**Course Name : Master of Science**
**Discipline : Zoology**
**COURSE SCHEME:**
**(For those who joined in June 2023 and after)**

## II year M.Sc. ZOOLOGY

| Component | Subject | Hours | Credit |
|---|---|---|---|
| I Semester | | | |
| Core 1 | Structure and function of Invertebrates | 6 | 4 |
| Core 2 | Comparative anatomy of Vertebrates | 6 | 4 |
| Core 3 | Lab: Course in Invertebrates & Vertebrates | 6 | 4 |
| Elective 1 | Biostatistics | 4 | 3 |
| Elective 2 | Aquaculture | 4 | 3 |
| PCC | Intellectual Property Rights | 2 | 2 |
| AECC 1 | Sericulture | 2 | 2 |
| II Semester | | | |
| Core 4 | Cell and Molecular Biology | 7 | 4 |
| Core 5 | Biochemistry | 7 | 4 |
| Core 6 | Techniques in Biology | 6 | 4 |
| Core 7 | LAB – Cell and Molecular Biology | 3 | 3 |
| Core 8 | LAB – Biochemistry | 3 | 3 |
| NME | Economic Zoology | 4 | 4 |
| | Internship/ Industrial training* | 0 | 2 |

| Semester | Part | Subject Name | Hours | Credit | Int + Ext =Total | Local | Regional | National | Global | Professional Ethics | Gender | Human Values | Environment & Sustainability | Employability | Entrepreneurship | Skill Development | Subject Code | Revised / New / No Change / Interchanged & Percentage of Revision |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| III | Core 11 | **Immunology and Microbiology** | 6 | 4 | 25+75=100 | ✔ | | | | ✔ | ✔ | ✔ | ✔ | ✔ | - | ✔ | **P24ZYC31** | **New** |
| | Core 12 | **Molecular Genetics** | 6 | 4 | 25+75=100 | ✔ | | | | ✔ | ✔ | | | ✔ | ✔ | ✔ | **P24ZYC32** | **New** |
| | Core 13 | **Ecology and Evolution** | 6 | 4 | 25+75=100 | ✔ | | | | | | ✔ | | ✔ | | ✔ | **P24ZYC33** | **New** |
| | Core 14 | **LAB: Immunology and Microbiology** | 3 | 3 | 40+60=100 | ✔ | | | | | | ✔ | | ✔ | | ✔ | **P24ZYCP31** | **New** |
| | Core 15 | **LAB: Ecology and Evolution** | 3 | 3 | 40+60=100 | ✔ | | | | | | ✔ | | ✔ | | ✔ | **P24ZYCP32** | **New** |
| | Elective 2 | **Research Methodology** | 6 | 5 | 25+75=100 | ✔ | | | | | | ✔ | | ✔ | | ✔ | **P24ZYE31** | **Revised - 10 %** |
| | **Total** | | **30** | **23** | | | | | | | | | | | | | | |
| | **Internship Programme (Extra Credit)** | | **60** | **2** | | | | | | | | | | | | | **U24IP51** | |
| IV | Core 16 | **Developmental Zoology** | 6 | 4 | 25+75=100 | ✔ | | | | | | ✔ | | ✔ | | ✔ | **P24ZYC41** | **New** |
| | Core 17 | Animal Physiology | 6 | 4 | 25+75=100 | ✔ | | | | ✔ | ✔ | ✔ | ✔ | ✔ | - | ✔ | **P24ZYC42** | **Mark Change** |
| | Core 18 | **Animal Biotechnology** | 6 | 4 | 25+75=100 | ✔ | | | | ✔ | ✔ | | | ✔ | ✔ | ✔ | **P24ZYC43** | **Title Change** |
| | Core 19 | **LAB: Developmental Zoology** | 3 | 3 | 40+60=100 | ✔ | | | | | | ✔ | | ✔ | | ✔ | **P24ZYCP41** | **New** |
| | Core 20 | **LAB:** Animal Physiology | 3 | 3 | 40+60=100 | ✔ | | | | | | ✔ | | ✔ | | ✔ | P22ZYP42/ **P24ZYCP42** | No change |
| | Elective 3 | Project | 6 | 5 | 50+50=100 | ✔ | | | | | | ✔ | | ✔ | | ✔ | P22ZY4PV/ **P24ZY4PV** | No change |
| | **Total** | | **30** | **23** | | | | | | | | | | | | | | |

**SEMESTER: III**

| **CORE: 11** | **IMMUNOLOGY AND MICROBIOLOGY** | **SEMESTER: III** |
|---|---|---|
| ***Contact hours per Week – 6 hours*** | | ***Credits: 4*** |
| ***Contact hours per Semester – 90 hours*** | | ***Subject Code:*** **P24ZYC31** |
| **Course Outcomes:**<br>At the end of the semester students able to | | |
| **CO 1**: Recognize the structure and functions of various cells of the immune system. | | |
| **CO 2:** Familiarize with the mechanism involved in humoral and cell-mediated immunity. | | |
| **CO 3:** Illustrate the properties and functions of immunoglobulins and analyze and interpret the importance of vaccines in immune diseases. | | |
| **CO 4:** Gain the knowledge about the classification, Structure, Nutritional requirements and growth of Bacteria. | | |
| **CO 5:** Understand the impact of microorganisms in the health of human beings. | | |

**UNIT – I** **(15 Hours)**

Historical perspectives: Louis Pasteur, Edward Jenner- Components of Immunity: attributes of innate (Anatomic, Physiologic, Phagocytic and Inflammatory) and Adaptive – Haematopoiesis: Factors that regulate hematopoiesis – Cells of Immune system – Lymphoid cells T, B cells and their types, Null cells; Myeloid lineage- Neutrophil, Eosinophil, Basophil, Mast cell, mononuclear cell and Dendritic cell - Primary Lymphoid organs: Structure and functions of Thymus, Bone marrow and Bursa of Fabricius - Secondary Lymphoid organs: Structure and functions of Spleen, Lymph node, MALT, GALT.

