

**J.C. Bose University of Science & Technology,  
YMCA Faridabad**

(NAAC Accredited "A" Grade University of State Govt. established by Haryana State  
Legislative Act No.21 of 2009)

**Department of Life Sciences**



**Scheme and Syllabi for  
M.Sc.  
Zoology  
(SEMESTER- III and IV)**

## PROGRAM OUTCOMES OF PG PROGRAM OF FACULTY OF LIFE SCIENCES

<b>PO1</b>	<b>Knowledge</b>	Capable of demonstrating comprehensive disciplinary knowledge gained during course of study
<b>PO2</b>	<b>Research Aptitude</b>	Capability to ask relevant/appropriate questions for identifying, formulating and analyzing the research problems and to draw conclusion from the analysis
<b>PO3</b>	<b>Communication</b>	Ability to communicate effectively on general and scientific topics with the scientific community and with society at large
<b>PO4</b>	<b>Problem Solving</b>	Capability of applying knowledge to solve scientific and other problems
<b>PO5</b>	<b>Individual and Team Work</b>	Capable to learn and work effectively as an individual, and as a member or leader in diverse teams, in multidisciplinary settings.
<b>PO6</b>	<b>Investigation of Problems</b>	Ability of critical thinking, analytical reasoning and research-based knowledge including design of experiments, analysis and interpretation of data to provide conclusions
<b>PO7</b>	<b>Modern Tool usage</b>	Ability to use and learn techniques, skills and modern tools for scientific practices
<b>PO8</b>	<b>Science and Society</b>	Ability to apply reasoning to assess the different issues related to society and the consequent responsibilities relevant to the professional scientific practices
<b>PO9</b>	<b>Life-Long Learning</b>	Aptitude to apply knowledge and skills that are necessary for participating in learning activities throughout life
<b>PO10</b>	<b>Ethics</b>	Capability to identify and apply ethical issues related to one's work, avoid unethical behaviour such as fabrication of data, committing plagiarism and unbiased truthful actions in all aspects of work
<b>PO11</b>	<b>Project Management</b>	Ability to demonstrate knowledge and understanding of the scientific principles and apply these to manage projects

## **PROGRAM SPECIFIC OUTCOMES (PSOs)**

The program specific outcomes (PSO's) are the statement of competencies/abilities that describes the knowledge and capabilities of the post-graduate will have by the end of program studies.

After successful completion of M.Sc. Zoology, the students will be able to

<b>PSO1</b>	Strengthen their foundation on various zoology concepts and phenomena through theoretical and practical knowledge
<b>PSO2</b>	Upgraded themselves with new discoveries in biological world and inculcate continuous learning and self-improvement and gets motivated for higher studies and research.
<b>PSO3</b>	Tackle detailed problem-solving and analytical tasks associated with pure and applied zoological questions, in areas that include evolution, ecology and conservation
<b>PSO4</b>	Develop independent thinking, good communication and scientific skills and to acquaint them with professional ethics so that they can work well in an industrial or academic environment

<b>SEMESTER-III</b>										
Sr. No.	Course Code	Subject	Teaching Hours per week			Maximum Marks			Credits	Category Code
			L	T	P	Internal	External	Total		
1	MZO-301	Structure and functions of non-Chordates	4			25	75	100	4	DCC
2	MZO-302	Animal Behaviour and Applied Zoology	4			25	75	100	4	DCC
3	MZO-303	Immunology	4			25	75	100	4	DCC
4	MZO-304	Genetics	4			25	75	100	4	DCC
5	MZO-305	Lab Course- I (Based on MZO 301-302)			6	30	70	100	3	DCC
6	MZO-306	Lab Course- II (Based on MZO 303- 304)			6	30	70	100	3	DCC
7	MZO- 307	Seminar				25		25	1	DCC
8	XXX	*Open Elective Course	3	0	0	25	75	100	3	OEC
<b>Total</b>								<b>725</b>	<b>26</b>	

DCC- Discipline core course  
**\*OEC – Open Elective Course-** The students have to choose one Open elective course related to another branch of Science/Engg. /other discipline required for enhancing professional performance as provided by the department/university-  
**OES-301A- Waste Management in Daily Life**  
**OES-302A- Environmental Conservation**  
**OCH 307A- Chemistry for sustainable Development**  
L – Lecture; T-Tutorial, P – Practical

<b>SEMESTER-IV</b>										
Sr. No.	Course Code	Subject	Teaching Hours per week			Maximum Marks			Credits	Category Code
			L	T	P	Internal	External	Total		
1	MZO-401	Structure and functions of Chordates	4			25	75	100	4	DCC
2	MZO-402	Developmental Biology	4			25	75	100	4	DCC
3	MZO-403	Evolutionary Biology	4			25	75	100	4	DCC
4	MZO-404	Lab Course- I (Based on MZO 401)			6	30	70	100	3	DCC
5	MZO-405	Lab Course- II (Based on MZO 402- 403)			6	30	70	100	3	DCC
6	MZO- 406	Project Report	0	0	12	-	-	100	6	
<b>Total</b>								<b>600</b>	<b>24</b>	

**Course Code: MZO 301**

**Subject: Structure & Functions of Non-Chordates**

**No. of credits: 4**

**L P**

**4 0**

**Maximum Marks: 100**

**Theory exam: 75**

**Sessional:25**

**Course Objectives:** The aim of the course is to develop understanding of the students about how life evolved from simple to complex organization by division of labour & enhancing efficiency in Invertebrates. Apart from this it will give an in depth knowledge of minor phyla and their organization and relationship with other invertebrates phyla

### **Unit 1**

Introduction to invertebrates with their general characters, Basic body plan, Concept of invertebrata v/s Vertebrata and Non-Chordata v/s Chordata; Organization of coelom, Concept and structure of Acoelomate, Pseudocoelomates and Coelomates. Protostomia and Deuterostomia, Metamerism in Annelida, Pseudometamerism.

