MAR IVANIOS COLLEGE

THIRUVANANTHAPURAM

(Autonomous)

Affiliated to

UNIVERSITY OF KERALA

THIRUVANANTHAPURAM

KERALA

SYLLABUS FOR MASTER'S PROGRAMME IN ZOOLOGY

(With effect from 2021 admission)

Preamble

The Department of Zoology of Mar Ivanios College has decided to revise the syllabus of all P. G. Programmes with effect from the academic year 2021-22 as part of its continued efforts to provide the latest information to the students. Accordingly, the Board of studies in Zoology and other Faculty members held several meetings during the months of November, December 2019 and January 2021. After deliberations and incorporating the suggestions of external experts namely, Dr. G M Nair, Dr. A. A. Mohammed Hatha, Dr. T. R. Santhosh Kumar, Dr Sherly Williams and Dr. Susha Dayanandhan, the syllabus was revised. The existing syllabus was updated by the addition of relevant information contents, web resources and avoiding duplication with the existing UG Syllabus, as far as possible. The UGC-CSIR NET syllabus and syllabi of other reputed universities and colleges in India and abroad were also given due consideration. Furthermore, the decision of the University Grants Commission banning the use of animals for dissections was considered while designing the practical experiments.

The compiled draft syllabus was circulated among the participants and feedback incorporated, as recieved. The revised draft was circulated among the members and approval was obtained online by the P. G. Boad of Studies.

The Chairman and Members of the P. G. Board of Studies would like to place on record their gratitude to the entire faculty who took part in the discussion and contributed to the design of the syllabus, which will be effective from the academic year 2021-22. Comments and suggestions for improvement are welcome.

Dr. Leenamma Joseph
Chairman BoS in Zoology & Head,
Department of Zoology
Mar Ivanios College, Thiruvananthapuram

Thiruvananthapuram
10-05-2021

MEMBERS OF THE SYLLABUS REVISION COMMITTEE

1. Dr. Leenamma Joseph (Chairperson, BoS and Head, Dept of Zoology, Mar Ivanios College)
2. Dr. G. M Nair (Nominee of University of Kerala, Advisor, Kerala Biotechnology Commission, KSCSTE, Thiruvananthapuram)
3. Dr. T. R. Santhosh Kumar (External expert; Scientist G, Tumor Biology, Rajiv Gandhi Centre For Biotechnology, Thiruvananthapuram)
4. Dr. A. A. Mohammed Hatha (External expert; Professor, Department of Marine Biology, Microbiology, Biochemistry, Cochin University of Science and Technology)
5. Dr Sherly Williams (representative from allied areas; Associate professor, Department of Environmental studies, University of Kerala)
6. Dr. Susha Dayanandhan (Alumnus member; Associate Professor and Head (former), Department of Zoology, University College, Thiruvananthapuram)
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10. Dr. Susan Kurian (Assistant Professor, Dept of Zoology, Mar Ivanios College)
11. Ms. Lija L. Raju (Assistant Professor, Dept of Zoology, Mar Ivanios College)
12. Dr. Sneha Chandran B.K (Assistant Professor on contract, Dept of Zoology, Mar Ivanios College)

General Instructions

1. Study of local fauna is to be made compulsory and included as part of field visit, as applicable.
2. Web resources, CDs, appropriate software etc should be used as far as possible.
3. Active participation of students in the teaching-learning process should be encouraged in the form of student seminars.
4. The Project should be given importance. Name of the supervising teachers is to be included in the dissertation. The project should be valued by the examiners who conduct the viva voce.
5. The topics for project should be decided during the beginning to the 3rd semester and the student should present a brief review and proposed methodology towards the middle of the semester in an internal presentation in the Department, involving all students and teachers.
6. Students should be encouraged to write proposals for student research grant from funding agencies such as KSCSTE.
7. A final departmental level presentation (preferably Powerpoint) should be made at the end of the 4th semester, including all students and teachers.
8. A presentation before the external examiners during the viva voce which will be the basis of awarding marks.
9. 25 marks is allotted for viva voce and 75 for the project report as per guidelines.

Table I: Scheme of question paper – Theory Courses: ESE

Type of Questions	Question No.	No. of questions to be answered	Marks
I. Short Answer	1 - 15	10	10 x 2 = 20
II. Short Essay	16 - 23	5	5 x 5 = 25
III. Long Essay	24 - 27	2	2 x 15 = 30
		Total	**75**

Table II: Components and weightage for CE of theory course

Sl.No.	Component	Marks
1.	Attendance	5
2.	Average of Class tests	10
3.	Seminar	5
4.	1 Assignment and viva voce	5
	Total	25

Table III: Components and weightage for CE of Practical course

Sl.No.	Component	Marks
1.	Attendance	5
2.	Average of Class tests	10
3.	Performance	5
4.	Record (punctuality)	5
	Total	25

Table IV: Grading of attendance

Attendance	Mark
Above 90%	5
86 to 90%	4
81 to 85 %	3
76 to 80%	2
75%	1

A student with attendance below 75% cannot appear for the ESE**.**

M.Sc. Zoology
Course Structure & Mark Distribution

Semester	Paper Code	Title	Distribution of hours / semester	Instructional hours/week L	P	Duration of ESA (Hrs)	Maximum Marks CA	ESA	Total
1	**APZO 121**	Biochemistry	100	5	-	3	25	75	100
	APZO 122	Genetics and Quantitative Analysis	100	5	-	3	25	75	100
	APZO 123	Biophysics, Instrumentatio Analytical techniques and Bioinformatics	100	5	-	3	25	75	100
	APZO 2P 1	Practical I	120	-	10	4	25	75	100
	Total for S 1		**450***	**15**	**10**	**-**	**100**	**300**	**400**
2	**APZO 221**	Advanced Physiology and Functional Anatomy	100	5	-	3	25	75	100
	APZO 222	Systematics, Evolutionary Biology and Research Methodology	100	5	-	3	25	75	100
	APZO 223	Cell and Molecular Biology	100	5	-	3	25	75	100
	APZO 2P II	Practical II	120	-	10	4	25	75	100
	Total for S 2		**450***	**15**	**10**	**-**	**100**	**300**	**400**
3	**APZO 321**	Microbiology and Biotechnology	100	5	-	3	25	75	100
	APZO 322	Ecology and Ethology	100	5	-	3	25	75	100
	APZO 323	Immunology and Developr Biology	100	5	-	3	25	75	100
	APZO 4P III	Practical III	120	-	10	4	25	75	100
	Total for S 3		**450***	**15**	**10**	**-**	**100**	**300**	**400**
4	**APZO 421**	Special Paper 1: Pollution Biology and Environmenta Physiology	100	8	-	3	25	75	100
	APZO 422	Special Paper 2: Environm Management	100	7	-	3	25	75	100
	APZO 4P IV	Special Paper Practical 1	100	-	5	4	25	75	100
	APZO 4P V	Special Paper Practical 2	120	-	5	4	25	75	100
	Total for S 4		**450***	**15**	**10**	**-**	**100**	**300**	**400**
		Project Project *Viva Voce* Comprehensive *Viva Voce*	-	-	-	-	 -	75 25 100	100 100
Grand Total			**-**	**-**	**-**	**-**	**400**	**1400**	**1800**

L – Lecture, P – Practical; T – Tutorial; CA Continuous Assessment; ESA – End Semester Assessment; * Tutorial 30 hours per week

PROGRAMME OUTCOMES (PO) – POST GRADUATE PROGRAMME

At the completion of the Post Graduate Programme, the student will be able to accomplish the following programme outcomes:

PO No.	Programme Outcomes
PO.1	Develop in-depth knowledge in the core subject and related branches which help in interdisciplinary learning and research.
PO.2	Develop scientific excellence and skill to apply the knowledge to design experiments, analyze and interpret data to reach an effective conclusion.
PO.3	Develop logical thinking and analytical and integrative problem-solving ability.
PO.4	Achieve competency for national and state level competitive exams (eg. CSIR-NET, SET) and to write research proposal for grants.
PO.5	Develop innovative ideas to initiate unique start-ups in the realm of life science.
PO.6	Recognize the need and develop the ability for life long and independent learning.

PROGRAMME SPECIFIC OUTCOMES (PSO) – POST GRADUATE PROGRAMME IN ZOOLOGY

At the completion of the Post Graduate Programme in Zoology, the student will be able to accomplish the following programme specific outcomes:

PSO No.	Programme Specific Outcomes
PSO.1	Obtain in-depth knowledge on different branches of Zoology and thereby develop inquisitiveness to explore advanced courses of learning and research.
PSO.2	Achieve employability in careers related to teaching and research that require postgraduation in Zoology.
PSO.3	Develop the ability to identify local fauna in relation to their environment and the need for conservation of the environment.
PSO.4	Acquire knowledge and skill to handle analytical equipments which will be useful for further research.
PSO.5	Develop innovative ideas to initiate unique start-ups in the realm of life science.

SEMESTER - I

APZO 121: BIOCHEMISTRY
(100 Hours)

CO No.	**Expected course outcomes** *Upon completion of this course, the students will be able to:*
1	Describe the unique properties and biological importanceof water.
2	Explain about pH and acid base balance and biological importanceof body buffers.
3	Describe the structure, classification and nomenclature of macromolecules such as carbohydrates, proteins and lipids.
4	Narrate the metabolism and biological importance of macromolecules such as carbohydrates, proteins and lipids.
5	Explain the structure and replication of nucleic acids.
6	Explain the details of enzymes, Mechanism of enzyme action, Enzyme kinetics and Enzyme regulation.
7	Describe the structure and fate of energy rich compounds and their biological significance.
8	Describe about free radicals and antioxidants, damage produced by free radicals and Free radical scavenger systems.
9	Explain the biochemistry of aging and the diseases associated with aging.

MODULE	COURSE DESCRIPTION	Hrs	CO No.
1	**Introduction**	**6**	**1,2**
1.1	Atoms, molecules. Inter and intramolecular interactions (bonds and forces): types of interactions – covalent, ionic, hydrogenbonds and van der Vaal's forces (London dispersion forces and dipole – dipole attraction)	2	1
1.2	Water: molecular structure, unique physical and chemical (solvent properties and ionic dissociation) properties of biological importance.	2	1
1.3	Acid - base balance: Hydrogen ion (pH) concentration; importance; Henderson-Hasselbalch equation and its application. Buffers: types, buffering action and biological significance.	2	2
2	**Carbohydrates: structure, function and classification**	**8**	**3**
2.1	Classification: Monosaccharides, Oligosaccharides, Polysaccharides & Glycoconjugates. Examples: a) Monosaccharides: glucose, fructose, galactose, mannose and ribose. b) Oligosaccharides: sucrose, lactose, maltose.	2	3

	c) Polysaccharides: i) *Homopolysaccharides* - starch, glycogen, cellulose, chitin. ii) *Heteropolysaccharides* - hyaluronic acid, heparin and agar-agar.		
2.2	Nomenclature of & biological importance of carbohydrates	2	3
2.3	Isomerism: structural isomerism and stereoisomerism, optical isomerism, epimerism and anomerism.	2	3
2.4	Reactions of monosaccharides: glycosidic bond; oxidation, reduction, ester formation, osazone formation.	2	3
3	**Carbohydrate Metabolism**	**16**	**4**
3.1	Major pathways of glucose utilization: Glycolysis, Pentose Phosphate Pathway (PPP), Glycogenesis.	4	4
3.2	Fate of pyruvate: a) Fermentation: lactic acid fermentation and ethanol fermentation; and b) Citric acid cycle.	4	4
3.3	Feeder pathways for glycolysis: Glycogenolysis, Gluconeogenesis and Cori cycle.	3	4
3.4	Hormonal regulation of carbohydrate metabolism.	2	4
3.5	Disorders of carbohydrate metabolism: Inborn errors associated with carbohydrate metabolism: glycogen storage diseases, lactose intolerance, galactosemia, galactosuria, diabetes, Hunter syndrome & mucopolysaccharidosis. OGTT (oral glucose tolerance test).	3	4
4	**Protein: structure, function and classification**	**10**	**3**
4.1	Aminoacids: Structure and classification. Properties of amino acids: pK value and iso-electric point. Reactions of amino acids: (due to - carboxyl group, amino group and side chains); Peptide bonds and peptide formation.	3	3
4.2	Proteins: Levels of structural organisation: a) Primary structure (e.g. insulin); b) Secondary structure: Alpha helix, Beta pleated sheet, Ramachandran angles and Ramachandran plot. c) Tertiary structure (e.g. Myoglobin) d) Quaternary structure (e.g. Haemoglobin)	3	3
4.3	Globular proteins (e.g. Myoglobin, Haemoglobin: biological importance) and Fibrous proteins (e.g. Keratin and Collagen: biological importance).	2	3
4.5	Chaperons: Definition, properties, kinds, important families, Mechanism of action.	2	3
5	**Metabolism of Proteins**	**4**	**4**
5.2	Catabolism of amino acids: deamination, transamination and trans-deamination, decarboxylation; catabolism of glucogenic and ketogenic aminoacids.	3	4

