CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA

DEGREE OF M. Sc. Zoology

MASTER OF SCIENCE IN ZOOLOGY

(CHOICE BASED CREDIT AND SEMESTER SYSTEM FOR POSTGRADUATE CURRICULUM)

UNDER THE FACULTY OF SCIENCE

SYLLABUS

(FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2019 – 20 ONWARDS)

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CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA - 680125, KERALA, INDIA

JUNE, 2019

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SEMESTER 1

ZO1CT01 - BIOCHEMISTRY AND BIOPHYSICS (90 hrs)

Part A - Biochemistry (72 hrs)

A. Chemistry and functions of Biomolecules (30)

1. Introduction (2 hr)

1.1. Macromolecules and their subunits

1.2. Chemical bonds of biomolecules (Covalent and Non-covalent bonds)

2. Carbohydrates (10 hr)

2.1. Monosaccharides

2.1.1. Classification with examples, Biological roles of monosaccharides

2.1.2. Structure of glucose, fructose, galactose, mannose and ribose

2.1.3. Methods of representation of sugars (Ball and stick, projection formula and perspective formula)

2.1.4. Isomerism – Structural isomerism (functional group isomerism) and stereo isomerism (optical isomerism); Mention - epimer, anomer and enantiomer with examples, Mutarotation.

2.1.5. Reactions – Oxidation (by acids, metal hydroxides & H2O2); Dehydration (by acid); Reduction (by alkali); Reactions with alanine as well as phenyl hydrazine

2.1.6. Derivatives – ascorbic acid, acetal and hemiacetal, ketal and hemiketal, glycosides –glycosidic bond and deoxyribose

2.2. Disaccharides

2.2.1. Structure and biological roles of Maltose, Sucrose, Lactose, Cellobiose and Trehalose

2.2.2. Biosynthesis of trehalose and lactose

2.3. Polysaccharides

2.3.1. Homopolysaccharides – Structure and biological roles of cellulose, starch, glycogen, inulin and chitin

2.3.2. Mode of action of amylase on homopolysaccharides (starch and glycogen)

2.3.3. Heteropolysaccharide - Structure and biological roles of hyaluronic acid, chondroitin, chondroitin sulphate, keratan sulphate, heparin and agar-agar

3. Proteins (7 hr)

3.1. Amino acids

3.1.1. Classification: (a) On the basis of number of amino and carboxyl group (b) On the basis of the chemical composition of side chain (c) On the basis on the polarity of side chain-R

3.1.2. Amphoteric properties of amino acids

3.1.3. pK value and isoelectric point (pI) of amino acids

3.1.4. Peptide bond and peptides (di, tri, tetra, oligo and polypeptide)

3.2. Structure of protein

3.2.1. Primary structure, Secondary structure (α-helix –parallel & antiparallel and β pleated sheet), random coil conformation, Tertiary structure, quaternary structure.

3.2.2. Brief note on protein domains, motifs, folds and Ramachandran plot.

3.2.3. Biological roles of proteins

4. Lipids (6 hr)

4.1. Classification of lipids -Simple lipids (fats, oils and waxes), compound lipids (phospholipids, glycolipids, lipoproteins and sulpholipids) and derived lipids.

4.2. Brief account of the chemistry of sterols, terpenes and carotenoids.

4.3. Acid number, saponification number, Iodine number, Polenske number and Reichert-Meissl number of lipids

4.4. Biological roles of lipids – as food reserves (storage lipids), structural lipids in membrane, as signals, as co-factors, as pigments, as insulators, as vitamin carriers

4.5. Prostaglandins – Chemical nature and functions.

4.6. Fatty acids – definition; essential fatty acids

4.7. Classification with examples– Saturated, unsaturated, hydroxyl and cyclic fatty acids

4.8. Nomenclature of fatty acids – Genevan system

5. Nucleic acids (5 hr)

5.1. Structure of nitrogen bases and nucleotides

5.2. Structural organization of DNA (Watson –Crick model)

5.3. Characteristic features of A-, B- and Z-DNA

5.4. Structural organization of t-RNA; brief note on micro-RNA

5.5. Biological roles of nucleotides and nucleic acids

B. Enzymology and Energetics (12 hr)

6. Enzymes (8 hrs)

6.1. Classification - (I.U.B. system)

6.2. Specificity of enzyme action

6.3. Mechanism of enzyme action: Formation of enzyme substrate complex - Gibbs free energy of activation; Michaelis-Menten theory, Fischer's template theory and

Koshland's induced fit theory. Electrostatic, hydrogen & Van der Waal's bonds in

Enzyme - substrate complex

6.4. Enzyme kinetics - Michaelis-Menten equation – derivation; significance of Km and Vmax Values

6.5. Lineweaver-Burk equation and double reciprocal plot of enzyme reaction

6.6. Enzyme inhibition – Competitive, non-competitive and uncompetitive inhibition (distinguish kinetically), suicide inhibition and feedback inhibition

6.7. Allosteric enzymes, Iso-enzyme and ribozyme

6.8. Factors influencing enzyme action- Coenzymes, Vitamins as coenzymes Classification, Structure and functions of Vitamins

7. Bioenergetics (4 hr)

7.1. Laws of thermodynamics and biological system

7.2. Enthalpy, Entropy, Free energy concept

7.3. Energy of activation, Standard free energy change

7.4. Role of ATP as a free energy carrier in the biological system

C. Metabolism and biosynthesis of biomolecules (30 hr)

8. Carbohydrate metabolism (12 hr)

8.1. Glycolysis – (PFK as pacemaker – Hexokinase conformation and change by glucose), Fate of pyruvic acid

8.2. Citric acid cycle; Pyruvate dehydrogenase complex and ketoglutarate dehydrogenase complex

8.3. Electron transport system and oxidative phosphorylation; Redox porential, Chemiosmotic hypothesis; inhibitors of electron transport chain

8.4. Gluconeogenesis. Glycogenesis and its regulation. Glycogenolysis and its regulation.

8.5. Pentosephosphate pathway (HMP pathway).

8.6. Uronic acid pathway

9. Amino acid metabolism (6 hr)

9.1. Biosynthesis and degradation of amino acids – glutamic acid, phenyl alanine, methionine, tryptophan, isoleucine, histidine. Valine.

9.2. Fate of amino acids in the body. Transamination, Decarboxylation and deamination reactions in the biological system.

10. Lipid metabolism (8 hr)

10.1. Oxidation of fatty acids

10.2. Biosynthesis of fatty acids

10.3. Biosynthesis of cholesterol

11. Nucleic acid metabolism (4 hr)

11.1. Biosynthesis and degradation of purines and pyramidines

Part - B. Biophysics (18 hrs)

D. Biophysical aspects (18 hrs)

12. Colloidal System (3 hrs)

12.1. Crystalloids and Colloids, biological importance of colloids.

12.2. Properties of colloids- Kinetic, optical and electrical properties- Electrosmosis, Cataphoresis, Coagulation.

12.3. Forms of colloids, Suspensions and Emulsions, preparation and properties of emulsions.

13. Transmembrane physics (7 hrs)

13.1 Physico-chemical properties of cell membrane, conformational properties of cell membranes

13.2. Transport – Nutrient transport across membranes, porins facilitated diffusion, glucose porter

13.3. Active transport: proton pumps, Na+ K+ pumps, Ca++ pumps & ionic channels.

13.4. Fick's law of diffusion and diffusion coefficient.

13.5. Electrolytic and ionic balance in biological fluid. Gibb's Donnan equilibrium.

13.6. Electrophysiology -patch clamp. Single-unit recording.

14. Bioacoustics (5 hrs)

14.1. Characteristics of sound.

14.2. Physical basis of hearing.

14.3. Physical organization of ear.

14.4. Physical aspects of sound transmission in the ear.

14.5. Audible sound frequency.

14.6. Pitch perception and theories.

14.7. Infrasonic and ultrasonic sounds.

14.8. Echolocation; receiving and analyzing echoes.

15. Radiation Biology (3 hrs)

15.1. Radioactivity, different types ionizing radiations and their sources.

15.2. Radioactive disintegration. Decay curve, half-life.

15.3. Biological effects of ionizing radiations - effects at macromolecular, cellular and organ system level, effects of whole body irradiation, radiation therapy.

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BIOCHEMISTRY

1. David L Nelson & Michael M Cox Lehninger, Principles of Biochemistry, 7th edition, (2017) Macmillan.

2. Robert Harper's Biochemistry, (2018) 31st Edition, K. Murray, Daryl K. Granner, Peter, A. Mayes and Victor, W. Rodwell Appleton and Lange, Prentice Hall of India Private limited, New Delhi,

3. Lubert Stryer, (2019) Biochemistry, 9 th edition, W.H. Freeman & Co.

4. Eric E. Conn, Paul K. Stumpf, George Bruening, Roy H. Doi, (2007) Outlines of Biochemistry, Vth edition, John Wiley & Sons, Inc.

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7. Voet, D. and Voet, J.G. & Pratt (2012). Principles of Biochemistry, John Wiley & sons.

8. Zubay, G (1997). Biochemistry, Mc Graw – Hill Publications

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1. Ackerman, E. (1962). Biophysical Science. Prentice Hall Inc.

2. Alonso, A and Arrondo, J.L.R (2006) - Advanced techniques in Biophysics, Springer.

3. Alok Srivastava and Ipsita Roy-(2009)-Bio-Nano- Geo Sciences- The future challenge-Ane Books Ltd.

4. Baker,E.J and Silverton, R.E. (1978) - Introduction to medical laboratory technology, ELBS

5. Bengt Nolting (2006), Methods in modern Biophysics 2nd edn. Springer.

6. Daniel, M (2002), Basic Biophysics for Biologists. Agro Botanics, Bikaner

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8. Das, D. (1991) Biophysics and Biophysical Chemistry, Academic Publishers, Calcutta.

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ZO1CT02 - BIOINSTRUMENTATION AND BIOSTATISTICS (90 hrs)

Part A - Bioinstrumentation (54 hrs)

1. pH (2 hrs)

1.1. Dissociation of water and a weak acid

1.2. Buffer –Importance of buffers in biology

1.3. Henderson Hasselbalch equation

1.4. Electrometric determination of pH, pH meter. pH value calculation

2. Microscopy -Principles and applications of the following (8 hrs)

2.1. Principle of microscope, resolving power of microscope

2.2. Histological methods- Microtome techniques, fixation and staining

2.3. Cytochemistry and Immunohistochemistry

2.4. Fluorescent microscope

2.5. Phase contrast microscope

2.6. Electron Microscopes (SEM & TEM)

2.7. Interference microscope

2.8. Atomic Force Microscopes

3. Separation Techniques (15 hrs)

3.1. Chromatography - Adsorption, Partition and Ion exchange chromatography

3.1.1. Column chromatography

3.1.2. Paper chromatography

3.1.3. Thin- layer chromatography

3.1.4. Gel-filtration

3.1.5. Gas chromatography

3.1.6. Affinity chromatography

3.1.7. HPLC.

3.2. Electrophoresis

3.2.1. Paper and Disc electrophoresis

3.2.2. Agarose gel electrophoresis (AGE)

3.2.3. PAGE, SDS-PAGE and two dimensional PAGE

3.2.4. Isoelectric focusing. (IEF)

3.2.5. High-voltage Electrophoresis. Immunoelectrophoresis

3.3. Centrifuge

3.3.1. Basic principles of sedimentation, Types of centrifuges, Analytical and Preparative centrifugation, Differential and density gradient centrifugation

3.3.2. Ultra centrifuge

3.4. Flowcytometry

3.4.1. Principles, working and application of FACS

4. Radiation biology techniques (6 hrs)

4.1. Autoradiography - Biological applications of radioisotopes

4.2. Radiation dosimetry - dose units and dose measurement

4.3. Radiation Detectors - Geiger Muller Counter, Solid and Liquid Scintillation Counter, Proportional counter, Semiconductor detectors

