

# **TAMIL NADU OPEN UNIVERSITY**

## **Regulations and Syllabi for B.Sc. Zoology [Semester Pattern - CBCS)]**

**Effective from the Academic Year 2022 - 2023**



**School of Science  
Tamil Nadu Open University  
Chennai - 600 015**

# **Bachelor of Science (B.Sc.) in Zoology**

## **Regulations**

(Effective from the Academic Year 2021 - 2022 onwards)

### **1. Objectives of the Programme:**

- PO-1 To impart knowledge in fundamental and basic aspects of Zoology.
- PO-2 To provide students the scientific skills of Animal Taxonomy and Classification.
- PO-3 To train the students in various quantitative and qualitative analyses of animal samples.
- PO-4 To enable the students to study of various key areas of natural science.
- PO-5 To train students in proper laboratory practice and safety.
- PO-6 To equip students with effective scientific communication skills.
- PO-7 To encourage students to learn application oriented areas of Zoology.

### **2. Learning Outcomes of the Programme:**

- PLO-1 Learners gain knowledge and develop skill over animal sciences, understands the interactions among various living organisms.
- PLO-2 Analyse the relationships among animals with their ecosystems
- PLO-3 Perform procedures as per laboratory standards in the areas of Animal Diversity, Animal Physiology, Ecology, Cell biology, Genetics, etc.,
- PLO-4 Define the concepts of genetics and its importance in human health.
- PLO-5 Give an attention to ecological factors, environmental conservation processes and its importance, pollution control and biodiversity and protection of threatened species.
- PLO-6 This programme is specific for applications of biology like Aquaculture, Apiculture, Sericulture etc.,
- PLO-7 Emphasize the applications of Zoology in daily life.
- PLO-8 Develops empathy and love towards animals

### **3. Specific Outcomes of the Programme:**

- PSO-1 Learners gain knowledge and develop skill over animal sciences, understands the interactions among various living organisms.
- PSO-2 Learners analyze the complex evolutionary processes and behavioral pattern of various animals.
- PSO-3 Understand and compare the physiological and biochemical processes of animals.

PSO-4 Analysis of ecological factors, environmental conservation processes and its importance, pollution control, biodiversity and protection of threatened species.

PSO-5 Apply the knowledge and understanding of Zoology to one's own life and work.

#### **4. Eligibility for Admission:**

Candidates should have passed the Higher Secondary Examination conducted by the Board of Higher Secondary Education, Government of Tamil Nadu or any other examination accepted by the syndicate, as equivalent thereto, with zoology or biology as one of the subjects in Higher Secondary Education. Admission will be in academic year alone.

#### **5. Duration of the course:**

The students shall undergo the prescribed course of study for a period of three academic years.

#### **5. Medium of instruction:** English

#### **6. Subject of study:**

Part 1: Tamil

Part 2: English

Part 3: Major (Zoology): Theory - 12 papers, Practical - 4 papers.

Ancillary I – Botany (I & II Semester)

Ancillary II – Chemistry (III & IV Semester)

Part 4: Skill Enhancement Elective - 1 Paper

Non major Elective /Generic Elective – 1 paper

Environmental Studies -1 (IV Semester)

#### **7. Passing Minimum:**

- (i) For theory examination: The candidate shall be declared to have passed the examination if the candidate secures not less than 25 marks in the Term End Examinations (TEE) in each theory paper and secures not less than 13 marks in the Continuous Internal Assessment (CIA) and overall aggregated marks is 40 in both the external and internal taken together.

Continuous Internal Assessment (CIA)	Term End Examination (TEE)	Overall Aggregated Marks	Maximum Marks
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Minimum Pass Mark	Maximum Mark	Minimum Pass Mark	Maximum Mark	CIA + TEE	
13	30	25	70	40	100

- (ii) For practical examination: The candidate shall be declared to have passed the examination if the candidate secures not less than 40 marks in the University practical examination. The mark distributions depend on results, record note book, procedure writing and *vivo voce* and all taken together for passing the examinations.

Passing Minimum: 40 Marks

Duration of Examination: 3 Hours

### 9. Classification of Successful Candidates:

Candidates who have pass all the courses prescribed and who secure 60 percent and above in the aggregate of marks in Core and Ancillary courses will be placed in the First class. Those securing 50 percent and above but below 60 percent in the aggregate will be placed in the Second class. All other successful candidates will be placed in the Third class.