5.3	Urea cycle: Formation and disposal of ammonia.	1	
6	**Nucleic Acids**	**5**	5
6.1	Structure of nucleotides and nucleic acids: Structural organization of DNA (Watson –Crick model). Bonds and forces found in nucleic acids. (*self study*)		5
6.2	Types of DNA: A, B, C, Z, triplex and tetraplex DNAs: Types of RNA: mRNA, tRNA, rRNA and snRNA.	1	5
6.3	Biological roles of nucleotides and nucleic acids.	1	5
6.4	Catabolism of purines and pyrimidines.	3	5
7	**Lipids: structure, function and classification**	**9**	**3**
7.1	Classification of lipids: Simple, compound and derived lipids. Biological importance of lipids. *(self study)*		3
7.2	Simple fats: Triacylglycerol (Triglycerides) - chemical structure; Fatty acids: classification and nomenclature.	2	3
7.3	Physical properties and chemical reactions: oxidation, hydrolysis, saponification, rancidification. Acid number, saponification number, iodine number *Reichert-Meissl*-Wollny value *(Definition and brief account).*	2	3
7.4	Compound lipids: Phospholipids - Lecithin, Phosphatidyl inositol, Cephalins, Plasmologens. Glycolipids, Sphingolipids *(Brief account)*	2	3
7.5	Lipoproteins.	1	3
7.6	Steroids: Biologically important steroids - cholesterol, vitamin D, bile acids and ergosterol. *(Brief account)*	2	3
8	**Metabolism of Lipids**	**13**	**4**
8.1	Fatty acid metabolism: Beta oxidation, alpha oxidation and omega oxidation of fatty acids.	3	4
8.2	Biosynthesis of fatty acids	2	4
8.3	Cholesterol: biosynthesis and regulation.	2	4
8.4	Prostaglandins: structure, types and functions.	2	4
8.5	Ketone bodies: formation, ketosis and keto acidosis.	2	4
8.6	Role of liver in lipid metabolism	2	4
9	**Enzymes**	**18**	**6**
9.1	Classification (I.U.B. system) and nomenclature of enzymes.	1	6
9.2	Enzyme kinetics: Energy of activation; Steady state enzyme kinetics: Michaelis-Menten equation. *Km* value and its significance.	4	6
9.3	Mechanism of action of enzymes: Enzyme specificity - active site; formation of enzyme substrate complex - covalent catalysis, acid-base catalysis, metal ion catalysis, and catalysis by approximation and orientation. Lock and key model & Induced fit model *(self study)*	5	6
9.5	Control of enzyme activity:	5	6

	a) Enzyme inhibition: Reversible inhibition - competitive, uncompetitive and mixed types. Irreversible inhibition: non-competitive and suicide inhibitions. b) Enzyme regulation: allosteric regulation, covalent modification, feedback or end product inhibition, compartmentalization, effect of regulatory molecules and cofactors.		
9.6	Co-enzymes, cofactors, iso-enzymes, ribozymes and abzymes.	3	6
10	**Energy metabolism**	**4**	**7**
10.1	High energy bonds and energy rich compounds in muscle - ATP, ADP and PC.	1	7
10.2	Biological oxidation: mitochondrial electron transport chain, oxidative phosphorylation, ATP synthesis, chemiosmotic theory.	3	7
11	**Free radicals and antioxidants**	**4**	**8**
11.1	Free radicals: generation of free radicals. reactive oxygen species (ROS). Damage produced by free radicals. Oxidative stress.	2	8
11.2	Antioxidants and Free radical scavengers: preventive antioxidants and chain breaking antioxidants; ROS Scavengers.	2	8
12	**Biochemistry of aging**	**3**	**9**
12.1	Theories of aging: a) Programmed theories of ageing: programmed longevity theory, endocrine theory, immunological Theory; and b) Damage or Error theories: Wear and tear theory, Rate of living Theory, Cross linking Theory, Free Radicals theory, and Somatic DNA damage theory.	2	9
12.2	Diseases associated with aging: e.g. Alzheimer's disease, Age-related macular degeneration, and Benign prostatic hyperplasia (BPH)	1	9

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APZO 122 :GENETICS AND QUANTITATIVE ANALYSIS
(Total 100 Hrs)

CO No.	Expected course outcomes *Upon completion of this course, the students will be able to:*
1	Explain the basic principles of inheritance
2	Explain non-Mendelian pattern of inheritance and the complexity of inheritance among living organism.
3	Explain the effect of linkage and recombination on gamete genotypes
4	Explain the underlying mechanism by which an individual develops into a female or a male and understand the phenomenon by which the levels of expression of many genes on the sex chromosomes are regulated.
5	Understand and describe genetic, physical maps (genes and their location on a chromosome) and describe various methods involved in genomic mapping.
6	Explain the mechanism of genetic changes by transposable elements and chromosomal variations.
7	Understand the genetic structure of a population and aware of the changes that can be produced in course of time. Explain the genetic and environmental processes leads to changes in equilibrium.
8	Explain the genetic architecture underlying naturally variable phenotypes and the impact of this in breeding.
9	Predict the mode of inheritance of various genetic diseases by analyzing the pedigree chart. Explain the clinical significance of various genetic disorders.
10	Explain the clinical relevance of various genetic approach for treatments/management.
11	Create basic idea about the statistical approaches in biology.
12	Use statistical theory in biological data analysis.
13	Identify appropriate tests to perform hypothesis testing, and interpret the outputs adequately.

MODULE	COURSE DESCRIPTION	Hrs	CO No.
	GENETICS	**80**	
1	**Introduction to Genetics**		
1.1	Review of Mendelian genetics: Alleles, Pseudo-alleles, Dominance, Independent assortment (self-study)		1
2	**Extensions and modifications of Mendelian genetics**	**25**	
2.1	Co- dominance, Incomplete dominance, Gene interactions with Epistasis, Complementation, Sex influenced and Sex-limited traits, Genetic maternal	5	2

	effect, Genomic Imprinting- Angelmann and Parder-Willi syndrome (Self-study: Environmental effects on gene expression, Expressivity, Penetrance, Phenocopy, Pleiotropy,Cytoplasmic inheritance)		
2.2	Linkage, recombination and crossing over - Linkage: complete and incomplete linkage, linkage analysis and genetic maps, Linkage and recombination of gene, Evidence for the physical basis of crossing over, Mechanism of crossing over, Holiday model.	5	3
2.3	Genetic analysis: Sex determination: Chromosomal, Genic and environmental sex determination, Sex determination and Dosage compensation in Mammals and Drosophila.	5	4
2.4	**(Prerequisite**): Methods of gene transfer in bacteria - Transformation, conjugation, transduction and F-duction) Gene mapping methods: Linkage maps, mapping with molecular markers, Gene mapping by two point and three-point test cross, Recombination frequency and map distance, Tetrad analysis in fungi, Cytogenetic mapping in drosophila, mapping by somatic cell hybrids, Lod score for linkage testing, Mapping genes using conjugation data.	10	5
3	**Chromosome variation and transposable elements**	**8**	
3.1	Chromosome morphology, types of chromosome mutations – duplications, deletions, inversions, translocations, aneuploidy (Brief account only)	2	6
3.2	Transposable elements: General characteristics, Transposable elements in bacteria and eukaryotes, retrotransposons, Transposable elements in humans, Genetic and evolutionary significance of transposable elements.	6	6
4	**Population Genetics**	**10**	
4.1	Basic concepts of population genetics: Genetic variations, Allele frequencies, Relating genotype frequencies to allele frequencies, Hardy-Weinberg equilibrium and its applications, Effect of inbreeding on Hardy Weinberg equilibrium	4	7
4.2	Genetic Forces driving Evolutionary changes: Mutation, Genetic Drift, Migration, Selection, Meiotic drive.	4	7
4.3	Molecular population genetics - DNA Polymorphisms	2	7
5	**Quantitative Genetics**	**7**	
5.1	Multi locus control; QTL analysis; Quantitative inheritance in plants and human, QTL Mapping.	3	8

5.2	Heritability, Types of heritability – Broad sense and Narrow sense heritability, Calculating heritability.	3	8
5.3	Genetically variable traits-change in response to natural selection	1	8
6	**Human Genetics**	**15**	
6.1	Pedigrees- gathering family history; Pedigree symbols; Construction of pedigrees (Self study); Presentation of molecular genetic data in pedigrees	4	9
6.2	Pedigree analysis of monogenic traits: Autosomal inheritance-dominant, recessive; Sex-linked inheritance- X-linked recessive, dominant; Y–linked, Mitochondrial inheritance; MIM number.	3	9
6.3	Molecular basis of genetic disease: Common single gene disorders.	3	9
6.4	Haematological disorders — Thalassemia, Hemophilia, Sickle cell disease (Causes, Inheritance and Clinical significance).	2	9
6.5	Neurological disorders—Huntington disease, Fragile X syndrome (Causes, Inheritance and Clinical significance). Neuromuscular disorders — Duchenne muscular dystrophy, Myotonic dystrophy (MD) (Causes, Inheritance and Clinical significance).	2	9
6.6	Biochemical basis of Genetic diseases; Inborn errors of metabolism (Galactosemia)—Disorders of immune system (Type 1 Diabetes) Brief account only.	1	9
7	**Applied Genetics**	**15**	
7.1	Pharmaco-genomics: Introduction, P-Glycoprotein, Drug transporters, Lipid lowering drugs (Brief account only)	3	10
7.3	Cancer pharmacogenomics: Biomarker discovery and development, Chemotherapeutic agents for cancer treatment.	3	10
7.4	Personalised medicine -Future and Scope.	2	10
7.5	Ethical issues and genetic services-Genetic counselling and methods of prenatal testing.	1	10
7.8	Gene therapy, Marker assisted breading, RNA interference, CRISPR Cas 9 mediated gene editing, Gene drive, Targeted Epigenetic Modifications, Artificial and synthetic chromosomes.	6	10
	QUANTITATIVE ANALYSIS	**20**	
8	**Introduction**	**2**	
8.1	Definition, history, scope of biostatistics and applications of statistics in biology (self study)		11
8.2	Descriptive and inferential statistics, Preliminary concepts - population and sample, statistic and parameter, variables, sampling, Collection of data-primary and secondary data, methods; use of software in statistics.	1	11

