CHOICE BASED CREDIT SYSTEM (CBCS)

Department of Zoology, University of Kalyani

Effective from 2021-2022Session

Semester wise Details of M.Sc. (Zoology) Course & Course Credit

SEMESTER–IV

Course Name	Paper	Points	Credit	Hours /Week
Theory (Core)				
ZCORT-411	Animal Behaviour and Microbiology	75	6	4
ZCORT-412	Molecular Biology, Biotechnology, Tools and Technique	75	6	4
Theory (Discipline Specific Elective - Minor) (any two)				
ZDSE(MN)T-407	Agricultural Entomology	25	2	1
ZDSE(MN)T-408	Cancer Biology and Medical Genetics	25	2	1
ZDSE(MN)T-409	Medical Embryology	25	2	1
ZDSE(MN)T-410	Aquaculture Technology	25	2	1
ZDSE(MN)T-411	Hormone and Signal Transduction	25	2	1
ZDSE(MN)T-412	Parasites and Diseases	25	2	1
Theory (Discipline Specific Elective - Major) (any one)				
ZDSE(MJ)T-403	Fish and Fisheries, Cytogenetics & Mol. Biology, Endocrinology & Rep. Biology, Parasitology &Immunology, Entomology, Cell & Development Biology	50	4	3
ZDSE(MJ)T-404	Fish and Fisheries, Cytogenetics & Mol. Biology, Endocrinology & Rep. Biology, Parasitology & Immunology, Entomology, Cell & Development Biology	50	4	3
Practical (Core)				
ZCORL-411	Animal Behaviour and Microbiology	25	2	3
ZCORL-412	Molecular Biology, Biotechnology, Tools and Technique	25	2	3
Practical (Discipline Specific Elective - Major)				
ZDSE(MJ)L-402	Discipline Specific Elective - Major (Lab)	50	4	3
	Project/ Dissertation			
ZDSEP-402	Project/ Review work/ Dissertation	100	8	1
Total points & Credits in Semester IV		500	40	30

SEMESTER–IV

THEORY (CORE)

Course Objectives:

The major objective of this core paper is to understand languages of animals by means of their behavioral study.

The paper microbiology deals with various types of microorganisms and their ability to produce disease in animals and human. Besides, this course is also to make awareness among the young students about various disease-causing microorganisms.

ZCORT-411: Animal Behaviour and Microbiology	**Points 75**
Animal Behaviour	**Points 37** **Lectures**
1. Introduction to animal behavior: History, foundation, approaches and methods	**5**
2. Learning and memory: Forms of learning and memory, learning and habitat selection - migration, navigation and orientation	**5**
3. Kinship: Relatedness, inclusive fitness. selfishness, altruism	**4**
4. Conflict: Sexual selection, aggression, competition dominance, Infanticide.	**5**
5. Game theory - Models and strategies.	**5**
6. Communications: Channels, functions, origin and modification of signal, signal receiving mechanism.	**6** **7**
7. Evolution of feeding behavior: optimal foraging theory.	
Microbiology	**Points 38** **Lectures**
1. History of microbiology.	2
2.Bacteriology: Structure and function of capsule, pili, flagella, cell wall, cell membrane, outer-membrane, chromosome and plasmid.	6
3. Virology: Structural organization of viruses, Prions and viroids, Lytic cycle of bacteriophages, Lysogeny and lysogeny control, lysogenic conversion, induction and significance.	6
4. Animal and Veterinary Microbiology:	
Microbial interactions with animals (marine and freshwater invertebrates, ruminants), symbiotic light production, sulfide-based mutualism.	8 6
5. Disease causing microbes: *Escherichia coli* and *Streptococcus* spp.	2
6. Culture techniques: Microbial nutrition and growth; types of culture media, sterilization of culture media; culture techniques: pure cultures.	
8. Industrial microbiology: Microbial fermentation; production and commercialization.	8
9. Mode of transmission, pathogenicity and prevention of microbial diseases: Air-borne (Tuberculosis), Food and waterborne (Typhoid) and Arthropod borne (JE and Yellow fever), SARS-COV 2 (infection and concept of herd immunity).	