**Minor Phyla:** Concept and significance, Organization and general characters of Acoelomate, Pseudocoelomates and Coelomates minor phyla (with special emphasis on Ctenophora, Rotifera, Endoprocta, Ectoprocta, Phoronida, Sipunculida and Echiuroidea).

### **Unit 2**

**Locomotion:** Flagella and ciliary movement in Protozoa, Hydrostatic movement in Coelenterata, Annelida and Echinodermata; **Nutrition and Digestion:** Patterns of feeding and digestion in lower metazoan, Filter-feeding in Polychaeta, Mollusca and Echinodermata;

**Respiration:** Organs of respiration: Gills, lungs, trachea, skin, Cloacal chamber, Buccopharyngeal area etc., Respiratory pigments, Mechanism of respiration

### **Unit 3**

**Excretion:** Organs of excretion: Coelom, coelomoducts, Nephridia and Malpighian tubules, Mechanism of excretion and osmoregulation

**Nervous system:** Primitive nervous system: Coelenterata and Echinodermata, Advanced nervous system: Annelida, Arthropoda (Crustacea and Insecta) and Mollusca (Cephalopoda), Trends in neural evolution.

### **Unit 4**

**Invertebrate larvae:** Larval forms of free living invertebrates, Strategies and Evolutionary significance of larval forms, Conservation of invertebrates. **Introduction to insects:** Mouthparts of Insects, Mechanism of insect flight and hovering, Metamorphosis in insects, Hormonal control of moulting; Economic importance of Invertebrates; Various Adaptations in Invertebrates

### **Suggested Readings:**

1. Kotpal, R.L. (2019). Modern text book of Zoology: Invertebrates. Rastogi Publications. 11<sup>th</sup> Edition
2. David Hickman, Jr., Cleveland; Roberts, Larry; Keen, Susan; Larson, Allan; Eisenhour (2021). Animal Diversity. McGraw Hill Education, 9<sup>th</sup> Edition.
3. Barnes, R.S.K., Calow, P.P., Olive, P.J., Golding, D.W. and Spicer, J.I., (2009). The invertebrates: a synthesis. John Wiley & Sons, 3<sup>rd</sup> Edition
4. Moore, J., (2006). An introduction to the invertebrates. Cambridge University Press. 2<sup>nd</sup> Edition
5. Pechenik, J. A. (2015). Biology of the Invertebrates. McGraw Hill, 7<sup>th</sup> Edition
6. Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, Holt Saunders International Edition, 8<sup>th</sup> Edition

**Course Outcomes:**

After successfully completion of this course students will be able to:

- CO1** Understand the progressive evolutionary history and adaptations which forms the basis of huge complex and diverse life forms.
- CO2** Acquire a clear understanding about organization of minor phyla and their relationship with other animal phyla
- CO3** Know the structure and significance of various systems of Invertebrates
- CO4** Develop a deep understanding about adaptations and significance of Invertebrates

**Mapping of CO and PO for MZO 301**

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
<b>CO1</b>	3	2	2	3	1	2	1	3	3	3	2	3	3	3	3
<b>CO2</b>	3	2	2	3	1	2	1	3	2	3	2	3	3	3	3
<b>CO3</b>	2	2	2	3	1	2	1	3	3	3	2	3	3	3	3
<b>CO4</b>	3	3	2	3	1	3	1	3	3	3	2	3	3	3	3

\*\*Mapping Scale: 1 to 3 (3: Strong; 2: medium; 1: weak)

**Course Code: MZO 302**

**Subject: Animal Behaviour & Applied Zoology**

**No. of credits: 4**

**100**

**L P**

**4 0**

**Maximum Marks:**

**Theory exam: 75**

**Sessional:25**

**Course Objectives:** This course exposes students to the broad field of animal behavior and applied zoology. After studying this the student will come to know the historical foundations of the animal behaviour, as well as current theories and evidence for a broad range of behavioral topics. In context to applied zoology the student get an in-depth knowledge about various practices followed by the humans as a source of income from animals.

### **Unit 1. Introduction to Animal behavior**

History of the study of animal behavior, concepts and objectives of behaviour, mechanism of behavior: Neural control of behavior, sensory processes and perception, ecology of senses.

Complex behavior- Instinct and learning, Innate releasing mechanisms: key stimuli, stimulus filtering, supernormal stimuli, open and closed IRM. Fixed action pattern- characteristics and evolutionary features. Mimicry, mimetic releaser and code breakers.

### **Unit 2. Mechanism of orientation**

Primary and secondary orientation; kinesis and taxis. Learning and cognition: habituation, classical conditioning, operant conditioning, latent learning, social learning, Homeostasis and behaviour: motivational system and their physiological basis, motivational conflict and decision making, displacement activity, Hormonal regulation of behaviours.

### **Unit 3: Apiculture, Lac culture and Sericulture**

Species of honey bee and their social organization, Methods of bee keeping, economic importance of honey; Life cycle of lac, Cultivation of Lac, Enemies of lac cultivation and economic importance; Life cycle of silk moth, Rearing of silk worm, Disease of silk worm, Status of sericulture industry in India.

Economics related to establishment of Apiculture, lac culture, and sericulture and cost benefit ratio

### **Unit 4: Pearl Culture, Poultry Farming and Fish Culture**

Pearl Producing Molluscs, Pearl Formation, Programming of Pearl Industry; Habitat of fowl, Fowl House, Food and feeding of Fowl, Rearing of Chickens, Disease of poultry, Processing and preservation of eggs; Fish culture- breeding pond, Nursery and rearing ponds and fish seed, types of hatching pits, methods of preservation of fish;

Economics related to establishment of Pearl Culture, Poultry Farming, and fish culture and cost benefit ratio. Pharmaceuticals from animals and their use in animal welfare. Recent Wild Life of India.