8.3	Statistical analysis tools – Parametric and Non-parametric, Bivariate and multivariate analysis	1	11
9	**Descriptive Statistics**	**4**	
9.1	Processing and classification of data, presentation of data-tabulation and graphical and diagrammatic representation (self study**)**		11
9.2	Measures of Central Tendency, problems	1	12
9.3	Measures of Dispersion : Introduction, Characteristics – Quartiles, Percentiles, Range, Quartile deviation, Mean deviation and standard deviation (Calculations/ Problems for frequency table)	2	12
9.4	Skewness and Kurtosis (Brief account only)	1	12
10	**Correlation and Regression**	**4**	
10.1	Correlation - Types and methods of correlation analysis, Karl Pearson's correlation co-efficient and Spearman's rank correlation	2	12
10.2	Regression – Regression and Line of Best Fit, Types and methods of regression analysis. Comparing correlation and regression	2	12
11	**Probability distribution**	**3**	
11.1	Definition, important terms and concepts	1	12
11.2	Theorems in probability	1	12
11.3	Important theoretical distributions- Binomial, Poisson, and Normal probability distributions.	1	12
12	**Parametric test**	**3**	
12.1	Basic idea - hypothesis testing, types of errors	1	13
12.2	Tests of significance for large and small samples- Z-test, Chi- Square Test, Student's't' test, F-test - problems -and ANOVA	2	13
13	**Non-parametric tests**	**2**	
13.1	Characteristics, advantages and disadvantages	1	13
13.2	Types (Brief account only)	1	13
14	**Vital statistics**	**2**	
14.1	Introduction, uses, methods of collection	1	12
14.2	Measures of Vital Statistics, life tables	1	12

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APZO 123 : BIOPHYSICS, INSTRUMENTATION, ANALYTICAL TECHNIQUES AND BIOINFORMATICS
(Total 100 Hrs)

CO No.	Expected Course Outcomes *Upon completion of this course, the students will be able to*:
1	Explain the concept of bio energetics and the basic principles of energy transformations in living systems.
2	Explain the biological effects and applications of ionising and non-ionising radiations.
3	Describe the basic principles of radioactivity, its measurement and biological and medical applications.
4	Explain the applications of nanobiotechnology in biology and medicine.
5	Explain the principle, working and applications of different instruments used in biological studies.
6	Explain the principle and applications of different bioanalytical techniques.
7	Describe the histological techniques for light as well as electron microscopy.
8	Describe about the various biological databases and bioinformatics tools for sequence alignment, data retrieval and phylogenetic tree construction.
9	Explain the concept of structural and functional bioinformatics.

MODULE	COURSE DESCRIPTION	Hrs	CO No.
	BIOPHYSICS	**30**	
1.0	**Bioenergetics**	**8**	
1.1	Thermodynamics- Laws of thermodynamics, Entropy, Enthalpy, Free energy. Systems – open, closed and isolated.	2	1
1.2	Photo bioenergetics: Photosynthesis – light and dark reactions, Redox couple and redox potential	3	1
1.3	Chemo-bioenergetics: electron transport and oxidative phosphorylation, Chemiosmotic theory and binding change mechanism of ATP synthesis.	3	1
2.0	**Electromagnetic spectrum and Radiation Biophysics**	**17**	
2.1	Regions of electromagnetic spectrum: Gamma radiation, X Rays, UV radiation, visible spectrum, Infrared rays, microwaves and radio waves – biological effects and applications. Ionizing and non-ionizing radiations. Cosmic radiation.	5	2
2.2	Radioactivity: units of radioactivity, exposure and dose. Dosimetry: Ionization chamber, GM counter, Solid and liquid scintillation counters, Autoradiography.	4	3
2.3	Radio-labelling and its applications in biology. Incorporation of radioisotopes in biological tissues and cells. Molecular imaging of radioactive material and safety guide lines	4	3
2.4	Nuclear medicine: Internally administered radioisotopes. Radioiodine in thyroid function analysis. Renal, liver and	4	3

	lung function analysis using radioisotopes.		
3	**Nanobiotechnology**	**5**	
3.1	Introduction to Nanobiotechnology – concepts and terminologies.	1	4
3.2	Nanomedicine: Nanobiotechnology in drug delivery and targeting. Nanotoxicology.	3	4
3.3	Nanobiosensors.	1	4
	INSTRUMENTATION AND ANALYTICAL TECHNIQUES	**55**	
4	**Microscopy**	**12**	
4.1	***Prerequisite***: Principles of microscopy. Bright field, Dark field and phase contrast microscopy. Inverted microscope.		5
4.2	Working principle of optical, electron and scanning probe microscopes.	1	5
4.3	Fluorescence microscope (mention the dyes used), laser scan confocal microscope.	3	5
4.4	Electron microscope- SEM, TEM and Environmental scanning electron microscope (ESEM).	5	5
4.5	Scanning Tunnelling Microscope (STM), Atomic Force Microscope (AFM)	3	5
5	**Centrifugation**	**4**	
5.1	Principle of centrifugation. Basic components and types of centrifuges. Different types of rotors.	2	5
5.2	Ultracentrifugation - analytical and preparative. Differential and density gradient centrifugation.	2	5
6	**Electrophoresis**	**10**	
6.1	Principle of electrophoresis. Native PAGE and SDS-PAGE. Agarose gel electrophoresis. (mention Disc-electrophoresis). Gel documentation.	3	5
6.2	Capillary electrophoresis, Two dimensional electrophoresis. High voltage electrophoresis.	2	5
6.3	Immunoelectrophoresis. Isoelectric focusing. Radioimmunoassay, Fluorescent immunoassay, ELISA.	5	5,6
7	**Chromatography**	**8**	
7.1	Principle and types of chromatography.	1	5
7.2	Thin layer chromatography, HPTLC.	2	5
7.3	Column chromatography, gel permeation chromatography and ion exchange chromatography.	3	5
7.4	Gas chromatography, High performance liquid chromatography (HPLC)	2	5
8	**Analytical techniques**	**12**	
	Self study: Spectrophotometry: Principle and applications of colorimetry and spectrophotometry.		
	Spectroscopy: IR spectroscopy, Fluorescent spectroscopy, Flame emission spectroscopy, Atomic absorption spectroscopy, Nuclear Magnetic- resonance spectroscopy	12	6

	(NMR), ESR spectroscopy, Mass spectroscopy. Mention GC-MS, LC-MS and MALDI-TOF MS. Surface plasmon resonance.		
9	**Histological Techniques**	**5**	
9.1	Techniques for preparation of temporary and permanent slides, whole mounts, smears, squashes and sections. Specimen preparation for TEM, SEM. Shadow casting, freeze fracturing, freeze etching, negative staining.	3	7
9.2	Histochemical techniques for detection of proteins, lipids and carbohydrates.	2	7
10	**Electrophysiological techniques**	**4**	
10.1	Single neuron recording, Patch clamp recording. Electroencephalography, Electrocardiography, Electromyography. Brain machine interface.	4	5
	BIOINFORMATICS	**15**	
	Prerequisite**:** Basic organisation of a computer. Hardware and software: Hardware-input/output devises, processor, storage devices. Software: System software & application software. Concept of free software. Internet and email. Cyber security, software piracy.		
11	**Introduction to bioinformatics**	**2**	
11.1	Introduction to bioinformatics, brief history, goal, scope, applications and limitations of Bioinformatics.	2	8
12	**Databases**	**4**	
12.1	Biological databases - primary, secondary and specialized data bases- NCBI, DDBJ, PDB, UniProt, OMIM; pitfalls of biological data bases.	2	8
12.2	Information retrieval from biological data bases – SRS, Entrez, DBGET. Database sequence submission – BankIt.	2	8
13	**Sequence alignment**	**3**	
13.1	Sequence allignment - Pairwise sequence allignment, evolutionary basis of sequence allignment, methods of sequence allignment, dot matrix method, dynamic programming method, scoring matrices - Palm and BLOSUM; Multiple sequence alignment.	3	8
14	**Phylogenetic trees**	**3**	
14.1	Phylogenetic tree construction methods-1. Distance matrix methods-UPGMA, Neighbor joining method 2. Character based methods- Parsimony,Maximum Likelihood method. Construction of rooted and un-rooted phylogenetic trees, their interpretation and use in analyzing evolutionary trends, steps in phylogenetic analyses.	3	8
15	**Structural and functional bioinformatics**	**3**	
15.1	Structural genomics, functional genomics, comparative genomics.	1	9
15.2	Systems Biology: Introduction, metabolomics. Kegg pathways. Synthetic biology.	2	9

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SEMESTER – II

APZO221: ADVANCED PHYSIOLOGY AND FUNCTIONAL ANATOMY
(100 Hours)

CO No.	Expected course outcomes *Upon completion of this course, the students will be able to:*
1	Describe the supporting system, its movement and clinical implications of muscular system.
2	Explain the different types of nutrition, gastro-intestinal enzymes and hormones and causes, symptoms and complications of abnormal conditions of gastro-intestine.
3	Describes the circulatory system, conducting system of heart and the cardiovascular disorders.
4	Explain the respiratory system and the mechanism and regulations of respiratory system and identify the respiratory disturbance.
5	Describe the mechanism and regulation of excretory system and identify the different disorders related with kidney
6	Explain the nervous system and its mechanism of impulse transmission and Identify the various diseases associated with neuron.
7	Describe various types of hormones, its structure, function and regulation.
8	Explain how the mechanisms of tactile. Pain, thermal, taste and position senses.
9	Describe the visual and auditory pathways and its mechanisms.
10	Describe the male and the female reproductive system.
11	Narrate pregnancy, gestation, labour and lactation.
12	Explain the metabolism during physical action and adaptations developed by sports persons in response to physical training.
13	Give a physiological definition of stress and discuss how the body adapts to stress through its hypo-endocrine system.

MODULE	COURSE DESCRIPTION	Hrs.	CO No.
1	**Introduction**		
1.1	A brief history of Physiology and Anatomy. Cell as a living Module of the body (*Self Study*)		
2	**Support and Movement**	**11**	**1**
2.1	Supporting Systems:Cytoskeleton, Hydrostatic skeleton; Musculo-skeletal system: Gross and microscopic structure of bone, cartilage and skeletal muscle	3	1
2.2	Movement: Amoeboid movement, Ciliary/flagellar movement and Muscular movement: theories and molecular basis of muscle contraction.	3	1
2.3	Neural control of muscle tone and posture; role of skeleton in locomotion with reference to humans.	3	1
2.4	Catch muscle and Fibrillar muscle.	1	1

2.5	Clinical implications: Muscular dystrophy, Muscle strain, Muscle cramps, Tennis elbow, Hamstring injuries, sprains (brief accounts only).	1	1
3	**Nutrition**	**9**	**2**
3.1	Types of nutrition; Feeding mechanism in animals, Human digestive system-functional anatomy (*self-study)*		2
3.2	Gastro-intestinal enzymes and hormones.	2	2
3.3	Neural Control of Gastrointestinal Function	2	2
3.4	Mechanism of Absorption of digested nutrients	2	2
3.5	Obesity: causes and consequences	1	2
3.6	Gastro -intestinal disorders: IBS, Constipation, Peptic ulcer, Diarrhoea, bloating, gastritis, etc., (brief account only).	2	2
4	**Circulation**	**13**	**3**
4.1	Types of heart, anatomy of human heart (*self study*)		3
4.2	Body fluids (intracellular and extracellular) in invertebrates and vertebrates. Haemopoiesis.	3	3
4.3	Systemic, pulmonary, Coronary and portal circulations.	3	3
4.4	Conducting system of heart and cardiac cycle; Heart sounds.	3	3
4.5	Cardiovascular disorders: Coronary heart disease – Atherosclerosis, Angina and myocardial infarction or heart attack, Heart failure, Hypertrophic cardiomyopathy, Stroke and Circulatory Shock.	2	3
4.6	Control of blood pressure and blood flow	2	3
5	**Respiration**	**9**	**4**
5.1	Respiratory organs in invertebrates and vertebrates, with special emphasis on anatomy and function. (*self-study*).		4
5.2	Phases of respiration; Mechanism of Pulmonary ventilation	2	4
5.3	Respiratory pigments in invertebrates and vertebrates (*self-study*). Structure and function of myoglobin and haemoglobin. Role of Hb in gas transport.	2	4
5.4	Neural and chemical regulation of respiration	1	4
5.5	Respiration in unusual environments – Aviation, High altitude, Deep sea diving, Foetal respiration.	2	4
5.6	Respiratory disturbance: Pulmonary Emphysema, Hypercapnia, Atelectasis, pneumonia, tuberculosis, asthma (brief account only).	1	4
5.7	Oxygen therapy, Artificial respiration	1	4
6	**Excretion**	**10**	**5**
6.1	Types of Excretion, Structure of kidney, Basic renal process (*self study*)		5
6.2	Regulation of sodium and water balance: Primary sodium reabsorption; Mechanism of urine concentration.	3	5