Suggested Literature:

1. Animal Behavior. Alcock J. Sinauer Associate Inc. USA (latest edition).

2. Animal behavior. Drickamer LC. Vessey SH. Mc. Graw-Hill (latest edition).
3. Recent trends in animal behavior. Ruhela A and Sinha M. Oxford (latest edition).
4. Animal Behavior. Mathur. Rastogi Pub (latest edition).
5. Microbiology an introduction. Gerard JT, Berdell RF and Christine LC. Pearson Education. (Latest edition)
6. Essentials of microbiology. Amita J &Parul J. Elsevier (Latest edition).
7. Text book of microbiology and immunology. Parija SC. Elsevier (Latest edition).
8. Text book of microbiology. Ananthanarayan R and Paniker CKJ. Universities press.
9. Microbiology with diseases by taxonomy. Bauman Robert W. Pearson Education (latest edition).
10. Medical microbiology and parasitology. Nagoba BS & Asha P. Elsevier India. (Latest Edition).

Course Learning Outcomes:

After successful completion of this course the students will be able: to understand animals' complicated behaviour, degree of inter-specific and intra-specific relationship among the animals, to know the facts behind learning and memory.

Learn to maintain their hygienic environment and know about biology of microorganisms and their interaction with animals and human.

Course Objectives:

Major objective of this core paper is to introduce to the students contemporary molecular techniques for manipulation of genome that could assist them towards advanced understanding of biological processes in broad range of host organisms. Lectures will specifically address the historical standard techniques, principles of various different fundamental processes, and gradual evolution and context dependent medications of molecular techniques for their extended use. The student should be able to understand standard and system-specific gene manipulation approaches ranging from bacteria to mammals. A prior exposure to recombinant DNA technology at undergraduate will help in the accelerated learning.

Tools and Techniques course is meant to impart knowledge to students on different techniques in Biological Sciences. The course is designed in such a way that the students get to understand the various different techniques that are used in biology; from the classical age-old methods to the present-day modern versions of various techniques. The course also deals with bioinformatics which would provide the students the confidence to use computer programs/ softwares for the daily design of experiments, data collection, and analysis of results.

ZCORT-412: Molecular Biology, Biotechnology, Tools and Technique	**Points 75**
Molecular Biology and Biotechnology	**Points 37** **Lectures**
1. Transcriptional gene expression: positive and negative regulations, RNA polymerases, promoters and regulatory sequences, activators and repressors of transcription, transcription initiation by RNA polymerases, regulation of transcription factor activity, elongation and termination of transcription.	**5**
2. Post-transcriptional gene control: Regulation of Pre-mRNA Processing; Splicing, Types of introns and their splicing, evolution of introns,	**5**

catalytic RNA, alternative splicing and proteome diversity, micro RNA and other non-coding RNAs. 3. RNA Transport, Translation and stability of RNA: Structure of nuclear membrane and nuclear pore complexes, processes of nuclear import and export and their regulation; Degradation of RNA; Translational machinery and translational control - energetics of amino acid polymerization, tRNAs and their modifications, aminoacyl tRNA synthetases, accuracy during aminoacylation of tRNA, regulation of initiation of translation in eukaryotes, elongation and its control, inhibitors of translations. 4.Basic recombinant DNA techniques: cutting and joining DNA molecules, restriction modification systems, various enzymes used in recombinant DNA technology, restriction maps and mapping techniques; nucleic acid probes, blotting techniques, DNA fingerprinting, foot-printing, methyl interference assay. Polymerase chain reaction– methods and applications. 5. Basic biology of cloning vectors: plasmids, phages, single stranded DNA vectors, high capacity vectors, retroviral vectors, expression vectors and other advanced vectors in use. Gene cloning strategies: methods of transforming E. coli and other cells with rDNA; methods of selection and screening of transformed cells; construction of genomic and cDNA libraries; strategies of expressing cloned genes; phage display. 6. Manipulating genes in animals: gene transfer to animal cells, genetic manipulation of animals, transgenic technology, application of recombinant DNA technology; genetically modified organisms: gene knockouts, mouse disease models, gene silencing, gene therapy, somatic and germ- line therapy, Genome manipulation-CRISPR-Cas9 System.	**6** **6** **8** **7**
Tools and Technique	**Points 38** **Lectures**
1.Techniques for Cell Study: i. Basic Concepts of Microscopy: Magnification, Resolution, Limit of Resolution, Chromatic Aberrations. Types of microscopies: Bright Field Microscopy, Dark Field Microscopy, Phase Contrast Microscopy and Differential Interference Contrast Microscopy: Fluorescent Microscopes, Confocal microscopy. ii. Electronic Imaging Systems- Electron Microscopy, TEM Vs. SEM. Different fixation and staining techniques for EM, freeze-etch and freeze-fracture methods for EM, image processing methods in microscopy. iii. Basic concept of flow cytometry. 2. Cell Fractionation Methods: i) Ultracentrifugation ii) Gradient Centrifugation. 3. Separation of Cell Constituents: i) Chromatography: ion exchange; gel filtration and HPLC. ii)Electrophoresis-PAGE, SDS-PAGE (One and Two dimentional).	8 4 4