5. Spectroscopy (12 hrs)

5.1. Properties of electromagnetic radiations

5.2. Beer-Lambert Law and Molecular analysis using UV / visible spectrometry

5.3. Laser and its applications in Biology

5.4. Structure determination using X-ray diffraction crystallography

5.5. Mass spectroscopy. (Brief only)

5.6. NMR spectroscopy. (Brief only)

5.7. Electron Spin Resonance (ESR) spectroscopy - Applications. (Brief only)

5.8. Circular dichroism. (Brief only)

5.9. Surface Plasmon Resonance (SPR). (Brief only)

6. Biomedical techniques (Brief only) (8 hrs)

6.1. Electrocardiography (ECG)

6.2. Brain activity recording. Electroencephalography (EEG)

6.3. Magnetic resonance imaging (MRI)

6.4. Computed axial tomography (CT scan)

6.5. PET Scan (Positron Emission Tomography)

7. Nanotechnology (3 hrs)

11.1. Introduction to Nanobiology

11.2. Role of nanotechnology in environmental management

11.3. Nanosensors and Nanomedicines

Part B - Biostatistics (36 hrs)

8. Introduction (2 hrs)

8.1 Biostatistics: Definition

8.2 Characteristics of Statistics

8.3 Importance and usefulness of statistics

8.4 Limitations of Statistics

9. Data: (5 hrs)

9.1 Types of data: classification based on Source of data, Compilation, Variable, Nature

9.2. Methods of data collection and classification

9.3. Types of sampling methods

9.4. Advantages and disadvantages of census and sampling method

9.5. Class intervals- exclusive and inclusive method

9.6 Frequency curve (types. skewness, kurtosis, ogive)

10. Statistical Methods: Measures of central tendency and dispersal (4 hrs)

10.1. Mean (raw data, discrete series and continuous series)

10.2. Standard deviation, Standard error, degree of freedom (raw data, discrete series and continuous series)

10.3. Quartile deviation- Box- whisker plot

11. Probability distributions (4 hrs)

11.1. Basic concepts and definition

11.2. Laws of probability

11.3. Probability distribution- Binomial, Poisson and Normal

12. Statistical inference (problems to be discussed) (7 hrs)

12.1 Difference between parametric and non-parametric statistics;

12.2. Testing of hypothesis

12.3. Errors

12.4. Confidence interval, levels of significance, Critical region

12.5. Normality test

12.6. t-test, chi-square test, F-test, ANOVA

12.7. Kruskal-Wallis, Mann-Whitney

13. Correlation and Regression (problems to be discussed) (7 hrs)

13.1. Types of correlation

13.2. Methods to measure correlation- Scatter diagram

13.3. Karlpearson's coefficient of correlation, Spearman's correlation

13.4. Types of regression analysis

13.5. Regression equations

13.6. Difference between regression and correlation analysis

14. Ecological data analysis (problems to be discussed) (7 hrs)

14.1. Alpha diversity, Shannon diversity index, Simpsons Dominance index, Pielou‟s evenness index, Margalef species Richness, Fisher‟s alpha

14.2. Beta diversity, Morisita Horn index, Sorenson index, Bray-Curtis similarity

References:

BIOINSTRUMENTATION

1. Ghatakk.L.(2011). Techniques and methods in Biology.PHI, Learning Pvt. New Delhi.
2. Gupta.A.(2009). Instrumentation and Bio-analytical techniques. Pragati Prakashan, Meerut.
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8. Zar, J.H. (2003). Biostatistical Analysis - Fourth edition. Pearson Education. New Delhi.

ZO1CT03 - ECOLOGY AND ETHOLOGY (90 Hours)

Part A - Ecology (54 hrs)

1. Introduction (3 hrs)

1.1. Habitat and niche

1.1.1. Concept of habitat and niche

1.1.2. Niche width and overlap

1.1.3. Fundamental and realized niche

1.1.4. Resource partitioning

1.1.5. Character displacement

2. Ecosystem (9 hrs)

2.1. Structure and function

2.2. Ecosystem energetics

2.3. Primary production

2.4. Energy flow models

2.5. Mineral cycling (CNP)

2.6. Trophic levels, Food chain, food web and secondary production

2.7. Decomposers and detritivores

3. Population Ecology (7 hrs)

3.1. Characteristics of a population

3.2. Methods of estimating population density of animals, ranging patterns through direct, indirect and remote observations

3.3. Sampling methods in the study of behaviour, habitat characterization

3.4. Ground and remote sensing methods

3.5. Population growth curves, Life tables, survivorship curves, population regulation, Life history strategies, r and k selection, Demes and dispersal, inter-demic extinctions, age structure of populations

3.6. Growth and regulation of human population

4. Species interaction (5 hrs)

4.1. Types of interactions, interspecific competition

4.2. Herbivory, Carnivory, Pollination, Symbiosis; - mutualism, commensalism and proto co-operation

5. Community Ecology (4 hrs)

5.1. Nature of communities.

5.2. Characteristics of a biotic community.

5.3. Species diversity and latitudinal gradients in diversity.

5.4. Edges and ecotones.

6. Ecological succession (4 hrs)

6.1. Types, mechanisms, changes involved in succession.

6.2. Concept of climax.

7. Biogeography (6 hrs)

7.1. Major terrestrial biomes:

(a) Tropical rain Forest (b) Grassland (c) Desert (d) Chaparral (e) Temperate deciduous Forest

(f) Temperate boreal forest (g) Tundra (h) Savanna

8. Biogeographical zones of India (4 hrs)

(a) Trans Himalayan zone; (b) Himalayan zone; (c) Desert zone; (d) Semiarid zone; (e) Western Ghats zone; (f) Deccan plateau zone; (g) Gangetic plain zone; (h) North east zone. (i) Coastal zone; (j) Islands present near the shore line.

9. Applied Ecology (8 hrs)

9.1 Carbon credit, Carbon trading, Blue Carbon

9.2 Green building technology and its ecological importance.

9.3 Discuss the benefits and disadvantages of the idea of (brief)

a. Inter linking of major rivers of India,

b. Sethusamudram ship canal project.

c. Biodiversity with special reference to India-status monitoring and documentation, major drivers of biodiversity change.

10. Conservation Biology (4 hrs)

10.1 Principles of conservation

10.2 Major approaches to management

10.3 Indian case studies on conservation & management strategy (concepts of project tiger, Biosphere reserves).

Part B - Ethology (36 hrs)

11. Concepts of Ethology (5 hrs.)

11.1. Introduction

11.2. Ethology as different from the other schools studying animal behavior like behaviourism.

11.3. Behaviour as a reaction to stimuli- sign stimuli, social releasers, Ethograms, super normal stimuli, stimulus filtering.

11.4. Concepts of Fixed Action Patterns (FAP), Innate Releasing Mechanism (IRM), Action Specific Energy (ASE), Concepts of Learning and Imprinting.

12. Motivating factors (5 hrs.)

12.1. General factors in motivation; Studies of motivation in guppies

12.2. Conflict behaviour- stress-displacement activities- Ritualization

13. Instinctive and Learned behaviour (11 hrs.)

13.1. Proximate and Ultimate factors.

13.2. Biological clocks, circadian rhythm

13.3. Reflex action, neural basis of sleep and arousal

13.4. Neural basis of learning, memory, cognition.

13.5. JP Scott's categories of behaviour.

13.6. Types of orientation- Reafference theory of Von Holst & Mittel Steadt.

13.7. Navigation and migration.

14. Social behavior (6 hrs.)

14.1. Mating systems, Parental investment, parental care and reproductive Success.

14.2. Development of social behavior. Social communication; Social dominance; use of space and territoriality; domestication and behavioral changes.

14.3. Social behaviour of termites and Primates.

15. Evolution and adaptiveness of behaviour (4 hrs.)

15.1. Altruism, Kin selection, inclusive fitness, selfish gene theory

15.2. Cultural transmission of behaviour.

16. Hormones and Behaviour (5 hrs.)

16.1. Hormones of gonads, adrenal gland, pituitary gland- hormonal effects on different behavioral patterns, Maternal behaviour- mechanism of hormonal action.

References:

ECOLOGY

1. Ahluwalia V.K. and Sunitha Malhotra (2008) Environmental Science. Ane Books Pvt. Ltd.
2. Allan Beebi and Anne-Marie Brennan. (2006) First Ecology - Ecological principles and environmental issues. Oxford university press.
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ETHOLOGY

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2. David McFarland (1999) Animal Behaviour: Psychobiology, Ethology and Evolution, 3rd Edition. Publisher: Pearson Education.
3. David McFarland (2006) A Dictionary of Animal Behaviour. Publisher: Oxford University Press.
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9. Martin, P. and Bateson, P. (2001) Measuring Behaviour- an introductory guide. Cambridge University Press, London.
10. Scott, J.P. (1972) Animal Behaviour. Publisher: University of Chicago.

SEMESTER 2

ZO2CT04 - PHYSIOLOGY (90 hrs)

1. Nutrition (10 hrs)

1.1. Constituents of normal diet and their daily requirements.

1.2. Physiological calorie value of food stuffs.

1.3. Antioxidant nutrients.

1.4. Movements of GI tract: deglutition, gastric motility and emptying, intestinal motility and defecation.

1.5. The role of hormones and neurotransmitters in the control of gastrointestinal Motility.

1.6. Energy balance and obesity-causes and consequences.

1.7. BMR and its significance.

2. Excretory System (12 hrs)

2.1. Introduction: Brief description of different types of excretory organs in different animal groups (flame cells, green glands, malpighian tubules).

2.2. Functional anatomy of mammalian kidney, nephron and juxtaglomerular apparatus structure, parts and function.

2.3. Urine formation (glomerular filtration, tubular reabsorption and tubular secretion)

2.4. Regulation of water balance -Mechanism of concentration of urine – Counter Current system (counter current multiplier and counter current exchanger).

2.5. Renal regulation of acid- base balance & electrolyte balance.

2.6. Structure of urinary bladder, micturition reflex and micturition.

2.7. Renal clearance – definition, concept and significance; clearance value of urea, creatinine, phosphate, potassium, chloride and sodium.

3. Respiratory system (10 hrs)

3.1. Introduction: Brief description of major respiratory organs (tracheal system, book lungs, gills and ctenidia).

3.2. Physiological anatomy and histology of respiratory passage and lungs.

3.3. Mechanism of pulmonary ventilation (inspiration & expiration).

3.4. Alveolar ventilation, dead space and its effect on alveolar ventilation.

3.5. Role of surfactant in alveolar expansion.

3.6. Pulmonary volumes and capacities – definition & normal values (tidal volume, inspiratory reserve volume, expiratory reserve volume, residual volume, functional residual capacity, inspiratory capacity, vital capacity, total lung capacity)**.**

3.7. Exchange of gases- partial pressures involved- lung and tissues.

3.8. Oxygen dissociation curve – factors affecting binding of oxygen to haemoglobin (PO_2, PCO_2 ,CO, pH, body temperature, diphosphoglyceric acid level, foetal haemoglobin and also myoglobin).

3.8. Neural and chemical regulation of respiration: Respiratory centres & factors regulating respiration.

4. Neurophysiology (22 hrs)

4.1. Organisation of human brain.

4.1.1. Cerebrum, cerebral hemispheres and cerebral lobes.

4.1.2. Cerebral cortex and its functional areas- Motor cortex, Broca's area, somatosensory cortex and its association area, gustatory cortex, visual cortex and its association area, auditory cortex and its association area, olfactory cortex, Wernick's area, Brodman map, cerebral dominance.

4.1.3. Cortical white matter- commissures, association fibers, projection fibers, corpus callosum and fornix, basal nuclei-organisation and function.

