

**Controller of Examinations  
SAMBALPUR UNIVERSITY  
JYOTI VIHAR, BURLA  
Sambalpur (Odisha), PIN- 768 019**



**PHONE and Fax: 0663-2430806  
e-mail: [coesuniv@gmail.com](mailto:coesuniv@gmail.com)**

**Corrigendum**

**( Both by post and by e- mail)**

No. 9444 / Acd.-I

Dated: 13/12/16

To

***The Principals,  
Government College,  
Sundargarh***

**Ref :- This office letter No 9143 / Acd.-I ( BOS) dated 03.12.16 .**

Sir,

In inviting a reference to the letter cited above, I am directed to say that the said letter have some inadvertent typographical errors.

The subject of the letter be read as "**M.Sc. Zoology** syllabus effective from the Academic Session 2016-17." **instead of** "**M.Sc. Botany** syllabus effective from the Academic Session 2016-17."

First line of the para No-1 be read as "In continuation to the letters and the subject cited above, I am directed to intimate you that the Vice- Chancellor has been pleased to approve the syllabus for **M.Sc. Zoology** Courses as per Course Credit Semester Examinations under 6 (15) of O.U. Act -1989 giving it effect from the Academic Session, 2016-17". **instead of** "In continuation to the letters and the subject cited above, I am directed to intimate you that the Vice-Chancellor has been pleased to approve the syllabus for **M.Sc. Botany** Courses as per Course Credit Semester Examinations under 6 (15) of O.U. Act -1989 giving it effect from the Academic Session, 2016-17."

**This is for your kind information and necessary action.**

Yours faithfully,


  
Controller of Examinations

**P.T.O.**

Memo No. 9445 /Acad.-I(BOS), dtd. 13/12/16

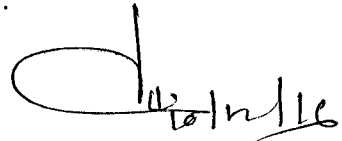
**Copy forwarded with enclosure for information and necessary action to:**

1. The Chairman, Post Graduate Council, Sambalpur University.
2. The H.O.D. , School of Life Science , Sambalpur University, Jyoti Vihar .
3. The Director, College Development Council, Sambalpur University.
4. The Director, Directorate of Distance and Continuing Education, Sambalpur University.
5. The Co-ordinator, Private Examination Cell, Sambalpur University.
6. Asst. Registrar (Examination), Sambalpur University.
7. Programmer, University Computer Unit, Sambalpur University.
8. Asst. Controller of Examinations, Sambalpur University.
9. Section Officer / Assistant –in- Charge, **e – Governance Cell**, Sambalpur University with request to provide all the materials in the official web- site accordingly.
10. Section Officers, Computer Unit, E.G.-III , E.C.- III ,EC- VI Sections.
11. Five spare Copies for Academic-I Sections with enclosure.

  
Controller of Examinations

Memo No. 9446 /Acad.-I(BOS), dtd. 13/12/16  
**Copy forwarded without enclosure for information and necessary action to:**

1. **The Dy. Director, e – Governance Cell**, Sambalpur University with request for needful to provide all the materials in the official web- site accordingly.
2. P.A. to the Vice- Chancellor, Sambalpur University.
3. P.A. to the Registrar, Sambalpur University.
4. P.A. to the Controller of Examinations, Sambalpur University.

  
Controller of Examinations

**Controller of Examinations  
SAMBALPUR UNIVERSITY**

**JYOTI VIHAR, BURLA**  
Sambalpur (Odisha), PIN- 768 019



**PHONE and Fax: 0663-2430806**  
**e-mail: [coesuniv@gmail.com](mailto:coesuniv@gmail.com)**

**Urgent**

**( Both by post and by e- mail)**

No. 9143 / Acd.-I

Dated: 02/12/16

To

*The Principals,  
Government College,  
Sundargarh*

Sub: M.Sc. Botany syllabus effective **from the Academic Session 2016-17.**

Ref :- This office letter No 5735(4) / Acd.-I ( BOS) dated 30.7.16 .

Sir,

In continuation to the letters and the subject cited above, I am directed to intimate you that the Vice- Chancellor has been pleased to approve the syllabus for M.Sc. Botany Courses as per Course Credit Semester Examinations under 6 (15) of O.U. Act -1989 giving it effect from the Academic Session, 2016-17. The detail Courses of Studies is enclosed herewith for your reference and necessary action.

**This may kindly be noted that it is the final syllabus for M.Sc. Zoology Courses as per Course Credit Semester system from the Academic Session, 2016-17. It may be made available to teachers and students concerned. Further you are requested to ensure teaching of the courses in your colleges accordingly.**

Any error and omission etc. may kindly be intimated to this office.

. Any queries on the matter may be made through e-mail: [coesuniv@gmail.com](mailto:coesuniv@gmail.com).

Thanking you,

Yours faithfully,

Encl:- As above

*[Signature]*  
02/12/16  
Controller of Examinations

**P.T.O.**

Memo No. 9144 /Acad.-I(BOS), dtd. 03/12/16

**Copy forwarded with enclosure for information and necessary action to:**

1. The Chairman, Post Graduate Council, Sambalpur University.
2. The H.O.D. , School of Life Science , Sambalpur University, Jyoti Vihar .
3. The Director, College Development Council, Sambalpur University.
4. The Director, Directorate of Distance and Continuing Education, Sambalpur University.
5. The Co-ordinator, Private Examination Cell, Sambalpur University.
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9. Section Officer / Assistant –in- Charge, **e – Governance Cell**, Sambalpur University with request to provide all the materials in the official web- site accordingly.
10. Section Officers, Computer Unit, E.G.-III , E.C.- III ,EC- VI Sections.
11. Five spare Copies for Academic-I Sections with enclosure.