4. Methods for analysis of gene expression at RNA and protein level, large scale expression, such as micro array based techniques.	4
5. Spectroscopy: UV- spectroscopy, Circular Dichroism, surface plasma resonance methods.	4
6. Blotting Methods: Southern, Northern & Western blotting. RFLP, RAPD and AFLP techniques.	4
7. Pesticide formulation.	5
8. Database search tool; Sequence alignment and database searching; Computational tools and biological databases, NCBI, EMBL, PDB,Sequence similarity tools; Blast and FASTA Phylogenetic analysis with the program PHYLIP, DISTANCES, and GROWTREE. Basics of designing a microarray, image analysis and normalization, annotations.	5

Suggested Literature:

1. Recombinant DNA: Genes and Genomics – a short course, Watson et al., W. H. Freeman and Company, New York, USA [Latest edition].
2. Principles of Gene Manipulation and Genomics, Primrose, S. B. and Twyman, R.M., (7th Ed. 2006), Blackwell Publishing, West Sussex, UK.
3. Cell and Molecular Biology. DeRobertis and De Robertis
4. Molecular Biology of the Gene, 2017, James D. Watson, A. Baker Tania, P. Bell Stephen (Author), Gann Alexander, Levine Michael, Losick Richard
5. Biochemistry Laboratory: Modern Theory and Techniques, 2nd Edition, ISBN-13: 9780136043027
6. Principles of Genetics, 7th Edition, D. Peter Snustad, Michael J. SimmonsISBN: 978-1-119-14228-7 2015
7. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 2018, ISBN: 9781316677056
8. Biochemistry Laboratory: Modern Theory and Techniques, Latest Edition, Rodney Boyer, Pearson Prentice Hall™ is a trademark of Pearson Education, Inc.ISBN-10: 0-13-604302-X, ISBN-13: 978-0-13-604302-7

Course Learning Outcomes:

After successful completion of the course the candidate should be able to design and comprehend experimental strategies for alteration of genes and gene products in variety of organisms.

The students will be able to have a comprehensive understanding about the techniques widely used in biological research and clinical understanding. At the end of the course, they would gain knowledge about the techniques and experiments that contributed to the understanding of molecular mechanisms of the cellular processes and be able to draw parallels between the physiological processes at the cellular and organismic levels. They will have in depth understanding of this rapidly changing field of modern biology and fast evolving tools and techniques for analysis of macromolecules, cells as well as understanding how bioinformatics can act as an efficient research tool.

THEORY (DISCIPLINE SPECIFIC ELECTIVE - MINOR)