### Proposed Structure for Bachelor of Science in Zoology

Part	Subject	Title of the paper	Subject Code	Examination			
				Credit	Marks Distribution		Max. Marks
					Assign-ments	Theory Exam	
<b>1<sup>st</sup> SEMESTER</b>							
Part I	Language	Language – I		3	30	70	100
Part II	Language	English – I		3	30	70	100
Part III	Core - I	Invertebrate Zoology-I	BZOOS-11	3	30	70	100
	Allied – I	General Botany-I	BZOOS-12A	3	30	70	100
	Core Practical –I	Invertebrate Zoology -I	--	-	Examination will be held at II Semester		
<b>2<sup>nd</sup> SEMESTER</b>							
Part I	Language	Language – II		3	30	70	100

Part II	Language	English – II		3	30	70	100
Part III	Core – II	Invertebrate Zoology –II	BZOOS-21	2	30	70	100
	Allied - II	General Botany-II	BZOOS-22A	3	30	70	100
	Core Practical – I	Invertebrate Zoology –I & II	BZOOS-P1	4	-	-	100
Part IV	Skill based subjects	Soft skill Elective – I*		2	30	70	100
<b>3<sup>rd</sup> SEMESTER</b>							
Part I	Language	Language – III		3	30	70	100
Part II	Language	English – III		3	30	70	100
Part III	Core – III	Vertebrate Zoology –I	BZOOS-31	3	30	70	100
	Allied - III	General Chemistry-I	BZOOS-32A	3	30	70	100
	Core Practical – II	Vertebrate Zoology –I	--	-	Examination will be held at IV Semester		
Part IV	NME (Generic Elective) NME-1		*	2	30	70	100
<b>4<sup>th</sup> SEMESTER</b>							
Part I	Language	Language – IV		3	30	70	100
Part II	Language	English – IV		3	30	70	100
Part III	Core – III	Vertebrate Zoology -II	BZOOS-41	2	30	70	100
	Allied - IV	General Chemistry - II	BZOOS-42A	3	30	70	100
	Core Practical – II	Vertebrate Zoology – I & II	BZOOS-P2	4	-	-	100
Part IV		Environmental Studies	CCE	2	30	70	100
<b>5<sup>th</sup> SEMESTER</b>							
Part III	Core – III	Cell Biology	BZOOS-51	4	30	70	100
	Core – IV	Genetics and Evolution	BZOOS-52	4	30	70	100
	Core – VI	Developmental Biology and Biotechnology	BZOOS-53	4	30	70	100

	Core -V	Elective – I Aquaculture	BZOOSE-51	4	30	70	100
	Core Practical – III	Cell biology, Genetics, Evolution, Developmental Biology and Biotechnology	-	-	Examination will be held at VI Semester		
<b>6<sup>th</sup> SEMESTER</b>							
Part III	Core - VII	Animal Physiology	BZOOS-61	4	30	70	100
	Core – VIII	Environmental Biology and Biochemistry	BZOOS-62	4	30	70	100
	Core – IX	Immunology and Microbiology	BZOOS-63	4	30	70	100
	Core -X	Elective –I Economic Zoology	BZOOSE-61	4	30	70	100
	Core Practical- III	Cell biology, Genetics, Evolution, Developmental Biology and Biotechnology	BZOOS-P4	4	-	-	100
	Core Practical- IV	Animal Physiology, Environmental Biology, Biochemistry, Immunology and Microbiology	BZOOS-66P	4	-	-	100
	<b>Total</b>			<b>100</b>			<b>3100</b>

\* Suitable courses from online platforms such as SWAYAM or NPTEL or MOOC are to be offered. An option is also given for the students to freely choose similar soft skills offered from other departments at TNOU. Essential soft skill courses include a variety of social skills, including communication skill, emotional intelligence, conflict resolution or any applied Zoology providing self-employment opportunities etc.