*R.K.W.*  
03/12/16  
Controller of Examinations

Memo No. 9145 /Acad.-I(BOS), dtd. 03/12/16

**Copy forwarded without enclosure for information and necessary action to:**

1. **The Dy. Director, e – Governance Cell**, Sambalpur University with request for needful to provide all the materials in the official web- site accordingly.
2. P.A. to the Vice- Chancellor, Sambalpur University.
3. P.A. to the Registrar, Sambalpur University.
4. P.A. to the Controller of Examinations, Sambalpur University.

*R.K.W.*  
03/12/16  
Controller of Examinations

**COURSES OF STUDY**  
**M.Sc. (ZOOLOGY): Four Semester Course**  
**SAMBALPUR UNIVERSITY, JYOTIVIHAR**

**OUTLINE COURSE STRUCTURE**

Semester	Paper	Course title	Credits	Marks
First	I	Animal Diversity (Non-Chordates & Chordates)	5 CH	50
	II	Biophysics and Biochemistry	5 CH	50
	III	Instrumentation and Biostatistics	5 CH	50
	IV	Practical (Related to theory papers)	3 CH	100
Second	I	Animal Physiology and Behaviour	5 CH	50
	II	Cell Biology and Cancer Biology	5 CH	50
	III	Genetics and Molecular Biology	5 CH	50
	IV	Practical (Related to theory papers)	3 CH	100
Third	I	Ecology, Evolution and Taxonomy	5 CH	50
	II	Microbiology and Immunology	5 CH	50
	III	Developmental Biology and Animal Biotechnology	5 CH	50
	IV	Practical (Related to theory papers)	3 CH	100
Fourth	I	Genetic Engineering	5 CH	50
	II	Special Paper-I (Any one) Ichthyology: (i) Ichthyology Biochemistry: (i) Metabolism and Regulation	5 CH	50
	III	Special Paper-II (Any one) Ichthyology: (ii) Fish culture and Ethology Biochemistry: (ii) Proteomics and Enzymology	5 CH	50
	IV	Practical (Based on special papers) (a) Ichthyology or (b) Biochemistry	3 CH	100
	V	Project Report/Study tour Report & Viva-voce	4 CH	100
	VI	Seminar	4 CH	100
<b>Grand Total</b>			<b>80 CH</b>	<b>1200</b>

## FIRST SEMESTER

### Paper-I ANIMAL DIVERSITY (NON -CHORDATES & CHORDATES)

#### UNIT-I (Non-chordates)

Nutrition in protozoa - Types and mode of feeding, Protozoan parasites in brief (Trypanosoma, Plasmodium), Canal system in Sponges, Coral reef formation and significance, Polymorphism in Coelenterates, Excretory structures and functions in Annelids, Helminth parasites (Taenia, Ancylostoma), Vision in insects

#### UNIT-II (Non-chordates & Protochordates)

Torsion in Gastropoda, Nervous system in Cephalopods, Water vascular system in Echinoderms, Reproduction and development in Echinoderms with evolutionary significance, General characters & interrelationship of Proto-chordates and Siphon mechanism in Tunicates.

#### UNIT-III (Chordates)

Structural peculiarities and affinities of Balanoglossus, Structure and development of Herdmania, Structure, affinities and development of amphioxus, General characters of cyclostomes, Accessory respiratory organs in fishes.

#### UNIT-IV (Chordates)

Origin of Amphibia, Classification of Amphibia, Adaptive radiation in reptiles, Classification of reptiles based on skull pattern, Origin of Bird, Flight adaptation in Birds, General characters of Prototheria and Metatheria, Adaptive radiation in mammals

### Paper-II (BIOPHYSICS AND BIOCHEMISTRY)

#### UNIT-I (Biophysics)

Principle of thermodynamics, Concepts of steady state, enthalpy, entropy & free energy changes, calculation of free energy changes, calculation of free energy from equilibrium constants & redox potentials, Molecularity and kinetic order of reaction. Theories of reaction rate and energy of activation. Intermolecular forces (hydrogen bonds, electrostatic bonds electrophobic interaction, Vanderwall's forces) Electromagnetic and ionizing radiations, it's interaction with living matters, Laws of light absorption.

#### UNIT-II (Amino acid and Protein)

Amino acids: Classification and properties, Acid-base properties, Peptide bond, ionization behaviour of peptides, biologically active peptides. Levels of protein structure, Determination of primary structure of protein. Protein structure (Secondary, tertiary and quaternary), Structural patterns (motifs and domains), Protein folding and stability. Amino acid metabolism (transamination, oxidative deamination, decarboxylation) and urea cycle.

#### UNIT-III (Glycobiology)

Carbohydrates: Classification, configuration and conformation of monosaccharides, sugar derivatives, disaccharides. Structural and storage polysaccharides, glucosaminoglycans, proteoglycans, glycoproteins and glycolipids. Carbohydrate metabolism: Glycolysis, TCA cycle, pentose-phosphate pathway. Gluconeogenesis, glycogen metabolism, regulation of carbohydrate metabolism, Oxidative phosphorylation and ATP synthesis.

#### **UNIT-IV (Lipid and Enzyme)**

Lipids: Classification, storage lipids, structural lipids (glycerophospholipid and sphingolipids), signaling lipids, Co-factors, terpenes, and pigments. Coenzymes and vitamins, Biosynthesis and oxidation of fatty acids, Regulation of fatty acid metabolism.