### **Suggested Readings:**

1. Aubrey Manning and Marian Stamp Dawkins (2012) An Introduction to Animal Behavior, Cambridge University Press. 6<sup>th</sup> Edition
2. John Alcock, (2009) Animal Behaviour: An Evolutionary Approach, Sinauer Associate Inc., USA. 9<sup>th</sup> Edition
3. Dustin R. Rubenstein and John Alcock (2018) Animal Behaviour, Sinauer Associate Inc., USA. 11<sup>th</sup> Edition
4. Dunham R.A. (2004) Aquaculture and Fisheries Biotechnology Genetic Approaches. CABI publications, U.K.
5. Mathur, S. (2009) Economic Zoology Biostatistics and Animal Behaviour. Deep and Deep Publications. 1<sup>st</sup> Edition
6. G.S.Shukla and V.B.Upadhyay (2017) Economic Zoology: A textbook for University students, Rastogi publication, Meerut. 5<sup>th</sup> Edition

**Course Outcomes:**

After successfully completion of this course students will be able to:

**CO1:** Acquire a clear understanding about behavior patterns in animals

**CO2:** Understand the basis on different behavior pattern found in animals

**CO3:** Explain the basic concepts of sericulture, apiculture, lac culture and other animal industries along with economics of pest management techniques.

**CO4:** Awareness about use of certain animals and their products for human welfare *vis-à-vis* animal welfare will be created.

**Mapping of CO and PO for MZO 302**

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
<b>CO1</b>	3	2	2	2	1	2	1	3	3	3	2	3	3	3	3
<b>CO2</b>	3	2	2	2	1	2	1	3	3	3	2	3	3	3	3
<b>CO3</b>	3	3	2	3	3	2	1	3	3	3	3	3	3	3	3
<b>CO4</b>	3	3	2	3	3	3	1	3	3	3	3	3	3	3	3

\*\*Mapping Scale: 1 to 3 (3: Strong; 2: medium; 1: weak)



**Course Code: MZO-303**

**Subject: Immunology**

**No. of credits: 4**

**L P**

**4 0**

**Maximum Marks: 100**

**Theory exam: 75**

**Sessional: 25**

**Course Objectives:** This course includes a detailed description of the immune response made in humans to foreign antigens including microbial pathogens. A description of cells involved in the immune response either innate or acquired. How the immune system recognizes self from non-self. B and T cell maturation and specific responses.

### **Unit I**

Cells and organs of immune system. Primary, secondary and tertiary lymphoid organs. Types of immunity - Innate and adaptive, Humoral and cell-mediated, Active and passive, PAMP: TLR, Clonal selection theory. Immunological memory, Antigens and immunogens, B and T cell epitopes; Haptens. Structure and functions of antibodies. Classes of immunoglobulins. CDRs, Valence, affinity and avidity. Antibody variants - Isotypes, allotypes and Idiotypes

### **Unit II**

The immunoglobulin genes: organization and assembly; generation of immunological diversity; Allelic exclusion. Major histocompatibility complex (MHC): structure and organization of MHC. Antigen processing and antigen presentation. T cell Receptor: Superantigens. B cell activation and maturation. T cell development and activation. Cytotoxic T cell mediated killing. Complement system and mechanism of its fixation. Complement deficiencies. V(D)J recombination, somatic hypermutation and class switch recombination of immunoglobulins: mechanism and regulation

### **Unit III**

Immunological tolerance. Autoimmunity and associated disorders. Allergy and hypersensitivity, types of Hypersensitivity. Transplantation immunology - Graft rejection, graft versus host reaction. Immune response to infectious diseases – viral, bacterial, protozoal. Immunosuppression - immunodeficiency diseases. Communicative Viral Diseases.

### **Unit IV**

Role of cytokines, lymphokines and chemokines. Vaccine and its different types. Different types of Vaccines for COVID-19 . Hybridoma Technology: Production of murine monoclonal antibodies (MoAbs)-Fusion strategies, HAT Selection; Strategies for production of human MoAbs- Humanization and antigenization of MoAbs-Chimeric, CDR-grafted

#### **Suggested Readings:**

1. Punt J, Stranford SA, Jones PP, and Judith AO (2019) Kuby immunology. WH Freeman. 8<sup>th</sup> edition.
2. Abbas AK, Lichtman AH, and Pillai S (2016) Cellular and Molecular Immunology. Saunders. 9<sup>th</sup> edition.
3. Male DK, Brostoff J, Roth D, and Ivan R (2012) Immunology. Gower Medical Publishing London. 8<sup>th</sup> edition.
4. Gupta SK (2010) Essentials of Immunology. Arya Publication. 2<sup>nd</sup> edition.
5. Khan FH (2009) The Elements of Immunology. Pearson Education India. 1<sup>st</sup> edition.

**Course Outcomes:**

After completion of the course the learners will be able to:

**CO1-** Understood the concept of innate and adaptive immunity.

**CO2-** Understood the various mechanisms that regulate immune responses and maintain tolerance.

**CO3-** Elucidated the reasons for immunization and awareness of different vaccination.

**CO4-** Understood the stages of transplantation response and success of various transplant procedures.

**Mapping of CO and PO for MZO 303**

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
<b>CO1</b>	3	2	3	2	2	2	2	3	3	3	2	3	3	2	3
<b>CO2</b>	3	2	3	2	2	2	2	3	3	3	2	3	3	2	3
<b>CO3</b>	3	2	3	2	2	3	2	3	3	3	3	3	3	2	3
<b>CO4</b>	3	2	3	2	2	3	3	3	3	3	3	3	3	2	3

\*\*Mapping Scale: 1 to 3 (3: Strong; 2: medium; 1: weak)

**Course Code: MZO-304**

**Maximum Marks: 100**

**Subject: Genetics**

**Theory exam: 75**

**Sessional: 25**

**No. of credits: 4**

**L P**

**4 0**

**Course Objectives:** To develop and demonstrate an understanding of the structure and function of genes and the organization of the human genome; the patterns of inheritance and clinical manifestations of genetic diseases; chromosomes, chromosomal abnormalities, and the clinical features of common chromosomal disorders.