4.1.4. Brain stem- organisation and function.

4.1.5. Cerebellum- structure and function.

4.1.6. Diencephalon – organisation and function.

4.2. Functional brain systems - Limbic system and reticular formation.

4.3. Protection of brain – Meninges, cerebrospinal fluid- formation and function, blood brain barrier and its function.

4.4. Diseased states of brain - schizophrenia, Alzheimer's disease, Senile dementia & Parkinson's disease.

4.5. Memory- definition, types of memory- short term, intermediate long term and Long-term memory, consolidation of memory.

4.6. PNS and Autonomic nervous system.

4.7. Spinal cord – structure.

4.8. Reflex action, reflex arc, monosynaptic and polysynaptic reflexes, inverse stretch reflex and golgi tendon organ.

5. Special senses (16 hrs)

5.1. Vision

5.1.1. Structure of eyeball

5.1.2. Fluid systems of the eye

5.1.3. Layers of Retina and photoreceptors (rods & cones)

5.1.4. Brief notes on the neuronal cell types and neural circuitary of the retina and visual pathways from retina to visual cortex

5.1.5. Image formation

5.1.5.1. Formation of image on the retina.

5.1.5.2. A brief general account of electrophysiology of vision

5.1.5.3. Photochemistry of vision & colour vision

5.2. Taste

5.2.1. Primary sensations of taste (agents and site of sensation)

5.2.2. Taste buds (location, structure, receptors and nerve supply)

5.2.3. Physiology of taste (receptor stimulation, generation of nerve impulse by taste buds and its transmission to CNS)

5.3. Smell

5.3.1. Olfactory membrane and receptor cells

5.3.2. Physiology of olfaction (stimulation of olfactory cells and transmission of smell signals to CNS)

6. Tactile response (brief note**) (4 hrs)**

6.1.1. Mechanoreceptors and their stimulation

6.1.2. Pain receptors and their stimulation

6.1.3. Thermal receptors and their stimulation

7. Cardiovascular system (9 hrs)

7.1. Introduction: Brief description of vertebrate hearts

7.2. Structural organization of myogenic heart (in human beings).

7.3. Physiological anatomy of cardiac muscle – specialized tissue**.**

7.4. Heart as a pump.

7.5. Cardiac cycle**.**

7.6. Neural and chemical regulation of heart function**.**

7.7. Blood volume and blood pressure**.**

7.8. Physiological anatomy of coronary blood flow.

7.9. Coronary blood flow and its control**.**

7.10. Ischemic heart disease – mention causes.

8. Lymphatic System (4 hrs)

8.1. Lymph channels of the body**.**

8.2. Composition and formation of lymph**.**

8.3. Functions of lymph and lymphatic system including role of it in controlling Interstitial fluid protein concentration, interstitial fluid volume and interstitial fluid pressure.

9. Environmental Physiology (3 hrs)

9.1. Thermal regulation.

9.1.1. Comfort zone, normal body temperatures (oral, skin & core).

9.1.2. Temperature regulating mechanism (hot & cold), mention the role of hypothalamus, thyroid and adrenal glands.

9.1.3. Acclimatization

References:

1. Arthur C. Guyton & John E. Hall (2003) Textbook of Medical Physiology, Saunders (An imprint of Elsevier).
2. William F. Ganong (1999) Review of Medical Physiology, Lange Medical Publications (Appleton & Lange).
3. Jain A.K. (2009) Text Book of Physiology (Vol. I & II), Avichal Publishing Company, New Delhi.
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ZO2CT05 - MOLECULAR BIOLOGY AND CYTOGENETICS (90 hrs.)

Part A - Molecular Biology (72 hrs)

1. DNA replication (7 hrs)

1.1. Semi discontinuous synthesis- Okazaki fragments

1.2. Replication origin and replication fork

1.3. Enzymes/proteins of replication- Primase, Replisomes, Helicase, DNA polymerases, Single strand binding proteins, Topoisomerases and Ligase; Fidelity of replication

1.4. Replication of the ends of eukaryotic chromosome – role of telomerase

1.5. Models of DNA replication –Rolling circle model, D-loop model, θ-model

1.6. Inhibitors of DNA replication – Methotrexate

2. Safeguard systems of DNA (5 hrs)

2.1. Restriction: significance, role and features of Type I, II & III restriction enzymes

2.2. Modification: enzymes and significance

2.3. Repair:

2.3.1. Major kinds of damage to DNA and causes

2.3.2. Repair mechanisms: Direct reversal, Mismatch repair, Excision repair, Recombination repair, SOS response

3. Transcription of mRNA in prokaryotes and eukaryotes (9 hrs)

3.1. Structural organization and life span of mRNA; monocistronic and polycistronic mRNA

3.2. Transcription in prokaryotes and eukaryotes

3.2.1. Promoter (mention Pribnow, TATA box), enhancer and silencer sites

3.2.2. Transcription factors; Transcription activators and repressors

3.3. Characteristic features of RNA polymerases of phages, prokaryotes and eukaryotes and their functions

3.4. Post transcriptional modification of RNA

3.4.1. Capping

3.4.2. Polyadenylation

3.4.3. Splicing

3.5. RNA editing: site specific deamination and role of gRNAs

3.6. mRNA transport

4. Genetic code (3 hrs)

4.1. Characteristics of genetic code

4.2. Start codons and stop codons

4.3. Degeneracy of the code: Wobble hypothesis and isoacceptor tRNAs

4.4. Point mutations that alter genetic code (missense, nonsense & frameshift)

5. Ribosome: The site of protein synthesis (4 hrs)

5.1. Structure

5.2. Composition; Reconstitution experiments

5.3. Topography: Methods to study ribosome structure - immune electron microscopy, cross linking

5.4. Biogenesis of ribosome in eukaryotes

6. Translation in prokaryotes and eukaryotes (7 hrs)

6.1. Aminoacylation of tRNA & initiation, elongation and termination of protein synthesis

6.2. Translational proof-reading

6.3. Differences in protein synthesis between prokaryotes and eukaryotes

6.4. Translational inhibitors in prokaryotes and eukaryotes – role of tetracycline, streptomycin, neomycin, chloramphenicol, erythromycin, puromycin and diphtheria toxin

6.5. Post- translational modification of proteins: protein folding (role of chaperones) and biochemical modifications

7. Control of gene expression at transcription and translation level (8 hrs)

7.1. Regulation of gene expression in Phages – alternate patterns of gene expression for control of lytic and lysogenic cycle in λ phage

7.2. Regulation of gene expression in bacteria – basic features of tryptophan, arabinose and galactose operons

7.3. Regulation of gene expression in eukaryotes –

7.3.1. Role of chromatin in regulating gene expression

7.3.2. Activation and repression of transcription

7.3.3. Regulation of translation by gene arrangement

7.3.4. Regulation of translation by alternate pathways of transcript splicing

7.3.5. Antisense RNA strategies for regulating gene expression

7.3.6. si RNA and mi RNA in regulation

8. Eukaryotic genome (5 hrs)

8.1. Special features of eukaryotic genome

8.2. Features, components and reassociation kinetics of Unique, Moderately repetitive and Highly repetitive DNA

8.3. Junk DNA, Satellite DNA and Selfish DNA

8.4. Cot value and complexity of genome

8.5. Organisation of human genome (brief account)

9. Interrupted genes (3 hrs)

9.1. Definition and explanation

9.2. Organisation and special features of interrupted genes

9.3. Evolution of interrupted genes

10. Gene families (6 hrs)

10.1. Definition and concept

10.2. Classification with example

10.2.1. Simple multigene family - organisation of rRNA gene in *Xenopus*

10.2.2. Complex multigene family - organisation of histone genes in sea urchin and tRNA genes in *Drosophila*

10.2.3. Developmentally controlled complex multigene family e.g., globin gene

10.2.3.1. Globin genes and its products

10.2.3.2. Organisation of globin genes and its expression in Man

10.2.3.3. Evolution of globin genes

10.2.4. Concept of an evolutionary clock

10.2.5. Pseudogenes

11. Transposable genetic elements - Transposons (6 hrs)

11.1. Definition, features and types

11.2. Transposition and mechanism

11.3. Transposons in bacteria

11.3.1. IS elements

11.3.2. Tn family

11.3.3. Mu phage as a transposable element

11.4. Transposons in eukaryotes

11.4.1. SINE, Alu family; LINE, L1

11.4.2. P elements in *Drosophila*

11.4.3. Transposons in Maize

11.5. Retroviruses and transposition

12. Molecular mechanisms involved in recombination of DNA (4 hrs)

12.1. Genetic recombination – types with example

12.1.1. Site specific recombination

12.1.2. Non-homologous recombination

12.1.3. Homologous recombination

12.2. Molecular mechanism involved in homologous recombination of DNA in eukaryotes - Holliday model: Holliday intermediate, heteroduplex DNA, gene conversion

12.3. Role of Rec A protein in genetic recombination

13. Cancer (5 hrs)

13.1. Cancer – benign and malignant

13.2. Virus-induced cancer

13.3. Alteration of cell cycle regulation in cancer

13.4. Interaction of cancer cells with normal cells

13.5. New therapeutic interventions of uncontrolled cell growth (immunotherapy and gene therapy).

Part B - Cytogenetics (18 hrs.)

14. Chromosome Organization (8 hrs.)

14.1. Structure of chromosomes: (2 hrs.)

Structure of prokaryotic and eukaryotic chromosomes.

14.2. Chromosomal basis of inheritance: (2 hrs.)

Mendelian and Non-Mendelian inheritance in humans.

Extrachromosomal inheritance- mitochondrial and chloroplast genes.

14.3. Abnormalities of Chromosome Number: (2 hrs.)

Polyploidy, aneuploidy. Factors causing aneuploidy - nondisjunction.

Autosomal aneuploid syndromes. Sex chromosome aneuploid syndromes.

14.4. Abnormalities of Chromosome Structure: (2 hrs.)

Duplication, deletion, translocation, reciprocal translocation, Robertsonian translocation, micro deletion.

15. Microbial genetics (4 hrs.)

15.1. *Escherichia coli* genome – basic features

Methods of genetic transfers in bacteria – Transformation (in *Streptococcus pneumoniae*), Conjugation and Sexduction, transduction

15.2. Brief note on mapping genes by interrupted mating - in bacteria.

16. Cytogenetics of Cancer (6 hrs.)

16.1. Growth characteristics of cancer cells; morphological and ultrastructural properties of cancer cells. (1 hr.)

16.2. Tumorogenesis - Type of growth - Hyperplasia, Dysplasia, Anaplasia and Neoplasia (1hr.)

16.3. Genetic rearrangements in progenitor cells. Oncogenes, Tumor suppresser genes and Protooncogenes (2 hrs.)

16.4. Telomeres and Telomerases- Introduction and function of telomeres and telomerases, steps involved, DNA repair and damage.

16.5. Regulation of telomere length (2 hrs.)

References:

Molecular Biology

1. Attwood T.K, Parry-Smith D.J. (2003): Introduction to Bioinformatics. Pearson Education
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3. Brown, T.A. (2006): Genomes 3. Garland Science, New York.
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Cytogenetics

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2. Bruce Alberts, Alexander Johnson, Julia Lewis, Martin Raff, Keith Roberts, and Peter Walter (2002), Molecular Biology of the cell. 4rth ed. Garland Science. New York.
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4. Karp, G. (2002). Cell and Molecular Biology. John Wiley, New York.
5. Kleinsmith, L.J. and Kish, V. M. (1995). Principles of Cell and Molecular Biology, 2nd Ed., Harper Collins College Publishers, New York.
6. Peter Snustad, Dand Michael J. Simmons (2000). Principles of Genetics, 2nd Ed., John Wiley and Sons Inc.
7. Purves W.K., Orians G.H. and Heller H.C. (1995). Life: The Science of Biology, 4th Ed., Sinauer Associates, Sunderland.
8. Robert H. Tamarin (2002). Principles of Genetics, 7th Ed., Tata McGraw-Hill Edu Pvt, New Delhi.
9. Sheeler, Philip, Bianchi and Donald (1987), Cell and Molecular Biology. 3rd Ed., John Wiley.