Enzymes: General properties, nomenclature and classification, Michaelis-Menten kinetics and its significance, Determination of  $V_{max}$  and  $K_m$ . Mechanism of enzyme action (acid-base catalysis, covalent catalysis, metal catalysis) with reference to RNAase, Lysozyme and Chymotrypsin. Enzyme inhibition (competitive, non-competitive, uncompetitive inhibition), Allosteric regulation, covalent modification.

### **Paper-III (INSTRUMENTATION AND BIOSTATISTICS)**

#### **UNIT –I (Microscopy and spectroscopy)**

Principle of operation and Instrumentation of Light, Fluorescence and Electron Microscopes  
Ultraviolet-visible absorption spectroscopy: Principle, Instrumentation and application,  
Fluorescence spectrophotometry: Principle, Instrumentation and application.

Principles of electrochemical techniques: Electrochemical cells and reactions, Potentiometry and voltmetry, pH electrode (Principle and types).

#### **UNIT –II (Centrifugation and electrophoresis)**

Centrifugation techniques: Basic principles of sedimentation, Types of centrifuges, Types of rotors, Methods in preparatory ultracentrifugation (differential and density gradient centrifugation).

Electrophoretic techniques: General principle, support media, electrophoresis of proteins (SDS-PAGE, native gel, gradient gel, isoelectric focusing and two dimensional), electrophoresis of nucleic acids (Agarose, pulse-field and sequencing gel).

#### **UNIT III (Chromatography and Radioisotopes)**

Chromatographic techniques: Principles of chromatography (Adsorption and Partition chromatography), Planar chromatography (Paper and Thin-layer chromatography), Column chromatography (Gas chromatography, Gel exclusion chromatography, Ion exchange chromatography, Affinity chromatography, HPLC).

Radioisotope techniques: Nature of radioactivity, isotopes in biochemistry, measurement of radioactivity (Carbon dating, Geiger-Muller counting and Liquid scintillation counting).

#### **UNIT –IV (Biostatistics)**

Statistical Methods: Sampling methods, sampling distribution, measures of central tendency and dispersion, Probability distribution: normal, binominal and poisson distribution. Sample homogeneity and heterogeneity analysis by binomial and poisson distribution,

Parametric and nonparametric statistics: paired and unpaired t-test and  $\chi$  test, analysis of variance: one factor and two factor ANOVA, linear and non-linear regression and correlation.

**Paper-IV (PRACTICAL)**  
(6 hours duration)

1. Mounting of mouth parts of mosquito-identification of genera.
2. Mouth parts of cockroach.
3. Determination of pH
4. Estimation of protein.
5. Estimation of carbohydrate.
6. Estimation of lipid.
7. Enzyme activity of salivary amylase  
(Effect of temperature, Substrate, Concentration and time)
8. Determination of pKa of Glycine.
9. Agarose gel electrophoresis of DNA
10. Separation of protein fractions using SDS PAGE (demonstration)
11. Chromatographic separation (demonstration)
12. Models (proteins, carbohydrates, lipids).
13. Solving problems related to biostatistics.
14. Study of museum specimens and/or slides from phylum protozoa to mammalian.

Protozoa	Euglena, Plasmodium, Paramecium,
Porifera	Sycon, Hyalonema, Euspongia
Coelenterata	Physalia, Gorgonia, Pennatula, Aurelia, Fungia
Platyhelminthes	Dugesia, Fasciola, Ascaris, Taenia
Annelida	Hirudinea, Sabella, Aphrodite, Nereis, Heteronereis, Arenicola, Trochophore larva, Lepas, Sacculina, Eupagurus.
Arthropoda	Larval forms in Arthropoda, Leaf insect and Stick insect
Mollusca	Chiton, Dentalium, Larval forms in Mollusca, Sepia, Nautilus, Loligo
Echinodermata	Larval forms, Antedon, Asterias, Echinus, Sea cucumber
Hemichordata	Balanoglossus
Cephalochordata	Amphioxus
Urochordata	Salpa, Doliolum, Ascidea
Cyclostomata	Petromyzon, Myxine
Pisces	Lung fish, Torpedo, Trygon, Exocoetus, Eel, Clarias, Hippocampus
Amphibia	Hyla, Alytes, Ichthyophis, Axolotl Larva, Salamander, Necturus
Reptilia	Chelone, Varanus, Draco, Russell viper, Naja naja, Gavialis
Aves	Psittacula, Dinopium, Type of Beaks, claws and feet
Mammalia	Echidna, Macropus, Pteropus, Rattus, Squirrel

15. Any other experiment including viva-voce and practical record.



## SECOND SEMESTER

### Paper-I (ANIMAL PHYSIOLOGY AND BEHAVIOUR)

#### UNIT-I (Digestion, respiration, circulation and excretion)

Composition of blood, RBC anatomy, RBC breakdown, Blood group, Mechanism of platelet plug formation and blood coagulation.

Digestive enzymes and its function. Digestion of proteins, carbohydrate and lipids. Heart: cardiac cycle & its regulation, pulmonary ventilation, respiratory surface and gaseous exchange, Regulation of respiration, Transport of gases, Acid base balance. Excretory system: Urine formation, glomerular filtration, selective reabsorption, tubular secretion, Renal mechanism of concentrating & diluting urine.