**UNIT-II** **(20 Hours)**

Antigen - Factors influencing immunogenicity, types, Adjuvants, Haptens, Epitope (B cell and T cell). B cell generation, activation, and differentiation, expression of Immunoglobin gene, Clonal selection theory - Structure, biological properties and functions of IgG, IgM, IgA, IgD, and IgE. Primary and Secondary immune response Complement: Classical and Alternate pathways- Antigen-Antibody interaction: Affinity, Avidity, Cross-reactivity, Precipitation- Radial immunodiffusion (Mancini method), Immunoelectrophoresis; Agglutination– Haemagglutination, bacterial agglutination, passive agglutination, and Agglutination inhibition assay, Radioimmunoassay, ELISA, Transplantation: Types of graft-mechanism of graft rejection, Oncogenes and Cancer, Cancer immunotherapy.

**UNIT –III** **(20 Hours)**

Structure of T-cell receptor (TCR) - Organization and rearrangement of TCR genes – Generation of TCR diversity – T cell accessory membrane molecules – CD4 and CD 8 coreceptors - T cell generation, activation, and differentiation - MHC polymorphism (Class I and Class II)– Structure of HLA Serological typing of HLA- Antigen processing and presentation (Cytosolic and Endocytic pathways) – Cytokines: Properties and functions,

Hypersensitivity reactions: Type I, Type II, Type III and Type IV. Immunological responses to AIDS, Vaccines – types and principles.

**UNIT – IV** **(15 Hours)**

General characters and classification of bacteria- Bacterial Morphology and staining- Ultra structure of Prokaryotic cell and function- Nutrition– Nutrient media and types –Culture methods– Pour plate, spread plate and streak plate. Synchronous, Continuous growth- Mode of nutrient uptake- Facilitated diffusion, active transport, group translocation and Iron uptake- Growth– Growth curve- Methods of measurement of growth– Factors influencing the growth of bacteria.

**UNIT – V** **(20 Hours)**

Microbes as pollution indicators, Water quality analysis by MPN method, Infective processes and control of Tuberculosis (Air Borne), Typhoid (Water borne) Dengue (vector borne), Tetanus (soil-borne) Gonorrhea and Syphilis (Sexually transmitted diseases), Genitourinary disease (Mycoplasmal disease), Candidiasis (Fungal disease) – Toxoplasmosis (Protozoan disease)- SARS, H1N1 (Viral disease). Humans Are Holobiont, The developments of Microbiome in Human.

**Text book:**

1 Owen, Punt, Stranford. Kuby Immunology 4th edition, New York, W.H. Freeman and Company. 2013.
2 Eli Benjamini, Text Book on Immunology, A short course, 3rd edition. UK, Blackwell Science,1996.
3 Joanne M. Willey, Kathleen M. Sandman and Dorothy H. Wood, Prescott's Microbiology, 11th Edition, Tata McGraw Hill Pub. Co. Ltd. 2020.
4 Hans G. Schlegel, General Microbiology, 7th Edition, UK, Cambridge University Press 1995.
5 Ananthanarayanan, Jayaram Paniker, Text Book of Microbiology, 5th Edition, New Delhi, Orient Longman. 1997.
6 Pelczar M.J., Chan E.C.S., Kreig N.R., Microbiology, 6th Edition, New Delhi, Tata McGraw Hill Pub. Co. Ltd. 2007.

**Reference Books:**

1 Roitt I.M., Essential Immunology, 9th edition, UK, Blackwell Science, 1994.
2 Janeway, travers, Walport and Shlomchik, Immunobiology – The Immune system in health and disease 6th Edition, NewYork, USA. 2005
3 A.K. Chakravarthy, Immunology, New Delhi. Tata McGraw Hill. 2000
4 James.T. Barrett , Text Book of Immunology 5th edition, New Delhi, IE International 1998.
5 Frazier W.C., Westhoff D.C., Food Microbiology, 4th Edition, New Delhi, Tata McGraw Hill Pvt. Ltd. 1995.

6 Adams and Moss, Food Microbiology, New Age International Publishers, New Delhi 1995.
7 Casida L.E., Industrial Microbiology, Wiley Eastern Ltd.1993.
8 Prescott, Harley, Klein, Microbiology, 4th Edition, New Delhi, WCB McGraw Hill Co. 1999.
9 Stainer R.Y., Doudoroff M, Addberg E.A., General Microbiology, 3rd Edition, MacMillan India 1970.
10 Ronald M Atlas, Principles of Microbiology, 2nd International Edition, New Delhi, McGraw Hill. 1997.
11 Michael T. Madigan & John K.Martinko, Brock Biology of Microorganisms, 11th edition, Pearson Prentice Hall, Printed in USA. 2006.
12 David Greenwood, Richard Slack and John Peutherer, Medical Microbiology, 15th Edition, ELST Publishers. 1997.
13 Talaro, K. & Talaro, A. Foundations in Microbiology, Third edition, Dubuque, McGraw Hill. 1999.