### **Unit I**

Mendelian vs. non-Mendelian inheritance, monohybrid and dihybrid crosses, Mendelian Principles-Dominance, Segregation and Independent assortment. Extensions of Mendelian principles: Codominance, Incomplete dominance, Multiple Allelism. Gene interactions-Epistasis, Collaboratory gene action, Duplicate genes, Complementary Gene action, Complementation Test. Pleiotropy. Phenocopy. Probability and Pedigree analysis. sex limited and sex influenced characters. Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL. Extrachromosomal Inheritance, Maternal effect.

### **Unit II**

Microbial genetics: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes. Linkage maps, recombination, tetrad analysis (Ordered and unordered Tetrad analysis), mapping with molecular markers, mapping by using somatic cell hybrids. Linkage Group

### **Unit III**

Cytogenetics: Chromosome: structure and nomenclature, centromere and telomere; Structural and numerical alterations of chromosomes: Deletion, duplication, Pericentric and Paracentric inversion, Inversion heterozygotes, Inversion homozygotes. Reciprocal and nonreciprocal translocation, Homozygotes as well as Heterozygote Trans locants. ploidy (Aneuploidy and Euploidy) and their genetic implications.

### **Unit IV**

Mutation: Types, causes and detection, mutant types – lethal, conditional, Base substitution and frame shift Mutation. Biochemical, loss of function, Gain of function, Germinal versus Somatic mutants, Ames Test.

Epigenetics: Introduction, methylation, histone modifications.

Allele frequency, Gene Frequency, Hardy Weinberg Equilibrium

### Suggested Readings:

1. Gardner EJ (2005) Principles of Genetics. John Wiley & Sons Ltd. 8<sup>th</sup> edition.
2. Tamarin RH (2017) Principles of Genetics. Tata McGraw-Hill Publishing Comp. Ltd. 7<sup>th</sup> edition.
3. Pierce BA (2016) Genetics – A conceptual approach. WH Freeman Company. 6<sup>th</sup> edition.
4. Snustad DP and Simmons MJ (2015) Principles of Genetics. John Wiley and Sons. 7<sup>th</sup> edition.
5. Hartl and Jones (2017) Genetics-Principles and Analysis. Jones & Bartlett. 9<sup>th</sup> edition.
6. Gupta PK (2018). Genetics. Rastogi publication.

### Course Outcomes:

After completion of the course the learners will be able to:

**CO1-** Understood the building block for genetics i.e., life cycles of model organisms, basic genetic experiments, polyploidy, and QTL.

**CO2-** Learn the organization of genome and specialized chromosomes, chromosomal theory of inheritance, linkage, inheritance modes in nature, maternal inheritance, crossing over, and recombination.

**CO3-** Understood the important hereditary diseases, their inheritance patterns, and pedigree analysis

**CO4-** Understood the significance and impact of mutations.

### Mapping of CO and PO for MZO 304

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
<b>CO1</b>	3	2	2	3	2	3	2	3	3	3	3	3	3	2	3
<b>CO2</b>	3	2	2	3	2	3	2	3	3	3	3	3	3	2	3
<b>CO3</b>	3	3	2	3	2	3	2	3	3	3	2	3	3	3	3
<b>CO4</b>	3	2	2	3	2	3	2	3	3	3	2	3	3	3	3

\*\*Mapping Scale: 1 to 3 (3: Strong; 2: medium; 1: weak)

**Course Code: MZO 305**

**Subject: Lab Course - I (Based on MZO 301–302)**

**Number of Credits: 3**

**L P**

**0 6**

- Permanent Preparation of: *Euglena*, *Paramecium*
- Study of prepared slides/specimens of *Entamoeba*, *Giardia*, *Leishmania*, *Trypanosoma*, *Plasmodium*, *Fasciola*, *Cotugnia*, *Taenia*, *Rallietina*, *Polystoma*, *Schistosoma*, *Echinococcus*, *Enterobius*, *Ascaris* and *Ancylostoma*
- Permanent Preparation of *Cimex* (bed bug), *Pediculus* (Louse), *Haematopinus* (cattle louse), fresh water annelids, arthropods; and soil arthropods.
- Larval stages of helminths and arthropods.
- Permanent mount of wings, mouth parts and developmental stages of mosquito and house fly.
- Permanent preparation of ticks/mites, abdominal gills of aquatic insects viz. *Chironomus* larva, dragonfly and mayfly nymphs, preparation of antenna of housefly
- Life history of silkworm, honeybee and lac insect.
- Study of different types of important edible fishes of India.
- Slides of plant nematodes.
- Project Report/ model chart making.
- **Dissections:** through multimedia/models
- **Cockroach:** Central nervous system

#### **Virtual Labs**

<https://www.vlab.co.in>

<https://zoologysan.blogspot.com>

[www.vlab.iitb.ac.in/vlab](http://www.vlab.iitb.ac.in/vlab)

<https://www.vlab.co.in>

<https://zoologysan.blogspot.com>

[www.vlab.iitb.ac.in/vlab](http://www.vlab.iitb.ac.in/vlab)

[www.onlinelabs.in](http://www.onlinelabs.in)

[www.powershow.com](http://www.powershow.com)

<https://vlab.amrita.edu>

<https://sites.dartmouth.edu>

*\*A minimum of eight practicals should be done from the above mentioned list.*

*\*\* Addition or deletion of the lab experiments can be done as per the availability of resources in lab.*

#### **Skill Developed-**

At the end of laboratory course,

CO1: Understand the diversity of invertebrates in terms of their classification and characteristic features