**Elective Courses:**

1. Ability Enhancement Compulsory – (i) Soft skill/ Information Technology Essential Courses (AECC)

(ii) Environmental Science

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|---------------------------------------|---|
| 2. Skill Enhancement Courses (SEC)    | – Core Practical - I, II, III & IV                                      |
| 3. Generic Elective (GE)              | – Candidates may choose one paper from the list given by the University |
| 4. Discipline Specific Elective (DSE) | – V and X   |

**Blue Print of the question paper (Major and Ancillary)**

**10. Question Pattern for Theory Examinations:**

Max. Marks: 70

Time: 3

hours

PART - A ( $5 \times 2 = 10$  marks)

Answer ALL the questions

1. From BLOCK - I
2. From BLOCK - II
3. From BLOCK - III
4. From BLOCK - IV
5. From BLOCK - V

PART - B ( $4 \times 5 = 20$  marks)

Answer any FOUR questions in about 150 words

All questions carry equal marks

6. From BLOCK - I
7. From BLOCK - II
8. From BLOCK - III
9. From BLOCK - IV
10. From BLOCK - V
11. From any BLOCK
12. From any BLOCK

PART - C ( $4 \times 10 = 40$  marks)

Answer any FOUR questions in about 500 words

All questions carry equal marks

13. From BLOCK - I
14. From BLOCK - II
15. From BLOCK - III
16. From BLOCK - IV

17. From BLOCK - V
18. From any BLOCK
19. From any BLOCK

**Practical (External only)**

Time: 3 hours

Max.marks:100

1. Major question – system/experiment - 35 marks
2. Minor question – analysis/mounting/experiment - 15 marks
3. Spotters (5 only) ( 5 x 6) - 30 marks
4. Record note book - 20 marks





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**B. Sc. ZOOLOGY SYLLABUS - I YEAR (DISTANCE MODE)**

<b>COURSE TITLE</b>	<b>:</b>	<b>INVERTEBRATE ZOOLOGY-I</b>
<b>COURSE CODE</b>	<b>:</b>	<b>BZOOS-11</b>
<b>COURSE CREDIT</b>	<b>:</b>	<b>3</b>
<b>SEMESTER</b>		<b>I</b>

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**COURSE OBJECTIVES**

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While studying the Invertebrate Zoology-I course; the student shall be able to:

**CO-1** Classify and explain the phylum Protozoa and describe their general characteristics and type study of *Plasmodium*.

**CO-2** Classify and explain the phylum Porifera and describe their general characteristics and type study of *sycon*.

**CO-3** Classify and explain the phylum Coelenterata and describe their general characteristics and type study of *Obelia*.

**CO-4** Classify and explain the phylum Platyhelminthes and describe their general characteristics and type study of *Taenia solium*.

**CO-5** Classify and explain the phylum Aschelminthes and describe their general characteristics, type study of *Ascaris* and parasitic adaptations in Nematodes and Helminthes

**BLOCK-I PROTOZOA**

Unit- 1. Principles of Taxonomy - Binomial nomenclature – Classification of the animal kingdom

Unit – 2. PROTOZOA: General characters, classification up to classes with examples

Unit-3. Type study – Plasmodium - parasitic protozoans (*Entamoeba*, *Trypanosoma* and *Leishmania*)

**BLOCK -II PORIFERA**

Unit- 4. PORIFERA- General characters and classification up to classes with examples

Unit - 5. Type study Sycon

Unit- 6. Canal system in sponges

### **BLOCK –III COELENTERATA**

Unit -7. COELENTERATA- General characters and classification up to classes with examples

Unit -8. Type study – *Obelia* - Structure and life cycle, Polymorphism

Unit- 9. Corals, coral reef formation and conservation

### **BLOCK –IV PLATYHELMINTHES**

Unit- 9. PLATYHELMINTHES: General characters and classification up to orders with examples

Unit- 10. Type study – *Taenia solium*

Unit- 11. General Topic - Parasitic adaptations

### **BLOCK –V ASCHELMINTHES**

Unit- 12. ASCHELMINTHES: General characters and classification up to orders with examples

Unit- 13. Type study – *Ascaris*

Unit- 14. General Topic – Nematode Parasites and diseases - *Wuchereria bancrofti*, *Enterobius vermicularis*, *Ancylostoma duodenale*

Unit- 15. Elementary idea of parasitic adaptations in helminthes

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## **COURSE LEARNING OUTCOMES**

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After completion of the Invertebrate Zoology-I, the student will be able to:

- CLO-1** Explain systematic and functional morphology of phylum Protozoa.
- CLO-2** Describe the general characteristic, classification and examples of phylum Porifera.
- CLO-3** Discuss the classification, general characteristics of phylum Coelenterata and coral reefs.
- CLO-4** Elucidate the classification and salient features of phylum Platyhelminthes.