**e-Resources:**

1. https://www.khanacademy.org/test-prep/mcat/organ-systems/the-immune-system/a/innate-immunity
2. https://archive.nptel.ac.in/content/storage2/courses/102103038/download/module3.pdf
3. https://youtu.be/Dyv6YiH5rME
4. https://archive.nptel.ac.in/content/storage2/courses/102103047/PDF/mod5.pdf
5. http://www.phrma-jp.org/wordpress/wp-content/uploads/old/library/vaccine-factbook_e/1_Basic_Concept_of_Vaccination.pdf
6. https://www.youtube.com/watch?v=k9QAyP3bYmc
7. https://www.youtube.com/watch?v=nqRn5fN22t4
8. https://www.youtube.com/watch?v=IUDSWPvfHgU
9. https://www.youtube.com/watch?v=jXTW4F-8jd4
10. https://www.youtube.com/watch?v=fELn4Fe9Ccc
11. https://www.youtube.com/watch?v=P8wCk8FU7_o
12. https://archive.nptel.ac.in/courses/102/103/102103015/
13. https://onlinecourses.nptel.ac.in/noc21_ce07/preview
14. https://www.sciencedaily.com/news/plants_animals/microbiology/
15. http://commtechlab.msu.edu/sites/dlc-me/
16. https://www.scasm.org/resources/links
17. https://openstax.org/details/books/microbiology
18. https://www.pathelective.com/micro-resources
19. https://nptel.ac.in/courses/102103015
20. https://microbenotes.com/
21. https://microbiologyinfo.com/

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| **CORE: 13** | **MOLECULAR GENETICS** |
|---|---|
| ***Contact hours per Week – 6 hours*** | ***Credits: 4*** |
| ***Contact hours per Semester – 90 hours*** | ***Subject Code:*** **P24ZYC32** |
| **Course Outcomes:** | |
| **CO1:** Predict the genotypic and phenotypic ratios in the meiotic products. | |
| **CO2:** Perform a quantitative analysis of the progeny of a dihybrid testcross to assess whether the two genes are linked on the same chromosome. | |
| **CO3:** Illustrate the features of DNA replication and the machineries that contribute to its speed and accuracy. | |
| **CO4:** Compare and contrast the critical roles played by different kinds of RNA in protein synthesis. | |
| **CO5:** Differentiate the molecular mechanisms of gene regulation in eukaryotes and bacteria. | |
| **CO6:** Describe human genetic diseases that are caused by genetic changes. | |

**Unit – I** **(18 hours)**

Mendel's postulates: Law of segregation and law of independent assortment; Molecular basis of Mendelian inheritance pattern: alleles at the molecular level – Chromosome theory of heredity: Gene mapping by linkage analysis; Three-point test cross; Linkage and Crossing over; Sex chromosomes and Sex determination; Sex linked genes in human, Dosage compensation of X linked genes – Genetic transfer in bacteria – Evolutionary significance of recombination.

**Unit – II** **(18 hours)**

Changes in chromosome structure: deletion and duplication; rearrangements of chromosome structure: inversions, translocations, compound chromosomes and Robertsonian translocations.Variation in chromosome number: Aneuploidy, euploidy; evolutionary significance; meiotic nondisjunction: Monosomy and Trisomy in human. Types and causes of mutation – molecular basis of mutation.DNA repair mechanisms: photo reactivation; excision repair; recombination repair; SOS repair.

**Unit III** **(18 hours)**

Experimental evidences for DNA as genetic material; Physical properties of DNA; Chargaff's rule; alternate forms of DNA; DNA Replication in Prokaryotes and Eukaryotes; models of replication; Enzymology of DNA replication; Proof reading activity of Replication apparatus; Role of DNA polymerase, helicases, ligase, and topoisomerases in Replication.

**Unit – IV** **(18 hours)**

Transcription in Prokaryotes and Eukaryotes; types of RNA. Post transcriptional modifications in eukaryotes: Capping, poly adenylation, splicing of introns and RNA editing; Role of snRNPs in pre-mRNA splicing. Genetic code: Properties of genetic code; deciphering the code. Translation: functional role of tRNA and ribosomes in protein synthesis.

**Unit – V** **(18 hours)**

Gene regulation in prokaryotes: Induction and suppression of *lac* operon in *E. coli*; Attenuation of *trp* operon; Positive and Negative control of *ara* operon; post translational regulatory mechanisms. Gene regulation in eukaryotes; alternate splicing of RNA; histone modification; heat shock genes; cytoplasmic control of mRNA stability; enhancers and silencers; transcription factors; RNA interference by miRNA and siRNA; activation and inactivation of whole chromosomes.

**Text book:**

1. William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino, Darrell Killian, Concepts of Genetics, Pearson Education, 11th Edition, 2019
2. Veer Bala Rastogi, Genetics, Medtech Publishers, 4th Edition, 2019

**Reference books:**

1. D. Peter Snustad and Michael J. Simmons, Principles of Genetics, John Wiley & Sons Inc, 7th Edition, 2016
2. Anthony J.F. Griffiths, Susan R. Wessler, Sean B. Carroll and John Doebley, Introduction to Genetic Analysis, W.H. Freeman & Company, 11th Edition, 2015,
3. Robert J. Brooker, Genetics: Analysis and Principles, McGraw-Hill Education, 6th Edition, 2018
4. Jocelyn Krebs, Stephen Kilpatrick, and Elliott Goldstein, Lewin's Genes XI, Jones & Bartlett Learning, 2014
5. James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick, Molecular Biology of the Gene, Pearson Education Inc, 7th Edition, 2013

**e-Resources:**

1. http://opengenetics.net/open_genetics.html
2. https://www2.le.ac.uk/projects/oer/oers/genetics/oers/Patterns%20of%20inheritance/Patterns%20of%20inheritance-TRF.pdf
3. https://www2.le.ac.uk/projects/oer/oers/genetics/oers/ger/ger.pdf
4. https://www2.le.ac.uk/projects/oer/oers/genetics/oers/DNA%20Genes%20and%20chromosomes/DNA%20Genes%20and%20chromosomes-TRF.pdf
5. https://www.youtube.com/watch?v=iJGY1boNOdg (Recombination in Bacteria)
6. https://www.youtube.com/watch?v=IJQv1H-2IoI (Splicing mechanism and its importance)
7. https://www.youtube.com/watch?v=CaCq4gglw0g (Lac Operon concept)
8. https://www.youtube.com/watch?v=Wv9csJGYLmU (Heat shock protein)
9. https://www.youtube.com/watch?v=-AhKTeekXYg (Trp attenuation)
10. https://www.youtube.com/watch?v=TAZgW6222fs (Gene regulation in Prokaryotes vs Eukaryotes).