CO2: Learn about the biology of important invertebrate species

CO3: Know the economic importance of some animal species

### Mapping of CO and PO for MZO 305

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
<b>CO1</b>	3	3	3	3	3	3	2	3	3	3	3	3	2	3	3
<b>CO2</b>	3	3	3	3	3	3	2	3	3	3	3	3	2	3	3
<b>CO3</b>	3	3	3	3	3	3	2	3	3	3	2	3	3	3	3

\*\*Mapping Scale: 1 to 3 (3: Strong; 2: medium; 1: weak)

## Course Code-MZO -306

### Subject: Lab Course-II (Based on MZO 303-304)

No. of Credits-3

<b>L</b>	<b>P</b>
<b>0</b>	<b>6</b>

1. To perform experiment using ammonium sulphate precipitation of antibodies in serum.
2. To perform experiment on the preparation of antigen -adjuvant (FCA) emulsion.
3. To perform experiment on the collection of blood from mice and separation of serum.
4. To perform experiment on antibody purification from the serum collected from immunized mice: affinity purification/chromatography.
5. To perform experiment on double diffusion and Immune-electrophoresis
6. To perform experiment on radial immune diffusion
7. To perform experiment of Band analysis of different types of plasma antibodies by SDS PAGE
8. To perform agglutination Reaction: a) Tube Agglutination Reaction b) Slide Agglutination Reaction c) Indirect Agglutination Inhibition Reaction
9. To perform experiment for Identification of histological slides of lymphoid tissue - Spleen, thymus, lymph node and bone marrow
10. To perform experiment of Mitosis - Onion root tip squash preparation- Preparation of Karyotypes, Determination of Mitotic index.
11. To perform experiment on Mendelian Inheritance and gene interactions using suitable examples/ seeds
12. To perform experiment on study of Linkage, Recombination, gene mapping using the available data
13. To perform experiment of centromere mapping by tetrad analysis
14. Analysis of pattern of inheritance of given pedigree.
15. Calculation of recombination frequency
16. To perform experiment on Bacterial gene mapping by interrupted conjugation method
17. Calculation of co-transformation and co-transduction frequency
18. Calculation of deviation in phenotypic ratios of different intergenic gene interactions
19. To perform experiment on comparison of ploidy level with respect to given example.

*\*A minimum of eight practical's should be done from the above-mentioned list.*

*\* Addition or deletion of the lab experiments can be done as per the availability of resources in lab.*

### Skill Developed-

At the end of laboratory course, learners-

**CO 1-** understood the basic Immunological aspects to be performed in the laboratory.

**CO 2-** learnt to analyze genetic problems and will be able to approach a research problem statistically.

**CO 3-**understood the centromere mapping as well as to calculate phenotypic ratios of different gene interactions

### Mapping of CO and PO for MZO 306

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
<b>CO1</b>	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3
<b>CO2</b>	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3
<b>CO3</b>	3	3	3	3	3	3	2	3	3	3	3	3	3	2	3

\*\*Mapping Scale: 1 to 3 (3: Strong; 2: medium; 1: weak)

### Seminar:

Seminar will be of 30- 45-minute duration during which the presentation will be followed by questions session by the audience comprising of faculty and students. Every student shall be required to submit the topic of his/her seminar in consultation with the Head of the Department/Faculty members/student advisors well in advance so that the same may be displayed on the notice board. The presenter has to write an Abstract to be distributed during Seminar in addition to two copies of write-up giving relevant details of the background of the subject, methods used and references/List of sources from where the material for presentation has been collected.





## J. C. Bose University of Science and Technology, YMCA, Faridabad

(Established by Haryana State Legislative Act No. 21 of 2009 & Recognized by UGC Act 1956 u/s 22)

**Accredited 'A' Grade by NAAC**

### DEPARTMENT OF LIFE SCIENCES

#### Program M.Sc. Zoology

#### Mapping of the Courses with the Employability/Entrepreneurship/Skill Development

#### M.Sc. Zoology Semester III (Program Code: 757)

Sr. No.	Course Code	Course Name	Employability	Entrepreneurship	Skill Development
1	MZO-301	Structure and functions of non-Chordates	√		√
2	MZO -302	Structure and functions of non-Chordates	√		√
3	MZO -303	Immunology	√		√
4	MZO -304	Genetics	√		√
6	MZO -305	Lab Course I (based on MLS 301 - 302)	√	√	√
7	MZO -306	Lab Course II (based on MLS 303 - 304)	√	√	√
8	MZO - 307	Seminar		√	√
9	XXX	Audit Course- Research Methodology	√		√

## SEMESTER-IV

Sr. No.	Course Code	Subject	Teaching Hours per week			Maximum Marks			Credits	Category Code
			L	T	P	Internal	External	Total		
1	MZO-401	Structure and functions of Chordates	4			25	75	100	4	DCC
2	MZO-402	Developmental Biology	4			25	75	100	4	DCC
3	MZO-403	Evolutionary Biology	4			25	75	100	4	DCC
4	MZO-404	Lab Course- I (Based on MZO 401)			6	30	70	100	3	DCC
5	MZO-405	Lab Course- II (Based on MZO 402- 403)			6	30	70	100	3	DCC
6	MZO- 406	Project Report	0	0	12	-	-	100	6	
<b>Total</b>								<b>600</b>	<b>24</b>	

**Course Code: MZO 401**

**Subject: Structure & Functions of Chordates**

**No. of credits: 4**

**L P**

**4 0**

Maximum Marks: 100

Theory exam- 75

Sessional-25

**Course Objective:** This paper deals with the comparative and evolutionary trends in structure and function of the organ systems of the vertebrate series. The student will be able to understand what are the general characters and different categories of chordates animal as well as the origin and evolutionary relationship in different subphylum of chordates.