6.3	Comparative account of excretion in different animal groups.	2	5
6.4	Kidney diseases; Creatine clearance - Plasma creatine; Diuretics, Haemodialysis, Peritoneal dialysis and kidney transplantation.	2	5
6.5	Renal and respiratory regulation of acid-base balance, regulation of blood volume and extra cellular fluid volume.	3	5
7	**Nervous Co-ordination**	**8**	**6**
7.1	Central and peripheral system, Structure and types of neurons and glial cells; Gross neuro-anatomy of the brain and spinal cord, and Giant nerve fibres in invertebrates (*self-study*)		6
7.2	Action potential, Ion channels and transmission of nerve impulse	3	6
7.3	Mechanism of synaptic transmission, neuro modulators, alpha and beta blockers and mechanism of neurotransmitter release	3	6
7.4	Neuronal disorders- Excitotoxicity and NMDA receptors, Parkinson's disease, Alzheimer's disease, Huntington's disease; Factors contributing to neuronal death	2	6
8	**Endocrinology**	**8**	**7**
8.1	Invertebrate and Vertebrate endocrine system (*self study*)		7
8.2	Classification, structure and function of Hormones. Proteins and polypeptide hormones, steroid hormones and amine hormones.	3	7
8.3	Mechanism of hormonal action	3	7
8.4	Neuro-endocrine feedback and response to various stimuli	2	7
9	**Somatic and Special senses**	**10**	**8,9**
9.1	Structure of Invertebrate (compound eye) and Vertebrate eye (*self study*)		9
9.2	Tactile, Pain, Thermal, Taste and Position Senses	2	8
9.3	Visual pathways - organisation of visual cortex; Analysis of visual information, detection of colour.	2	9
9.4	Auditory pathways - Functions of cerebral cortex in hearing.	2	9
10	**Human Reproduction**	**8**	**10**
10.1	Male reproductive system- Anatomy with reference to function; Spermatogenesis; structure of sperm; Hormonal control of male reproductive function (*self-study*).		10
10.2	Female reproductive system- Anatomy with reference to function; Oogenesis; Structure of Graafian follicle (*self-study*).		10
10.3	Menstrual cycle: Ovarian and uterine changes; hormonal regulation. Androgen in women.	2	10

10.4	Pregnancy, Gestation and Labour: Events in pregnancy –approximation of gametes, sperm activation, fertilization, implantation, maintenance of corpus luteum and development of placenta; Gestation: Foetal development during I, II, and III trimesters; Hormonal regulation of pregnancy. Parturition: Stages of parturition; Hormonal regulation of parturition; Lactation: Functional anatomy of mammary glands; Hormonal regulation of lactation.	4	11
10.5	Adjustments of the infants to extra uterine life.	1	11
10.6	Birth control: different strategies; Pre-natal diagnostic tests.	1	11
11	**Sports Physiology**	**6**	**12**
11.1	Muscles in exercise: Strength, Power, and Endurance of Muscles, Muscle Hypertrophy.	2	12
11.2	Muscle metabolic systems in exercise: (1) the phosphocreatine-creatine system, (2) the glycogen-lactic acid system, and (3) the aerobic system	2	12
11.3	Adaptations of cardiovascular system in exercise	1	12
11.4	Performance enhancing drugs in sports; Dope test	1	12
12	**Stress Physiology and adaptation**	**4**	**13**
12.1	Stress, stressors, Types of stress-Eustress, Distress, acute stress, episodic acute stress and chronic stress.	1	13
12.2	Stress response or General Adaptation Syndrome (GAS)-Stages, Stress hormones, Hypothalamic-Pituitary-Adrenal axis (HPA axis).	3	13

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APZO 222: SYSTEMATICS, EVOLUTIONARY BIOLOGY AND RESEARCH METHODOLOGY
(100 Hours)

CO No.	Expected course outcomes *Upon completion of this course, the students will be able to:*
1	Explain Taxonomy and its significance
2	Describe the tools and techniques in taxonomic identification
3	Distinguish and delimit types of taxonomic publications
4	Explain various aspects of nomenclature in systematics
5	List out types and hierarchial system of classification
6	Describe different approaches in taxonomy and its recent advancements
7	Explain types of research, steps in solving a research problem, reference citation and ethics in research
8	Narrate origin life and concept of evolution
9	Explain the events in molecular evolution
10	Describe eukaryotic evolution
11.	Explain the different stages in human evolution.

MODULE	COURSE DESCRIPTION	Hrs	CO No.
	SYSTEMATICS	**40**	
1	**Definition and basic concepts of Systematics and Taxonomy**	**5**	**1**
1.1	History of systematics	2	1
1.2	Importance and application of systematics in biology	1	1
1.3	Taxonomic impediments and its impact in taxonomy Ethics in Taxonomy	2	1
2	**Taxonomic tools and techniques**	**15**	
2.1	*Taxonomic Procedures*-collection, preservation, curatting and process of identification.	3	2
2.2	*Taxonomic characters of different kinds*- quantitative and qualitative analysis of variation. Identification: Taxonomic keys:Types of taxonomic keys- Simple Dichotomous key, Bracket key, Indented Key, Serial key, Branching key, Circular key, Box key, computer key. Its merits and demerits	2 2	2
2.3	Process of typification, *Different zoological types*- Holotype, Paratype, Lectotype, Syntype, Neotype, Allotype and their significance.	2	2
2.4	*Systematics Publications:* Different types- Short Research papers, Revision, Monograph,Faunal/Floral, Synopses and Reviews, Handbooks and Manuals, Catalogues and Checklists and Atlases. Preparation of taxonomic publications.	2	3

2.5	International code of zoological nomenclature and its operative principles. Law of Priority and Law of Homonymy. Scientific Nomenclature (Uninomial, Binomial Nomenclature and Trinomial Nomenclature (brief account).	2	4
2.6	*Zoological nomenclature* - Homonymy and Synonymy. Rejection of names- Nomen nudium, Nomen confusum, Nomen dubium, Nomen oblitum, Nomen conservanda, Nomina rejecta, Nomina ambiguum.	2	4
3	**Taxonomic Classification**	**8**	
3.1	*Kinds of classification:* Natural classification,Cladistic/Phylogenetic classification, Phenetic classification, Biological classification,Omnispective classification and Hierarchical classification	4	5
3.2	*Hierarchy of classification :* Linnean Hierarchy. species category,-sub species, deme and other intra specific categories.	4	5
4	**Trends in systematics**	**12**	
4.1	*Approaches in taxonomy* – Morphological, Anatomical, Developmental, Biochemical (chemotaxonomy), Cytological (Cytotaxonomy), Ecological and Ethological (brief account)	3	6
4.2	*Molecular Systematics*- DNA bar coding and Barcoding of life. Phylogenetic tree (brief account)	7	6
4.3	Recent trends based on proteomics and genomics	2	6
	EVOLUTIONARY BIOLOGY	**40**	
5	**Origin of life**	**3**	
5.1	*Theories of origin of life.* Origin of basic biological molecules, abiotic synthesis of organic monomers and polymers, concept of Oparin - Haldane, Miller-Urey Experiments. The RNA world. The First Cell.(self study)	3	8
6	**Concepts of evolution**	**3**	
6.1	Pre-Darwanian, Lamarck, Darwin and Wallace and Post-Darwanian concepts of evolution. Concepts of variation, adaptation, struggle, fitness and natural selection. Phylogenetic gradualism and punctuated equilibrium Micro, macro, divergent and convergent evolution; co evolution and parallel evolution; adaptive radiation. (self study)	3	8
7	**Geological timescale**	**3**	
7.1	*Geological time scale*– eras, periods and epochs. Major events in evolutionary timescale. Mass extinction and its consequences. Fossils- fossilization and its significance.	**3**	**8**

8	**Molecular evolution**	**11**	
8.1	Neutral evolution. Molecular clock and its significance. Ancient DNA.	3	9
8.2	Evolution of genes and gene families. Genome evolution. C-Value paradox.	4	9
8.3	Evolution of proteins in organisms.	4	9
9	**Eukaryotic evolution**	**10**	
9.1	Origin of eukaryotic cells	1	10
9.2	Origin of metazoa, Theories of origin	1	10
9.3	Origin, evolution and extinction of Trilobites	2	10
9.4	Origin and evolution of vertebrate groups- Pisces, Amphibia, Reptilia, Aves and mammals.	6	10
10	**Primate evolution and Human origin.**	**10**	
10.1	*Stages in Primate Evolution* - Prosimii, Anthropoidea and Hominids. Factors in human origin-Hominid fossils.	4	11
10.2	*Cytogenetic and Molecular basis of origin of man*- African origin of modern man- Mitochondrial Eve, Y chromosomal Adam.	3	11
10.3	*Evolution of human brain*- communication, speech and language. *Evolution of culture*: early migration, hunter-gatherer societies.	3	11
	RESEARCH METHODOLOGY	**20**	
11	Introduction Definition, meaning, objectives, and significance of research, Research Approaches, Characteristics of good research, Role of computer in research	2	7
12	*Types of research* – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative and Conceptual vs. Empirical.	2	7
13	*Steps of research*- Formulating research problem, Literature survey(e books, e journals, periodicals, books), Development of working hypothesis, Research Design, Sampling design, data collection, execution of project, Analysis of data, testing of hypothesis, generalization and interpretation. Report/thesis writing	6	7
14	Research report writing (thesis, dissertations) - characteristics and format Writing and preparation of articles for publication and for oral and poster presentation Project proposal and report writing.	6	7
14.1	Impact factor of Journal articles. Reference citation of Books, Research Articles, Chapter in a book, Proceedings, Thesis.	2	7
15	*Ethics in research*- Research misconduct: fabrication, falsification and plagiarism.	2	7

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APZO223: CELL AND MOLECULAR BIOLOGY
(100 Hours)

CO No.	Expected course outcomes *Upon completion of this course, the students will be able to:*
1	Explain the structure and functions of plasma membrane, cytoskeleton, extracellular matrix and the communication between cells.
2	Explain about the mechanism of different signalling pathways.
3	Describe about the cell cycle and its regulation in normal and malignant cells as well as the process of apoptosis.
4	Explain about the organisation of eukaryotic genome.
5	Describe about the replication of DNA and mechanisms of DNA damage and repair.
6	Explain the detailed mechanisms involved in the central dogma of molecular biology.
7	Describe the different mechanisms involved in regulation of gene expression.