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| **CORE: 12** | **ECOLOGY AND EVOLUTION** |
|---|---|
| ***Contact hours per Week – 6 hours*** | ***Credits: 4*** |
| ***Contact hours per Semester – 90 hours*** | ***Subject Code:*** **P24ZYC33** |
| **Course Outcomes:** | |
| **CO 1:** To study the concept and components of ecosystem. | |
| **CO 2:** To understand the characteristics of population and to learn its interaction with environment. | |
| **CO 3:** To sensitize the students on the careful utilization of environmental resources. | |
| **CO 4:** To learn the origin of earth, process and theories of evolution. | |
| **CO 5:** To understand the mechanism of formation of new species and isolation. | |

**Unit – I** **18 hours**

Ecosystem: concept and components; Light and temperature as limiting factors; trophic structure of ecosystem

Functions of ecosystem: productivity, energy flow: food chain, food web, trophic levels, and ecological pyramids.

Homeostasis - cybernetic nature; stability

**Unit – II** **18 hours**

Population: characteristics, density, natality, mortality, survivorship curve, life tables; Biotic potential, growth curves, growth models, fluctuations, structure, concept of r and k selection; Life history traits and tactics; population regulation: density dependent and density independent factors; Interspecific interactions: commensalism, mutualism, parasitism, predation, competition.

**Unit – III** **18 hours**

Community: Characteristics and structure

Physical structure: growth forms; stratification: vertical, horizontal and temporal stratification, seasonality, periodicity

Biological structure: species abundance, species diversity, species dominance, diversity indices ; factors regulating species diversity

Ecological niche: types, guild, ecotone and edge effect; concept of climax; ecological succession; ecological indicators

**UNIT– IV Theories of Evolution** **(18 hours)**

Theories of evolution– Lamarckism, Darwinism and Mutation theory of De Vries. Modern synthetic theory - Hardy-Weinberg equilibrium- Allele frequencies and Haplotype frequencies. Types of selection, Macroevolution, Evolution of Adaptation - Evolution of Lungless Salamanders, Evolutionary Trends, Adaptive radiation in Mammals, Darwin's Finches, Parallel Evolution, Convergent Evolution, Preadaptation and Post adaptations, Coadaptation.

**UNIT – V Speciation and Isolation** **(18 hours)**

Species concepts: Morphological and Biological concepts– subspecies, Sibling species, Races, Rassenkreis, Clines and Demes, Modes of speciation: Allopatric, Sympatric, Parapatric and peripatric . Isolating mechanisms: Geographic and Reproductive isolation- prezygotic and post- zygotic isolating mechanisms- role of isolating mechanisms in speciation. Genetics of reproductive isolation.

**Text Books:**

1. Rastogi, V.B. Organic Evolution (Evolutionary Biology), 13th edition- Reprint- Kedar Nath Ram Nath, R.V. Printers, Meerut (2017).
2. Dobzhansky, T., Ayala, F.J., Stebbins, G.L. and Valentine, J.W. Evolution, Surjeet Publications, New Delhi (1971).
3. Tomar and Singh. Evolutionary Biology, Ninth Edition, Rastogi Publication, Meerut – New Delhi.

**Reference Books:**

1. Moody, P.A. Introduction to Evolution, Harper International. (1978)
2. Dodson, E.V. Evolution process and product, East West Press, New Delhi. (1960)
3. Bendall, D.D. Evolution from molecule to Man, Cambridge University Press. (1983)
4. Grese, M. Dimensions of Darwinism, Cambridge University Press. (1983)
5. Minkoff, E.C. Evolutionary Biology, Addison Wesley. (1984)
6. Strickberger, M.W. Evolution. Jones and Barlett publishers Inc., London. (1996)
7. Dobzhansky, T., Ayala, F.J., Stebbins, G.L. and Valentine, J.W., Evolution. Surjeet Publications and Co., New York. (1975)

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| **CORE: 14 LAB: IMMUNOLOGY and MICROBIOLOGY** | |
|---|---|
| ***Contact hours per Week – 3 hours*** | ***Credits: 3*** |
| ***Contact hours per Semester – 45 hours*** | ***Subject Code:* P24ZYCP31** |
| **Course Outcomes:**<br>At the end of the semester, students will be able to | |
| **CO1:** compare the histological features of lymphoid organs. | |
| **CO2:** illustrate the morphological features of immune cells. | |
| **CO3:** demonstrate the antigen-antibody reaction. | |
| **CO4:** culture microorganisms by various methods. | |
| **CO5:** differentiate the molecular features of gram positive and gram negative bacteria. | |

**Immunology**

1. Lab safety rules and regulations in microbiology lab
2. Collection of serum from blood
3. Blood Grouping Experiment

4. Study of histology of Thymus, Spleen, Lymph node and Bursa of Fabricius using permanent slides.
3. Morphological Identification of immune cells by Leishman's stain.
4. Preparation of antigen (Chick/ Sheep blood).
5. Immunisation and Bleeding techniques in Rat (Photographs/ ICT tools).
6. Isolation of lymphocytes from the fish blood.
7. Observation of Latex agglutination using Rheumatoid arthritis test kit.
8. Spotters: Primary immune response curve, Immunoglobulin G and A, Di- George Syndrome, and Well Plate.
9. Demonstration of ELISA
10. Demonstration of Western blot

**Microbiology**

1. Sterilization techniques - Hot air Oven, Autoclave, Membrane filter and Radiation
2. Preparation of culture media (Liquid and Solid) and agar slants for microorganisms.
3. Counting of viable cells by serial dilution – Spread plate and streak plate.
4. Total microbial count in soil sample by pour plate method
5. Motility determination – Wet mount/Hanging Drop for E. coli
6. Standard qualitative analysis of drinking water – MPN method
7. Estimation of microflora of milk by Methylene Blue Reduction (MBR)
8. Differentiation of bacteria by Gram staining
9. Biochemical Test: Catalase and TSI
10. Demonstration of antibiotic sensitivity test