#### UNIT-II (Neuromuscular physiology)

Ultra structure of muscles, Regulatory, structural and contractile proteins, Mechanism of contraction. General organization of central nervous system, Type of neuronal cells, Structure and function of neuron and glia, Types of ion channels, Action potential, Electrical and Synaptic transmission, Neurotransmitters, Neuromuscular Junction, Blood brain barrier.

#### UNIT-III (Endocrinology)

Hormones and their feedback regulation, Mechanism of hormone action (fixed membrane- and mobile receptor mechanisms), Second messenger concept. Anatomy, chemistry and biological action of pituitary hormones; Anatomy, biosynthesis and function of thyroid hormones; Anatomy and function of parathyroid hormone; Anatomy, biosynthesis and functions of pancreatic hormones; Anatomy, biosynthesis, functions of cortical and medullary hormones, Gonadal steroid hormone biosynthesis and their biological functions.

#### UNIT-IV (Ethology)

Classification and analysis of behaviour patterns, Tools and techniques used in behavioral study, Neural and hormonal basis of regulation of animal behavior, Communication in animals, Social organization in insects and mammals, Mimicry. Biological rhythms: Circadian, Parental care, Orientation and navigation: Migration of fish and bird.

### Paper-II (CELL BIOLOGY AND CANCER BIOLOGY)

#### UNIT-I (Cellular organization and signaling)

Cell Theory, General organization of Prokaryotic and Eukaryotic cells. Plasma membrane: Composition and dynamics and their role in cell recognition. Cell junction, cell adhesion and extra-cellular matrix. Cell-cell interaction and cellular signaling. Signal transduction pathways and regulation.

#### UNIT-II (Cell cycle and cell division)

Euchromatin and Heterochromatin, karyotype and its significance. Lambrush chromosome, Polytene chromosome, telocentric chromosome, Inter-phase chromatin.

Cell cycle: Molecular models and events. Regulation and checkpoints in cell cycle. Molecular mechanism of cell division: Mitosis and Meiosis (Behaviour of chromosomes, formation of mitotic spindle, sister chromatid separation), Cytokinesis: its events and mechanism.

### **UNIT-III (Cellular organelles and transport)**

Cell inclusions: pigments and nutritive materials. Structure and function of nuclear envelope, nucleolus. Cytoskeleton: Microtubules, intermediate filaments and microfilaments. Structural organization and function of intracellular organelles: Mitochondria, Golgi bodies, Endoplasmic reticulum, Ribosomes, Lysosomes.

Transport across the cell membrane: Membrane transport (Active transport, Co-transport, Symport, Antiport, Ion channels, Osmosis),  $\text{Na}^+$  -  $\text{K}^+$  pump,  $\text{Ca}^{++}$  pump.

### **UNIT-IV (Cancer Biology)**

Biology of cancer cell, Oncogenes: transformation of normal cell to cancer cell, Genetic basis of cancer: Proto-oncogenes, Viral and cellular oncogenes, Tumor suppressor gene: structure, function and mechanism of action of pRB and p53 oncoproteins, Role of carcinogens. Oncogenic DNA and RNA viruses.

## **Paper-III (GENETICS AND MOLECULAR BIOLOGY)**

### **UNIT-I (Mendelian principles)**

Mendel's laws of inheritance, Mendelian principles: co-dominance, incomplete dominance, Gene interaction with epistasis or modified mendelian dihybrid ratio: masking gene action, supplementary gene, duplicate gene, complementary gene. Linkage, crossing over and recombination. Multiple allele in human (ABO blood group); eye colour in Drosophila, self incompatibility in plants. Polygenic inheritance, pleiotrophy.

### **UNIT-II (Chromosomal mapping and Population Genetics)**

Chromosomal mapping, Gene mapping methods: linkage maps, pedigree analysis, Sex chromosomes, Sex determination in animals. Sex linked genes in man and drosophila, Sex chromosome disorders in man, Quantitative inheritance. Maternal effects and cytoplasmic inheritance, Mitochondrial and chloroplast genome. Structural and numerical changes of chromosomes, chromosome disorders and syndromes. Population genetics: gene pool, gene frequency. Hardy-Weinberg genetic equilibrium, gene flow and genetic drift.

### **UNIT-III (DNA replication and Repair)**

Molecular organization of genome in Prokaryotes and Eukaryotes, Nucleosome concept, Transposable elements. DNA replication: Replication in prokaryotes, replication fork, initiation, elongation, termination, Replication in eukaryotes, D-loop model of DNA replication, DNA replication in single stranded DNA, rolling circle replication, DNA synthesis by reverse transcription. DNA Repair (mismatch repair, base excision, nucleotide excision, direct repair, SOS repair).

### **UNIT -IV (Transcription and translation)**

Genetic code and its attribute (Universality, non-ambiguity, degeneracy, Wobble hypothesis. Transcription in Prokaryotes and Eukaryotes and its regulation: RNA polymerases, Eukaryotic promoters and enhancers, Transcription factors, Mechanism of transcription regulation. Post-transcriptional modification of RNA: 5'-cap formation, transcription termination, 3'-end processing and polyadenylation, splicing, editing, synthesis and processing of non-coding RNAs. Processing of tRNA and rRNA.

Translation (Initiation, elongation and termination), post translational modification. Regulation of gene expression (lac, tryptophan and arabinose operon).