**CLO-5** Explain the genera characteristics, classification and type study of Aschelminthes.

### **Reference**

1. Ekambaranatha Ayyar, M. and T.N. Ananthkrishnan, 1992. Manual of Zoology Vol. 1 (Invertebrata), Part I and II. S. Viswanathan (Printers and Publishers) Pvt. Ltd, Madras.
2. Jordan, E.L. and P.S. Verma, 1993. Invertebrate Zoology, 12th Edition. S. Chand and Co. Ltd, New Delhi.
3. Kotpal, R.L. 1988 - 1992 Protozoa, Porifera, Coelenterata, Helminthes, Arthropoda, Mollusca, Echinodermata. Rastogi Publications, Meerut.
4. Parker and Haswell, 1964. Text Book of Zoology. Vol I (Invertebrata). A.Z.T; B.S. Publishers and Distributors, New Delhi.
5. Borradi L.A and F.A. Pott. 1987. The Invertebrates. Cambridge University Press,UK.
6. Adam Sedgwick.1972. A student text book Zoology. Vol. I and II. Central Book Depot. Allahabad.
7. Dhama P.S and J.K. Dhama. 1980. Invertebrate Zoology. S. Chand and Co. New Delhi.
8. Hyman L.H. 1982. The Invertebrate Vol. I-VI. McGraw Hill Co New York.
9. Barnes, R.D. Invertebrate Zoology (1982) VI Edition. Holt Saunders International Edition.
10. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. & J.I., Spicer (2002) The Invertebrates: A New Synthesis. III Edition, Blackwell Science.
11. Barrington, E.J.W. (1979) Invertebrate Structure and Functions. II Edition. E.L.B.S.

### **WEBLINK**

1. <https://youtu.be/r83JW-yFVZE>
2. <https://youtu.be/KQBE94x5TfE>
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14. <https://youtu.be/y0qU06Jy2O4>
15. <https://youtu.be/vXGg2v4rN-s>
16. [https://youtu.be/9WX\\_E0\\_ZFE4](https://youtu.be/9WX_E0_ZFE4)

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**COURSE TITLE** : **INVERTEBRATE ZOOLOGY -II**  
**COURSE CODE** : **BZOOS-21**  
**COURSE CREDIT** : **2**  
**SEMESTER** : **I**

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## **COURSE OBJECTIVES**

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While studying the Invertebrate Zoology course-II, the student shall be able to:

**CO-1** Classify and explain the phylum Annelida and describe their general characteristics and type study of Earthworm.

**CO-2** Classify and explain the phylum Arthropoda and describe their general characteristics and type study of Prawn.

**CO-3** Classify and explain Crustaceans and discuss the economic importance of insects.

**CO-4** Classify and explain the phylum Mollusca and describe their general characteristics and type study of Freshwater mussel.

**CO-5** Classify and explain the phylum Echinodermata and describe their general characteristics, type study of starfish and significance of Echinoderm larvae.

### **BLOCK –I ANNELIDA**

Unit -1. ANNELIDA: General characters and classification up to classes with examples

Unit -2. Type study – Earthworm

Unit- 3. Trochophore larva and its evolutionary significance

Unit- 4. Vermiculture

Unit- 4. Coelom in Annelida

Unit- 5. Economic importance

### **BLOCK –II ARTHROPODA**

Unit -6. ARTHROPODA: General characters and classification up to classes with examples

Unit -7. Type study - Prawn

Unit - 8. General Topics: *Peripatus* and its affinities

### **BLOCK – III CRUSTACEAN**

Unit- 9. Crustacean larvae and their significance

Unit- 10. Mouth parts of Insects

Unit- 11. Economic importance of insects

Unit- 12. Social Life in Insects

### **BLOCK –IV MOLLUSCA**

Unit -13. MOLLUSCA: General characters and classification up to classes with examples

Unit -14. Type study - Freshwater Mussel

### **BLOCK –V ECHINODERMATA**

Unit -15. ECHINODERMATA: General characters and classification up to classes with examples

Unit- 16. Type study – Starfish

Unit- 17. Echinoderm larvae and their significance

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### **COURSE LEARNING OUTCOMES**

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After completion of the Invertebrate Zoology-II, the student will be able to:

**CLO-1** Explain the systematic and functional morphology of Annelida.

**CLO-2** Explain the comparative analysis of economic importance, affinities and adaptations of Arthropoda.

**CLO-3** Define the interactions among various living crustaceans.

**CLO-4** Classify the molluscs based on their salient features.

**CLO-5** Explain the general characteristics, classification and type study of phylum echinodermata.

### **Reference**

1. Ekambaranatha Ayyar, M. and T.N. Ananthkrishnan, 1992. Manual of Zoology Vol. 1 (Invertebrata), parts I and II.S. Viswanathan (Printers and Publishers) Pvt. Ltd, Madras.
2. Jordan, E.L. and P.S. Verma, 1993. Invertebrate Zoology, 12th Edition. S. Chand and Co. Ltd, New Delhi.
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<b>COURSE TITLE</b>	<b>:</b>	<b>CORE PRACTICAL – I – INVERTEBRATE ZOOLOGY I&amp;II</b>
<b>COURSE CODE</b>	<b>:</b>	<b>BZOOS-P1</b>
<b>COURSE CREDIT</b>	<b>:</b>	<b>4</b>
<b>SEMESTER</b>		<b>II</b>

## **COURSE OBJECTIVES**

While studying the Core Practical - I Invertebrate Zoology course, the student shall be able to:

**CO-1** Explain the concept of animal adaptation and biological significance through the respective model (specimen-Spotters) of life.

**CO-2** Comparative analysis of morphological observations of selected animals.

**CO-3** Gather the knowledge of the structure and functions of animal parts.

**CO-4** Identify the microscopic organisms and classify the organisms based on their salient features.

**CO-5** Analysis of affinities in different phyla, their distribution.

## **MAJOR PRACTICALS**

CD / Chart / Models / Video - Anatomical observation and comments - Cockroach - Digestive, Reproductive and Nervous system

## **MINOR PRACTICAL**

Slides / Model / Chart – Identification (draw and label):

1. Cockroach: Mouth Parts
2. Earthworm: Penial setae and body setae
3. Honey bee, House fly, Mosquito - Mouth Parts
4. Prawn - Appendages

## **SPOTTERS**

- 1. Study of the following specimens to bring out their external morphology and adaptations to their respective modes of life.**

*Entamoeba, Trypanosoma, Leishmania, Sycon, Taenia solium, Ancylostoma duodenale, Enterobius vermicularis, Ascaris, Wuchereria bancrofti, Chaetopterus, Leech, Limulus,*  
Any two crustacean larvae and starfish

- 2. Study of the following specimens to bring out their external morphology and**



**biological significance:**

*Obelia*, Corals (Any 3), *Physalia*, *Porpita*, *Vellela*, Trochophore Larva, *Peripatus*, *Sacculina*

Crab, Sea Anemone on Hermit Crab, Pearl Oyster and Bipinnaria Larva

**3. Study of the following to relate structure and function:**

Sponge Spicules, *Obelia* ploy, *Taenia* Scolex, Prawn Appendages and Pedicellaria of Starfish

**4. Study of the following to draw labelled sketches:**

T.S. of the Earthworm, T.S. of Leech, *Obelia*, Medusa and T.S. Through arm of Starfish

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**COURSE LEARNING OUTCOMES**

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After completion of the Core Practical - I Invertebrate Zoology, the student will be able to:

**CLO-1** Explain the concept of animal adaptation and biological significance to respective model (specimen-Spotters) of life.

**CLO-2** Define the morphological observation of selected animals.

**CLO-3** Define the structure and functions of animal parts.

**CLO-4** Analysis the microscopic organisms.

**CLO-5** Identify and draw selected parts of animal's origin.

**REFERENCES:**

1. A Manual of Practical Zoology (6<sup>th</sup> Edition) by P.S. Verma and V.K. Agarwal, 2003 – S. Chand Publication, New Delhi.
2. Invertebrate Zoology: A Laboratory Manual (5<sup>th</sup> Edition) by Robert L. Wallace, Walter Kingsley Taylor and D. Elden Beck, 2004.