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| **CORE: 15** | **LAB: ECOLOGY AND EVOLUTION** |
|---|---|
| ***Contact hours per Week – 3 hours*** | ***Credits: 3*** |
| ***Contact hours per Semester – 45 hours*** | ***Subject Code:* P24ZYCP32** |
| **Course Outcomes:**<br>At the end of the semester, students will be able to | |
| **CO1:** estimate primary productivity of macrophytes in aquatic and terrestrial ecosystems. | |
| **CO2:** determine the water quality parameters in industrial effluents/ domestic sewage. | |
| **CO3:** differentiate the concept of chemical and biological oxygen demand. | |
| **CO4:** describe the importance of homologous organs to explain evolutionary process. | |
| **CO5:** compare the features of different human fossils to understand the trends in human evolution. | |

**Ecology:**

1. Estimation of primary productivity of aquatic macrophytes– Light and dark bottle method
2. Estimation of primary productivity of terrestrial plants – Harvest method
4. Estimation of $CO_2$ in the sewage water sample.

5. Analysis of industrial effluents – Total and dissolved solids
6. Analysis of industrial effluents – Biological Oxygen Demand (BOD)
7. Analysis of industrial effluents – Chemical Oxygen Demand (COD)
8. Estimation of soil organic matter
9. Estimation of dust pollution in urban locality – Time course kinetics of deposition of dust

**Evolution:**

1. The assessment of Hardy -Weinberg equilibrium through bead experiment
2. Identification of serial homology in the appendages of prawn
3. Exploration of human evolution using three key hominid fossil records (Chart/Photographs)
4. Study of animal cranial morphology (Skull)

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| **ELECTIVE: 2** | **RESEARCH METHODOLOGY** |
|---|---|
| ***Contact hours per Week – 6 hours*** | ***Credits: 5*** |
| ***Contact hours per Semester – 90 hours*** | ***Subject Code:* P24ZYE31** |
| **Course Outcomes:** | |
| CO 1: It makes the understanding of finding a problem, related data collection from sources and designing and executing the experiment. | |
| CO 2: Identify various sources of information for literature review and data collection. | |
| CO 3: Critically analyze research methodologies identified in existing literature. | |
| CO 4: Emphasis knowledge to write a research report and thesis. | |
| CO 5: Analyze the data using statistical tools to interpret the result significantly. | |

**Unit I** **(18 Hours)**

Initiation of the Research Objectives of Research- Criteria of Good Research- Critical thinking- Motivation in Research- Types of Research- Essential steps in research- Identification and selection of research problem- Topic selection and Justification- Importance of Research- Research Process. -Research Design and its types

**Unit II** **(18 Hours)**

Research resources Sources of information- Methods of literature collection- Online- world wide web- Technical papers, Review of literature, Monographs, abstract- Index card and reference card- search tools - citation indices- ethical and moral issues in research- Plagiarism- tools to avoid plagiarism- IPR- Copy right laws– Patent rights.

**Unit III** **(18 Hours)**

Research Report Introduction- components of research report- significance of Report Writing- Different Steps in Writing Report- Layout of the Research Report- Types of Reports - Oral Presentation Writing a Research paper for journals - proof correction – symbols and method of correction. Standard of journals - Impact factor - H-index - citation index - Precautions for Writing Research Reports.

**Unit IV** **(18 Hours)**

Formatting Research report Preparation and presentation of research paper- Margin- Paragraph indentations- spacing – alignment – fonts - Title page - Authors and addresses – abstract - keywords introduction - materials and methods – results – discussion – conclusion - acknowledgements – references - Tables and figures - numbering and captions, footnotes- Evaluation of research report.

**Unit V** **(18 Hours)**

Role of Computer in Research. Data storage and analysis - Scientific simulations - Standard deviation, Standard Error, Correlation, Regression, t-test and ANOVA using EXCEL and SPSS - SCOPUS and Web of Sciences.

**Text books:**

1. P. Saravanavel. Research Methodology. Patna: Kitab Mahal Agencies, Ashok Rajpath.1994. 2. N. Gurumani. Research methodology for Biological Sciences. Chennai: MJP Publishers.2006.
2. Reference Books: 1. C.R. Kothari. Research Methodology-Methods and techniques (Second revised edition). New Delhi: New Age International Publishers; 2004.
3. 2. Ranjit Kumar. Research Methodology-A step wise step guide for beginners (Third edition). London: SAGE Publications Ltd; 2014.
4. 3. Robert A. Day. How to write and Publish a Scientific paper. University City Science Centre, Philadelphia: ISI Press. 1979. 4. Anderson, A.H., Dursaton and Poole, M .Thesis and Assignment Writing.-Wiley Eastern, 1970.
5. Leedy, P.D. Practical Research-Planning and Design (8 th edition). Pearson; 2005.

**e-Resources:**

1. https://www.indeed.com/career-advice/career-development/research-objectives
2. 2.https://www.slideshare.net/maheswarijaikumar/criteria-to-select-a-good-researchproblem
3. https://research-methodology.net/research-methodology/research-process/
4. https://www.standoutessay.com/study-tools/free-paraphrasing-tool
5. https://research.cc.lehigh.edu/ethical-issues-research
6. https://eduvoice.in/types-research-report-writing/
7. https://www.ou.edu/webhelp/librarydemos/isi/
8. 8.http://kwangaikamed.weebly.com/evaluating-and-reporting-ofresearch.html#:~:text=Research%20evaluation%20is%20the%20process,the%20significance%20of%20a%20research.
9. https://ori.hhs.gov/education/products/n_illinois_u/datamanagement/datopic.html 10. https://www.goskills.com/Lean-Six-Sigma/Resources/Use-anova-in-Excel