### **Unit 1**

**Introduction to Chordates with their general characters, Origin of Chordates, Concept of Protochordate or pre-vertebrates, Classification of Vertebrates upto orders.**

**Integument and its derivatives:** Development, general structure and functions of skin and its derivatives, Glands, scales, horns, claws, nails, hoofs, feathers and hair

### **Unit 2**

**Skeletal system:** Form, function, body size and skeletal elements of the body, Comparative account of jaw suspensorium, Vertebral column, Limbs and girdles; **Digestive system:** Dentition, Stomach, Digestive Glands, Anatomy of gut in relation to feeding habits- herbivores, carnivores and omnivores, Comparative physiology of digestion and absorption; **Respiratory system:** Characters of respiratory tissue, Internal and External Respiration, Comparative physiology of respiratory systems with special emphasis on respiratory organs

### **Unit 3**

**General plan of circulation in various groups:** Components of Blood, General plan of circulation in reptiles, birds and mammals, Evolution of heart, aortic arches and Portal systems, Comparative physiology of circulatory systems; **Evolution of Urinogenital system in vertebrates:** Structure and functions of different types of kidneys, Urino-genital ducts, Comparative physiology of excretory systems, Flight adaptation in birds, Migration in fish and Birds

### **Unit 4**

**Nervous system:** Comparative anatomy of the brain in relation to its functions, Comparative physiology of nervous systems with special emphasis on anatomy of spinal cord, Nerves-Cranial, Peripheral and Autonomous nervous systems; **Sense organs:** Simple receptors, Organs of Olfaction and taste, Lateral line system, Electroreception

### **Suggested Readings:**

1. Kotpal, R. L. (2019). Modern Text Book of Zoology: Vertebrates. Rastogi Publications, 4<sup>th</sup> Edition
2. David Hickman, Jr., Cleveland; Roberts, Larry; Keen, Susan; Larson, Allan; Eisenhour (2021). Animal Diversity. McGraw Hill Education, 9<sup>th</sup> Edition.
3. Young, J. Z. (2004). The Life of Vertebrates. Oxford university press. 3<sup>rd</sup> Edition
4. Pough, F. H., Janis, C. M., & Heiser, J. B. (2013). Vertebrate life. Pearson Higher Ed. 9<sup>th</sup> Edition.
5. Hildebrand, M., Goslow, G. E., & Hildebrand, V. (1998). Analysis of vertebrate structure, Wiley, 3<sup>rd</sup> Edition
6. Kardong, K. V. (2019). Vertebrates: comparative anatomy, function, evolution. McGraw-Hill Education. 8<sup>th</sup> Edition

### **Course Outcomes:**

After successfully completion of this course students will be able to:

**CO1** Understand various biological functions, the evolution of life from most primitive to most advanced form with respect to their habit and habitat.

**CO2** Develop a deep understanding in various systems, adaptations and other special features in

chordates.

**CO3** Do the classification of phylum chordate based on distinguish features of different classes

**CO4** Explain the important features of animals that comes under phylum chordata

### Mapping of CO and PO for MZO 401

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
<b>CO1</b>	3	2	2	3	1	2	1	3	3	3	2	3	3	3	3
<b>CO2</b>	3	2	2	3	1	2	1	3	2	3	2	3	3	3	3
<b>CO3</b>	2	2	2	3	1	2	1	3	3	3	2	3	3	3	3
<b>CO4</b>	3	3	2	3	1	3	1	3	3	3	2	3	3	2	3

\*\*Mapping Scale: 1 to 3 (3: Strong; 2: medium; 1: weak)

**Course Code: MZO 402**  
**Subject: Developmental Biology**  
**No. of credits: 4**  
**L P**  
**4 0**

**Maximum Marks: 100**  
**Theory exam: 75**  
**Sessional: 25**

### **Unit 1. Basic concepts of developmental biology and model systems**

Cell division, cell differentiation, signaling, patterning; Evolution of developmental patterns; Vertebrates model organism- *Xenopus laevis*, chicken, mammals, zebrafish; invertebrate model organism- *Drosophila melanogaster*, Sea urchin, *Caenorhabditis elegans*.

### **Unit 2. Embryonic development and Morphogenesis**

Early embryonic development of vertebrates and invertebrates: structure of the gametes– the sperm, the egg; cleavage and gastrulation; axes and germ layers; Morphogenesis: cell adhesion, cleavage and formation of blastula, gastrulation, neural tube formation, cell migration; Axis specification in *Drosophila*: role of maternal genes, patterning of early embryo by zygotic genes- gap genes, pair-rule genes, segment polarity genes, homeotic selector genes- bithorax and antennapedia complex.

### **Unit 3. Organogenesis and Postembryonic development**

Development and patterning of vertebrate limb, homeobox genes in patterning, signaling in patterning of the limb; Insect imaginal discs—organizing center in patterning of the leg and wing, the homeotic selector genes for segmental identity; insect compound eye; Postembryonic development: growth, cell proliferation, growth hormones; aging- genes involved in alteration in timing of senescence; **Regeneration**: Epimorphic regeneration of reptile (salamander) limb; Morphollaxis regeneration in hydra; embryonic stem cells and their applications

### **Unit 4. Endocrinology**

**Histology of endocrine glands**- pineal, pituitary, thyroid, parathyroid, pancreas, and adrenal glands; and functions of hormones secreted by them; **Male reproductive system** – Structure of Testes, Biosynthesis of testosterone, Regulation and functions; **Female reproduction system** – Structure of Ovary, Biosynthesis of estrogen, Feedback regulation and functions; **Female Reproductive Cycle**– Estrous, Menstrual, Placental hormones–parturition – Lactation.