**Paper-IV (PRACTICAL)**  
(6 hours duration)

1. Preparation of slides and study the stages of mitosis and meiosis.
2. Separation of proteins, lipids & nucleic acids from tissues and their quantification.
3. Isolation of genomic DNA from animal tissue/blood.
4. Microtomy, microscopic preparation and histological techniques.
5. Isolation of Mitochondria.
6. Estimation of WBC & RBC count using haemocytometer.
7. Estimation of haemoglobin
8. Pedigree analysis
9. Population genetics and Hardy-Weinberg Law  
(Blood group, Ear lobe and Tongue rolling experiment)
10. Study of endocrine glands (slides/visual aids)
11. Models (DNA, t-RNA etc).
12. Permanent slides (Polytene chromosome, Lambrush chromosome etc)
13. Any other experiment including viva-voce and practical record.

**THIRD SEMESTER**

**Paper-I (ECOLOGY, EVOLUTION AND TAXONOMY)**

**Unit I (Energy flow and Biogeochemical cycles)**

Concept of Ecosystem and components, Concept of primary and secondary productivity, method of measuring productivity, Energy flow in ecosystem: sources and pattern; food chain and food web in terrestrial and aquatic ecosystems, Biogeochemical cycles (Carbon, Nitrogen, Sulphur, Phosphorus).

Water & Air pollutants: fates and effects, role of plants for pollution control, Global climate change, green house effect, ozone depletion- causes and effects.

**Unit-II (Population Ecology and Diversity)**

Population ecology: Concept, population characters, biotic potential. Kinetics of population growth. Laws of population growth, Limiting factors and regulation of population density, r and k selection. Population interactions (positive, negative and inter-specific relationship). Population regulation: competitive exclusion, density dependent and independent regulation. Community structure and its classification, Biodiversity (genetic diversity, species diversity, ecosystem diversity), ecotone and edge effect, Succession: model and mechanism, Biodiversity and its conservation (in situ, ex situ and germplasm conservation).

**Unit-III ((Evolution)**

Theories of evolution (Lamarckism, Darwinism, Synthetic theory), Evidences in support of evolution (Morphology to molecular level), Mechanism of evolution (Isolation, speciation and natural selection). Evolution of horse and human.

**Unit-IV Taxonomy)**

Origin and development of taxonomy, Theories of ranking and nomenclature, Types of classification (Artificial, Natural, phylogenetic and Phenetics), Modern trend in taxonomy (biochemical, serological, numerical and molecular phylogeny), Types of fossil and fossilization, Biological realms, Principle of zoogeography.

**Paper- II (METABOLISM AND REGULATION): Special Paper-I**

**Unit-I (Bioenergetics)**

Energy transduction in cells and types of transducers, Energetics of biochemical reactions, Redox potential. Energy transformation in mitochondria, Enzyme complexes and electron carriers in mitochondrial membrane, Energetics of electron transfer reactions, Mechanism of oxidative phosphorylation and electron transfer. Proton gradient as the central motif of bioenergetics in mitochondria.

**Unit-II (Metabolism)**

Nucleic acid: *de novo* and Salvage pathway of nucleic acid biosynthesis. Biosynthesis of essential, non-essential and aromatic amino acids, Oxidative degradation of amino acids leading to acetyl CoA  $\alpha$ -ketoglutarate pathway, succinic pathway, fumarate pathway and oxaloacetate pathway of amino acid oxidation.

**Unit-III (Lipid metabolism)**

Degradation of odd and even carbon fatty acids, Oxidation of mono and polygenic fatty acid. Fatty acid oxidation. Biosynthesis of saturated and unsaturated fatty acids and triglycerides. Biosynthesis of phospholipids & cholesterol, Regulation of cholesterol biosynthesis.

**Unit-IV (Metabolic Regulation)**

Glycolysis and its regulation, TCA cycle and its control, Glyoxylate cycle and its regulation, Regulation of glycogen metabolism. Energetics of lipid oxidation and its regulation. Signal transduction pathways. Signal response coupling in metabolic processes: Ca-calmodulin signaling, c-AMP as 2<sup>nd</sup> messenger, GTP binding protein and kinase/phosphatase cascade).

**Paper- III (FISH CULTURE AND ETHOLOGY): Special Paper-II**

**Unit-I (Breeding and culture)**

Natural breeding of Indian major carps-Location of breeding grounds, factors responsible for natural breeding, wet and dry bundh, techniques for breeding of Indian major carps. Induced breeding of fishes with special reference to major carps: Principle, technique and advantages of hypophysation selective breeding and hybridization.

Fisheries of Indian seas with special reference to the coastal fisheries of Odisha. Fresh water fish culture in India, fish seed resources , hatching of eggs, transport of live fishes, planning and management of fresh water fish. Application of remote sensing and GIS in fisheries;

**Unit-II (Methods of fishing and conservation)**

Crafts and gears used in India for fishing in inland and marine waters. Advantages in fishing methods: electrical fishing, light fishing, fish finders (echo-sounder, sonar) and their utilities.

Fish preservation, handling and cleaning of fresh fish (chilling, freezing, use of chemical preservatives and antibiotics, irradiation, salting, drying, freeze drying, smoking, canning and packaging. Preservation of prawn and tail of lobster and their quality control. Problems in fish and prawn preservation.

**Unit-III (Animal Biotechnology-I)**

Basics of animal tissue culture, cell line culture, culture medium, physico-chemical and metabolic function of different constituents of culture medium, *in vitro* mammalian cell culture, Primary explantation techniques (organ and embryo culture). *In vitro* fertilization and embryo transfer, Disaggregation of tissue and primary culture, Maintenance of cell culture, cell separation, scaling up of animal cell culture. Cell cloning and manipulation.