ZO2CT06 - SYSTEMATICS AND EVOLUTION (90 hrs)

Part A - Systematics (54 hrs)

I. Introduction **(1 hr)**

2. Definition and basic concepts in Systematics and Taxonomy **(4 hrs)**

- 2.1 Levels of Taxonomy
  - (a) Alpha, Beta and Gamma taxonomy
- 2.2 Importance and applications of taxonomy
- 2.3 Goals of taxonomy
- 2.4 Definition of systematics
- 2.5 Definition of classification

3. Species **(4 hrs)**

- 3.1 Monotypic species
- 3.2 Polytypic species
- 3.3 Ecospecies and Cenospecies
- 3.4 Morphospecies
- 3.5 Super species
- 3.6 Species as a Population Complex

4. Species Concepts **(6 hrs)**

- 4.1 Typological Species Concept
- 4.2 Nominalistic Species Concept

4.3 Biological Species Concept

4.4 Evolutionary Species Concept

4.5 Difficulties in the application of the biological species concept

5. Classification **(7 hrs)**

5.1 Uses of Classification

5.2 Purpose of Classification

5.3 Theories of Classification

(a) Essentialism (b) Nominalism (c) Empiricism (d) Cladism (e) Evolutionary Classification

5.4 Hierarchy of Categories

5.5 The objectives of classification

6. Taxonomic Collections and the Process of identification **(8 hrs)**

6.1 Taxonomic collections: Types of collections, Value of Collection

6.2 Purpose of scientific collection

6.3 Preservation of Specimens

6.4 Labeling

6.5 Curating of collections

6.6 Curating of types

6.7 Identification- Methods of identification

6.8 Use of keys, types of keys.

6.9 Merits and demerits of different keys

6.9.1 Description and publication

7 .Taxonomic Characters **(6 hrs)**

7.1 Nature of taxonomic characters

7.2 Taxonomic characters and adaptation

7.3 Kinds of taxonomic characters

(a) Morphological (b) Physiological (c) Ecological (d) Ethological and

(e) Geographical characters

7.4 Taxonomic characters and classification

7.5 Taxonomic characters and evolution

7.6 Functions of taxonomic characters

8. Zoological Nomenclature **(6 hrs)**

8.1 Brief History of nomenclature

8.2 International Code of Zoological Nomenclature

8.3 The nature of scientific names

8.4 Species and infraspecies names

8.5 Gender of generic names

8.6 Synonyms and Homonyms

8.7 The Law of Priority

8.8 Rejection of names

8.9 Type method and different kinds of types

9. Newer trends in systematics **(4 hrs)**

9.1 DNA Bar coding

9.2 Molecular systematics

9.3 Chemo taxonomy and serotaxonomy

9.4 Cytotaxonomy

9.5 Numerical taxonomy

9.6 Cladistics

10. Ethics related to taxonomic publications **(4 hrs)**

10.1 Authorship of taxonomic papers

10.2 Correspondence

10.3 Suppression of data

10.4 Undesirable features of taxonomic papers

10.5 Taxonomist and user communities

11. Taxonomic impediments **(4 hrs)**

11.1 Impediments in taxonomic collections and maintenance

11.2 Shortage of man power

11.3 Lack of funding for taxonomic research

11.4 Lack of training and library facilities

11.5 Impediments in publishing taxonomic work

11.6 Solutions to overcome the impediments

(a) Improve international co-operation (b) Development of taxonomic centers

(c) Need for efficient international networking (d) the desired end product

Part B - Evolution (36 hrs)

12. Natural Selection **(7 hrs)**

12.1 Mechanism of natural selection- directional, disruptive and stabilizing selection

12.2 Natural selection in islands

12.3 Sexual selection; intrasexual and intersexual selection- secondary sexual characteristics-sexy son hypothesis, good gene hypothesis

13. The Mechanisms (7 hrs)

13.1 Population genetics- populations, gene pool, gene frequency, Hardy-Weinberg law, founder principle, bottleneck effect and genetic drift as factors in evolution

13.2 Evidence for evolution: DNA evidence, fossil evidence, embryological evidence, geological evidence, evolution in action, imperfection of evolution

13.3 Co-evolution: microevolution, macroevolution, convergent evolution (homoplasy), divergent (parallel) evolution

14. Tempo of evolution (5hrs)

14.1 Gradualism Vs punctuated equilibrium

14.2 Anagenesis Vs Cladogenesis

15. Molecular evolutions (8 hrs)

15.1 Neutral theory of molecular evolution

15.2 Molecular divergence

15.3 Molecular drive

15.4 Molecular clocks, genetic equidistance, human mitochondrial molecular clock

15.5 Phylogenetic relationships- Homology, homologous sequence of proteins and DNA, orthologous and paralogous evolution, nucleotide sequence analysis

16. Evolutionary trends (9 hrs)

16.1 Biochemical evolution- Collapse of orthogenesis

16.2 Stages in primate evolution including Homo: dry and wet nosed primates, prosimians and simians, human and the African apes, African origin for modern humans, Y-chromosome. Adam and mitochondrial Eve

16.3 Can evolution explain language? Communication, speech, language and self- awareness in primates.

References:

Part -A SYSTEMATICS

1. David.M.H, Craig Mortiz and Barbara K.M (1996) Molecular Systematics. Sinauer Associates, Inc

2. David, M.S (2009) DNA bar-coding will frequently fail in complicated groups: an example in wild potatoes. American journal of Botany 96(6): 1177-1189. Downloadable from www.vcru.wisc.edu/spoonerlab/.../ Bar Codes %20 and % 20 wild % 20 Potatoes.pdf

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7. Narendran, T.C (2008) An introduction to Taxonomy. Zoological Survey of India
8. Sneath P.H.A. (1973) Numerical Taxonomy: The Principles and Practice of Numerical Classification.W.H. Freeman &Co

Part - B EVOLUTION

1. Coyne, J.A and Allen O.H (2004) Speciation. Sinauer Associates Inc. Massachusetts, USA
2. David, M.H, Craig Moritz and Barbara K.M (1996) Molecular Systematics. Sinauer Associates, Inc.
3. David, M.S (2009) DNA bar-coding will frequently fail in complicated groups: an example in wild potatoes. American journal of Botany 96(6): 1177-1189. Downloadable from www.vcru.wisc.edu/spoonerlab/.../ Bar Codes %20 and % 20 wild % 20 Potatoes.pdf
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11.Futuyama, D.J. (2005). Evolution. Sinauer Associates Inc. Sunderland, Massachusetts.

PRACTICALS

SEMESTER 1

ZO 2CP 01 – BIOCHEMISTRY

1. Actual acidity and titrable acidity of a strong and a weak acid.
2. Comparison of the buffering capacities of two buffers of same pH
3. Qualitative tests for carbohydrates
    a) Qualitative tests for monosaccharides (Glucose and fructose)
    b) Qualitative tests for disaccharides (Lactose, Maltose & Sucrose)
    c) Qualitative tests for polysaccharides (Dextrin & Starch)
    d) Identification of unknown carbohydrates (Glucose, Fructose, Lactose, Maltose, Sucrose, Dextrin & Starch) by suitable tests.
4. Quantitative estimation of carbohydrates
    1.1 Estimation of blood glucose by colorimetric method (Somogy-Nelson method/ O-Toluidine method)
    1.2. Estimation of total carbohydrate by phenol-sulphuric acid method
5. Qualitative tests for proteins
    a) Colour reactions with proteins (Albumin, Casein, Peptones & gelatin)
    b) Precipitation reactions with proteins (Albumin, Casein, Peptones & gelatin)
    c) Identification of unknown protein (Albumin, Casein, Peptones & gelatin)
6. Qualitative tests for non-protein nitrogenous substances (urea, uric acid and creatinine)
7. Identification of unknown carbohydrates, protein and non-protein nitrogenous substances from a given solution.
8. Quantitative estimation of proteins
    a) Estimation of proteins by Biuret method
    b) Isolation of casein from cow's milk
9. Quantitative estimation of non-protein nitrogenous substances
    a) Quantitation of blood urea by diacetyl monoxine method
    b) Determination of urine creatine by alkaline picrate method
10. Quantitative estimation of lipids
    a) Estimation of total serum cholesterol by Zak's method
    b) Saponification number of oils - coconut oil & ground nut oil.
    c) Iodine number of fats

References:

1. Plummer David, T. (2007). An introduction to practical biochemistry -Tata Mc Graw-Hill, New Delhi.
2. Oser, B.L., (1965) Hawk's Physiological Biochemistry, McGraw Hill Book Co.
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7. Sawhney, S.K.and Singh Randhir (2006). Introductory Practical Biochemistry. Narosa Publishing House, New Delhi.

ZO 2 CP 02 – BIOINSTRUMENTATION

1. pH meter and measurement of pH
2. Paper chromatography of amino acids
3. Separation and identification of amino acids in mixtures
4. Thin layer chromatography
5. Gel electrophoresis.
6. Determination of unknown concentration of coloured solutions by calibration curve using colorimeter.
7. Absorption spectrum and λmax of a coloured solution (KMnO4).
8. Drawings using Camera lucida.

BIOSTATISTICS

1. Preparation of frequency table with given data
2. Diagrammatic presentation of census data in Kerala in the form of bar diagrams and pi diagrams. (prepare same graph in Excel and keep print out)
3. Graphic presentation of population distribution in the form of histogram, frequency polygon and frequency curve. (prepare same graph in Excel and keep print outs)
4. Computation of measures of central dispersion anthropometric data of School children. (prepare same in Excel and keep print outs and add steps for excel)
5. Simulation of binomial and poison distributions.
6. Estimation of mean number of children per family (data from at least 10 families nearby campus) (prepare same in Excel and keep print outs and add steps for excel).
7. Designing of an experiment for the comparison of efficacy of a few diets on different types of animals by the method of ANOVA. (prepare same in Excel and keep print outs and add steps for excel).
8. Regression analysis and correlation analysis of a data of height and weight of a group of students. (prepare same in Excel and keep print outs and add steps for excel)

BIOPHYSICS AND BIOSTATISTICS:

1. Daniel, M. (1998). Basic Biophysics for Biologists. Agri. Botanica, Bikaner.
2. Das, D. (1987). Biophysics and Biophysical Chemistry. Academic Publishers, Calcutta.
3. Gassey, E.J. (1962). Biophysical concepts and mechanics. Van Norstrant Reinhold co.
4. Hoppe, W (1988). Biophysics, Springer Veilag.
5. White, D.C.S. (1974). Biological Physics, Chapman and Hall. London.

6. John T (2002) Practical statistics for environmental and biological scientists. John Wiley and Sons.

ZO 2CP 03 - ECOLOGY AND ETHOLOGY

Part A – Ecology

1. Identification of marine plankton.
2. Quantitative estimation of marine plankton.
3. Estimation of BOD in polluted water sample.
4. Estimation of salinity in water samples.
5. Estimation of nitrate-nitrogen in water samples.
6. Separation and identification of soil arthropods using Berlese funnel.
7. Determination of moisture content of soil sample.
8. Determination of water holding capacity of soil sample.
9. Testing the transparency of water using Secchi disc
10. Determination of primary productivity in pond water using light and dark bottle.
11. Study of termitorium / ant colony
12. Principle and application of the following instruments- GPS, Thermo hygrometer, Altimeter, Air samplers,Water samplers, Soil samplers, Berlese funnel, Lux meter, anemometer, Rain gauge, Plankton net, Plankton counting chamber, Weather balloon, Secchi disc etc. **(at least six items)**
13. FIELD STUDY-A study tour of at least five days duration (need not be at a stretch) to observe the ecology and behaviour of animals should be undertaken. The places of visit shall include inter tidal region, freshwater bodies, lakes, rivers, hill streams, wetlands, mangroves, forests, grasslands, drinking water treatment plants, and sewage treatment plants. A report of the field study is to be included in the practical record to be submitted at the time of examination.

