pickling, pasting, spicing and fermentation); Fishery by – products, their production and utilization(liver oils, body oils, fish meal, fish flour, fish silage, fish protein, fish guano and bone meal).
- UNIT 3 Aquaculture systems – extensive, semi – extensive, intensive culture of fish; pen and cage culture in lentic and lotic water bodies; Brood stock management, induced breeding, physical and chemical inducing agents; sewage fed fisheries, integrated fish farming, composite fish culture; Aquarium keeping.
- UNIT 4 Different types of nutrient requirements; feed formulation (General principles, different steps of feed formulation and classification of feed ingredients) Importance of live feed and artificial feed, different type of feed available for larvae.
- UNIT 5 Types of fish diseases, symptoms and prophylaxis; Diseases diagnostic tools; Technique for isolation and identification of fungi; isolation and culture of different types of bacteria; Biological indicators and indices of water quality; Sanitation in aquaculture systems; algal bloom and environmental microflora.

DSE 2 (PRACTICAL): FISH BIOLOGY - II [MZOD 4.12(A)]

Practical Credit: 2

1. Induced breeding of IMC
2. Determination of primary productivity by LB – DB method.
3. Determination of percentage saturation of dissolved oxygen.
4. Estimation of free carbon dioxide of water samples.
5. Estimation of total alkalinity.
6. Estimation of total hardness of water samples.
7. Estimation of calcium and magnesium hardness.
8. Estimate of chloride content of water samples.
9. Rearing of live fish food
10. Study of fish diseases from chart and micrograph

Recommended Books and References:

1. Goldman, C.R and Horne, A.J. (1983) Limnology, McGraw-Hill International Book Company.
2. Sugunam V.V, and Bhaumik, U. (1990) Technologies for Inland Fisheries Development, Central Inland Capture Fisheries Research Institute.
3. Kumar S. and Tembhire M. (2011) Fish and Fisheries, New Central Book Agency (P) Ltd. (NCBA).
4. Ahmad S.H. and Singh A.K. (2011) Freshwater Aquaculture, Daya Publishing House, New Delhi, India.
5. Jhingran V.G. (2007) Fish and Fisheries of India, 3rd edn., Hindustan Publishing Corporation, India.
6. Talwar P.K. and Jhingran V.G. (1991) Inland Fisheries of India and Adjacent Countries, Oxford and IBH Publishing Co. Pvt. Ltd.

DSE 2 (THEORY): LIMNOLOGY-II [MZOD 4.11(B)]

Theory Credit: 4

- UNIT I Lotic: origin of lakes and their diversity; ponds, Bog lakes, Swamp; size, depth, elevation of lakes, lake margin, nature of lake bottom, composition of aquatic organisms.
- UNIT II Lentic: Origin of rivers and their characteristics; water movement, temperature, light, dissolved gases, dissolved solids, pH.
- UNIT III Biotic community: phytoplankton, zooplankton; adaptation of strong water current by aquatic organisms, vegetation around periphery of water bodies.
- UNIT IV Biomonitoring of inland water: concept of biomonitoring, bio-indicators and bio-indices; Ganga Plan; Waste water: limnological characteristics, waste stability ponds, and their role in waste stabilization.
- UNIT V Waste water treatment: mechanical, biological and chemical treatment, alternative system of treating raw sewage, reclamation and harvesting of water from sludge, recycling and reuse of waste water.

DSE 2 (PRACTICAL): LIMNOLOGY-II [MZOD 4.12(B)]

Practical Credit: 2

1. Study of origin of lakes and ponds
2. Study of rivers and its tributaries
3. Determination of water chemistry of lotic samples in the locality
4. Determination of water chemistry of lentic samples in the locality
5. Qualitative analysis of plankton in lotic samples
6. Qualitative analysis of plankton in lentic samples
7. Study of water pollutants in the locality
8. Field study of water management

Recommended Books and References:

1. Allan J.A. (1995) Stream Ecology; Structure and function of running waters. Chapman & Hall.
2. Jefferies M. And Mills D. (1992) Freshwater-ecology, CBS Publishers.
3. Kalff (2002). Limnology, Prentice-Hall.
4. Goldman C.R. and Horne A.J (1983). Limnology, McGraw-Hill International
5. Moss B. (1988) Ecology of Freshwaters, Blackwell Scientific Publications.
6. Payne A.I (1986) The Ecology of Tropical Lakes and Rivers, John Wiley & Sons.
7. Wetzel R.G (2001). Limnology: Lakes and River ecosystems, Academic Press.
8. Wetzel R.G and Likens, G.E (2000) Limnological Analysis, Springer-Verlag.
9. Wetzel R.G (1983) Limnology, Saunders College Publishing.

DSE 2 (THEORY): ENTOMOLOGY – II [MZOD 4.11(C)]

Theory Credit: 4

- UNIT 1 Insect life history patterns; voltinism; polymorphism and polyphenism.
Eusocial insects from Hymenoptera and Isoptera - life cycle and development;
polyethism in bees and mechanism of caste differentiation; parasites, predators and
pathogens.
- UNIT 2 Introduction of Lac culture: Life cycle of the lac insects; Lac cultivation, Composition &
uses of Lac.
Introduction to Sericulture: Life cycle of the silk moth, cultivation, composition and uses
of silk.
Introduction to Apiculture: Types of honey bees, Bee keeping, economic importance of
honey bee.
Insects as pollinators.
- UNIT 3 Concepts of Insect pest; Principles and methods of cultural, biological and chemical
control; Uses of sex attractants, Pheromones and hormones in insect control;
Concept of IPM; Information required in dealing with a pest problem.
- UNIT 4 Plant feeding insects: plant host range, types of insect injury to plants, relationship of
pest injury and quality of produce, Insect and plant disease.
Damage, life cycle and control of pest – *Earias vitella*, *Sesamia inferens*, *leptocorisa
acuta*, *Pyrilla perpusilla*, *Sitophilus oryzae*.
- UNIT 5 Medical entomology: Venoms and allergens.
Life cycle, damage and control of – fleas, mosquitoes, bed bugs, human lice, sand flies &
house flies.