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## SEMESTER - IV

| **CORE: 16** | **DEVELOPMENTAL ZOOLOGY** | **SEMESTER: IV** |
|---|---|---|
| ***Contact hours per Week – 6 hours*** | | ***Credits: 4*** |
| ***Contact hours per Semester – 90 hours*** | | ***Subject Code:*** **P24ZYC41** |
| **Course Outcomes:** | | |
| **CO 1:** Recognize the formation and maturation of germ cells in human. | | |
| **CO 2:** Paraphrase the molecular changes that occur in an egg following the fusion of gametes. | | |
| **CO 3:** Demonstrate the development of organs from germinal layers. | | |
| **CO 4:** Distinguish between the causes of normal and abnormal development at genetic level. | | |
| **CO 5:** Associate the role of hormones in ontogenetic development of insects and amphibians. | | |

**Unit I** **(18 Hours)**

Historical review of embryology– phases of ontogenetic development in metazoa– Spermatogenesis in human– meiosis– spermiogenesis– ultrastructure of spermatozoa– gene function in spermatogenesis– mammalian sperm maturation– male accessory sex glands in mammals– Oogenesis: growth of oocyte– oocyte-accessory cell interactions during oogenesis – vitellogenesis – types of egg– gene expression during oogenesis– organization of the egg– egg envelopes– maturation of egg– hormonal control of oogenesis in human.

**Unit II** **(18 Hours)**

External fertilization and activation of egg metabolism in sea urchin– acrosomal reaction and fusion of genetic material in mammalian egg – cortical reaction– block to polyspermy– initiation of cleavage – types of cleavage– patterns of cleavage– role of yolk on cleavage – blastulation and gastrulation in amphibians– axis formation in Zebra fish– gene activity during gastrulation– Determination of primary organ rudiments– inductive tissue interactions– primary embryonic induction– formation and functions of organizer.

**Unit III** **(18 Hours)**

Ectodermal derivatives: development of Brain and Eye in Chick– differentiation of lens and cornea– Mesodermal derivatives: development of Heart and Kidney in Chick– formation of blood vessels– Endodermal derivatives: development of digestive tube and respiratory tube– extra embryonic membranes in birds– placentation in mammals– types and significance.

**Unit IV** **(18 Hours)**

Cytodifferentiation and chemo-differentiation– mechanisms of differential gene expression in development– differential RNA processing– control of gene expression at the

level of translation– Homeotic genes and Hox genes - Genetic errors of human development – Teratogenesis: teratogenic agents– endocrine disruptors.

**Unit V** **(18 Hours)**

Insect metamorphosis: imaginal discs – hormonal control – molecular biology of 20-hydroxy ecdysone. Amphibian metamorphosis: morphological, physiological and biochemical changes – tissue reactivity– hormonal control. Regeneration– regenerative ability in various animals– biochemical changes– stem cell mediated regeneration in Planaria– epimorphic limb regeneration in Salamander– compensatory regeneration in the Mammalian liver– polarity and gradients in regeneration.

**Text books:**

1. Balinsky, B.I., *An Introduction to Embryology*, W.B. Saunders Company, Philadelphia (1981).
2. Verma, P.S., Agarwal V.K., *Chordate Embryology: Developmental Biology,* S. Chand Publications, New Delhi. (2014).

**Reference books:**

1. Gilbert, S.F. and Barresi M.J.F., 2016, *Developmental Biology*, 11th Edn., Sinauer Associates, Inc. Publishers, Sunderland
2. Browder, L.N., 1980, *Developmental Biology*, Saunders College, Philadelphia
3. Slack J.M.W., 2012, *Essential Developmental Biology*, Wiley-Blackwell.
4. Wolpert L., 2002, *Principles of Development*, 2nd Edn., Oxford Univ. Press.
5. Beril N.J., 1986 *Developmental Biology*, Tata McGraw-Hill Publishing Ltd, New Delhi
6. Berry A.K., 2007, *An Introduction to Embryology*, Emkay Publications, New Delhi

**e-Resources:**

1. https://people.ucalgary.ca/~browder/virtualembryo/learning.html
2. https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_ug/154
3. https://learninglink.oup.com/access/barresi12xe-student-resources#tag_all-chapters
4. https://www.sdbcore.org/
5. https://www.jove.com/education/3149/developmental-biology
6. https://qubeshub.org/community/groups/coursesource/publications?id=2649&v=1

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| **CORE: 17** | **ANIMAL PHYSIOLOGY** |
|---|---|
| ***Contact hours per Week – 6 hours*** | ***Credits: 4*** |
| ***Contact hours per Semester – 90 hours*** | ***Subject Code:* P24ZYC42** |
| **Course Outcomes:** | |
| CO1: To acquire the knowledge of nutrients, digestion of food and its metabolism. | |
| CO2: To know the structure and physiology of various organ systems in animals. | |

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| CO3: To interpret the different types of sense organs of animals. |
| CO4: To recall the knowledge of the effectors for the body movements |
| CO5: To elaborate the role of hormones in physiological processes. |

**UNIT – I** **(20 hours)**

**Nutrition and Digestion**

Nutrition – Types, Micronutrients and Macronutrients – Source, Physiological importance and deficiency diseases of Iron and Iodine.(Micronutrients) Calcium and Sodium (Macronutrients) Dietary components – Carbohydrate, Proteins and Fats. Vitamins - Source, Physiological functions, Site of actions and Deficiencies of Fat soluble Vitamins - A, D, E and K – Water soluble vitamins – B Complex & C (Ascorbic acid). Digestion – Intracellular and Extracellular digestion – Human Digestive system - digestion and absorption of Carbohydrates, Proteins and Fats – Coordination of digestive activities- control of digestive secretions- Metabolism: Q10, metabolic rate, Metabolic energetics of carbohydrate, protein and fat- Respiratory quotient, Energy storage molecules..