MODULE	COURSE DESCRIPTION	Hrs	CO No.
	***Prerequisite**:* Nucleus and Cell organelles – structure and functions.		
1	**Membrane structure and function**	**5**	
1.1	Fluid Mosaic Model of plasma membrane. Membrane transport – passive and active transport (Uniport, Symport, Antiport, Co-transport, bulk transport) (***self study***)		1
1.2	Chemical composition of plasma membrane. Ion channels and pumps. Membrane potentials. Functions of plasma membrane.	5	1
2	**Cell junctions and extracellular matrix**	**9**	
2.1	Cell junctions – occluding junctions, anchoring junctions and comunicating junctions (brief account of the types and structure).	3	1
2.2	Extracellular matrix: Basal lamina and laminin, Collagen, Proteoglycan, Fibronectin. Interaction of cells with extracellular matrix: Integrins.	6	1
3	**Cytoskeleton & cell motility**	**4**	
3.1	Microtubules, Microfilaments, Intermediate filaments – structure and functions. Molecular motors.	4	1
4	**Cell signalling**	**15**	
4.1	Extracellular messengers (signaling molecules), role of Calcium and Nitric oxide (NO) as intracellular and intercellular messengers.	3	1
4.2	Receptors: G- Protein coupled receptors, Receptors with intrinsic enzymatic activity (Receptor tyrosine kinases - RTK), Ion channel receptors, Cytokine receptors (Tyrosine kinase linked receptors).	4	1

4.3	Signalling pathways: G-protein coupled receptor (GPCR) and cyclic AMP pathway – role of protein kinase A (PKA), Receptor protein tyrosine kinase and Ras-MAP kinase pathway, JAK-STAT pathway. Regulation of signalling pathways.	8	1,2
5	**Cell cycle and programmed cell death**	**15**	
5.1	Overview of cell cycle ***(self study).*** Check points in cell cycle, cyclin dependent kinases (Cdk) and cyclins, regulation of Cdk-cyclin activity. Check points in the cell cycle	6	3
5.2	Proto onco genes, Onco genes, Tumour suppressor gene. Regulation of cell cycle in malignant cells	4	3
5.3	Programmed cell death(apoptosis): extrinsic and intrinsic pathways. Significance of apoptosis.	5	3
6	**Organisation of genes and chromosomes**	**12**	
	Detailed structure of nucleosome; higher order structure of chromatin and the role of histones, scaffold proteins, and radial loop model *(self study)*		4
	Genomic size and genetic content, Complexity of eukaryotic genome: Intragenic sequences - exons, introns; split gene organization; regulatory sequences; Intergenic sequences: Unique sequences, Repetitive sequences: Highly repeated sequences – satellite, minisatellite and microsatellite DNAs; Moderately repeated sequences (e.g. SINEs and LINEs)	8	4
	Organelle genomes-mitochondrial and plastid DNAs	4	4
9	**DNA replication and repair**	**10**	
	Prokaryotic and Eukaryotic DNA replication. DNA replication machinery: Enzymes and accessory proteins involved in replication.	6	5
	DNA damage and repair ***(self study)***. Damage signaling and checkpoints. DNA repair-associated disorders	4	5
10	**Transcription and RNA processing**	**10**	
	Mechanism of prokaryotic and eukaryotic transcription. Binding the transcription complex-promoters, factors and RNA polymerases. Regulation of transcription.	5	6
	Post-transcriptional processing of RNA precursors, spliceosomes. Reverse transcription – Teminism (***self study***)	5	6
11	**Translation and protein processing.**	**10**	
	Mechanism of prokaryotic and eukaryotic translation.	5	6
	Co-and post translational modifications of proteins. Hormonal regulation of protein synthesis.	5	
12	**Regulation of gene expression at transcriptional and translational level.**	**10**	

	Gene regulation in prokaryotes(Operon concept- Lac operon and Trp operon) and eukaryotes at transcriptional and traslational levels: Gene regulatory proteins and DNA-binding domains (Zinc-finger motif, Zipper motifs and Helix-loop-helix motif); Transcription signals – TATA Box, CAAT BOX, enhancers, silencers. Role of chromatin in gene expresssion and gene silencing; RNA interference (RNAi). Knocking out genes.	10	7

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PRACTICAL I

APZO 2 P I: Biochemistry, Biophysics, Instrumentation and Analytical Techniques, Biostatistics and Bioinformatics

CO No.	Expected course outcomes *Upon completion of this course, the students will be able to:*
1	Determine the amount of acid, pKa value and isoelectric pH
2	Estimate the amount of biomolecules in the sample
3	Determination the acid value and saponification value
4	Familiarize basic instruments
5	Visualize biomolecules using computational tools
6	Construct phylogenetic trees
7	Compute statistical problems using computer and graphical means
8	Apply suitable statistical methods to research studies

MODULE	COURSE DESCRIPTION	CO No.
A.	**Biochemistry**	
1	Titration curve of acetic acid. Titration of a measured volume of acetic acid with sodium hydroxide (NaOH) to determine the amount of acid in the given solution and pKa of acetic acid	1
2	Determination of the isoelectric pH of the given amino acid by titration method.	1
3	Estimation of DNA/RNA	2
4	Quantitative estimation of glycogen of a tissue	2
5	Quantitative estimation of blood glucose	2
6	Quantitative estimation of protein(tissue/ serum).	2
7	Determination of acid value of the given fat.	3
8	Determination of saponification value of the given fat.	3
9	Estimation of serum cholesterol using a standard protocol	2
10	Determination of the Michaelis constant (Km value) for the digestion of case in by trypsin.	2
11	Estimation of acid/ alkaline phosphatase or transaminases.	2
12	Preparation of buffer solution for a given pH	2
B.	**Biophysics, Instrumentation and Analytical Techniques, Biostatistics and Bioinformatics**	
1	Micrometry: Measurement of microscopic objects using micrometer	4

2	Separation of haemolymph of serum protein by gel electrophoresis	4
3	Sketching of biological specimens using a camera Lucida	4
4	Quantification estimation of Na, K, Ca of the given sample with the help of flame photometer/ spectrophotometer.	4
5	Preparation of tables and bar diagrams using suitable softwares, from the data provided	7
6	Statistical Analysis (Chi-square, t-test, correlation, regression, standard deviation and standard error) of the given data using suitable softwares.	8
7	Preparation of histogram, frequency polygon and pie diagram using appropriate software.	7
8	Molecular visualization using any suitable tools like Rasmol	5
9	Study of FASTA format, Gen Bank Database, Identify and evaluate features of NCBI, BLAST.	5
10	Phylogenetic tree construction of any taxa using any selected annotated genes	6
11	Analysis of ligand binding characteristics using any programmes like AutoDoc	5

PRACTICAL II

APZO 2 P II: Advanced Physiology, Functional Anatomy, Systematics And Evolutionary Biology, Genetics, Cell And Molecular Biology

CO No.	Expected course outcomes *Upon completion of this course, the students will be able to:*
1	Demonstrate the effect of salivary amylase on starch
2	Demonstrate the transport of glucose through the intestinal wall, effect of temperature and pH on the ciliary movements of bivalves and muscle contraction
3	Demonstrate the working of heart, effect of drugs on the heart beat
4	Enumerate RBC, WBC, differential count and blood histology of different animals and the effect of various pH on RBC.
5	Identify and mount the various mouth parts, in relation to food and feeding habit.
6	Make the squash preparation of Drosophila larva and grasshopper testis.
7	Demonstrate the histological preparation and histochemical localisation of glycogen and protein
8	Extract DNA/RNA and separate by gel electrophoresis
9	Demonstrate karyotyping
10	Identify animals using standard keys
11	Explain the preservation media and tools and materials for taxidermy
12	Compare prokaryotic and eukaryotic cells by staining and mounting

MODULE	COURSE DESCRIPTION	CO No.
A	**ADVANCED PHYSIOLOGY , FUNCTIONAL ANATOMY**	
1	Effect of salivary amylase on starch (colorimetric) a) Influence of temperature and calculation of Q10 b) Influence of pH	1
2	Transport of glucose through intestinal wall (everted gut sac) of a suitable animal	2
3	Observation of ciliary movement of bivalve in relation to temperature and pH	2
4	Effect pH/ temperature on muscle contraction.	2
5	Recording of heart beat and the effect of drugs (accetylcholine and adrenaline) in chick or other suitable animal.	3
6	Effect pH different concentrations of NaCl (0.1% to 2%) on the diameter of RBCs using micrometry.	4
7	Enumeration of RBCs in vertebrate blood	4
8	Enumeration of WBCs in vertebrate blood	4
9	Blood histology of earthworm/cockroach, fish and chick.	4
10	Differential count of WBCs	4

11	Studies on feeding-Mounting of mouth parts of housefly, honey bee and mosquito in relation to food and feeding.	5
B	**GENETICS , CELL AND MOECULAR BIOLOGY**	
1	Chromosome study- Squash preparation of Drosophila/Chironomus larva.	6
2	Study of meiosis – Squash preparation of grass hopper testis.	6
3	Histological prepation of liver,gut and muscle.	7
4	Histochemical localization of glycogen and protein.	7
5	Extraction of DNA/RNA from tissue and Gel electrophoretic seperation.	8
6	Karyotyping using lymphocyte culture/ any suitable tissue of any animal groups.	9
C	**SYSTEMATICS AND EVOLUTIONARY BIOLOGY**	
1	Collection and identification of the following using standard keys: A Insects (3 nos) B. Prawn (2 nos) C. Crab (2 nos) D. Fishes (3 nos)	10
2	Study of preservation media and tools and materials for taxidermy	11
3	Comparative study of prokaryotic and eukaryotic cells by staining and mounting (evolutionary significance).	12

SEMESTER – III

APZO 321: MICROBIOLOGY & BIOTECHNOLOGY
[100 Hrs]

CO No.	Expected course outcomes *Upon completion of this course, the students will be able to:*
1	Explain the principles of bacterial classification and microbial taxonomy.
2	Explain the nature of virus and its structural peculiarities.
3	Explain the morphological features and structural components of bacterial cell and its staining procedures.
4	Explain and understand the nutrition, cultivation, growth and preservation of microbial culture.
5	Explain the process and techniques for the production and purification of antibiotics, enzymes, amino acids and steroids and the principles of food-processing, preservation and fermentation procedures.
6	Explain and apply principles of environmental microbiology to solve the current environmental issues.
7	Explain the concept, etiology and epidemiology of infections and mechanisms of infection and the control measures of diseases.
8	Describe the varied fields of application and scope of Biotechnology.
9	Explain the major events in the development of rDNA technology.
10	Explain the techniques involved in construction of genomic DNA library and cDNA library.
11	Explain the principle and steps involved in PCR and real-time PCR and the need for molecular markers in genome analysis.
12	Describe the strategies for whole genome sequencing and various expression analysis techniques and its importance in biotechnology.
13	Explain the use of biotechnology and genetic engineering for the use of human wellbeing and its ethical and social implications.
14	Explain about the principle and techniques in animal cell culture and various cell viability and toxicity assays as well as the current trends in stem cell technology.