**WEBLINK**

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19. <https://youtu.be/rGrHDmwI-2Q>
20. <https://youtu.be/8p-GAX4Xb2A>
21. <https://youtu.be/wylff4jVhJ0>

## **B. Sc. ZOOLOGY SYLLABUS - II YEAR**

**COURSE TITLE : VERTEBRATE ZOOLOGY -1**

**COURSE CODE : BZOOS-31**

**COURSE CREDIT : 3**

**SEMESTER II**

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### **COURSE OBJECTIVES**

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While studying the Vertebrate Zoology course- I, the student shall be able to:

**CO-1** Explain the origin and classification of Chordata.

**CO-2** Describe the general characteristics of Prochordata and elucidate the type study of Balanoglossus.

**CO-3** Define Agnatha and discuss their general characteristics and type study of Cyclostomata.

**CO-4** Classify the phylum Pisces and describe the general characteristics, type study and accessory respiratory system of phylum Pisces.

**CO-5** Explain the general characteristics, adaptive features, parental care and type study of Amphibia.

### **BLOCK –I ORIGIN AND CLASSIFICATION OF CHORDATA**

Unit -1. Salient Features of Chordata

Unit- 2. General classification of Phylum Chordata up to orders

Unit -3. Origin of Chordata

### **BLOCK –II PROCHORDATA**

Unit – 4. Prochordata: General Characters with examples for Hemichordata, Cephalochordata and Urochordata

Unit -5. Type study: Balanoglossus

Unit -6. General Topics – Affinities and systematic position of Hemichordata, Urochordata and Cephalochordata

### **BLOCK –III AGNATHA**

Unit –7. AGNATHA: General characters

Unit -8. Type study – Petromyzon

Unit -9. General Topic – Affinities of Cyclostomata

#### **BLOCK –IV PISCES**

Unit -10. PISCES: General characters and classification up to orders

Unit -11, Type study: Shark

Unit -12. Parental care of fishes

Unit -13. General Topic – Affinities of Dipnoi

Unit -14. Types of scales and fins

Unit -15. Accessory respiratory organs – Air bladder

Unit -16. Migration

Unit -17. Economic importance

#### **BLOCK – V AMPHIBIA**

Unit -18. AMPHIBIA: General characters and classification up to orders

Unit -19. Adaptive features of Anura, Urodela and Apoda

Unit- 20. Type study: Frog

Unit – 21. Parental care in Amphibia

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#### **COURSE LEARNING OUTCOMES**

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After completion of the Vertebrate Zoology-I, the student will be able to:

**CLO-1** Explain the systematic and functional morphology of various groups of Chordates.

**CLO-2** Explain the systematic and functional morphology of various groups of prochordata.

**CLO-3** Describe the general characteristics, type study and general topics of agnatha.

**CLO-4** Distinguish the accessory respiratory organs of pisces and general characteristics and classification of pisces.

**CLO-5** Explain the systematic and functional morphology of amphibians.

#### **REFERENCES:**

1. Ekambarantha Ayyar, M and T.N. Ananthkrishnan. 1992. A Manual of Zoology Vol. II [Chordata]. S. Viswanaathan (Printers and Publishers] Pvt. Ltd., Madras.

2. Jordan E.L. and P.S. Verma 1995. Chordata Zoology and Elements of Animal Physiology. S. Chand and Co., New Delhi.
3. Kotpal R.L. 1992. Vertebrata, Rastogi Publications, Meerut
4. Nigam.H.C. 1983 Zoology of Chordates, Vishal publications, Jalandhar.
5. Waterman, Allyn J.et al.1971. Chordate Structure and Functions. Mac.Millan and Co., New York.
6. Jollie. M. 1968. Chordate Morphology. East west press Pvt. Ltd., New Delhi.
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#### **WEBLINK**

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13. <https://youtu.be/CpzCJS2NeHE>

**COURSE TITLE : VERTEBRATE ZOOLOGY -II**

**COURSE CODE : BZOOS-41**

**COURSE CREDIT : 2**

**SEMESTER IV**

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## **COURSE OBJECTIVES**

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While studying the Vertebrate Zoology – II course, the student shall be able to:

**CO-1** Explain the general characteristics, classification of Reptiles and type study of Calotes.

**CO-2** Describe the origin of Reptiles and analyse the identification of poisonous and non-poisonous snake.

**CO-3** Discuss the general characteristics aves, type study of pigeon, evolutionary significance of Archaeopteryx and adaptations in flight and flightless birds.