**Unit-IV (Animal Biotechnology-II)**

Teratogenesis: Environmental assaults on human development, teratogenic agents like alcohol, retinoic acid etc. Application and approaches of cell and tissue engineering, Application of animal cell culture. Stem cell culture, Embryonic stem cell and its application. Cell culture based vaccines. Gene therapy. Ethics related to animal cloning.

**Paper-IV (PRACTICAL)**

(6 hours duration)

1. Antigen-antibody interaction: blood grouping
2. Preparation of blood smear for differential count and type of leucocytes
3. Study of lymphoid organs (demonstration)
4. Study of life cycle of different anurans
5. Effect of thyroxin on amphibian development
6. Whole mount preparation of chick embryo
7. Study of Frog development (through slides)
8. Sterilization and preparation of culture media (liquid & solid)
9. Study of Fossils (models or visual aids)
10. Estimation of dissolved oxygen content of water
11. Estimation of alkalinity of water samples.
12. Estimation of total hardness.
13. Estimation of primary productivity
14. Determination of chloride
15. Qualitative and quantities analysis of plankton in collected water samples.
16. Study of diversity indices.
17. Any other experiment including viva-voce and practical record.

**FOURTH SEMESTER**

**Paper-I (GENETIC ENGINEERING)**

**Unit-I (Recombinant DNA technology)**

Concept and scope of genetic engineering, Molecular techniques in gene manipulation, DNA isolation and purification, DNA sequencing method (Maxam-Gilbert, Sanger's method), Restriction endonucleases, Ligase. Cloning vectors: Plasmid, Cosmid, Phagemid, Lambda bacteriophage, M13, BAC, YAC and Expression vectors. Genomic and C-DNA library.

**Unit-II (Molecular techniques)**

Polymerase chain reaction and its application in biological sciences, Blotting techniques (Southern, northern and western blotting), Nucleic acid hybridization. DNA fingerprinting and foot printing, Site-directed mutagenesis, Expression of heterogeneous genes: *in vitro* transcription and translation, Gene knock out strategies, RNA interference: Anti-sense RNA, siRNA and miRNA. DNA microarray.

11 *[Signature]*

### **Unit-III (Genetic transformation)**

Genetic transformation, Strategies used for gene transformation (calcium phosphate method, electroporation, biolistic, liposomal, microinjection and *Agrobacterium* mediated transformation). Selection and screening of transgenic animals using molecular markers (RAPD and RFLP).

### **Unit-IV (Application and limitation)**

Production of genetically modified organisms, Production of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection. Application of genetic engineering in medicine, agriculture and industries. DNA vaccines and its application. Genetic engineering regulations and guidelines.

## **Paper- II (ICHTHYOLOGY): Special Paper-I**

### **Unit-I (Classification and adaptation, body forms and diversity)**

Classification of fish with distinguish characters and important examples of principal subdivisions. Phylogenetic significance of Acanthodians and Placoderms. Evolution and adaptive radiation of Chondrichthyes (Elasmobranchii and Bradyodonti), Actinopterygii, Crossopterygii and dipnoi.

Fin types, structure, modification and functions. Types of jaw suspension in fishes. Structure, arrangement and homology of Weberian ossicles. Neuro-cranium and visceral arches of typical shark and teleosts.

### **Unit-II (Anatomy and physiology)**

Food, feeding habits, feeding adaptation, feeding behavior, structure of the alimentary canal and physiology of digestion and absorption. Structure of heart, Cardiac activity and its regulation, blood vessels and circulation of blood, blood forming organs, transport of respiratory gasses, adaptation of fish haemoglobin and functional significance of swim bladder and tuna muscle.

Organization and modification of gill with respect to habit, morphology of gill epithelia, filament epithelium and lamellar epithelium, gas exchange in gill surface, gas exchange between blood and tissue.

### **Unit-III (Special organs)**

Sound producing mechanism, mechanism for detection of sound acoustic communication. Electric fish and their types, location of electric organs, origin, structure and function of electric organs. Evolution of electro receptors and electric organs. Location, structure and control of luminescent organs, Physiological and biological significance of luminescence.

### **Unit-IV (Ecology, adaptation and fish biotechnology)**

Ecology of aquatic ecosystems-river, estuary lake, sea and reservoirs. Growth and age studies of fishes. Fish population- density, structure, estimation of population and population dynamics. Aquatic population and fisheries. Deep sea fishes, hill stream fishes, aestivation of dipnoi, freezing avoidance of arctic and Antarctic fishes. Culture technology using chromosomal and gene manipulation. Transgenic fish and its significance.

OR

**Unit-III (Animal Biotechnology-I)**

Basics of animal tissue culture, cell line culture, culture medium, physico-chemical and metabolic function of different constituents of culture medium, *in vitro* mammalian cell culture, Primary explantation techniques (organ and embryo culture). *In vitro* fertilization and embryo transfer, Disaggregation of tissue and primary culture, Maintenance of cell culture, cell separation, scaling up of animal cell culture. Cell cloning and manipulation.

**Unit-IV (Animal Biotechnology-II)**

Teratogenesis: Environmental assaults on human development, teratogenic agents like alcohol, retinoic acid etc. Application and approaches of cell and tissue engineering, Application of animal cell culture. Stem cell culture, Embryonic stem cell and its application. Cell culture based vaccines. Gene therapy. Ethics related to animal cloning.