Part B - Ethology

1. Studying and reporting the behaviour and ecology of animals in selected fields (Social Spider / Jungle babbler /white headed babbler or Bonnet Macaques)
2. Foraging behaviour of ants.
3. Study of circadian rhythm
4. Behavioural reaction to moisture and light

References:

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2. Goodenough, J; McGuire B. and Robert, W. (1993) Perspectives on Animal Behaviour. John Wiley and Sons, Lond.
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4. Manning, A. and Dawkins, M.S. (1995). An introduction to Animal Behaviour, Cambridge Press.

5. Bonnie,J,Plager and Ken Yamkawa (2003). Exploring Animal Behaviour in Laboratory and Field. Academic press.
6. Michael, P. (1984). Ecological methods for field and laboratory investigations. Tata McGraw Hill publishing co.
7. Webber, w.J (1972).Physicochemical Processes for water quality control. Wiley interscience.
8. George,T, Franklin, L. Burton and David, S.H.(2002). Waste water Engineering Metcalf and Eddy. 4th ed. Inc. Tata McGraw Hill publishing co.

PRACTICALS

SEMESTER 1

ZO 2 CP 02 – PHYSIOLOGY

1. Kymograph: working principle and applications
2. Effect of different substrate concentration, pH and temperature on human salivary amylase activity. colorimetric method, plot graphs.
3. Qualitative demonstration of digestive enzymes in cockroach – amylases, lipases, proteases, invertases and controls.
4. Digestion in a vertebrate and calculation of peptic value.
5. Influence of temperature and pH on the ciliary activity in fresh water mussel/mytilus using silver foil. Plot graph
6. Determination of respiratory quotient – estimation of O2 consumption by an aquatic animal.
7. Determination of the rate of salt loss and gain in an aquatic animal (fish or crab).
8. Estimation of urea and ammonia in human urine. Titrimetric method.
9. Rate of glucose – absorption – calculation of Cori coefficient.
10. Estimation of haemoglobin of Fish/Man – Sahli‟s method.
11. Blood volume determination by dye dilution method (Vertebrate).
12. Blood: clotting time, bleeding time, rouleaux formation, preparation of haemin crystals.
13. Enumeration of RBCs in human blood.
14. Determination of lactic acid in muscle tissue.
15. Differential count of human WBCs
16. Haematocrit and ESR of human blood.
17. WBC total count

References:

1. Oser B.L. (1965). Hawk‟s Physiological chemistry, McGraw Hill Book Company
2. Hill R.W., Wyse G.A. (1989), Animal Physiology 2nd edition. Harper Collins Publishers

3. Schmidt-Nielsen, K. (1997), Animal Physiology, adaptation and environment, Cambridge University Press.
4. Dounersberger, Anne.B.Lesak, Anne,C and Timmons, Maichael,J.(1992).A laboratory Text Book Of Anatomy and Physiology. 5th ed. D.C.Heath & Co.

ZO 2 CP O2 - CELL & MOLECULAR BIOLOGY

1. Homogenization, cell fractionation and isolation of nuclear fraction.
2. Preparation of salivary gland polytene chromosome from *Drosophila* larva.
3. Grasshopper testes- squash preparation to study various meiotic stages.
4. Estimation of DNA by Diphenyl Amine method
5. Estimation of RNA by Orcinol method
6. Estimation of Protein by Lowry's method.
7. Isolation of genomic DNA.
8. Isolation of DNA from Liver/Spleen/Thymus.
9. Study of principle and application of DNA finger printing.

References:

1. Brown, T.A. (1998): Molecular biology Lab Fax. Vol. 1 and 2, Academic press
2. Brown, T.A. (2007): Essential Molecular Biology – A practical approach Vol. 2, Oxford University Press
3. Wilson & Walker (2006): Principles and techniques of Biochemistry and Molecular biology, Cambridge University Press.

ZO 2 CP 03 - SYSTEMATICS AND EVOLUTION

Part A – Systematics

1. Collection, Preservation and Curation of specimens
2. Identification of animals (Fishes/insects/any other) up to family/ generic / species level- minimum 15 specimens.
3. Preparation of dichotomous (simple bracket) keys to selected families with reference to insect orders Orthoptera, Hemiptera, Coleoptera, Diptera and Hymenoptera (minimum five specimens from each order) or fishes (minimum five specimens)

Part B - Evolution

4. Exercises in convergent evolution.
5. Exercises in divergent evolution.
6. Sympatric and Allopatric speciation.
7. Exercises in co-evolution.
8. Calculation of genotype / gene frequency based on Hardy –Weinberg equilibrium.

SEMESTER 3

ZO3CT07 - IMMUNOLOGY AND CELL BIOLOGY (90 hrs.)

Part A - Immunology (72 hrs)

1. Introduction (4 hrs)

1.1. Humoral & Cell mediated response

1.2. Innate and adaptive immunity

1.3. Antigens, Antigenicity, immunogenicity and Haptens

1.4. Factors influencing immunogenicity

2. Immune Activation (6 hrs)

2.1. Haematopoiesis - major cells of the immune system

2.2. Activation and differentiation of B and T cells

2.3. Structure and signaling of BCR and TCR-CD3 complex

3. Antibodies (10 hrs)

3.1. Detailed structure of IgG antibody molecules

3.2. Generation of Antibody diversity -Variable region gene rearrangements – VDJ recombination

3.3. Hybridoma Technology and antibody engineering **(3)**

4. Antigen - Antibody Interactions (15 hrs)

4.1. Strength of Antigen Antibody Interactions

4.2. Cross reactivity, precipitation reactions, agglutination reactions

4.3. Immunotechniques - ELISA, RIA, Immunoblot, Immunoprecipitation **(5)**

5. Immune Effector Mechanisms (10 hrs)

5.1. Cytokines & Cytokines antagonists

5.2. Compliment system components, functions, activation & regulations

5.3. Toll –like receptors

5.4. Inflammation process

6. Major Histocompatibility Complex (9 hrs)

6.1. MHC genes & molecules General organization in mice and humans.

6.2. Cellular distribution and inheritance of MHC molecules **(3)**

6.3. Endogenous and Exogenous pathways for antigen processing, presentation **(3)**

7. Immune system in Health and Diseases (18 hrs)

7.1. Immune responses during bacterial (Tuberculosis) parasitic (malaria) and viral (HIV) infections. **(3)**

7.2. Hypersensitivity reactions- Gell and Coombs classification. **(3)**

7.3. Autoimmune diseases (organ specific and systemic)

7.4. Immunodeficiency diseases - Bruton's disease, Di-George syndrome, severe combined immunodeficiency.

7.5. Transplantation Immunology- Immunologic basis of graft rejection

7.6. Vaccines –Recombinant Vector, DNA vaccines, synthetic peptide vaccines and multivalent vaccines

Part B - Cell Biology (18 hrs)

8. Membrane structure and function (4 hrs)

8.1. Molecular organization of cell membrane - Lipid bilayer and membrane protein.

8.2. Mechanism of sorting and regulation of intracellular transport.

8.3. Electrical properties of membranes.

8.4. Microvilli and cell coat.

9. Cellular communication (4 hrs)

9.1. General principles of cell communication

9.2. Cell-cell interactions – cell adhesion and roles of different adhesion molecules

9.3. Intercellular attachments- gap junctions, desmosomes, intermediary and tight junctions.

9.4. Interaction of cells with extracellular matrix: Integrins. Focal adhesion and hemidesmosomes.

9.5. Interaction of cells with other cells: Selectins, Immunoglobulins, Cadherins, Adherins.

10. Cell signaling (6 hrs)

10.1. Signal transduction - Signaling through cell surface receptors: G protein linked receptors; signaling via cAMP, PKA, IP3, Ca2+/calmodulin, PKC, Ca-MK, Enzyme linked receptors, Receptor tyrosine kinase (RTK), signaling of growth factors, Tyrosine kinase associated receptors, Receptor protein tyrosine phosphatase (PTP), Receptor serine/threonine kinase, Receptor guanyl cyclase, cGMP, PKG, Histidine kinase associated receptors. Receptor desensitization.

11. Apoptosis and its significance (4 hrs)

11.2 Process of apoptosis: Initiation, Execution: cytochrome C, caspases, Phagocytosis

11.3 Regulation of apoptosis - Extracellular and Intracellular

11.5 Mechanism of cell death

11.6 Genes involved in apoptosis

References:

Immunology

1. Abbas A. K and A. H. Lichtman (2004). Basic immunology -Functions and Disorders of the immune system. (second edition, Elsevier Science, USA)
2. Abbas A. K and A. H. Lichtman (2003). Cellular and Molecular Immunity (5th ed., Elsevier Science, USA).
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Cell Biology

1. Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons. Inc. 6th Edition.
2. De Robertis E.D.P. and De Robertis E.M.F. (2006) Cell and Molecular Biology.

3. Cooper, G.M. and Hausman, R.E. (2013) The Cell: A Molecular Approach. Sinauer Associates, Inc.; 6th ed.
4. Tropp, B. E. (2008): Molecular Biology, Jones and Bartlet.
5. Berk, A., Chris A.K., Lodish, H. and A. Amon (2016) Molecular Cell Biology, 8th ed. WH Freeman, New York.

ZO3CT08 - DEVELOPMENTAL BIOLOGY & ENDOCRINOLOGY (90 hrs)

Part A - Developmental biology (54 hrs)

1. Introduction: Basic concepts of development (6 hrs)

1.1. Cell fate, potency, determination and differentiation.

1.2. Commitment

1.3. Specification - autonomous, conditional, syncytial

1.4. Genomic equivalence and cytoplasmic determinants

1.5. Morphogenetic gradients

1.6. Genomic Imprinting

1.7. The stem cell concept- Progenitor cells, Adult stem cells, Mesenchymal stem cells, Multipotent adult stem cells, Pluripotent Embryonic stem cells, Stem cell therapy.

2. Gametogenesis, fertilization and early development (10 hrs)

2.1. Production of gametes- Spermatogenesis and Oogenesis, Ultrastructure of gamates

2.2 Cell surface molecules in sperm-egg recognition in animals (sea urchin and mammals)

2.3 Zygote formation

2.3.1. Encounter of sperm and egg

2.3.2. Capacitation

2.3.3. Acrosome reaction

2.3.4. Activation of ovum

2.3.5 Amphimixis

2.3.6. Prevention of Polyspermy (Fast block and Slow block)

2.4. Cleavage and blastula formation

2.5 Gastrulation and formation of germ layers in amphibia

2.6 Embryonic fields

3. Embryogenesis and Organogenesis (10 hrs)

3.1 Axis formation in amphibians - The phenomenon of the Organizer- Nieuwkoop center, primary embryonic induction, mechanism of axis formation

3.2 Anterior posterior patterning in Amphibians - Hox code hypothesis

3.3 Anterior posterior patterning in *Drosophila* – anterior forming genes (bicoid, hunchback), posterior forming genes (nanos, caudal), terminal forming gene (torso), segmentation genes- gap genes, pair rule genes, segmentation polarity genes, homeotic selector genes, realist or genes.

3.4. Dorso-ventral patterning in *Drosophila*- dorsal protein gradient

3.5. Limb development in chick- Formation of the Limb Bud, Generating the Proximal-Distal Axis of the Limb, Specification of the Anterior-Posterior Limb Axis, Generation of the Dorsal-Ventral Axis

3.6. Insect wings and legs formation

3.7. Vulva formation in *Caenorhabditis elegans.*

3.8. Eye lens induction.

4. Cellular and Molecular basis of development (7 hrs)

4.1. Induction and competence- cascade of induction- reciprocal and sequential inductive events, instructive and permissive interactions.