**CO-4** Explain the general characteristics and classification of mammals along with the type study of rabbit.

**CO-5** Discuss the origin of mammals, egg laying mammals and marsupials, adaptations and dentition in mammals.

### **BLOCK –I REPTILIA**

Unit -1. REPTILIA: General characters and classification up to order level

Unit -2. Type study - Calotes

### **BLOCK – II ORIGIN OF REPTILES**

Unit -3. Origin of reptiles

Unit -4. Snakes of India

Unit -5. Identification of poisonous and non-poisonous snakes

Unit -6. Poison apparatus and biting mechanism of snakes

Unit -7. Skull in reptiles

Unit -8. Golden age of reptiles and extinct reptiles

### **BLOCK –III AVES**

Unit -9. AVES: General characters and classification up to orders

Unit -10. Type study-Pigeon

Unit -11. Characters of Archaeopteryx and its evolutionary significance

Unit -12. Flightless birds (Ratitae) and Flight adaptations

### **BLOCK –IV MAMMALIA**

Unit -13. MAMMALIA: General characters and classification up to orders

Unit -14. Type study-Rabbit

### **BLOCK –V ORIGIN OF MAMMALS**

Unit -15. General Topics: Flying Mammals and Aquatic mammals

Unit -16. Egg laying mammals and Marsupials

Unit-17. Adaptive radiation in mammals

Unit -18. Dentition in mammals

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### **COURSE LEARNING OUTCOMES**

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After completion of the Vertebrate Zoology - II, the student will be able to:

**CLO-1** Explain the systematic and functional morphology of various groups of reptilia.

**CLO-2** explain the origin of Reptiles and analyse the identification of poisonous and non-poisonous snake.

**CLO-3** Describe the animal diversity, distributions, classification and general characteristics of aves.

**CLO-4** Discuss the general characteristics and classification of mammals.

**CLO-5** Elucidate the origin of mammals.

### **REFERENCES:**

1. Ekambarantha Ayyar, M and T.N. Ananthakrishnan. 1992. A Manual of Zoology Vol. II[Chordata]. S. Viswanaathan (Printers and Publishers] Pvt. Ltd., Madras.
2. Jordan E.L. and P.S. Verma 1995. Chordata Zoology and Elements of Animal Physiology. S. Chand and Co., New Delhi.
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**COURSE TITLE** : **CORE PRACTICAL – II**  
**VERTEBRATE ZOOLOGY I&II**

**COURSE CODE** : **BZOOS-P2**

**COURSE CREDIT** : **4**

**SEMESTER** : **IV**

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## **COURSE OBJECTIVES**

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While studying the Core Practical –II Vertebrate Zoology course, the student shall be able to:

- CO-1** Gain the basic morphology of vertebrate animals (Specimen Spotters).
- CO-2** Learners will gain skill about slide preparation, staining and mounting.
- CO-3** Identify the anatomical observations of vertebrates.
- CO-4** Gather basic concept of animal adaptation and biological significance to respective model (specimen-Spotters) of life.
- CO-5** Distinguish the animals of different phyla, their distribution and their relationship with the environment

### **MAJOR PRACTICAL**

CD / Model / Chart - Anatomical observation and comments. Frog - Digestive system, Urino genital system, Arterial and venous systems (alternatively few edible fishes will be studied)

### **MINOR PRACTICAL**

Slides / Model / Chart – Identification (draw and label): 1. Frog vertebrate: Brain and Hyoid apparatus. 2. Placoid Scales

### **SPOTTERS**

- 1. Study of the following specimens to bring out features and their adaptations to their respective modes of life.** *Balanoglossus, Ascidian, Ichthyophis, Draco, Phrynosoma, Sea snake and Bat.*
- 2. Study of the following specimens to bring out their biological significance:**  
*Amphioxus, Epiceratodus, Shark, Anabas, Hippocampus, Narcine, Echeneis, Arius, Flying Fish, Eel, Amblystoma, Axolotl Larva, Bufo, Hyla, Cobra, Krait, Ressels Viper, Echies carinatus, Turtle, Pigeon, Owl and King Fisher.*
- 3. Study of the following to relate structure and function:** Placoid Scale of Shark, Quill

Feather of Pigeon.

4. **Study of the following to draw labelled sketches:** T.S. of *Amphioxus* through Pharynx.