MODULE	COURSE DESCRIPTION	Hrs	CO No.
	Microbiology	**40**	
1	**Introduction to Microbiology**		**CO. 1**
1.1	Scope and history of Microbiology; Characteristic features and classification of Microbes, Bergey's manual-ICTV (Self study)		1

1.2	Mycoplasma, Extremophiles and Microalgae. Survey of harmful and beneficial microbes (self study)		1
2	**Viruses**	**3**	
2.1	General Properties of Viruses, Viroids, Prions (self study)		2
2.2	Structure and chemical composition of the viruses, Viral Capsid, Viral Envelope, Viral Nucleic Acids.	2	2
2.3	SARS-Cov-2 structure, mode of transmission and clinical significance (brief account)	1	2
3	**Bacterial Cell Structure & Function**	**10**	
3.1	Bacterial cell: ultra structure and function of different components -Cell wall, cell membrane, cytoplasmic inclusions, nucleiod, pili, flagella, fimbriae, capsules, slime layers etc.	6	3
3.2	Gram staining, differences between gram positive and negative bacteria.	4	3
4	**Microbial Nutrition & Growth**	**6**	
4.1	Nutritional diversity among prokaryotes. Nutritional requirements of microorganisms	2	4
4.2	Types of culture media- complex medium, synthetic medium, selective and non- selective medium, selective and differential medium- with examples for each type.	1	4
4.3	Microbial growth – overview of cell growth, generation time, measurement of growth. Typical growth curve, continuous culture systems- chemostat and turbidostat, effect of environmental factors on growth. Stress response	2	4
4.4	Control of Microorganisms – various physical & chemical methods.	1	7
5	**Industrial Microbiology**	**10**	
5.1	Application of microbes in industry (self study)	3	5
5.1.1	Concept of fermentation. Types of fermentation – submerged, solid state – mention briefly.	2	5
5.1.2	Basic design and types of fermenters.	1	5
5.1.3	Products of Industrial Microbiology such as Alcohol, Antibiotics (e.g. Penicillin), Organic acids (e.g. Acetic acid, Lactic acid).	2	5
5.1.4	Microbiology of milk & foods: Microbial spoilage of food.	1	5
5.1.5	Preservation. Preservation of milk - Pasteurization techniques. Probiotics.	1	5
5.2	**Environmental Microbiology**	**5**	
5.2.1	Introduction to soil and aquatic microbiology. Role of microbes in biogeochemical cycles.	2	6
5.2.2	Microbiology of waste treatment. Brief account of microbial treatment of waste water and solid wastes.	2	6
5.2.3	Microbial bioremediation	1	6
6	**Medical Microbiology**	6	

6.1	Host-microbe interaction – process of infection	1	7
6.2	Exotoxins-classification and mechanism of action of exotoxins. e.g. Diphtheria, Botulinum, Tetanus, and Cholera toxins. Mention endotoxins	2	7
6.3	Use of antibiotics and other antimicrobial drugs.	1	7
6.4	Drug resistance and emergence of multiple drug resistance – recent cases of TB (XDR, TDR); NDM etc.	2	7
	Biotechnology	**60**	
7	**Introduction to Biotechnology**	**4**	
7.1	History of Biotechnology (self study).		8
7.2	Broad areas of BT – traditional and modern; types – plant biotechnology, animal biotechnology and microbial biotechnology.	2	8
7.3	India's Biotechnology Policy. Biotechnology Regulatory Agencies in India.	2	8
8	**Molecular Cloning**	**18**	
8.1	Gene cloning – basic steps in gene cloning.	4	9
8.2	Vectors – types and characteristics e.g. plasmids, phages, hybrid vectors, artificial chromosomes.	2	9
8.3	Enzymes used in gene cloning	2	9
8.4	Techniques of gene transfer – calcium chloride transformation,lipofection,microinjection,electroporation, shotgun cloning (gene gun), Agrobacterium mediated transfer, etc.	6	9
8.5	DNA libraries: Genomic libraries and cDNA libraries. Application of genomic libraries and cDNA libraries,	4	10
9	**Techniques in rDNA technology**	**18**	
9.1	Polymerase chain reaction and its types - RT-PCR, qRT-PCR	4	11
9.2	Molecular markers and marker techniques: SNP, VNTR, RFLP, AFLP, RAPD; SSR, STMS, FISH and GISH	4	11
9.3	Chromosome walking and jumping	2	11
9.4	Nucleic acid sequencing (Maxam and Gilbert method, Sangers method); Automated DNA sequencers.	4	11
9.5	Gene expression analysis – Western blotting, Southern blotting, Northern blotting, Immuno-blotting, and microarrays.	4	12
10	**Recent Trends in Biotechnology**	**6**	
10.1	Synthetic Biology – description and developments in the area.	2	13
10.4	Application of genetic engineering, Transgenic animals and Genetically modified organisms.	2	13
10.5	Gene therapy	2	13
10.6	Microbial warfare – bio-weapons and bioterrorism		13

	Bioethics: Ethical, legal and social issues (ELSI) of biotechnology (self study).		
11	**Cell culture techniques**	**14**	14
11.1	Animal cell culture: Primary and secondary cell cultures, 2D and 3D cultures, cell lines, cell strain, immortalized cell cultures, transformed cell lines.	3	
11.2	Media – media components and physico-chemical parameters. Growth factors promoting proliferation of animal cell cultures; Animal bioreactors.	3	14
11.3	Cryo-preservation of cultures; Cell viability assays - measurement of viability and toxicity --MTT assays, comet assay, DNA laddering assay, Caspase assay. Assessment of cell death.	3	14
11.4	Stem cells: types of stem cells; stem cell niche; Medical prospects of stem cell research.	3	14
11.5	Lab safety and maintenance.	2	14

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BIOTECHNOLOGY

1 Bejamin Lewin – Genes X (2011).
2 James D Watson - Molecular Biology of the Gene (6th Edition)
3 George W Burns, the Science of Genetics, Mae Millan C0 New York.
4 A Gib De Busk, Molecular Genetics, Mae Millan C0 New York.
5 Edgar Altenberg, Genetics, Oxford and IBH Publisher, New Delhi.
6 Janeway, Travens, (1996) Immunobiology Current Biology Ltd., Middle Sex House- 34-42 Cleveland Street, London.
7 Gunther S. Stent & Richard Calender Molecular Genetics, CMS Publishers, 485 Jain Bhawan, Bholanath Nagar, Shahdra, Newdeli
8 Richard Losick, (2004) Molecular Biology& Genes, Pearson Education.
9 Strickberger, M.W. Genetics, Macmillan Publishing Co., Inc., New York.
10 J.M. Walker and R. Rapley, (2002), Molecular Biology and Biotechnology, Purnima Publishing Corporation, New Delhi.

Useful websites

1. http://www.microbeworld.org

2. *http://www.ncbi.nlm.nih.gov*
3. http://www.accessexcellence.org/RC/AB/BA/
4. http://www.accessexcellence.org/RC/AB/IE/
5. http://bacteriamuseum.org

APZO 322: ECOLOGY AND ETHOLOGY
[100 Hrs]

CO No.	Expected course outcomes *Upon completion of this course, the students will be able to:*
1	List out population characteristics, species characteristics and environmental interactions
2	Describe the flow of energy and productivity in an ecosystem.
3	Clearly distinguish and elaborate various species concepts, mechanisms of speciation, and concepts of habitat, niche and guild.
4	Critically evaluate and narrate the degree of threat to extant species and management practices to be taken based on this.
5	Estimate population size in an ecosystem using mark-recapture method.
6	Describe various species interactions.
7	Elaborate various types of learning.
8	Explain control of nervous system on behavioural pattern of organism.
9	Narrate an account on complex behavioural pattern of animals.
10	Explain the role of environment on behavioural pattern of animals.
11	Describe the importance of social organization and its benefits.

MODULE	COURSE DESCRIPTION	Hrs	CO No.
	ECOLOGY	**50**	
1	**Self study** Biotic and abiotic factors and their interactions. Gaseous and sedimentary cycles Characteristics of population: density, natality, mortality, biotic potential, environmental resistance, growth forms. immigration, emigration and migration. Characteristics: Species diversity, stratification, dominance, boundaries, ecotone and edge effect.		**1**
1	**Ecological Energetics**	**10**	
1.1	Solar energy and photosynthetic production, efficiency of energy capturing, chemosynthesis.	2	2
1.2	Energy flow - features of energy flow (unidirectional flow and loss of energy as heat) and pathways of energy flow	3	2
1.3	Productivity - primary production and production efficiency, secondary production, standing crop.	2	2
1.4	Food chain (grazing, detritus and auxiliary food chains), food webs, trophic levels and ecological pyramids (pyramid of numbers, pyramid of biomass and pyramid of energy)	3	2
2	**Concepts of Species, Habitat, Niche and Guild**	**20**	

2.1	Species Concept: Biological, Phylogenetic, evolutional, Ecological	3	3
2.2	Mechanism of speciation- Sympatric and Allopatric speciation, reproductive isolation, biological mechanism genetic incompatibility	3	3
2.3	IUCN classification of degree of threat to species- Endangered, Critically Endangered, Vulnerable, Extinct in the wild and Extinct. Sixth Extinction	3	4
2.4	Habitat, microhabitat and niche. Different types of niches: spatial niche, trophic niche, species niche, multidimensional niche, fundamental and realised niche.	4	3
2.5	Niche overlap, Gause's principle-Lotka -Voltera model, resource partitioning, compression hypothesis, concept of Guild, character displacement, ecological equivalents.	5	3
2.6	Techniques to quantify population density- Quadrat method, Line transects, Berlese funnel, Mark recapture method.	2	5
3	**Species Interactions**	**20**	
3.1	Types of interactions: Intra and interspecific interactions. Co-evolution	3	6
3.2	Competition- types.	3	6
3.2	Predation- herbivory and carnivory Adaptations of predator. Defense mechanisms of prey- Mimicry-Batesian, Mullerian, aggressive, Colouration- Aposematic, Cryptic	4	6
3.4	Parasitism – types, Mutualism, Commensalism Pollination (Plant-pollinator relation).	4	6
4	Life history strategy: r-selection, k- selection Characteristics of r- and k-selected species.	3	6
5	Population Ecology-Hardy Weinberg equilibrium Factors affecting equilibrium- migration, mutation Genetic drift, founder effect, Bottle neck effect	3	6
	ETHOLOGY	**50**	
	Prerequisite: History, development and applications; Motivation and models of motivation; reflexes, neural mechanisms in behaviour; hormones and behaviour.		
	Motivation and models of motivation; reflexes, neural mechanisms in behaviour; hormones and behaviour.	2	7
6	**Learning**	**6**	
	Classification of learning: Imprinting, habituation, imitation (self study), classical conditioning, instrumental/operant conditioning,cognitive learning, latent learning, insightful learning	6	7
7	**Nervous System and Behaviour**	**12**	

7.1	Stimulus filtering, sign stimulus, innate release mechanism and fixed action plans (FAPs).	5	8
7.2	Neural centres (hypothalamus and limbic system) and mechanisms in behaiour: drinking, feeding, learning, memory and cognition.	7	8
8	**Complex Behaviour Patterns**	**10**	
8.1	Orientation, Navigation and homing.	3	9
8.2	Migration (Fishes and birds).	2	9
8.3	Biological rhythms – biological clock, circadian, circannual, lunar, tidal and seasonal periodicities, sleep and arousal, genetics of biological rhythms.	5	9
9	**Environment, genetics and Evolution of behaviour**	**10**	
9.1	Habitat selection and territoriality.	2	10
9.2	The Evolution of communication; Development of bird song.	4	10
9.3	The evolution of reproductive behaviour and mating systems.	4	10
10	**Sociobiology**	**10**	
10.1	Social groups – merits and demerits, Advantages of grouping.	3	11
10.2	Social Insects- honey bee dance, pheromones and chemical communication.	4	11
10.3	Social organization in vertebrates.(brief account)	3	11

References

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1. Beck, W.S., Liem, K.F. & Simpson, G.G. (1991). *Life: An Introduction to Biology* (3rd Ed.). Harper Collins Publishers, New York, pp 1361. ISBN: 0 06 500009 9.
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APZO 323: IMMUNOLOGY AND DEVELOPMENTAL BIOLOGY
(100 Hrs)

CO No.	Expected course outcomes *Upon completion of this course, the students will be able to:*
1	Explain about the different types of immunity and the cells and organs of immune system as well as different types of vaccines.
2	Describe about the characteristics of antigens and antibodies, different classes of Ab and their effector functions as well as engineered antibodies.
3	Explain the genetic basis of the production of diverse array of antibodies in the body and the temporal differences in expression of the different classes.
4	Describe about the characteristics and mechanisms of immune responses and antigen-antibody interactions.
5	Explain about the structure of MHC and its role in antigen presentation and tissue transplantation.
6	Explain about the different pathways of complement activation and its biological effects.
7	Explain about mechanisms of graft rejection, immunosuppressive therapy and immune diseases.
8	Explain about the different types of eggs, process of fertilization and cleavage.
9	Describe about concepts such as potency, determination, differentiation, induction, etc. and the early development and axis formation in different model organisms.
10	Explain about the differential gene expression during development and the various signalling pathways associated with development.
11	Explain about embryonic induction and the functions of organizers.
12	Describe about the protocol and different types of medically assisted reproductive techniques.
13	Give an account on cloning experiments in animals and its ethical implications.