ZDSE(MN)T 408: Cancer Biology and Medical Genetics	**Points 25** **Lectures**
1. Multistep tumorigenesis; Cell immortalization; Differences of normal cells and cancer cells; cell transformation and factors for cell proliferation; DNA and RNA tumor viruses.	5
2. Chromosomal abnormalities and molecular basis of cancer; Knudson's two-hit hypothesis in tumorigenesis; Genome instability in cancer;Epigenetics of Cancer; Cancer diagnosis, screening and treatment.	5
3. Genetic disease diagnosis and treatment: Application of medical genetics; Genetic Testing, Cytogenetic, Biochemical and Molecular; Gene therapy.	5
4. Pharmacogenomics - Concepts of Pharmacogenomics; Pharmacogenetics in disease prognosis and treatment, response and toxicity; Nutrigenomics; Personalized medicine.	5
5. Concept of nanotechnology and nanomedicine in cancer treatment.	5
Suggested Literature: **1.** Human molecular genetics. T Strachan and A P Read CRC press fifth edition **2.** Molecular cell biology. H Lodish, CA Kaiser et al WH Freeman and Company Seventh edition. **3.** Nanotechnology: advances and real-life application. C Bhargava, A Sachdeva CRC press 2020 First edition **4.** Handbook on nanotechnology application. K Faungnawakij et al Elsevier publication 2020 first edition	
Course Learning Outcomes: This course will decipher current knowledge on disease treatment including cancer.	
Course Objectives: The course has been design to cover several diagnostics and treatment strategies used in medical sciences in the light of embryological perspectives	
ZDSE(MN)T 409: Medical Embryology	**Points 25** **Lectures**
1. Medical implications : Infertility- Diagnostic infertility, causes of infertility	5
2. Assisted Reproductive Technologies: Sperm and ova bank; Artificial Insemination donor (AID); in vitro fertilization (IVF), procedures, variations of IVF, Success rates and complications; Gamete Intrafallopian transfer (GIFT), Intracytoplasmic sperm Injection (ICSI), Surrogate mothers.	5
3. Genetic errors of human development- Down syndrome, Fragile X syndrome, Turner's Syndrome.	5
4. Future of medicine: Differentiation therapy, gene therapy (Ex Vivo and In vivo), germ line gene therapy.	5
5. Techniques used in Medical Embryology :i) Amniocentesis ii) Chorionic villus sampling iii) Ultrasonography iv) DNA Finger printing v) Karyotyping	5
Suggested Literature: 1. Developmental Biology: Michael J.F. Barresi Scott F. Gilbert,(12 th Ed). 2. Principles of Development: Lewis Wolpert and Cheryll Tickle (4th Ed.). 3. Principles of Genetics. 3rd Ed. D. Peter Snustad and Michael J. Simmons. Wiley Publication.	

4. iGenetics: A molecular approach. 3rd Ed. Peter J. Russell. Pearson International Edition.
5. Biology of human reproduction. Ramon Pinon Jr. University Science Book publishers.

Course Learning Outcomes:

The students shall have an overall idea in the area of medical sciences which have been explored in diagnostic and therapeutic application in embryologic stage.

Course Objectives:

To enable the students to know about the Stock Improvement of fish, Non conventional aquaculture technology, Pheromones and reproductive behaviour, Physiology of fish migration and behaviour and Coastal aquaculture.

ZDSE(MN)T 410: Aquaculture Technology	**Points 25 Lectures**
1. Stock Improvement: Induced breeding and bundh breeding, sex reversal and sterility, Selective breeding, Androgenesis and Gynogenesis, Polyploidy, Hybridization, Shell fish reproduction: Endocrine control of reproduction, role of neurotransmitters.	4
2. Non conventional aquaculture technology: Raceways and recirculatory system, Cages and pen culture, Wastewater aquaculture Organic aquaculture, Aquaponics and hydroponics, Biofloc culture.	4
3. Pheromones and reproductive behaviour, parental care. Regulation of seasonal reproduction: Role of environment (photoperiod, temperature, rainfall), Role of hypothalamo-hypophyseal system and pineal gland, role of peripheral endocrine system.	4
4. Physiology of fish migration and behavior: Behavioral response to the environment. Circadian rhythm. Hormones in communications, pheromones, concept on fish behavior and regulatory mechanism.	4
5. Coastal aquaculture: Status of coastal aquaculture in India,	
Culture of prawn: major cultivable species, techniques of larval rearing, growout technology.	4
Culture of shrimp: major cultivable species, Reproduction and rearing Grow out of shrimp.	5

Suggested Literature:

1. Bardach, J. E. and Ryther, J. H. (1972). *Aquaculture*. John Wiley and Sons.
2. Beaumont, A. R. and Hoare, K. (2003). *Biotechnology and Genetics in Fisheries and Aquaculture*. Blackwell Publishing.
3. Jhingran, V. G. (1991). *Fish and Fisheries of India*.3rd ed. Hindusthan Pub. Corp. John Wiley and Sons.
4. Pillay, T. V. R. and Kutty, M. N. (2005). Aquaculture Principles and Practices. 2nd ed. Blackwell Publishing Ltd.
5. Chakraborti, N.M.; Chakraborty, P. P. and Mandal, S. C. (2010). *Biology, Breeding and Farming of Important Food Fishes.* Narendra Publishing House. New Delhi.
6. Lagler, K. F., Bardach, J. E., Miller, R. R. and Passino, D. R. (1977). *Ichthyology*.2nd ed. John

Course Learning Outcomes:

At the completion of Aquaculture Technology, students will be able to:

K now about different technology of Aquaculture that will help to their research activity and also in practical life if they are engage in fish farming related activity.