**Paper-IV (PRACTICAL)**

(6 hours duration)

1. Antigen-antibody interaction: blood grouping
2. Preparation of blood smear for differential count and type of leucocytes
3. Study of lymphoid organs (demonstration)
4. Study of life cycle of different anurans
5. Effect of thyroxin on amphibian development
6. Whole mount preparation of chick embryo
7. Study of Frog development (through slides)
8. Sterilization and preparation of culture media (liquid & solid)
9. Study of Fossils (models or visual aids)
10. Estimation of dissolved oxygen content of water
11. Estimation of alkalinity of water samples.
12. Estimation of total hardness.
13. Estimation of primary productivity
14. Determination of chloride
15. Qualitative and quantities analysis of plankton in collected water samples.
16. Study of diversity indices.
17. Any other experiment including viva-voce and practical record.

**FOURTH SEMESTER**

**Paper-I (GENETIC ENGINEERING)**

**Unit-I (Recombinant DNA technology)**

Concept and scope of genetic engineering, Molecular techniques in gene manipulation, DNA isolation and purification, DNA sequencing method (Maxam-Gilbert, Sanger's method), Restriction endonucleases, Ligase. Cloning vectors: Plasmid, Cosmid, Phagemid, Lambda bacteriophage, M13, BAC, YAC and Expression vectors. Genomic and C-DNA library.

**Unit-II (Molecular techniques)**

Polymerase chain reaction and its application in biological sciences, Blotting techniques (Southern, northern and western blotting), Nucleic acid hybridization. DNA fingerprinting and foot printing, Site-directed mutagenesis, Expression of heterogeneous genes: *in vitro* transcription and translation, Gene knock out strategies, RNA interference: Anti-sense RNA, siRNA and miRNA. DNA microarray.

(15)

## Paper- II (METABOLISM AND REGULATION): Special Paper-I

### Unit-I (Bioenergetics)

Energy transduction in cells and types of transducers, Energetics of biochemical reactions, Redox potential. Energy transformation in mitochondria, Enzyme complexes and electron carriers in mitochondrial membrane, Energetics of electron transfer reactions, Mechanism of oxidative phosphorylation and electron transfer. Proton gradient as the central motif of bioenergetics in mitochondria.

### Unit-II (Metabolism)

Nucleic acid: *de novo* and Salvage pathway of nucleic acid biosynthesis. Biosynthesis of essential, non-essential and aromatic amino acids, Oxidative degradation of amino acids leading to acetyl CoA  $\alpha$ -ketoglutarate pathway, succinic pathway, fumarate pathway and oxaloacetate pathway of amino acid oxidation.

### Unit-III (Lipid metabolism)

Degradation of odd and even carbon fatty acids, Oxidation of mono and polygenic fatty acid. Fatty acid oxidation. Biosynthesis of saturated and unsaturated fatty acids and triglycerides. Biosynthesis of phospholipids & cholesterol, Regulation of cholesterol biosynthesis.

### Unit-IV (Metabolic Regulation)

Glycolysis and its regulation, TCA cycle and its control, Glyoxylate cycle and its regulation, Regulation of glycogen metabolism. Energetics of lipid oxidation and its regulation. Signal transduction pathways. Signal response coupling in metabolic processes: Ca-calmodulin signaling, c-AMP as 2<sup>nd</sup> messenger, GTP binding protein and kinase/phosphatase cascade).

## Paper- III (FISH CULTURE AND ETHOLOGY): Special Paper-II

### Unit-I (Breeding and culture)

Natural breeding of Indian major carps-Location of breeding grounds, factors responsible for natural breeding, wet and dry bundh, techniques for breeding of Indian major carps. Induced breeding of fishes with special reference to major carps: Principle, technique and advantages of hypophysation selective breeding and hybridization.

Fisheries of Indian seas with special reference to the coastal fisheries of Odisha. Fresh water fish culture in India, fish seed resources, hatching of eggs, transport of live fishes, planning and management of fresh water fish. Application of remote sensing and GIS in fisheries;

### Unit-II (Methods of fishing and conservation)

Crafts and gears used in India for fishing in inland and marine waters. Advantages in fishing methods: electrical fishing, light fishing, fish finders (echo-sounder, sonar) and their utilities.

Fish preservation, handling and cleaning of fresh fish (chilling, freezing, use of chemical preservatives and antibiotics, irradiation, salting, drying, freeze drying, smoking, canning and packaging. Preservation of prawn and tail of lobster and their quality control. Problems in fish and prawn preservation.



### **Unit-III (Pathology and sustainable aquaculture)**

Fish pathology: symptoms, etiology prophylaxis, and treatment of common diseases and pathological condition in cultivable fish. Exotic fishes, history of transportation of important exotic fishes in India, bionomics of important exotic fishes and their utility in Indian waters. Larvivorous fishes, exotic and indigenous species with special reference to malaria control.

Bio-chemical composition of raw fish, nutritive value of raw and preserved fish as food. Fish products and bi-products: liver oil, body oil meal, flour, manure, guano, glue, isinglass, roe, fins and leathers. Sustainable aquaculture, Extensive, semi-intensive and intensive culture of fish, Pen and cage culture, Polyculture, Composite fish culture, Brood stock management, Preparation and maintenance of fish aquarium, Preparation of compound diets for fish, Role of water quality in aquaculture.

### **Unit-IV (Adaptation features and behaviour)**

Colouration - Chromatophores, Pigments and colouration, Physiological and morphological significance colour changes, biological significance of colouration. Causative factors for development of air-breathing, structural adaption for air - breathing and gas exchange in air - breathing fishes. Poisonous fishes and poison apparatus, pharmacology and toxicology of fish poison. Migration of fishes with reference to Hill ilisha, Parental care in fishes, Shoaling of fishes, Brackish water fish and prawn culture in India, Oyster culture and pearl industry.