MODULE	COURSE DESCRIPTION	Hrs	CO No.
	IMMUNOLOGY	**50**	
1	**Introduction to Immune System**	**2**	
1.1	Types of immunity, innate and acquired immunity; passive and active immunity; humoral and cell-mediated immunity (***self study***)		1
1.2	Organs of immune system: Primary and Secondary lymphoid organs (***self study***).		1
1.3	Immune cells: types, production and functions.	2	1
2	**Immunogens (Antigens)**	**4**	

2.1	General properties, Antigenicity, Immunogenicity. Factors affecting antigenicity. T-dependent and T-independent antigens. Superantigens.	2	2
2.2	Epitopes (antigenic determinants), Properties of B cell and T cell epitopes. Haptens.	2	2
3	**Immunoglobulins (antibodies)**	**17**	
3.1	General Properties, Structure ***(self study)*** Antibody domains; Antigenic determinants of immunoglobulins: isotype, allotype, idiotype.	1	2
3.2	Different classes of immunoglobulins (1gA, 1gD,1gE,1gG and 1gM) and their functions.	2	2
3.3	Genetic basis of antibody diversity: Immunoglobulin gene organization. Gene rearrangement: Somatic recombination: V (D) J recombination and junctional diversity (p-nucleotide addition, exonuclease trimming, N- nucleotide addition). Somatic hyper mutation and affinity maturation.	6	3
3.4	Expression of B cell receptors: allelic exclusion, receptor editing, transcriptional regulation, alternative RNA splicing. Class switching and Class switch recombination.	4	3
3.5	Polyclonal & Monoclonal antibodies. Abzymes. Production of monoclonal antibodies : Hybridoma technology. Application of monoclonal antobodies. Antibody engineering.	4	2
4	**Immune response & Antigen – antibody interactions**	**8**	
4.1	Antigen – antibody interactions: Precipitation, Agglutination, complement fixation, neutralization, opsonisation. Antibody affinity, antibody avidity, cross reactivity.	2	4
4.2	Primary and secondary immune responses: characteristics, stages, immune cell activation and memory.	3	4
4.3	Immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections	3	4
5	**Antigen processing and presentation**	**5**	
5.1	Major Histocompatibility Complex (MHC) and MHC proteins – structure and function	2	5
5.2	Role of antigen presenting cells; cytosolic pathway and endocytic pathway.	3	5
6	**Complement System**	**3**	
6.1	Complement systems-General features. Classical, alternate and lectin pathways, complement receptors.	2	6
6.2	Biological effects of complement activation.	1	6
7	**Transplantation immunology**	**5**	

7.1	Classification of grafts. Role of MHC in tissue transplantation – HLA tissue typing (brief account).	2	5,7
7.2	Mechanism of graft rejection.	2	7
7.3	General immunosuppressive therapy	1	7
8	**Defects in Immune Mechanisms**	**4**	
8.1	Congenital and acquired immunodeficiencies	2	7
8.2	Autoimmunity. Auto immune diseases – systemic and organ specific.	2	7
9	**Vaccines**	**2**	
9.1	Types of vaccines: whole organisms (live attenuated, killed) purified macromolecules (subunit, toxoid, conjugate), others (mRNA vaccine). Role of adjuvants in vaccines.	2	1
	DEVELOPMENTAL BIOLOGY	**50**	
10	**Introduction**	**2**	
10.1	***Prerequisite***: Definition, history, Scope of embryology and Practical applications.		
10.2	Types of eggs and pattern of cleavage. brief account (asexual means; parthenogenesis; sexual means; gonochorism, hermaphroditism, metamorphosis)	2	8
11	**Fertilization**	**4**	
11.1	Events in fertilization Cytoplasmic changes and Nuclear changes	1	8
11.2	Prevention of polyspermy- Primary block to polyspermy, Secondary block to polyspermy.	2	8
11.3	Significance of fertilization	1	8
12	**Basic concepts of development:**	**5**	
12.1	Potency, commitment, specification, induction, competence, determination and differentiation.	3	9
12.2	Genomic equivalence and differential gene expression; the cytoplasmic determinants; genomic imprinting	2	9, 10
13	**Developmental Model Systems**	**25**	
13.1	***Prerequisite***: Genetic control of development Early development of *Drosophila*-Egg, cleavage, mid-blastula transition, gastrulation	5	
13.2	Gene action in development of Drosophila:- Maternal effect genes; Zygotic genes- Segmental genes (gap genes, pair-rule gene and segment polarity gene) and Homeotic genes (homeobox and homeodomains) Axes and pattern formation in Drosophila	7	9,10
13.3	Hox cluster genes in vertebrates	1	10
13.4	Early development of *Caenorhabditis elegans*-Egg, cleavage and gastrulation. Vulva formation in *Caenorhabditis elegans*,.	2	9
13.5	Cell aggregation and differentiation in *Dictyostelium*	2	9

13.6	Surface receptors and signal transduction pathway - Smad pathway, Wnt pathway, Hedgehog pathway and BMP pathway.	4	10
13.7	Mechanism of Axes and pattern formation in Amphibia.	4	9
14	**Embryonic Induction**	**6**	
14.1	***Prerequiste:*** Types of embryonic induction – Primary, Secondary and Tertiary Induction (Experiments of Spemann and Mangold)	3	
14.2	Functions of organizer: Niewkoop centre; the diffusible proteins of the organizer 1; the BMP inhibitors.	3	11
15	**Medically assisted human reproductive technologies**	**6**	
15.1	Conventional in vitro fertilization and embryo transfer (IVF-ET) – general protocol (Patient selection, manipulation of menstrual cycle, superovulation, oocyte re trieval, preparation of semen sample, IVF treatment, embryo transfer.	3	12
15.2	Gametic Instrafallopian Transfer (GIFT) Zygotic Intrafallopian Transfer (ZIFT) Tubal Embryo stage Transfer (TET) Intra-cytoplasmic sperm injection (ICSI)	3	12
16	**Cloning experiments in animals**	**2**	
16.1	Cloning in animals; prospects and demerits.	1	13
16.2	Different types of cloning	1	13

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Developmental Biology

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SEMESTER – IV

APZO 421: POLLUTION BIOLOGY & ENVIRONMENTAL PHYSIOLOGY
(100 hrs)

CO No.	Expected course outcomes *Upon completion of this course, the students will be able to:*
1	Describe the sources of pollution and acquire ideas about the control measures at the point sources
2	Explain the adverse impact of air, water and soil pollution.
3	List out the adverse effects of secondary pollutants.
4	Narrate adverse impact of land pollution.
5	List out food additives and better understanding their impacts on human health.
6	Describe the adverse impact of pollution on historical monuments.
7	Explain effects of noise pollution and radiation pollution.
8	Describe the adaptations of animals at different environmental conditions.

MODULE	COURSE DESCRIPTION	Hrs	CO No.
1	**Introduction**	**5**	
1.1	*Environmental pollution* – Introduction, concepts and definitions. Sources:Point sources, Non point sources,Natural sources, Anthropogenic (Agriculture, Industrial, Transport). Classification of environmental pollutants- Physical, Chemical, Biological and uncertain origin. Role of man in environmental pollution control.	3	1
1.2	*Food Safety:* *Types of food additives* -antioxidants, colours, flavour enhancers, sweeteners, emulsifiers and stabilizers and preservatives. Adulteration of food and its impacts on human health.	2	5
2	**Air Pollution**	**15**	
2.1	*Sources and Categories of air pollutants*- Primary air pollutants-Carbondioxide, Carbon Monoxide, Hydrocarbons, oxides of Nitrogen, SO_2, NH_3, H_2S Secondary air pollutants – Ozone, PAN	5	3
2.2	Interaction of air pollutants in the atmosphere-Smog formation –Classical(London smog. 1952) and photochemical smog formation (Los Angels smog 1943), Thermal inversion (brief account)	3	3
2.3	*Air Pollution:* sources and impacts (Acid rain, effects on buildings and historical monuments, plants,	2	6

	animals and human health, Global warming and ozone depletion, Green house effect).		
2.4	A brief survey of major air pollution episodes 1997 Indonesian forest fires Episode 2006 Southeast Asian Haze Episode 1984 Bhopal Gas Tragedy Episode 2020Amazon rainforest fire 2020Australian fire	3	2
2.4	Air pollution abatement technologies – A brief account on working of gravity settling chamber, centrifugal collectors, wet scrubbers, fabric filters and electrostatic precipitators.	2	2
3	**Noise pollution**	**4**	
3.1	Sources	1	7
3.2	Effect of noise pollution on materials, animals and humans.	1	7
3.3	Sonic boom- causes and effects	1	7
3.4	Abatement strategies	1	7
4	**Water pollution**	**35**	
4.1	**Organic pollution**	**15**	
4.1.1	Origin and sources of organic pollutants – Biodegradable and non-biodegradable; Domestic, agricultural and industrial sources, Effects of organic pollution on aquatic systems, Eutrophication – Sources and effects.	5	2
4.1.2	Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and its relevance as a measure of water pollution	5	2
4.1.3	Biocides, fungicides and herbicides - Sources and effects	2	2
4.1.4	Bio magnification: Toxic effects on non-target organisms and hazards to man	3	2
4.2	**Industrial pollution**	**20**	
4.2.1	Heavy metals-Effects of various heavy metals (such as Hg, Pb, Cd, As, Cr, Zn, etc) in the ecosystem and human population	4	2
4.2.2	Fluoride pollution on human life	2	2
4.2.3	Thermal pollution-sources, effects and control.	2	2
4.2.4	Oil spills-sources, effects and control.	2	2
4.2.5	Water pollution abatement technology- Primary systems- Screens, Grit chamber, Sedimentation tank, Secondary system- aerated lagoons, oxidation pond activated sludge process, trickling filters and tertiary treatment systems- sludge digestion Desalination	10	2
5	**Radioactive Pollution**	**5**	
5.1	Sources of nuclear radiation	2	7
5.2	Biological effects of ionizing radiations and non-ionizing radiations.	1	7

5.3	Nuclear waste disposal	2	7
6	**Terrestrial Pollution**	**10**	
6.1	Sources and causes of land pollution	2	4
6.2	Solid wastes and disposal (garbage, ashes, rubbish, street litter, agricultural waste, mining waste and industrial wastes). Biomedical waste: classification and handling (brief account)	6	4
6.3	Strategies for control of solid waste pollution	2	4
7	**Environmental Physiology**	**25**	
7.1	**Temperature adaptations**	**5**	
7.1.1	Morphological and physiological adaptations: Relation between body size and metabolic rate. Temperature and metabolic rate: Thermal acclimation; Enzymatic acclimation in extreme temperatures	3	8
7.1.2	Thermal migration	1	8
7.1.3	Implications of global warming on animals.	1	8
7.2	**Pressure adaptations**	**5**	
7.2.1	Adaptations to hyper baric stress with particular reference to deep sea organisms.	2	8
7.2.2	Biochemical mechanisms of animals to high altitudes (hypo aria and hypoxia)	3	8
7.3	**Osmoregulation and ionic regulation**	**5**	
7.3.1	Osmoregulation in fresh water, marine estuarine and terrestrial animals	3	8
7.3.2	Sodium pump, Na+/K+ ATPase in relation to salinity adaptations.	2	8
7.4	**Eco-physiological adaptations**	**10**	
7.4.1	Echolocation	3	8
7.4.2	Bio-luminescence	3	8
7.4.3	Electric organs	4	8