Course Objectives: The course will provide detailed knowledge about various types of hormones and their mechanism of action.	
ZDSE(MN)T 411: Hormone and Signal Transduction	**Points 25** **Lectures**
1.Wnt, Hedgehog, TGFβ, Notch signalling pathways. 2.Subclasses of nuclear receptor ligand, Nuclear Receptor Signalling Mechanism. 3.Hormones in tumorigenesis. 4.Immune response and cancer therapy with special emphasis on hormonal therapies. 5. Neuroendocrine regulation of immune system; Stress hormones and immune responses; Melatonin. 6. Neuroendocrine disorders; genetic versus environmental cause.	4 4 4 4 4 5
Suggested Literature: 1. Vertebrate endocrinology-Norris DO. Elsevier academic press (latest edition). 2. Basic endocrinology, an interactive approach-Neal JM. Blackwell Science (latest edition). 3. Endocrine physiology-Molina PE. McGraw Hill Lange (latest edition). 4. Medical immunology-VirellaG. Informa Health care(latest edition). 5. Immunology-Kindt TJ, Goldsby RA, Osborne BA &Kuby J. WH Freeman & Co.	
Course Learning Outcomes: At the end of the course the students will –gather concept of various types of hormones & their receptors, be able to understand deep knowledge about hormone signalling and know about neuroendocrine disorders as well as its regulation by immune system.	
Course Objectives: The course examines the general biology, life cycles, modes of transmission, and pathogenesis of major parasites on global human health. The students would be able to learn about transmission, epidemiology, diagnosis, clinical manifestations, pathology, treatment and control of major protozoan, helminths and arthropod parasites.	

THEORY (DISCIPLINE SPECIFIC ELECTIVE – MAJOR I)

Course Objectives: Epigenetic alterations are heritable changes in gene expression that occur without causing any change in DNA sequences. This course is oriented about the progression of scientific knowledge using different model organisms as well as the mechanism underlying epigenetics. This course will give a vivid idea about the transposition mechanism and transposition related to cancer. This course contains the subject on intriguing features of human evolution with transposition. The content of syllabus having the point on extra chromosomal inheritance will focus on mitochondrial inheritance and related disorders.	
ZDSE(MJ)T 403: Cytogenetics and Molecular Biology	**Points 50** **Lectures**
Unit I **Epigenetics**	
1. A brief history of epigenetics - overview and concepts; Chromatin Structure, Chromatin modifications and their mechanism of action, types and mechanism of chromatin remodelling; concept of 'histone-code' hypothesis.	7

2. Epigenetics in saccharomyces cerevisiae, position effect variegation, heterochromatin formation, and gene silencing in Drosophila, fungal models for epigenetic research: *Schizosaccharomyces pombe* and *Neurospora crassa*; RNAi and heterochromatin assembly, role of noncoding RNAs;	7
3. Chromatin structure and epigenetics marks - transcriptional silencing by polycomb group proteins, transcriptional regulation by trithorax group proteins, histone variants and epigenetics, epigenetic regulation of chromosome inheritance, epigenetic regulation of the X chromosomes in *C.elegans*, dosage compensation in Drosophila, dosage compensation in mammals.	7
4. Epigenetics and genome imprinting - DNA methylation in mammals, genomic imprinting in mammals, nuclear transplantation and the reprogramming of the genome. epigenetics and human disease, epigenetic determinants of cancer.	7
Unit II **Transposons and Extra-nuclear inheritance**	
1. Mobile genetic elements: Characteristics of transposable elements in prokaryotes and eukaryotes; AC/DS system in maize; P element in Drosophila; Salmonella phase variation; retrosposons	7
2. Extra-nuclear inheritance: Streptomycin resistance in chlamydomonus; Kappa particles; criteria for extra-chromosomal inheritance, infectious heredity.	7
3. Recombination: Homologous recombination, Mechanism of recombination in bacteria and mammals, Gene conversion, Classes of recombinases and types of site-specific recombination, Transpositional recombination, Mitotic and meiotic recombination, Recombination and genomic instability, Application in genetic engineering.	7