DSE 2 (PRACTICAL): ENTOMOLOGY – II [MZOD 4.12(C)]

Practical Credit: 2

1. Dissection of silk gland from silkworm larvae.
2. Study household and stored grain pests.
3. Study if insect pest of agricultural crops.
4. Study of insect medical and veterinary importance.
5. Study of insect pests of fruits.
6. Study of useful insects.
7. Study of appliances used in chemical control.
8. Determination LC50 value of some chemicals.

Recommended Books and References:

1. Blum M.S (1985) Fundamental of Insect Physiology, John Wiley and Sons.
2. Imms A.D. (1977). A General textbook of entomology, 10thEdn. Methuen & Co. London.
3. Gullan P.J and Cranston P.S (2010) The Insects: An Outline of Entomology. Wiley-Blackwell.
4. Hermes, W.B. (1995) Medical and Veterinary Entomology. CAB International U.K.
5. Hermes, W.B. (1950) Medical Entomology, Macmillan and Co. NY.
6. Hill D.S (1994) Agricultural Entomology, Oregon Timber Press.
7. Ramakrisnan, T.V. (1984). Handbook of Economic Entomology of South India, International Books and Periodicals Service India.
8. Lamb. K.P (1974). Economic entomology in the tropics, London, Academic Press.
9. Abhrol D.P (2009) Bees and Bee Keepings in India, Kalyani Publishers, New Delhi.
10. Fenemore P.G and Prakash Alka (1995). Applied Entomology, Wiley Eastern limited New Age International.

DSE 2 (THEORY): ENDOCRINOLOGY-II [MZOD 4.11(D)]

Theory Credit: 4

- UNIT 1 Hormonal mechanism of integration; Neuro-secretion and neuro-endocrine system; Neuroendocrine system in vertebrates; Structure and function of the hypothalamus; Hypothalamic hormones; Hormonal feedback mechanism; Chemistry and biosynthesis of hormones; Steroid hormones, Thyroid hormones and melatonin; Metabolism of hormones.
- UNIT 2 Hormone receptors: characteristics and types of receptors; membrane-bound receptors and intracellular receptor recycling; hormone-receptor complex and signal transduction mechanism; mechanism of action of peptide/protein and steroid hormones.
- UNIT 3 Hormones and reproduction: hormonal regulation of estrous and menstrual cycle; hormonal regulation in reproduction; metamorphosis; diapause and osmoregulation and the role of hormones in animals; Hormonal regulation of reproductive behaviour in vertebrates.
- UNIT 4 Neuro-endocrine regulation of immune system; stress hormones and immune responses; regulation of systemic homeostasis by nervous and immune system interactions; Neuro-endocrine disorders; genetic versus environmental cause.
- UNIT 5 Hormones as therapeutic agents; current developments in design and production of hormonal contraceptives; recombinant protein hormones-production and application in regulation of fertility in farm animals and humans.

DSE 2 (PRACTICAL): ENDOCRINOLOGY-II [MZOD 4.12(D)]

Practical Credit: 2

1. Study of endocrine glands in albino rat/mouse using charts/models/computer software.
 2. Histological study of endocrine glands (thyroid, adrenal, testis and ovary) using charts/models/ computer software.
 3. *Castration in albino rat/mouse.
 4. Study of estrous cycle in albino rat/mouse.
 5. Steroid and thyroid hormone assay by ELISA.
- *Subjected to permission.

Recommended Books and References:

1. Bentley P.J. (1998) Comparative Vertebrate Endocrinology, Cambridge University Press.
2. Charles G.D and Marshall N.J. (2001) Essential Endocrinology, 4thEdn., Blackwell Science, London.
3. Covacs W.J and Odeja S.R. (2011) Textbook of Endocrine Physiology, 6thEdn., Oxford University Press, New York.
4. Gorbman A., Dickoff W.W., Vigna S.R., Clark N.B and Ralph C.L (1983) Comparative Vertebrate Endocrinology, wile International.
5. Hadley M.E. (2000) Endocrinology (5thEdn, Prentice Hall Internal, Inc.
6. Hadley M.E and Levine J.E. (2007) Endocrinology, Pearson Prentice Hall.
7. Jones R.E (1997) Human Reproductive Biology, Academic Press, London.
8. Larsen P.R., Kronenberg H.M, Melmed S. and Polonsky K.S (2011) Williams Textbook of Endocrinology, 12thEdn., W.I Saunders Company.
9. Martine C.R (1985) Endocrine Physiology, Oxford University Press, London.
10. Noris D.O. and Carr J.A (2013) Vertebrate Endocrinology, 5thEdn., Academic Press.
11. Norman W.A and Litwack G. (1997) Hormones, 2ndEdn., Academic Press.
12. Turner C.D and Bangnara J.T. (1976) General Endocrinology, W.B. Saunders Company.
13. Nelson R.J. (2011) An Introduction to behavioural Endocrinology, Sinauer Associates, inc, Publishers.

DSE 3: DISSERTATION [MZOD 4.21]

Credit: 6