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APZO 422: ENVIRONMENTAL MANAGEMENT
(100 Hrs)

CO No.	Expected course outcomes *Upon completion of this course, the students will be able to:*
1	List out environmental resources and influence of man on environment
2	Elaborate various tools and techniques for the study of environment
3	Describe and implement different strategies of biodiversity management.
4	List out the International and National Treaties of Biodiversity conservation
5	Explain the importance of environmental education and environmental management
6	Explain the principles and importance of sustainable development.
7	Describe pollution abatement technologies

MODULE	COURSE DESCRIPTION	Hrs	CO No.
1	**Resources of Earth**	**10**	
1.1	Renewable and non-renewable resources	1	1
1.1.1	Fossil fuels, minerals-their over-exploitation for domestic, agricultural and industrial purposes.	2	1
1.1.2	Water resources-protection of water shed, reclamation of sewage and waste and water management in India.	3	1
1.2	Conservation of natural resources	2	1
1.3	Remote sensing for resource management- GIS, Application of GIS in resource management(brief account)	2	2
2	**Biodiversity – Concepts and biogeographic zones of India**	**14**	
2.1	**Prerequisite:** Introduction: Definition, levels of biodiversity (genetic diversity, species diversity and ecosystem diversity), values of biodiversity (self study). Alpha diversity, Beta diversity and Gamma diversity.	2	3
2.2	Techniques for biodiversity Estimation- Diversity indices: Richness, Shannon-Weiner index, Simpson's index, Berger-Parker Index Species diversity and ecosystem stability.	5	3
2.3	**Biodiversity in India: Major biogeographic zones of India-** 1: The Trans-Himalayas, 2: The Himalayas, 3: The Indian Desert, 4: The Semi-Arid, 5: TheWestern Ghats (Biodiversity Hot Spot), 6: The Deccan Peninsula, 7: The Gangetic Plain, 8: North-East India, 9: The Islands	7	3

	10: The Coasts India as a mega diversity nation; hot spots of biodiversity (brief account).		
3	**Biodiversity Conservation and Management**	**13**	
3.1	*Depletion of biodiversity:* Current estimates of species loss. Causes of biodiversity loss- habitat destruction, deforestation, Invasive Alien species , Impacts on biodiversity) Ecological impacts of intensive aquaculture.	5	3
3.2	*Strategic species concepts:* Keystone species, Ecosystem engineer, Indicator species and umbrella species, Flagship species.	2	3
3.3	*Strategies of conservation: in situ*- biospheres reserves, National parks, nature reserves, sancturies and *ex situ* conservation-, botanical gardens, zoos, aquarium, homesteadgarden; herbarium. In-vitro Conservation: Gene Banks,Germ plasm bank, tissue culture (breif account) Conservation of wild life, establishment of protected areas, habitat conservation, captive breeding, pollution control.	4	3
3.4	Biodiversity registering and patenting of biodiversity	2	3
4	**Conventions & Treaties for Conservation of Biodiversity**	**13**	
4.1	Stockholm declaration on human Environment (1972), World conservation strategy (1980), Convention on Regulation of Antarctic Marine Resources Activities (RAMRA, 1986), Moduleed Nations World Charter for Nature (1982), Kyoto Protocol and Framework Convention on Climate Change (UNFCCC). Brundtland Report (1987).	3	4
4.2	Earth summit (1992) – detailed study - Rio Declaration on Environment and Development, Agenda 21, Forest Principles, Convention on Biological Diversity.	2	4
4.3	*Species based treaties:* Migratory Bird Treaty Act (MBTA) of 1918, International Convention for the Regulation of Whaling (ICRW), Washington, 1946, Convention on International Trade on Endangered Species (CITES, 1975).	3	4
4.4	*Ecosystem based treaty:* Ramsar Convention (1981) – Ramsar sites in India and Kerala	2	4
4.5	An evaluation of the “Project Tiger” and “Project Elephant” programmes. (brief account) National Biodiversity Action Plan 2008: a brief outline of objectives & plans	3	4
5	**Environmental Policy and Education**	**15**	

5.1.1 5.1.2	*Environmental policy*-social, economic and legal aspects. *Environmental laws*- The Water (Prevention and Control of Pollution) Act of 1974, The Air (Prevention and Control of Pollution) Act of 1981, The National Green Tribunal (NGT) Act, 2010, W ild Life (Protection) Act 1972, Biodiversity Act, 2000,	10	5
5.2	*Environmental awareness*-role of Government, media and voluntary organizations	5	5
6	**Environmental Impact Assessment and Sustainable Development**	**15**	5
6.1	**Environmental Impact Assessment (EIA)**		5
6.1.1	Definition, aim, principles and concepts of EIA	2	5
6.1.2	Elements of environmental impacts	2	5
6.1.3	Methods for preparing EIA-Check list method	2	5
6.1.4	EIA Process making inventories, sampling and data processing, impact prediction and stimulation.	3	5
6.2	**Sustainable Development**		
6.2.1	Our common future. Concepts and Principles of sustainability	2	6
6.2.2	The 2030Agenda for sustainable development.	2	6
6.2.3	Criteria for Sustainable development- population growth control, poverty reduction, agricultural sustainability, protection of forest and other habitats, water and energy sustainability	2	6
7	**Environmental Biotechnology**	**20**	
7.1	**Pollution abatement using microbes introduction**	1	
7.1.1	Sewage treatment	3	7
7.1.2	Solid waste disposal	3	7
7.2	Soil enrichment by using microbes	2	7
7.3	Genetic engineering of nitrogenase gene (‘nif’ genes) and nodulation genes.	3	7
7.4	Microbial insecticides : Insecticidal toxin of *Bacillus thuringiensis.* Baculoviruses as biocontrol agents and their genetic engineering for improved biocontrol.	8	7

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PRACTICAL - III

APZO 4P III: Microbiology, Biotechnology, Immunology & Developmental Biology, Ecology and Ethology

CO No.	Expected course outcomes *Upon completion of this course, the students will be able to:*
1	Familiarise the technique of isolation and characterisation of Bacteria from soil and water
2	Prepare medium for microbiology and Cellculture and will be able to culture microbes and cells
3	Maintain cell culture and microbiology lab
4	Explain Antigen-antibody interactions and Concepts of immunology
5	Identify different types of eggs and developmental stages of an embryo
6	Estimate Primary productivity and can describe ecological adaptations
7	Correlate behaviour with physiology

MODULE	COURSE DESCRIPTION	CO No.
A	**Microbiology & Biotechnology**	
1	Techniques for Isolation of bacteria – serial dilution, pour plate, spread plate techniques	1
2	Enumeration of bacteria from water and soil	1
3	Motility Testing – hanging drop method	1
4	Gram staining	1
5	Determination of quality of milk – methylene blue reductase test	1
6	Biochemical tests – catalase test, kovac's oxidase test, gas production etc	1
7	Water quality testing – MPN method, membrane filter method	1
8	Antibiotic sensitivity testing – Kirby Bauer test	1
9	Isolation of DNA from plant/animal tissue	1
10	Plasmid isolation	1
11	Care and maintenance of microbiology and cellculture lab and glasswares	3
12	Medium preparation for microbiology and cell culture	2
13	Primary cell culture	2
14	Lymphocyte isolation ,culturing , cell counting	2
15	Cell viability- Trypan blue	2
16	Cryopreservation	2
17	Cytotoxicity assay- MTT assay,staining techniques	2
B	**Immunology**	
1	Antigen-antibody interaction in vitro and identification of blood groups	4
2	Blood film preparation and identification of cells	4
3	Enzyme Linked Immunosorbent Assay (ELISA)	4

4	Immuno-diffusion and Immuno-electrophoresis	4
C	**Developmental Biology**	
1	Induced ovulation and artificial fertilization (any model)	5
2	Preparation of temporary whole mounts of chick blastoderm	5
3	Vital staining of chick blastoderm and tracing the development of stained parts (window method)	5
4	Effect of drugs on heart beat of chick embryo	5
5	Study of different types of eggs: insect egg, frog's egg, hen's egg, mammalian egg- using models/charts	5
6	Morphological and histological studies of different placental types of mammals (3 numbers)	5
7	Identification of cross sections of chick embryo through heart, eye and ear	5
D	**Ecology and Ethology**	
1	Estimation of Primary productivity using dark and light bottles	6
2	Description of ecological adaptations of any 10 organisms	6
3	Habituation in *Pila* / alarm response in ants or fishes / maize learning in rats	7

PRACTICAL - IV

APZO 4 P IV: Pollution Biology & Environmental Physiology

(10 Practicals to be carried out)

CO No.	Expected course outcomes *Upon completion of this course, the students will be able to:*
1	Analyse the physicochemical properties of water and soil samples
2	Determine LC50
3	Estimate pollution of water and soil and can explain the effects of pollution on living organisms

MODULE	COURSE DESCRIPTION	CO No.
1	Analysis of soil texture using micrometry	1
2	Determination of moisture content of soil	1
3	Determination of soil pH (different soil samples)	1
4	Determination of organic carbon	1
5	Determination of porosity/water retaining capacity of soil	1
6	Determination of chlorine in water	1
7	Determination of H2S in water	1
8	Determination of Ammonia in water	1
9	Short term bioassays and determination of LC50 of fish exposed to a given pollutant	2
10	Effect of soil pollution on the population of earthworms	3
11	Study of indicator organisms	3
12	Effect of pollution on the Oxygen consumption of fishes	3
13	Temperature/pH preferences of fishes	3
14	Field work-Students are expected to make a field study on the problem of environmental pollution in their area	3

PRACTICAL - V

APZO 4 P V: Environmental Management & Biodiversity Conservation

(10 Practicals to be carried out)

CO No.	Expected course outcomes *Upon completion of this course, the students will be able to:*
1	Analyse the properties of water samples
2	Explain the principles, use and working of instruments used in water quality analysis
3	Estimate BOD and COD of polluted water
4	Estimate biodiversity and can calculate biodiversity indices
5	Get practical experience in construction of ecological pyramid

MODULE	COURSE DESCRIPTION	CO No.
A	**Environmental Management**	
1	Determination of pH of water	1
2	Determination of electrical conductivity of water	1
3	Determination of turbidity of water	1
4	Determination of salinity of water	1
5	Determination of hardness of water	1
6	Determination of BOD and COD of polluted water	3
7	Instrumentation: Principles, use and working of the following instruments. 7.1 pH meter 7.2 Electrical conductivity meter. 7.3 Flame photometer 7.4 Hygroscopic soil thermometer.	2
8	Estimation of primary productivity (Chlorophyll method)	1
9	Estimation of secondary productivity	1
10	Construction of pyramids of numbers and biomass from a pond collection	5
B	**Biodiversity Conservation**	
1	Species diversity estimation with reference to a fresh water pond/soil	4

2	Study of biodiversity indices: Population Density and relative density Frequency and relative frequency Abundance and distribution Modified similarity Index Shannon-Wiener Index	4
3	Composition assessment of the Taxonomic diversity/biodiversity in a habitat (grass land, wet land, etc.)	4
4	Assessment of Invertebrate and Vertebrate diversity in your locality (e.g. campus).	4
5	Quantitative estimation of plankton	4
6	Poster Presentation on a relevant topic (e.g. International conventions and treaties, species interactions, biodiversity loss, etc.)	4