**UNIT – II** **(20 hours)**

**Respiration, Circulation Excretion and Osmo &Thermo regulation**

Respiration – Structure and respiratory mechanism of Tracheal, Gill and Human lungs. Respiratory pigments – transport of respiratory gases – Neural and Chemical control of respiration. Body fluids– patterns of circulation in vertebrates – Structure of Human heart - structure and functions of pacemaker – regulation of blood flow and blood pressure– heart valves, elasticity of blood vessels and sustained pressure, peripheral resistance, vasomotor reflexes, vasoconstrictor and vasodilator substances- Excretion of nitrogenous wastes-Urea. Ultrastructure of kidney and Nephron-Mechanism of urine formation – Juxtaglomerular apparatus - Hormonal control of urine regulation. Osmoregulation: Principle of Osmosis , Osmoregulation in Freshwater and Marine animals, Thermoregulation in Poikilotherms and Homeotherms

**UNIT – III** **(15 hours)**

**Nervous system and Sensory organs**

Neuron: structure - Transmission of signals in a single neuron Signal propagation in Neuron– synaptic transmission- measuring membrane potentials– resting, action potentials– ionic basis of action potential – Refractory period – Reflex action - Sense organ in vertebrates: chemoreceptor (Taste buds), mechanoreceptor (Ear), thermoreceptor (Skin) photoreceptor (Eye).

**UNIT – IV** **(15 hours)**

**Muscle and Movement**

Types of muscle– ultrastructure of striated muscle– contraction of sarcomere– sliding filament theory– role of calcium ion– cross bridge attachment– excitation– contraction coupling - energy consumption - Length tension relationship of skeletal muscle –molecular

changes during muscle contraction, neuromuscular junction– insect flight muscle– physiology of electric organ in Electric ray.

**UNIT – V** **(20 hours)**

**Endocrine glands and reproduction**

Endocrine glands and their secretions in human – Comparison of Exocrine and Endocrine glands – Salient features of Hormones Neurohormones – Mechanism of hormone action. Structure, Secretory hormones and the physiological functions of Pituitary gland, Thyroid, Adrenal gland –Mechanism of hormone action– metabolic hormones: glucocorticoids, catecholamines, growth hormones, insulin, thyroxine, corticosteroid hormones - epinephrine and norepinephrine aldosterone, parathormone and Calcitonin. Reproductive hormones: male and female sex hormones in human- Role of hormones in Menstrual cycle- Role of hormones in Parturition. Oestrous cycle in mammals. Role of Hormones in Insect development.

**Text books:**

1. Nagabhushanam R., Kodarkar M.S., Sarojini R. Text Book of Animal Physiology (2 nd Edition). Oxford & IBH; (1999).
2. Hoar W.S. General and Comparative Physiology (3 rd Edition). Prentice Hall of India; (1984).

**References:**

1. Eckert Animal Physiology : Mechanisms & Adaptations(4 th Edition). New York: Randall D., Buurggren W., French K. W.H. Freeman and Company; (1997).
2. Knut Schmidt Nielson Animal Physiology: Adaptation and Environment(4 th Edition). Cambridge University Press; (1994).
3. Prosser C.L.Comparative Animal Physiology(3 rd Edition). W B. Saunders Company;(1984).
4. Mohan. P.Arora. Animal Physiology, Himalya Publishing house,Reprint, 2017.

**e- Resources:**

1. https://www.amazon.in/Essentials-Animal-Physiology-S-C- Rastogi/dp/8122420141
2. https://www.researchgate.net/publication/286456096_DrPBReddy's_TEXT_BOOK_OF_ANIMAL_PHYSIOLOGY
3. https://www.pdfdrive.com/animal-physiology-books.html

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| **CORE: 18** | **ANIMAL BIOTECHNOLOGY** |
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| ***Contact hours per Week – 6 hours*** | ***Credits: 4*** |
| ***Contact hours per Semester – 90 hours*** | ***Subject Code:* P24ZYC43** |
| **Course Outcomes:**<br>At the end of the semester students able to | |
| **CO1:** To gain the knowledge and familiarize the tools and techniques of | |

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| biotechnology. |
| **CO2:** To understand the gene transfer and gene cloning methods. |
| **CO3:** To gain the knowledge about animal cell culture and tissue culture. |
| **CO4:** To understand the applications and advantages of biotechnology in industries. |
| **CO5:** To gain the idea about role of biotechnology in bioremediation, healthcare, safety and legal issues. |

**Unit I** **(18 Hours)**

**DNA Technology**

Enzymes in DNA technology: Polymerases, ligase, nucleases, restriction enzymes and alkaline phosphatase. Cloning vectors: Properties of a cloning vector- Types of cloning vectors: plasmids (pBR322, pBR327, pUC); phages (lambda phage); cosmids, Phagemids, virus- SV40, BAC, YAC and MAC- Shuttle vectors and expression vectors. Gene cloning in E. coli, yeast, plant and animal cells; Gene transfer methods: Transformation, electroporation, microinjection, shot gun cloning, liposome mediated gene transfer, Diethylaminoethyl (DEAE) – Dextran-mediated gene transfer; Viral vectors; Selection of clones: Blue-white selection method and colony hybridization.

**Unit II** **(18 Hours)**

**Core techniques in biotechnology**

Isolation and purification of DNA: Gel electrophoresis. Gene cloning: Steps in cloning of a gene; cDNA synthesis; Genomic libraries: Cloning genomes in pieces. DNA Sequencing: Maxam and Gilbert's chemical degradation method, Sanger's dideoxynucleotide synthetic method and automated DNA sequencing; Synthesis of oligonucleotides: Linkers and adapters. Enzyme biotechnology: Immobilization techniques; Industrial uses of enzymes.

**Unit III** **(18 Hours)**

**Animal Cell Culture Techniques**

Composition and Types of Culture media - Bioreactors: Types - Establishment of Primary culture and cell line- Disaggregation of Tissue: Physical and Chemical method- Types of culture: Tissue culture, Organ culture, Embryo Culture- Cryopreservation of cell lines- IVF and Embryo transfer in human and farm animals- Method of production of transgenic animals and their applications- Stem cells: Characteristics and applications.