OR

### **Paper- III (PROTEOMICS AND ENZYMOLOGY): Special Paper-II**

#### **Unit-I (Protein Engineering)**

Protein sequencing (N and C-terminal determination, amino acid composition). Protein stability (Vander Waals force, electrostatic, hydrogen bonding, weakly polar interaction and hydrophobic effects), Factors affecting stability (pH, temperature, amino acid sequence, aggregation propensities etc). Ranchandran plot.

#### **Unit-II (Proteomics)**

Characterization of proteins (affinity and specificity) using different spectroscopic methods (UV, CD, Fluorescence and NMR). 2D electrophoresis of proteins, Isoelectrofocusing, Peptide fingerprinting. Computational approach of 3D structure analysis of proteins. Protein microarray, Proteomics and drug discovery.

#### **Unit-III (Enzymology)**

Briggs and Haldane quasi steady-state approximation, Enzyme inhibition (competitive, non-competitive, uncompetitive) and inhibition kinetics, Turnover number and Kcat. Factors affecting enzyme activity. Bi-substrate reaction kinetics, Ordered and Random kinetics, Ping-Pong catalysis (Delziel's form). Allosteric enzymes and its significance.

#### **Unit-IV (Enzyme immobilization)**

Extraction and purification of enzymes illustrating the downstream processing. Enzyme immobilization: methods and application. Enzyme biosensors (Bio-electrodes, Optrodes, Immunochemical sensors). Application of enzymes in food industries.

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**Paper-IV (SPECIAL PAPER PRACTICAL: ICHTHYOLOGY)**

(6 hours duration)

1. Study of Petromyzon, Myxine, Pristis, Chimaera, Exocoetus, Hippocampus, Gambusia, Labeo, Heteropneustes, Anabas
2. Study of different types of scales (through permanent slides/ photographs).
3. Study of crafts and gears used in fisheries.
4. Water quality assessment for aquaculture (pH, conductivity, total solids, total dissolved solids).
5. Study of air breathing organs in Channa, Heteropneustes, Anabas and Clarias.
6. Demonstration of induced breeding in Fishes (visual aids).
7. Collection of pituitary gland and preparation injection extract.
8. Demonstration of parental care in fishes (visual aids) through visit to any fish farm.
9. Taxonomical status of local fishes (at least 30 local fishes).
10. Dissections of afferent, efferent branchial arteries of scoliodon.
11. Dissections of cranial nerves of scoliodon, internal ear of scoliodon.
12. Microscopic preparation of fish scales.
13. Any other experiment including viva-voce and practical record.

**OR**

**Paper-IV (SPECIAL PAPER PRACTICAL: BIOCHEMISTRY)**

(6 hours duration)

1. Estimation of protein content in the biological sample.
2. Estimation of reducing sugar content.
3. Determination of crude lipid content of oily seed.
4. Estimation of total free amino acid content
5. Estimation of enzyme activity
6. Effect of pH on enzyme activity.
7. Effect of temperature on enzyme activity.
8. Effect of enzyme concentration and incubation temperature on enzyme activity.
9. Effect of substrate concentration on enzyme activity.
10. Determination of Vmax and Km of enzyme activity through Line weaver Burke plot.
11. Demonstration of protein sequence databases and structure prediction.
12. Solving problems related to enzyme kinetics using the data supplied.
13. Any other experiment including viva-voce and practical record.

**Paper-V (PROJECT REPORT AND VIVE VOCE)**

**(Project report 50 marks and Viva-voce 50 marks)**

Project report should include introduction, methodology, techniques, results, discussion and bibliography. Institutional cum industrial study tour report emphasizing theoretical aspects should be included. Evaluation of the project report and viva-voce will be open defense type through power point presentation evaluated by the external examiner.

**Paper-VI (SEMINAR)**

Seminar presentation is through power point presentation and evaluated by faculty members based on (i) selection of topic (20), (ii) presentation and eloquence (20), (iii) depth of understanding (20), (iv) use of articles & seminar report (20) and (v) defense to queries (20).

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**SAMPLE QUESTION PAPER**

**(THEORY)**

**Time: 2 hours**

**Full Marks: 50**

**(Answer all questions carrying equal marks.)**

Q.1 Answer the following (any four). [Atleast one from each unit]

(4x5)

- (a) Justify the statement "\_\_\_\_\_".
- (b) Differentiate between \_\_\_\_\_ and \_\_\_\_\_.
- (c) Define \_\_\_\_\_.
- (d) Explain the principle of \_\_\_\_\_.
- (e) Mention the advantages and limitation of \_\_\_\_\_.

Q.2 Long question [From Unit-I]

(10)

or

Long question or Write short notes on

- (a)
- (b)

Q.3 Long question [From Unit-II]

(10)

or

Long question or Write short notes on

- (a)
- (b)

Q.4 Long question [From Unit-III]

(10)

or

Long question or Write short notes on

- (a)
- (b)

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# SAMPLE QUESTION PAPER

## (PRACTICAL)

Time: 6 hours

Full Marks: 100

(Answer all questions.)

Q.1 Minor experiment. (Any one) (20)

(a)

(b)

(c)

(d)

(e) Any other experiment suggested by the external examiner.

Q.2 Major experiment. (Any one) (35)

(a)

(b)

(c)

(d)

(e) Any other experiment suggested by the external examiner.

Q.3 Spotting (five in consultation with the external examiner) (5x5)

(museum specimens/slides/models/visual aids/ instruments etc.)

Q.4 Practical record (10)

Q.5 Viva voce (10)

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