4.2. Epithelial- mesenchymal interactions- paracrine factors-The Hedhog family, The Wnt family, Juxtacrine signaling and cell patterning, notch pathway.

4.3. Cellular interactions concerned in fertilization, blastulation, gastrulation and organogenesis.

4.5. Molecular basis of cellular differentiation – cadherins.

5. Genetic basis of development (8 hrs)

5.1. Differential gene transcription –Promoters and Enhancers, DNA methylation, Transcription factors, Silencers and Insulators.

5.2. Differential RNA processing- X chromosome inactivation- dosage compensation.

5.3. Control of gene expression at the level of translation-Differential mRNA longevity, selective inhibition of mRNA translation, Selective activation of mRNA translation, micro RNAs, Control of RNA expression by cytoplasmic localization.

5.4. Post translational regulation of gene expression.

5.5. Models of cell differentiation- hematopoiesis, myogenesis, differentiation of neural crest cells.

5.6. Reversibility of patterns of gene activity-cell fusion, trans differentiation.

6. Metamorphosis, Regeneration and Ageing (7 hrs)

6.1. Metamorphosis in Amphibians and Insects and their hormonal control

6.2. Types of regeneration - Super, Hetero, Epimorphic, Morphallactic and Compensatory regeneration, Histological process during regeneration

6.3. Ageing – The biology of senescence, cellular and extra cellular ageing, Genes and ageing, DNA repair enzymes, Ageing and the insulin signaling cascade, The mTOR pathway, Chromatin

modification, Wear and tear, Oxidative damage, Mitochondrial genome damage, genetically programmed ageing.

7. Environmental regulation of animal development (4 hrs)

7.1 Environmental regulation of normal development - types of polyphenism

7.2 Environmental disruptions of normal development (Teratogenesis) Teratogenic agents - Alcohol, retinoic acid, Bisphenol A(BPA), heavy metals, pathogen, Testicular Dysgenesis Syndrome, DES as an endocrine disruptor, Endocrine disruptors as obesogens

7.3. Environmental oestrogens.

7.4. Impact of pesticide on development.

8. Developmental Mechanisms of Evolutionary change (2 hrs)

Heterotopy, Heterochrony, Heterometry, Heterotypy. (Brief)

Part B - ENDOCRINOLOGY (36 hrs)

9. Endocrine glands and their Hormones (Brief account) (5 hrs)

9.1. Hormone secreting organs and tissues -skin, liver, kidney, heart.

9.2. General classes of chemical messengers- Peptide, thyroid, steroid hormones, neurotransmitters and pheromones

9.3. Synthesis and delivery of hormones- storage, secretion and transportation

9.4. Control of hormone secretion.

9.5. Physical characteristics of hormones - latency, post-secretary modification and half- life

9.6. Physiological roles of hormones.

10. General mechanisms of Hormonal action (5 hrs)

10.1. Hormone Receptors and transducers;

2.1.1. types of receptors- g protein coupled receptors, steroid receptors and nitric oxide receptors,

2.1.2. Regulation of receptor number, receptor activation

10.2. Second messengers of hormone action- cAMP, cGMP, inositol triphosphate, diacylglycerol,

10.3. Receptor signal transduction

10.4. Eicosanoids and hormone action

11. Anatomy of endocrine glands; structure, physiological functions, and control of secretion of their hormones and pathophysiology. (13 hrs)

11.1. Hypothalamus

11.2. Hypophysis

11.3. Thyroid

11.4. Parathyroid

11.5. Adrenal

11.6. Pancreas

12. Hormones and male reproductive physiology (7 hrs)

12.1. Synthesis, chemistry, and metabolism of androgens

12.2. Endocrine control of testicular function

12.3. Physiological roles of androgens and estrogens

12.4. Pathophysiology

13. Hormones and female reproductive physiology (3 hrs)

13.1. Synthesis, chemistry, and metabolism of Ovarian steroid hormones

13.2. Physiological roles of Ovarian steroid hormones

13.3. Hormonal regulation of female monthly rhythm

13.4. Hormonal factors in pregnancy, parturition and lactation

14. Neurohormones (3 hrs)

14.1. Gases as neural messengers

14.2. Endorphins- physiological roles, mechanism of action and pathophysiology

14.3. Brain hormones and behaviour

14.4. Neuroendocrine pathophysiology

References:

DEVELOPMENTAL BIOLOGY

1. Balinsky B. I. (1981) An introduction to Embryology. Holt Saunders, Philadelphia.
2. Berril N.J. and Karp G. (1978) Developmental biology. Tata McGraw Hill., New Delhi.
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12. Vasudeva Rao K. (1994) Developmental Biology-a modern synthesis. Oxford IBH, New Delhi.
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ENDOCRINOLOGY

1. Bentley, P. J.(1998). Comparative vertebrate endocrinology.3rd ed.Cambridge University Press
2. Bern, H. A. Text book of comparative endocrinology
3. Bolander, F. F.(2006). Molecular endocrinology, Academic press, New Delhi.
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6.Harris, G. W. (1995). Neural control of the pituitary gland, Edward Arnold, London.
7. Hazelwood, R. (1990). The endocrine pancreas, EnglewoodCliffs, Prentice Hall, NJ.
8. Horrbin, D. F. Essentials of Biochemistry, endocrinology and nutrition.
9. Prakash Lohr. Hormones and human health
10. Nelson R. J. Introduction to behavioural endocrinology
11. Norris D. O.(2005). Vertebrate endocrinology.
12. Vinzen, G. Et al, (1992). Adrenal cortical steroid hormones, EnglewoodCliffs, PrenticeHall, NJ.
13. Brown, J.H. and Wet, G.B.(2000).Scaling in Biology.Oxford University Press,New York.
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17.Guyton, A.C. and Hall, J. E. (2001). Text Book of Medical Physiology.10thed. Prism Books, Pvt. Ltd. Harcourt Asia Ltd.India ed.
18.Hadley, M.G. (2000). Endocrinology .3rd ed. Prentice Hall International Inc. New Jersey

ZO4CT09 - MICROBIOLOGY & BIOTECHNOLOGY (90 hours)

Part A - Microbiology (36 hrs)

1. Introduction (1 hr)

1.1 History and scope of microbiology

1.2 Contributions of Louis Pasteur, Robert Koch, Alexander Flemming and Edward Jenner.

2. Microbial Taxonomy and Phylogeny (3 hrs)

2.1. Major characteristics (classic and molecular)

2.2. Numerical taxonomy

2.3. Taxonomic ranks

2.4. Phylogenetic studies

2.5. Phenetic classification

2.6. Bergey's Manuel (mention major groups)

3. Bacterial cell structure and function (5 hrs)

3.2. Plasma membrane and internal system - Cytometrix, inclusions, ribosomes, nucleoid

3.3. Bacterial cell wall Peptidoglycan - structure-

3.4. Gram positive and gram negative cell wall- Mechanism of gram staining

3.5. Components external to cell wall; pili and fimbriae, capsule and slime layers, Flagella and motility

4. Microbial nutrition (4 hrs)

4.1. Nutritional requirements,

4.2. Nutritional types (Auto, Hetero, Chemo, Phototrophs & obligate parasites)

4.3. Culture media and types of media.

4.4. Mixed microbial population and pure cultures.

5. Microbial growth (4 hrs)

5.1. Growth curve -synchronous growth

5.2. Continuous culture

5.3. Influence of environmental factors on growth

5.4. Measurement of growth

5.5. Measurement of cell numbers- Petroff, Hassuer counting Chamber, spread plate and pour plate techniques

5.6. Measurement of cell mass-Turbidity and microbial mass measurement

6. Utilization of energy (3 hrs)

6.1. Biosynthetic process-peptidoglycan synthesis, amino acid synthesis,

6.2. Non synthetic processes -Bacterial motility and transport of nutrients. (biochemical reactions not required).

7. Viruses (3 hrs)

7.1. General structural properties

7.2. Types: DNA viruses, RNA viruses, and enveloped viruses

8. Microbial diseases (4 hrs)

8.1. Human diseases caused by bacteria- Typhoid, Cholera, Tetanus, Leprosy, Tuberculosis and Pneumonia.

8.2. Human diseases caused by viruses- AIDS, Rabies, Measles, Swine Flu, Bird flu, SARS

8.3. Fungal diseases- Candidiasis

9. Control of microorganisms (4 hrs)

9.1. Disinfectants; A - physical- Heat, filtration and radiation

B-Chemical agents - Phenol and Phenolic compounds, alcohols, halogens and aldehydes.

9.2. Antibiotics- Penicillin, Cephalosporins, Chloramphenicol, Tetracyclines

9.3. Microbial drug resistance.

10. Microbial fermentation (2 hrs)

10.1. Lactic acid fermentation - Homolactic and heterolactic fermenters, Mention dairy products - cheese and yogurt

10.2. Alcoholic fermentation.

11. Environmental microbiology (3 hrs)

11.1 Microbiological analysis of drinking water.

11.2. Microbial Bioremediation

11.3. Biogas plant.

Part B - Biotechnology (54 hrs)

12. Introduction (1 hr)

12.1. Definition, branches, scope and importance

13. Vectors (5 hrs)

13.1. Cloning vectors

13.1.1. Plasmids: pBR322 and pUC

13.1.2. Phages: λgt10 and M13 vector

13.1.3. Cosmids: general features

13.1.4. Phagemids: general features

13.1.5. Viruses: SV40 and CaMV

13.1.6. Transposones; Ac transposon and Ds transposon of Maize, P-element of *Drosophila*

13.1.7. Artificial chromosomes: BAC, YAC and MAC.

13.2. Shuttle vectors: applications and example

13.3. Expression vectors: mention commonly used promoters in expression vectors (Nopaline synthase (*nos*) promoter from T-DNA, 35 S RNA promoter of CaMV, Polyhedrin promoter from Baculovirus

14. Different steps involved in *in vivo* cloning (3hrs)

14.1. Construction of chimeric DNA (Blunt end ligation, cohesive end ligation, homopolymer tailing, use of linkers)

14.2. Selection of transformed cells –blue white selection method, colony hybridization, Plaque hybridization

14.3. Amplification - Multiplication, Expression, and integration of the DNA insert in host genome

15. Molecular probes (3 hrs)

15.1. Production

15.2. Labelling

15.3. Applications

15.4. FISH, McFISH and GISH

16. Genomic and cDNA library (4 hrs)

16.1. Construction

16.2. Screening –By DNA hybridization, Screening by immunological assay, and screening by protein activity. (Refer unit 4-Molecular Biotechnology by Glick and Pasternak-ASM press)

16.3. Blotting techniques- Southern blot, Northern blot, Western blot, Dot blot and Slot blot

16.4. Chromosome walking

17. Polymerase Chain Reaction (3 hrs)

17.1. Basic PCR - raw materials and steps involved

17.2. Inverse PCR, Anchored PCR, Asymmetric PCR, PCR for mutagenesis and Real Time PCR

17.3. Applications of PCR in Biotechnology and genetic engineering

18. Molecular markers: detection and applications (3 hrs)

18.1. RFLP

18.2. AFLP

18.3. RAPD

18.4. Minisatellites (VNTR)

18.5. Microsatellites (SSR)

18.6. SNPs

19. Isolation, sequencing and synthesis of genes (3 hrs)

19.1. Isolation (for specific proteins and tissue specific proteins)

19.2. DNA sequencing – Maxam and Gilbert‟s chemical degradation method, Sanger‟s dideoxynucleotide synthetic method

19.3. Synthesis of gene-Chemical synthesis of tRNA gene, Synthesis of gene from mRNA, Gene synthesis machines

20. Transfection methods and transgenic animals (3 hrs)

20.1. Definition, Methods - Electroporation, DNA micro injection, Calcium phosphate precipitation, Dextran mediated transfer, shot gun method, virus mediated lipofection method, engineered embryonic stem cell method

20.2. Transgenic animals for human welfare

21. Biotechnology - Animal and human health care (4 hrs)

21.1. Vaccines

21.2. Disease diagnosis

21.3. Gene therapy

21.4. Transplantation of bone marrow, artificial skin,

21.5. Antenatal diagnosis

21.6. DNA finger printing

21.7. Forensic medicine

22. *In vitro* fertilization (3 hrs)

22.1. *In vitro* fertilization and embryo transfer in human

22.2. *In vitro* fertilization and embryo transfer in live stock

23. Animal cell and tissue culture (3 hrs)

23.1. Culture media – natural and artificial

23.2. Culture methods – primary explantation techniques, various methods of cell and tissue culture

23.3. Tissue and organ culture

24. Gene Silencing techniques (2 hrs)

24.1. Antisence RNA

24.2. RNAi

24.3. Gene knockouts and Knock out mouse

25. Cloning (2 hrs)

25.1. Cloning procedures (adult DNA cloning, Therapeutic cloning, Embryo cloning)

25.2. Advantages and disadvantages of cloning

26. Environmental biotechnology (3 hrs)

26.1. Pollution control – cleaner technologies, toxic site reclamation, removal of oil spill, reducing of pesticides and fertilizers, biosensors, miomonitoring.