**Unit IV** **(18 Hours)**

**Industrial Biotechnology**

Major microbial products and processes of industrial importance: Antibiotics, amino acids, organic acids and biopolymers. Isolation of microbes for enzyme production- Methods of strain improvement for industrially important secondary metabolites- Downstream process: Centrifugation, Extraction, Purification, Product recovery- Fermenter design- Applications of microbes in industrial biotechnology: Cellulose utilization and Alcohol production.

**Unit V** **(18 Hours)**

**Biotechnology and Healthcare**

Gene therapy: Somatic cell gene therapy, germ-line cell therapy and stem cell therapy - Vaccine: Production of recombinant vaccine, DNA vaccine- Disease Diagnosis: DNA as Diagnostic and Therapeutic agent- Recombinant DNA in Medicine- rDNA and Environment: Biosensors, GMO in Bioremediation of heavy metals and tetrachloroethylene- Ethics of rDNA technology: Hazards of Biotechnology- Human safety; Biotechnology Regulatory Authority of India (BRAI) - Legal issues: Intellectual Property Rights (IPR), Patent, Copyright, Trade secrets and Trademarks.

**Text books:**

1. S.C. Rastogi. Biotechnology: Principles and Applications.New Delhi: Narosa Publishing House Pvt Ltd; 2009.
2. R.C. Dubey. A Textbook of Biotechnology.New Delhi: S. Chand & Company Ltd; 2012.
3. P.K. Gupta. Elements of Biotechnology.Meerut:Rastogi Publications; 2003.

**Reference books:**

1. Joanne willey et. al., Prescott's Microbiology, (11th edition), McGraw Hill, New York, 2020.
2. R.W. Old and S.B Primrose, Principles of Gene Manipulation (5th Edition, New Jersey, Blackwell Science;1996.
3. B. R. Glick and J.J. Pasternack, Molecular Biotechnology: Principle and Applications of Recombinant DNA (2nd Edition), ASM Press New York, 1988.
4. E.J. Higgins, D.J Best and J. Jones. Biotechnology:Principles and Applications, Blackwell Science, New Jersey,1988.
5. E.L Winnacker. From Genes to Clones: Introduction to Gene Technology, Panima Educational Book Agency, New Delhi, 1987.
6. James D Watson, Michel Gilman, Jan A Witkowski and Mark Zolle, Recombinant DNA, (2nd Edition), W.H. Freeman, Newyork, 1992.

**e- Resources:**

1. https://www.youtube.com/watch?v=8y_RuMOxySY
2. https://www.youtube.com/watch?v=UV7T9JsxdXA
3. https://www.youtube.com/watch?v=74ZZ-U5BP5Y
4. https://www.youtube.com/watch?v=OBagQf8_lZM
5. https://www.youtube.com/watch?v=7-979zLDlBM

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| **CORE: 19** | **LAB: DEVELOPMENTAL ZOOLOGY** |
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| ***Contact hours per Week – 3 hours*** | ***Credits: 3*** |
| ***Contact hours per Semester – 45 hours*** | ***Subject Code:*** **P24ZYCP41** |
| **Course Outcomes:**<br>At the end of the semester, students will be able to | |
| **CO1:** differentiate the anatomical and histological features of reproductive structures of invertebrates and vertebrates. | |
| **CO2:** identify the stages of oestrous cycle in mammals. | |
| **CO3:** illustrate the morphology of mammalian spermatozoa | |
| **CO4:** understand the organogenesis in chick at different stages of development. | |
| **CO5:** comprehend the effect of chemical molecules on the embryonic development of chick. | |

1. Comparative morphology and histology of testis and ovary – Grasshopper/ Cockroach and Fish.
2. Comparative study of histology of testis and ovary in Frog and Rat/ Squirrel based on permanent slides.
3. Staging of oestrous cycle in rat based on permanent slides/ charts/ photographs etc. (https://doi.org/10.1186/s40738-020-00074-3)
4. Sperm count from any domestic animal using haemocytometer (Source of semen: Government artificial insemination centre)
5. Observation of sperm motility in Tilapia fish/ Bull Sperm.
6. Study of developmental stages of chick through slides and whole mounts – 24 hrs, 48 hrs, 72 hrs and 96 hrs.
7. Embryonic development of the egg of Tilapia fish (demonstration only).
8. Effect of thyroxin/ retinoic acid/ proline/ pesticide in developing Chick embryo.
9. Changes in biochemical profiles of developing Chick embryo.
10. Morphological study of different types of placenta (ICT tools/ models/ charts/ photographs etc).

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| **CORE: 20** | **LAB: ANIMAL PHYSIOLOGY** |
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| ***Contact hours per Week – 3 hours*** | ***Credits: 3*** |
| ***Contact hours per Semester – 45 hours*** | ***Subject Code:*** P22ZYP42/ **P24ZYCP42** |
| **Course Outcomes:**<br>At the end of the semester, students will be able to | |
| **CO1:** demonstrate the effect of temperature on the physiological parameters in organisms. | |
| **CO2:** identify the digestive enzymes of different animals in the alimentary canal. | |
| **CO3:** contrast the morphological features of various types of blood cells. | |
| **CO4:** distinguish the physiological response of fish to salt loss and salt gain. | |

**CO5:** explain the principle and applications of physiological instruments.

1. Effect of temperature on Opercular movement in fish
2. Effect of temperature on Oxygen consumption in fish
3. Mounting of Tilapia fish Gill
4. Qualitative analysis of digestive enzymes in cockroach and fish
5. Qualitative examination of hemin crystals
6. Preparation of Human blood smear to study the blood cells
7. Study of permeability of biological membranes
8. Salt loss in fish
9. Salt gain in fish
10. Qualitative analysis of Glucose and Urea in urine sample. (Cow urine).
11. Spotters: Sphygmomanometer, Kymograph, Haemoglobinometer and Electrocardiogram

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