Suggested Literature:

1. Genetics. R J Brooker McGraw Hill publication. Fourth edition
2. Review of Epigenetics: A reference manual by J M Craig and N C Wong 2021 NCBI
3. Epigenetics and cancer. Z Herceg and T Ushijima Academic press 2020
4. Extrachromosomal inheritance. JL Jinks. Prentice Hall foundation of Modern genetics series.
5. Lewin's Genes XII .Jones and Barlett publisher Inc. 2017.

Course Learning Outcomes:

This part of syllabus will enhance the knowledge on epigenetics and related mechanisms basically of the students who are studying Cytogenetics and molecular biology as specialization.

Course Objectives:

To cultivate the essence of advancement in the developmental genetics, structure and function of genes and genomics, and aquatint the students with
recent advances in the epigenetics and trans generational inheritance which covers inheritance beyond genomics.

ZDSE(MJ)T 403: Cell and Developmental Biology	Points 50 Lectures
Unit-I **Gene expression during organogenesis**	
1. Genetic regulation during development: Gradients in early embryogenesis in Drosophila. Cell fate and differentiation, signaling pathways. Role of microtubules in development, Axis specification, Gap genes; pair rule genes, segment polarity genes; axis formation; homeotic genes; homeo-domains; Hox genes & HOM-c genes, Dosage compensation in *Drosophila* and in mammals; sex determination, developmental mutations in *Drosophila*. 2. Development of *C. elegans*: Asymmetric cell divisions and cell – cell interaction. Signaling pathways in vulval induction. Epigenetic regulation of the genetic material in *C.elegans*.	**16** **10**
Unit-II **Growth, development and Regeneration**	
1. Growth: Definition, pattern, factors influencing growth and development. 2. Post embryonic development- larval forms in *Xenopus*, environmental regulation of normal development. 3. Promising field of tissue repair and restoration, factors; Field action in regeneration. Sonic hedgehog and limb enhance-specification of antero-posterior pattern; Interaction between positional information and self-organization mechanism; mechanism of Shh signalling.	6 10 10
Suggested Literature: 1. Developmental Biology: Michael J.F. Barresi Scott F. Gilbert, (12 th Ed) 2. Principles of Development: Lewis Wolpert and Cheryll Tickle (4th Ed.)3. Principles of Genetics. 3rd Ed. D. Peter Snustad and Michael J. Simmons. Wiley Publication. 4. iGenetics: A molecular approach. 3rd Ed. Peter J. Russell. Pearson International Edition.	

THEORY (DISCIPLINE SPECIFIC ELECTIVE – MAJOR II)

Course Objectives:

This course content gives emphasis on developmental genetics and human population genetics. As research in this area spans a broad range of topics , approaches and experimental system, this course is oriented about the molecular aspect of genetic control of growth and development of organisms. The second unit gives emphasis on the fate of genes in space and time at the level of a reproducing population and its associated gene pool specifically human.

ZDSE(MJ)T 404: Cytogenetics and Molecular Biology	Points 50 Lectures
Unit I **Developmental genetics and Genomics**	
1. Genetic regulation during development: Gradients in early embryogenesis in Drosophila. Cell fate & signaling pathways. Gap genes; segment polarity genes; axis formation; homeotic genes; homeo-domains; Hox genes & HOM-c genes.	6