### **Suggested Readings:**

1. Michael J.F. Barresi and Scott F. Gilbert, (2020). Developmental Biology, Sinauer Associates Inc., Massachusetts, USA. 12<sup>th</sup> Edition
2. Wolpert, L., Beddington, R., Brockes, J., Jessell, T., & Lawrence, P. (2019). Principles of Development Oxford University Press. New York. 6<sup>th</sup> Edition
3. Analysis of Biological Development, Kalthoff, (2000), McGraw-Hill Science, New Delhi, INDIA. 2<sup>nd</sup> Edition
4. Slack, J. M. (2012). Essential developmental biology. John Wiley & Sons. 3<sup>rd</sup> Edition
5. Wolpert, L., Tickle, C., & Arias, A. M. (2015). Principles of development. Oxford University Press, USA. 5<sup>th</sup> Edition
6. Mac E. Hadley and Jon E. Levine (2009) Endocrinology. Pearson Education, 6<sup>th</sup> Edition.
7. Tortora, G.J. & Grabowski, S. (2020) Principles of Anatomy & Physiology. XI Edition John Wiley & sons, 16<sup>th</sup> Edition

### **Course Outcomes:**

After successfully completion of this course students will be able to:

- CO1: Develop a systematic and organized learning about the concepts of growth and development.
- CO2: Explain the concepts of embryological development and morphogenesis in animals
- CO3: Understand the process of organogenesis and post embryonic development.
- CO4: Describe biological processes and their importance for living organisms.

## Mapping of CO and PO for MZO 401

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
<b>CO1</b>	3	2	2	2	2	2	1	3	3	3	1	3	3	3	3
<b>CO2</b>	3	2	2	2	2	2	1	3	3	3	2	3	3	2	3
<b>CO3</b>	3	2	2	2	2	2	1	3	3	3	1	3	3	2	3
<b>CO4</b>	3	2	2	2	2	2	1	3	3	3	2	3	3	2	3

\*\*Mapping Scale: 1 to 3 (3: Strong; 2: medium; 1: weak)

**Course Code: MZO 403**  
**Subject: Evolutionary Biology**  
**No. of credits: 4**  
**L P**  
**4 0**

**Maximum Marks: 100**  
**Theory exam: 75**  
**Sessional:25**

**Course Objectives:** The aim of the course is to provide students with a deeper insight into the evolutionary processes - both selective and random - which can explain the genetic composition of populations, form, behavior and distribution of organisms, and to teach students the basic methods of analyzing the evolutionary relationships.

### **Unit 1: Origin of Life and Evidence of Evolution**

Life's Beginnings: Chemogeny, RNA world, Biogeny, Origin of photosynthesis, Evolution of eukaryotes; Historical review of evolutionary concept: Lamarckism, Darwinism, Neo-Darwinism, Evidences of Evolution: Fossil record- types of fossils, transitional forms, geological time scale, evolution of horse, Molecular - universality of genetic code and protein synthesizing machinery, three domains of life, neutral theory of molecular evolution, molecular clock, example of globin gene family, rRNA/cyt c

### **Unit 2: Population Genetics**

Hardy-Weinberg Law (statement and application of law to human Population); Evolutionary forces upsetting H-W equilibrium. Natural selection (concept of fitness, selection coefficient, derivation of one unit of selection for a dominant allele, genetic load, mechanism of working, types of selection, density-dependent selection, heterozygous superiority, kin selection, adaptive resemblances, sexual selection. Genetic Drift (mechanism, founder's effect, bottleneck phenomenon); Role of Migration and Mutation in changing allele frequencies

### **Unit 3: Product of evolution**

Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation—allopatric, sympatric, Adaptive radiation / macroevolution (exemplified by Galapagos finches); Extinctions, Back ground and mass extinctions (causes and effects), detailed example of K-T extinction

### **Unit 4: Human Evolution**

Origin and evolution of man, Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from Dryopithecus leading to Homo sapiens, molecular analysis of human origin, Phylogenetic trees, Multiple sequence alignment, construction of phylogenetic trees, interpretation of trees

### **Suggested Readings:**

1. Ridley, M (2004). Evolution, Blackwell publishing 3<sup>rd</sup> Edition
2. Hall, B.K. and Hallgrimson, B (2008). Evolution. Jones and Barlett Publishers. 4<sup>th</sup> Edition
3. Futuyma, D. J., & Kirkpatrick, M. (2017). Evolution, Sinauer Associates. 4<sup>th</sup> Edition
4. Muehlenbein, M. P. (Ed.). (2010). Human evolutionary biology. Cambridge University Press. 1<sup>st</sup> Edition
5. Bradshaw, J. L. (2014). Human evolution. Psychology Press. 1<sup>st</sup> Edition

### **Course Outcomes:**

After successful completion of this course students will be able to:

CO1: Understand and explain the main forces of evolution along with evidences of evolution.

CO2: Comprehend the knowledge population genetics and consequences of selection, mutation, migration, inbreeding, genetic drift, an important evolutionary force.

CO3: Explain the concepts of macro evolution and micro evolution.

CO4: Get complete understanding about human evolution

### Mapping of CO and PO for MZO 403

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
<b>CO1</b>	3	2	2	2	2	3	1	3	3	3	2	3	3	3	3
<b>CO2</b>	3	2	2	2	2	2	1	3	3	3	2	3	3	3	3
<b>CO3</b>	3	2	2	2	2	3	1	3	3	3	1	3	3	3	3
<b>CO4</b>	3	2	2	2	2	2	1	3	3	3	1	3	3	3	3

\*\*Mapping Scale: 1 to 3 (3: Strong; 2: medium; 1: weak)