26.2. Restoration of degraded lands - reforestation using micro propagation, development of stress tolerant plants

27. Agricultural Biotechnology (3 hrs)

27.1. Biofertilizers

27.2. Insect pest control (Pheromones, hormone mimics & analogues)

27.3. Biopesticides (Baculovirus, *Bacillus thuringiensis*, NPV)

28. Intellectual property rights (3 hr)

28.1. Intellectual property protection,

28.2. Patents, copy right, trade secrets, trademarks

28.3. GATT and TRIPS, patenting of biological materials,

28.4. International co-operation, obligation with patent applications, implications of patenting-current issues

29. The ethical and social implications (3 hrs)

29.1. Ethics of Genetic engineering - Social impacts - Human safety-Virus resistant plants-Animals and ethics-

29.2. Release of GEOs-Use of herbicide resistant plants-Human genome alterations by biotechnology

29.3. Social acceptance of biotechnology-Transgenic crops - Social acceptance of medical biotechnology- Acceptance of GM crops for food and pharmaceutical production, Social acceptance of Industrial biotechnology.

References:

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SEMESTER 4

ELECTIVE COURSE - FISHERY SCIENCE - I

ZO3ET10 - TAXONOMY, BIOLOGY, PHYSIOLOGY & ECOLOGY (90 hrs)

1. Fish Taxonomy (10 hrs)

1.1. Fundamentals of fish taxonomy

1.2. Classification of fin fishes - mention the following families [referring to their orders] with common or economically important examples: Hemiscyllidae, Carcharhinidae, Sphyrnidae, Notopteridae, Anquillidae, Clupeidae Chanidae, Cyprinidae, Bagridae, Siluridae, Claridae, Heteropnuestidae, Ariidae, Salmonidae, Harpodontidae, Hemiramphidae, Belonidae, Aplocheilidae, Poecilidae, Syngnathidae, Platycephalidae, Ambassidae, Carangidae, Teraponidae, Leiognathidae, Gerreidae, Nandidae, Cichlidae, Mugilidae, Trichiuridae, Channidae, Cyanoglossidae and Tetraodontidae.

2. Integument (7 hrs)

2.1. Exoskeleton

2.2. Skin and scales

2.3. Colouration

2.4. Chromatophores and pigments

2.5. Structure, function and modification of fins

3. Locomotion (5 hrs)

3.1. Body shape and musculature

4. Life history of fishes (5 hrs)

4.1. Reproduction, reproductive hormones, reproductive behaviour, oviparity, ovoviviparity

4.2. Age and growth

4.3. Migration

5. Digestive physiology (8 hrs)

5.1. Food and feeding

5.2. Feeding behaviour

5.3. Feeding mechanism

5.4. Digestive enzymes

5.5. Absorption

6. Circulatory physiology (6 hrs)

6.1. Heart

6.2. Blood, blood cells, blood pigments and functions of blood

6.3. Circulation

7. Respiratory physiology (6 hrs)

7.1. Gills and Accessory respiratory organs

7.2. Gas transport

8. Excretory and Osmoregulatory physiology (6 hrs)

8.1. Excretory organs

8.2. Osmoregulation in marine, brackish water and fresh water fishes

9. Endocrine physiology (6 hrs)

9.1. Endocrine glands – structure and function

9.2. Regulation of endocrine secretion

9.3. Crustacean neurosecretory system and its role in reproduction

10. Adaptive physiology (6 hrs)

10.1. Deep sea fishes

10.2. Cave dwelling fishes

10.3. Hill stream fishes

11. Oceanography (15 hrs)

11.1. Ecological subdivisions of the sea

11.2. Major topographic features of continental shelf, continental slope and ocean floor

11.3. Physico-chemical properties of sea water

11.4. Ocean currents

11.5. Ocean productivity

11.6. Coral reefs

12. Brackish water ecology (5 hrs)

12.1. Characteristics of brackish and estuarine waters

12.2. Estuarine productivity

13. Limnology

13.1. Classification of inland waters – ponds, lakes, rivers and reservoirs.

13.2. Physico-chemical properties of inland waters

References:

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2. Cambell J. (1998) An introduction to marine sciences. John Wiley & Sons.
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4. Jayaram K.C. (1981) The freshwater fishes of India, Pakistan, Bangladesh, Burma and Srilank- A Handbook - ZSI.
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6. Jayaram K.C. (2002) Fundamentals of fish taxonomy, NPH, Delhi.
7. Jhingran V.G. (1975) Fish and fisheries of India. HPC, Delhi.
8. Kurian C.V. and Sebastian V.O. (1982). Prawns and prawn fisheries of Kerala. HPC, Delhi.
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ELECTIVE COURSE - FISHERY SCIENCE- II

ZO4ET11 - CAPTURE AND CULTURE FISHERIES (90 hrs)

Part A - CAPTURE FISHERIES

1. Marine fisheries - Crustacean, Molluscan and fin fishes (8 hrs)

1.1. Shrimps, Crabs and Lobsters

1.2. Mussels, Oysters and Cephalopods

1.3. Sardine, Mackerel, Bombay duck, Pomfrets, Ribbon fishes and Tuna

2. Freshwater fisheries (4 hrs)

2.1. Major river systems and fisheries

2.2. Lakes and reservoir fishery

3. Estuarine fisheries (3 hrs)

3.1. Major estuaries and fisheries

Part B - CULTURE FISHERIES

4. Aquaculture (5 hrs)

4.1. History, scope and importance, present state and future prospects of aquaculture

4.2. Classification of aquaculture practices – habitat based; temperature based. Extensive, semi-intensive and intensive practices

5. Design and construction of aqua farms and hatcheries (12 hrs)

5.1. Site selection for aqua farms and hatcheries, preliminary and detailed investigations

5.2. Pond design and layout - size and shape - basic units involved

5.3 Types of pond - barrage ponds, contour ponds, paddy ponds

5.4. Pond preparation

5.5. Design and construction of hatcheries

5.6. Aquaculture tanks

5.7. Raceways

5.8. Cage farms

5.9. Pens and enclosures

5.10. Ranching

6. Transportation and acclimatization (4 hrs)

6.1. Transportation – dry and wet

6.2. Receptacles for transportation

6.3. Methods adopted for acclimatisation

7. Nutrition and feeds (4 hrs)

7.1. Feeding habits and food utilization

7.2. Live feeds

7.3. Artificial feeds

8. Water quality management (4 hrs)

8.1. Water quality parameters

8.2. Techniques for monitoring

8.3. Management strategies

9. Fertilizers and chemicals in aquaculture (2 hrs)

10. Reproduction and genetic selection (10 hrs)

10.1. Reproductive cycles

10.2. Control of reproduction

10.3. Induced breeding

10.4. Use of hormone analogues

10.5. Cryo-preservation of gametes

10.6. Sex reversal

10.7. Genetic selection and hybridization

11. Control of weeds, pests and predators in aquaculture (2 hrs)

12. Aquaculture practices (20 hrs)

12.1. Integrated fish farming - paddy cum fish, duck cum fish and pig cum fish culture

12.2. Polyculture

12.3. Culture of shrimps and prawns

12.4. Culture of crabs

12.5. Culture of edible oysters, pearl oysters and mussels

12.6. Culture of sea weeds

12.7. Culture of fresh water fishes - Indian major carps and exotic carps

12.8. Culture of cold water fishes - Trout and Mahaseer

12.9. Culture of brackish water fishes - mullets, milk fish and *Etroplus*

13. Preparation and maintenance of aquarium (5 hrs)

13.1. Types of aquaria

13.2. Preparation and maintenance

13.3. Equipment

13.4. Water chemistry

13.5. Aquarium fishes and plants

14. Pathology (7 hrs)

14.1. Major diseases encountered in fish culture - viral, bacterial, protozoan and fungal

14.2. Control measures and treatment

References:

1. T. V. R. Pillay. (1993). Aquaculture – Principles and practices. Fishing News Books.
2. T. V. R. Pillay and Dill W. A. (1979). Advances in aquaculture fishing. Fishing News Books.
3. Lucky Z. (1997). Methods for the diagnosis of fish diseases. APC Pvt. Ltd., New Delhi.
4. Barg U. C. (1997). Guidelines for the promotion of environmental management in coastal aquaculture development, DPH, Delhi.
5. Biswas K.P. (1992). Prevention and control of fish and prawn diseases. NPH, Delhi.
6. Amalacher E. (2009). Text Book of fish Diseases. NPH, Delhi.
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8. Rick Parker. (2011). Aquaculture Science. Delmar-Thomson Learning/Cengage Learning.

ELECTIVE COURSE - FISHERY SCIENCE- III

ZO4ET 12 - HARVESTING, POST HARVESTING TECHNOLOGY AND MARKETING (90 hrs)

PART A – HARVESTING

1. Commercial fishing method (1 hr)

1.1. Brief history of commercial fishing

1.2. Introduction to materials for construction of nets and ropes

2. Crafts and gears for harvesting (21 hrs)

2.1. Towed or dragged gear

2.1.1. Bottom trawling

2.1.2. Beam trawl

2.1.3. Otter trawl

2.1.4. Side trawling

2.1.5. Stern trawling

2.1.6. Bottom pair trawling

2.1.7. Mid water (pelagic) trawling

2.1.8. Targeted and selective trawling

2.1.9. Turtle excluder device (TED)

2.1.10. Dredging

2.2. Encircling gear

2.2.1. Beach seining

2.2.2. Purse seining

2.2.3. Seine nesting

2.3. Static gear

2.3.1. Gill nets

2.3.2. Trap nets

2.3.3. Long lines

2.3.4. Pots and traps

2.4. Other gears

2.4.1. Squid jigging

2.4.2. Net fishing

2.4.3. Harpooning

2.5. Fish aggregating devices (FAD)

2.6. Echo-sounder and sonar

2.7. Catch per unit effort and economic consideration of vessel operations.

2.8 Onboard handling and processing

Part B - POST HARVEST TECHNOLOGY

3. Chemical composition of fish (2 hrs)

3.1. Chemical composition of fish muscle

3.2. Significance of proteins and lipids

3.3. Nutritive value of fish muscle over red meat

4. Post-mortem changes in fish muscle (4 hrs)

4.1. Pre-rigor mortis and post mortem changes

4.2. Physical and biochemical changes associated with the post mortem changes

4.3. Importance of post mortem changes in fish processing

4.4. Problems associated with post mortem changes and solutions

5. Fish spoilage mechanisms (4 hrs)

5.1. Microbial spoilage

5.2. Enzymatic spoilage

5.3. Biochemical spoilage

6. Handling of fresh fish (3 hrs)

6.1. Icing and icing methods

6.2. Different types of ice - block ice, flake ice and dry ice

6.3. Handling - on board chilling and use of refrigerated sea water (RSW)

6.4. Fish landing platforms

6.5. Hygienic handling of fish on board and on shore

7. Methods (Techniques) of processing/preservation and their products (10 hrs)

7.1. Drying

7.2. Salting

7.3. Smoking

7.4. Freezing - plate freezers, blast freezers and individual quick freezing (IQF)

7.5. Battered and breaded products

7.6. Accelerated freeze drying (AFD)

7.7. Immersion freezing and cryogenic freezing

7.8. Canning

7.9. Irradiation

7.10. Assessment of capacity of plate, blast and IQF freezers

8. Processing of shrimps (3 hrs)

8.1. Commercially important prawns and shrimps of India

8.2. Pre-processing of prawns and shrimps into different varieties - peeled and devined (PD), peeled and undevined (PUD), head-less shrimps (HI), head on shrimps (HON)