2. Medical implications of developmental genetics: Infertility, Teratogenesis, Stem cells and tissue engineering. 3. Structural genomics: Genome sequencing, High resolution genome mapping- radiation hybrid mapping; physical mapping of genomes, FISH 4. Functional genomics: Study of gene interaction by the yeast two-hybrid system; Protein-DNA interaction, ChIP Assay, Study of developmental regulation using DNA-chips, Loss of functional gene-Mutagenesis, RNAi, knockdown/knockout model. 5. Comparative genomics: Homologous genes-Orthologous, paralogous; Sequence homology; Evolutionary relationships, Phylogenetic analysis. Comparative genomics of bacteria, organelles, and eukaryotes.	5 5 6 6
Unit II **Population genetics**	
1. Allele frequencies and genotype frequencies: Hardy-Weinberg relationship 2. Haplotype frequencies and linkage disequilibrium, changing allele frequencies. 3. Population structure and inbreeding. 4. Evolutionary genetics: Origin of species, phylogenetic trees, molecular evolution, evolutionary developmental biology.	6 6 5 5
Suggested Literature: 1. Principles of developmental genetics. Sally A Moody Academic Press publication second edition 2. Developmental genetics. B Wilson. Scientific e resource. 2014 3. Principles of population genetics. D L Heart and AG Clark OUP USA Fourth edition 4. Population genetics: A concise guide. J H Gillespie John Hopkins University Press second edition.	
Course Learning Outcome: Students will get knowledge on genetic basis and advances in the research on early development and growth of organism. From the second unit they can be enlightened with the idea of genetic makeup in the environment and population.	

Course Objectives: The goal of this course is to provide students with education and training that enables them to make significant contributions to understand and tackle the different signaling mechanism involved in initiation and progression of multitude of metabolic processes. Students also learn about the current state of the epidemiology, clinical diagnosis, treatment, and prevention of human cancers.	
ZDSE(MJ)T 404: Cell and Developmental Biology	**Points 50** **Lectures**
UNIT I **Cell Synchronization**	
1. Physiology of cell division: Cell Cycle, synchrony in cell division, inhibition of cell division, source of energy.	**10**

2. Intracellular Signaling and Cell surface receptor Signaling a). G-proteins, G-protein-coupled receptors and their effectors, Receptor Tyrosine kinases (RTKs),Auto-phosphorylation of RTKs, initiation of MAP kinase signaling, JAK-STAT Signaling pathway, TGFβ Signaling pathway b) Intracellular receptors, steroid hormone signaling pathways	**10**
3.Characteristics of tumor cells; detection of tumor using CAT scan, MRI scan and fMRI scan, Oncogenes and their proteins, classification and characteristics of chemical carcinogen; role of radiation and DNA repair in carcinogenesis. Importance of nano-medicine in cancer therapy.	**10**
Unit-II **Cell Contact and Developmental Neurobiology**	
1.Cell -cell adhesion: types of cell binding, adhesive proteins, their role in cell-cell interaction, gap junctions, extracellular matrix, integrins differentiation movement of leucocytes into tissues.	**10**
2. Developmental neurobiology: General organization of nerve fibers, axon ultra structure, neurotubules and neurofilaments, neural induction, neurogenesis, emergence of central nervous system, neural tube polarity, program cell death during neuronal development, common neuronal disorders.	**10**
Suggested Literature: 1. Developmental Biology: Scott F Gilbert [Latest edition]. 2. Principles of Development: Louis Wolpert [Latest edition]. 3. Principles of Genetics. 3rd Ed. D. Peter Snustad and Michael J. Simmons. Wiley Publication. 4. iGenetics: A molecular approach. 3rd Ed. Peter J. Russell. Pearson International Edition. 5. The Cell: A molecular Approach. Geoffrey M. Cooper and Robert E. Hausman. 3rd Ed. ASM Press Washington, DC. 6. Molecular Cell Biology- 4th Ed. James E. Darnell, Harvey Lodish, Arnold Berk, Lawrence Zipursky, Paul Matsudaira, David Baltimore 7. Molecular Biology of the Cell. 4th Ed. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter.	
Course Learning Outcomes: The students should be well versed with the multi parametric cellular signaling pathways involved in metabolic pathways, their malfunctioning, their detection with the aid of recent sophisticated diagnostic tools with special emphasis to cancer biology which would encourage the students to pursue a research career in future.	

PRACTICAL (CORE)

Course Objectives: This lab course is intended to introduce students to Animal Behaviour and Microbiology. The course also will provide students with a hands-on training on microbiology.	
ZCORL 411: Animal Behaviour and Microbiology	**Points 25**
Animal Behaviour 1. Demonstration of behavioral change of fish /chick in relation to toxicant / chemicals. 2. Study of habituation to light stimulus in the earthworm.	