**Course Code: MZO 404**

**Subject: Lab Course - I (Based on MZO 401)**

**Number of Credits: 3**

**L P**

**0 6**

1. Protochordates (Museum specimens and slides) – Salpa sexual, Salpa-sexual, Botryllus, Herdmania.
2. Fishes (Museum specimens and slides) - *Rhinobatus*, *Chimaera*, *Acipenser*, *Amia*, *Periophthalmus*, *Tricanthus*, *Notopterus notopterus*, *Scatophagus*, *Aargus*, *Trichurus*, *Mastacembalus armatus*, *Exocoetus* (flying fish), *Diodon hyterix*, *Echeneis*, *Neurates*.
3. Amphibians (Museum specimens and slides) –*Necturus*, *Siren*, *Ichthyophis*, *Geganophis*, *Rhacophorus*, *Rana tigrina*, *Amblystoma uraetyphlus*, *Cryptobranchus*, *Axolotl Larvae*, *Salamander*, *Amphiuma*, *Trilon*.
4. Reptiles (Museum specimens and slides) – Chameleon, *Phrynosoma*, *Chelone mydas*.
5. Birds (Museum specimens and slides) – Indian Oriole, Indian Koel (male), India koel (female), Indian tailor birds, Kite, jungle fowl.
6. Mammals (Museum specimens and slides) – Indian otter, Marmoset, Loris, Bat (*Megaderma lyra*), Pangolin, Echidna, *Ornithorhynchus*, Hedgehog, Scaly-ant eater, Porcupine, Mongoose.
7. Skull and lower jaw of Chelonia, Crocodile, Bird, Carnivore-mammal (dog), Herbivore mammal (horse).
8. Comparative Osteology of Vertebrates (Frog, Chicken, Rat, Rabbit etc.): Girdles, Limb-bones
9. To prepare stained/unstained slide of placoid scales.
10. Different types of important edible fishes of India.
11. Study of an aquatic ecosystem, its biotic components and food chain.
12. Study on use and ethical handling of model organisms (Mice, rats, rabbit and pig).

### **Virtual Labs**

<https://www.vlab.co.in>

<https://zoologysan.blogspot.com>

[www.vlab.iitb.ac.in/vlab](http://www.vlab.iitb.ac.in/vlab)

<https://www.vlab.co.in>

<https://zoologysan.blogspot.com>

[www.vlab.iitb.ac.in/vlab](http://www.vlab.iitb.ac.in/vlab)

[www.onlinelabs.in](http://www.onlinelabs.in)

[www.powershow.com](http://www.powershow.com)

<https://vlab.amrita.edu>

<https://sites.dartmouth.edu>

*\*A minimum of eight practical should be done from the above mentioned list.*

*\*\* Addition or deletion of the lab experiments can be done as per the availability of resources in lab.*

### **Course Outcomes:**

After the successful completion of this course students will be able to:

CO1: Understand the salient features of hemichordates and protochordates

CO2: Learn about the biology of some important vertebrate species

CO3: Classify vertebrates and will get complete knowledge about the diversification of vertebrates around the world

### Mapping of CO and PO for MZO 404

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
<b>CO1</b>	3	3	3	3	3	3	1	3	3	3	3	3	2	3	3
<b>CO2</b>	3	3	3	3	3	3	1	3	3	3	3	3	2	3	3
<b>CO3</b>	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3

\*\*Mapping Scale: 1 to 3 (3: Strong; 2: medium; 1: weak)

**Course Code: MZO 405**

**Subject: Lab Course - II (Based on MZO 402-403)**

**Number of Credits: 3**

**L P**

**0 6**

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages)
2. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages)
3. Permanent preparation of chick embryo developmental stages.
4. Study of the developmental stages and life cycle of *Drosophila*
5. Morphological studies on the developmental stages of snail, fish, frog, chick and mouse c
6. Histological slides of various organs and systems during development using stained serial sections
7. Identification of whole mounts and histological sections of embryos larvae, pupae and nymphs
8. Study of fossils from models
9. Study and verification of Hardy-Weinberg Law by chi square analysis
10. Demonstration of role of natural selection and genetic drift in changing allele frequencies using simulation studies
11. Graphical representation and interpretation of data of height/ weight of a sample of 100 humans in relation to their age and sex.
12. Construction of phylogenetic trees with the help of bioinformatics tools (Clustal X, Phylip) and its interpretation.

*\*A minimum of eight practical should be done from the above mentioned list.*

*\*\* Addition or deletion of the lab experiments can be done as per the availability of resources in lab.*

**Course Outcomes:**

After the successful completion of this course students will be able to:

CO1: Develop a deep understanding about various stages of embryological development

CO2: Analyze the biological specimens along with their characterization

CO3: Interpret evolutionary relationship among different species of animals

**Mapping of CO and PO for MZO 405**

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
<b>CO1</b>	3	3	3	3	3	3	1	3	3	3	3	3	2	3	3
<b>CO2</b>	3	3	3	3	3	3	1	3	3	3	3	3	2	3	3
<b>CO3</b>	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3

**\*\*Mapping Scale: 1 to 3 (3: Strong; 2: medium; 1: weak)**

**Course Code: MZO-406**

**Subject: Project Report**

**No. of credits: 6**

**Course Objectives:**

The objective of this course is to provide students with a hands-on training in specialized area of sciences

**Contents:**

- The student will be reading and analysing the published information in the chosen area of science under direct mentoring of a faculty member and will participate in research activity.
- Preparation and submission of Review article

**Course Learning Outcomes:**

Students will acquire the following:

- Knowledge on techniques and tools of research
- Quantitative and qualitative data analysis
- Analysis and interpretation of data in the perspective of existing knowledge



## J. C. Bose University of Science and Technology, YMCA, Faridabad

(Established by Haryana State Legislative Act No. 21 of 2009 & Recognized by UGC Act 1956 u/s 22)

**Accredited 'A' Grade by NAAC**

### DEPARTMENT OF LIFE SCIENCES

Program M.Sc. Zoology

**Mapping of the Courses with the Employability/Entrepreneurship/Skill Development**

#### **M.Sc. Zoology Semester IV (Program Code: 757)**

Sr. No.	Course Code	Course Name	Employability	Entrepreneurship	Skill Development
1	MZO -401	Structure and functions of Chordates	√		√
2	MZO -402	Developmental Biology	√		√
3	MZO -403	Evolutionary Biology	√		√
4	MZO -404	Lab Course- I (Based on MZO 401)	√	√	√
6	MZO -405	Lab Course- II (Based on MZO 402- 403)	√	√	√
8	MZO - 406	Project Report	√	√	√