8.3. Grades of shrimps

8.4. Cooked shrimps

8.5. IQF shrimp

9. Processing of lobsters (3 hrs)

9.1. Commercially important lobsters of India

9.2. Pre and processing lobsters into different varieties of products

9.3. Grades of packing

10. Processing of cephalopods (3 hrs)

10.1. Commercially important cephalopods (squids and cuttlefish) of India

10.2. Pre-processing of cephalopods into different varieties

10.3. Grades of packing

11. Processing of fish (4 hrs)

11.1. Commercially important fishes of India

11.2. Fish filleting

11.3. Surimi

11.4. IWP products, grades for fish products

12. Fishery by-products (9 hrs)

12.1. Body oil, liver oil and sauces

12.2. Shark fins, fin rays, fish maws/isinglass

12.3. Fish silage, chitin and chitosan

12.4. Fermented fishery products

13. Fish processing plant and cold storage (2 hr)

13.1. The pre-processing and processing plant, cold storage – general conditions relating to premises, building, equipment, general conditions of hygienic of plant and workers, conditions of storage of frozen products

13.2. Requirements for registration with MPEDA, approval of processing plant by FIA allotment code

14. Quality control (7 hrs)

14.1. Fundamental aspects of quality

14.2. Major quality problems in sea foods

14.3. Quality of water and ice-chlorination and use of UV rays

14.4. Microbiology

14.5. Microbial hazards of sea foods - *E. coli*, *Salmonella*, *V. cholerae*, *Staphylococcus*

14.6. Inspection systems

14.7. Brief introduction to the quality control concepts of HACCP, ISO and TQM (total quality management)

15. Packing and export of seafood (4 hrs)

15.1. Methods of packing of various sea food products for export

15.2. Identification marks

15.3. In house stuffing and transport in refrigerated containers

16. Fishery education, research, development and export promotion agencies (3 hrs)

16.1. Objectives and activities of the following institutions (very brief) – CIFT, CMFRI, CIRNET, NIO, FSI, CIBA, FIA, MPEDA

16.2. Objectives of fishery extension

16.3. Qualities for fishery extension workers

16.4. Organizations of extension programs

Part C - FISHERY MANAGEMENT AND INTERNATIONAL MARKETING

17. Fishery management (2 hrs)

17.1. Marketing of fish in India

17.2. Fisherman and fisherman co-operatives

18. International marketing (4 hrs)

18.1. Scope and importance.

18.2. Major sea food products and markets of India.

18.3. Documents required for export - letter of credit, invoice, bill of landing etc.

18.4. Buyers and buyers agents

18.4.1. Trade promotion

18.4.2. Role of trade promotion offices and embassies

18.4.3. Seafood trade fairs

18.4.4. Trade promotion visits

18.4.5. Value added products and its marketing.

References:

1. Hall G. M. (1997) Fish processing technology. Blackie Academic & Professional.
2. Govindan T.K. (1985) Fish processing technology. Oxford & IBH., New Delhi.
3. Gopakumar K. (1997) Tropical Fishery products. Oxford & IBH., New Delhi.
4. Connel J.J. (1980) Control of fish quality. Fishing News Books.
5. Sathiadhas R. (1996) Production and marketing management of marine fisheries in India.
6. Srivastava, Dharma Reddy and Gupta. (1982) Management of marine fishing industry. Oxford & IBH.
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8. Ibrahim (1992) Fisheries Development in India. Classical Publishing Company, New Delhi.
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10. Saravanavel P. (1987) International Marketing. Himalaya Publishing House, Bombay.
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17. Bremner H. A. (2002) Safety and Quality Issues in Fish Processing. Woodhead Publishing Series in Food Science, Technology and Nutrition, 1st Edition.
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19. Les Bratt. (2010) Fish Canning Handbook. Wiley-Blackwell.
20. Balachnadran K.K. (2001) Post-Harvest Technology of Fish and Fihsery Prodcuts. Daya Publishing House, Delhi

PRACTICALS

SEMESTER 3

ZO4CP04 - IMMUNOLOGY AND CYTOGENETICS

1. Study of cells of immune system.
2. Histology of organs of immune system.
3. Bleeding of animals and preparation of serum.
4. Seperation of lymphocytes.
5. Demonstration of agglutination reaction.
6. Immuno Electrophoresis.
7. Demonstration of ELISA technique.
8. Production of antibodies.
9. Preparation of antiserum.
10. Titration of antiserum.
11. Study of normal human karyotype (male and female).
12. Study of genetic syndromes- Turner's, Klinefelter's, Down's, and Edward's.

References:

1. Talwar, G.P. and Gupta, S.K. (2002). A hand book of practical and clinical immunobiology. 2nd ed. CBS Publishers, India.
2. Wilson.K. and Walker,J. (1995). Practical Biochemistry- Principles and Techniques. Cambridge University Press.

ZO4CP04 - DEVELOPMENTAL BIOLOGY & ENDOCRINOLOGY

1. Induced ovulation in fish.
2. Identification of different developmental stages of frog - Egg, blastula, gastrula, neurula, tadpole external gill and internal gill stage.
3. Vital staining of chick embryo.
4. Preparation of temporary/permanent whole mounts of chick embryo of the following stages to study the extent of development of the circulatory and nervous system in detail in 20, 24, 33, 48 & 72 hours of incubation.
5. Tracing the development of stained parts. Candling, identification of blastoderm, window preparation - staining using stained agar strips and following the development.
6. Preparation of stained temporary/permanent mounts of larvae.
7. Experimental analysis of insect development - *Drosophila*.
8. Regeneration studies in frog tadpole tail.
9. Demonstration of sperm of rat/calotes/frog.
10. Morphological and histological studies of different types of placenta in mammals.
11. Hormones in Amphibian metamorphosis - Thyroxine/Iodine solution.
12. Culture of early chick embryo in vitro.
13. Study of invertebrate/vertebrate larval forms (minimum 7).
14. Observation of the mid-sagittal sections and cross sections of the chick embryo through head/ heart region of 24, 48 & 56 hours of incubation.

References:

1. Adamstone, E. B. and Waldo Shumway (1954). 3 Ed. A Laboratory Manual of Vertebrate Embryology. John Wiley & Sons, Inc.
2. Roberts Rugh (1961). Laboratory Manual of Vertebrate Embryology. Indian Ed., Allied Pacific Pvt. Ltd.
3. Browden, L. W., Erikson, C. A., and Jeffery, R. W. (1991). Developmental Biology. 3 Ed., Saunders College Publi., Philadelphia.
4. Zarrow, M. X., Yochim, J. M., Mc Carthy, T. L. and Sanborn, R. C. (1964). Experimental Endocrinology: A source book of basic Techniques. Academic Press, New York.
5. Thomas, J. A. (1996). Endocrine methods. Academic press, New York.
6. Humason, G. L. (1962). Animal Tissue techniques. W. H. Freeman & Co.

ZO4CP04 -BIOTECHNOLOGY

1. Isolation of genomic DNA
2. Separation of DNA by electrophoresis.
3. Bacterial transformation.

4. PCR

5. Cell immobilization.

ZO4CP04 – MICROBIOLOGY

1. Selective isolation and enumeration of bacteria.
2. Bacterial staining technique
    a. Simple staining of bacteria.
    b. Negative staining
    c. Hanging drop technique.
    d. Gram staining.
    e. Endospore staining.
3. Turbidity test for contamination of milk.
4. Preperation of media and sterilization.eg: Nutrient agar, MacConkey agar,
5. Cultivation of yeast and molds
6. Bacteriological analysis of water e.g., fecal pollutants.
7. Antibiotic sensitivity test.
8. Maintenance of *E.coli*.culture (shake and surface cultures) and quantitative evaluation (number of cells/ml) of a given sample of culture by dilution and plating.

ZO4CP04 - MICROTECHNIQUE AND HISTOCHEMISTRY

1. Preparation of stained and unstained whole –mounts.
2. Identification of the various tissues of animals in serial sections prepared using nuclear and cytoplasmic stains.
3. Processing a few types of tissues for the histochemical staining-Staining of serial sections to show the presence of
    a) Carbohydrates by PAS method
    b) Proteins by Mercuric bromophenol blue method
    c) Fats by Sudan Black B method
    d) DNA by Feulgen Technique.

Submission:

Stained/unstained Whole mounts	-	4numbers
Double stained serial histology slides	-	4 numbers
Histochemical slides	-	2 numbers

PRACTICALS

SEMESTER - 4

ELECTIVE COURSE - FISHERY SCIENCE - I

ZO4EP05 – TAXONOMY, BIOLOGY, PHYSIOLOGY & ECOLOGY

1. Identification of common and local fishes
2. Dissection of accessory respiratory organs
3. Dissection of urino-genital system
4. Dissection of arterial system
5. Mounting of internal ear
6. Study of different types of scales
7. Determination of haemoglobin content in fish blood
8. Determination of amylase, protease and lipase activities in different parts of alimentary canal of fish
9. Determination of rate of ammonia and urea excretion in fishes.
10. Age determination of fishes using scales and otolith.

FISHERY SCIENCE - II

ZO 4 EP 05 – CAPTURE AND CULTURE FISHERIES

1. Demonstration of induced breeding in fishes
2. Estimation of fecundity
3. Identification and study of ecto and endoparasites in fishes
4. Study of gut content analysis in fishes
5. Study and maintenance of fresh water aquarium
6. Determination of water and soil p^H
7. Studies of texture of soil
8. Test for H_2S
9. Test for alkalinity
10. Test for salinity
11. Determination of water transparency
12. Determination of Ammonia, Nitrogen, Phosphorous and free Calcium carbonate
13. Identification of culturable species of shrimps, prawns and fishes
14. Identification of larval stages of shrimps, prawns and fishes

FISHERY SCIENCE - III

ZO4EP06 - HARVESTING POST HARVESTING TECHNOLOGY AND MARKETING

1. Identification of fishing craft, gears and gear material from models, drawings and photographs
2. Study of processing of commercially important fin fishes and shell fishes.
3. Identification of different fishery byproducts
4. Identification of different mechanisms used in fish processing.
5. Staining of bacteria
6. Preparation of culture media
7. Study of bacterial culture
8. Laboratory technique to detect pathogenic bacteria of public health, significance of *E. coli*, *Salmonella*, and *Staphylococcus*
9. Preparation of scoring key to identify different stages of fish spoilage
10. Estimation of ash and water content of fish muscle
11. Estimation of total amino acid in fish muscle
12. Estimation of trimethyl amine
13. Extraction of liver and body oil
14. Study of canning and refrigeration

STUDY TOUR

A study tour not less than ten days duration (Need not be at a stretch) to fishery research institutes such as CIFT, CMFRI, CIFNET, IFP, etc., fish hatcheries, fish landing centers, boat building yards, aqua-farms etc. The field reports with dated signature of the teacher concerned and duly certified should be submitted at the time of examination.