3. Demonstration of photo tactic response of house fly.	
Microbiology 4. Preparation of liquid media (broth) and solid media for routine cultivation of bacteria, Preparation of slant and stab. 5. Pure culture techniques: Spread plate, pour plate and streak plate. 6. Simple staining of bacteria and study of cell types; differential staining: Gram staining. 7. Biochemical tests for characterization: Catalase, Nitrate reduction, Indole production, Methyl red and Voges–Proskauer test. 8.Laboratory note book &Viva voce.	
Course Learning Outcomes: The course provides the students training on Animal Behaviour and Microbiology. Microbiological training will help to advantages on getting industrial job.	
Course Objectives: This lab course is intended to introduce students to standard biochemical techniques common in a molecular biology lab, such as Gel electrophoresis, DNA digestion, setting up genetic crosses, DNA and protein estimation etc. The course also will provide students with a hands-on understanding of how modern cell and molecular biology techniques can be used to discover and understand cellular function.	
ZCORL 412: Molecular Biology, Biotechnology, Tools and Technique	**Points 25**
Molecular Biology and Biotechnology 1. Setting up and solving of genetic crosses. 2. Demonstration of short term tissue culture. 3. Restriction enzyme digestion of plasmid DNA. 4. Demonstration of PCR Analysis and DNA Electrophoresis. **Tools and Techniques** 5. Centrifugation technique: Differential centrifugation for separation of nuclei, cell debris, mitochondria. 6. Colorimetric estimation of Protein, DNA/RNA. 7. Demonstration of PAGE. 8.Demonstration of PBMC isolation and counting under microscope. 9.Direct estimation of biochemical parameters of blood/urine using biochemistry analyser. 10. Formulation of commercially available pesticide. 11.Laboratory note book &Viva voce.	
Course Learning Outcomes: The course provides the students with the necessary training to enable them to understand theprinciples that underpin basic and applied research, and to translate that understanding into good researchpractice.	

PRACTICAL (DISCPLINE SPECIFIC ELECTIVE MAJOR)

Course Objectives:

This course content comprises the items for hands on experience of the students on different protein purification techniques.

In seminar presentation, is usually done in the form of review of the relevant literature in the respective field.

Cytogenetics and Molecular Biology	
ZDSE(MJ)L 402: Lab	**Points 50**
1. Localization of Ag- NORs, C-heterochrornatin in mouse chromosomes. 2. Isolation of Total RNA, determination of its purity and concentration. cDNA synthesis. 3. Demonstration of dosage compensation by study of sex chromatin in human buccal epithelial cell Smear. 4. Isolation of membrane proteins from mammalian cells through different chromatographic techniques. Separation of proteins using native and SDS gel electrophoresis. 5. Demonstration of ELISA. 6. Model scientific paper writing general rules. 7. Laboratory Notebook + Viva voce.	

Suggested Literature:

1. Protein purification techniques-a practical approach. Simon Roe OUP Oxford second edition, 2001
2. Culture of animal cells. A manual of basic techniques and specialized applications. R L Freshney Wiley-Blackwell seventh edition 2016.
3. Seminar papers . J B WeltonSr Broken Weather press 2016.

Course Learning Outcome:

The students also get exposed to the tissue culture methods and techniques of identification of proteins on paper and solution by antigen-antibody reaction.

After that the specific topic is presented through power point mode and the merit of the review paper is evaluated.

Course Objectives:

The course would help to inculcate in the students the urge to comprehend and relate the theoretical techniques with that of practical training. The curriculum has been designed to nurture their ideas, skill, and competency which would trigger their research outlook so that they may utilize their experience for their future research.

Cell and Developmental Biology	
ZDSE(MJ)L 402: Lab	**Points 50**
1. a) SDS-PAGE for separation of proteins, b) Western blot. 2. Demonstration of ELISA, cell culture techniques. 3. Estimation of % cellular cytotoxicity by Trypan blue method. 4. Immunohistochemistry for detection of protein. 5. Review on recent developments in cell biology and developmental genetics. 6. Laboratory notebook + viva voce.	

Course Learning Outcomes:

At the end of the course the students should be able to design research problems independently and find out the solution of the same. The overall training would help them to explore different molecular techniques which would definitely help them in their future research endeavor.