5. **Osteology:**

- a. Study of the following skulls with reference to dentition –Dog, Rat, Rabbit and Man.
- b. Pectoral girdle of Frog, Calotes, Pigeon and Rabbit.
- c. Pelvic girdle of Frog, Calotes, Pigeon and Rabbit.
- d. Fore limb of Frog, Calotes, Pigeon and Rabbit.
- e. Hind limb of Frog, Calotes, Pigeon and Rabbit.
- f. Sinsacrum.

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### **COURSE LEARNING OUTCOMES**

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After completion of the Core Practical –II Vertebrate Zoology, the student will be able to:

**CLO-1** Explain the basic morphology of vertebrate animals (Specimen Spotters).

**CLO-2** Methods of slides preparation, staining and mounting.

**CLO-3** Describe the structure and functions of animal parts.

**CLO-4** Identify the anatomical observations of vertebrates.

**CLO-5** Explain the concept of animal adaptation and biological significance to respective model (specimen-Spotters) of life.

### **REFERENCES:**

1. A Text Book of Practical Zoology – Vertebrate by S.S. Lal, Oscar Publication, New Delhi.
2. Jordan E.L. and P.S. Verma 1995. Chordata Zoology and Elements of Animal Physiology. S. Chand and Co., New Delhi.

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**COURSE TITLE : CELL BIOLOGY**  
**COURSE CODE : BZOOS-51**  
**COURSE CREDIT : 4**  
**SEMESTER V**

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## **COURSE OBJECTIVES**

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While studying the Cell biology course, the student shall be able to:

- CO-1** Explain the structure and organization of cell and difference between the prokaryotic and eukaryotic cell.
- CO-2** Describe the structure of mitochondria, composition of mitochondria and its impact on respiratory activities.
- CO-3** Illustrate and explain the cytoplasmic organelles along with its functions.
- CO-4** Explain the structural organization of nucleus and abnormal chromosomes.
- CO-5** Elucidate the cell cycle and characteristics of cancer cells.

### **BLOCK -I: CELL STRUCTURE**

- Unit -1. Cell Structure and Plasma Membrane
- Unit -2. Structure and organization of bacteria and virus
- Unit -3. Difference between prokaryotic and Eukaryotic cells
- Unit -4. Plasma membrane - structure - composition - functions

### **BLOCK -II: MITOCHONDRIA**

- Unit -5. Mitochondria: Structure of mitochondria - Shuttle system - Pasteur's effects
- Unit -6. Role of mitochondria in metabolism - chemical coupling hypothesis - conformational coupling hypothesis
- Unit -7. Control of respiratory activity enzyme system

### **BLOCK -III: CYTOPLASMIC ORGANELLES**

- Unit -8. Other Cytoplasmic Organelles: General morphology and function of Golgi complex
- Unit -9. Lysosome - Secretory cycles, primary and secondary lysosome
- Unit -10. Structure and functions of endoplasmic reticulum
- Unit -11. Structural organization and function of Prokaryotic and Eukaryotic ribosome

## **BLOCK -IV: NUCLEUS**

Unit -12. Nucleus: Structural organization and functions of nucleus

Unit -13. Membrane pore complex and nucleolus

Unit -14. Organization of DNA into chromosome, nucleosome, Solenoid, Loops, rosette coil, chromatid, chromosome, heterochromatin

Unit -15. Euchromatin, Lampbrush chromosome, Polytene chromosome

## **BLOCK -V: CELL CYCLE AND CANCER**

Unit -16. Cell Cycle and Cancer: Various stages of cell cycle - regulation of cell cycle

Unit -17. Cell cycle and its relation to cancer

Unit -18. Characteristics of cancer cells - types of cancer - theories of cancer

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## **COURSE LEARNING OUTCOMES**

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After completion of the Cell biology, the student will be able to:

- CLO-1** Explain the concepts of Cell Biology along with various cellular structures.
- CLO-2** Describe the structure and functions of mitochondria.
- CLO-3** Comparative analysis the cellular and intercellular organelles and its biological functions.
- CLO-4** Differentiate the structure of nucleus.
- CLO-5** Analysis of different types of cell division and cell cycle.

## **Reference**

- 1) Karp, G., 1979. Cell Biology. Mc Graw Hill Kogakusha Ltd. Japan.
- 2) Avers, C.J., 1976. Cell Biology. D. Van Nostrand Co., New York.
- 3) Watson, J.D., 1977. Molecular Biology of the Gene. 3<sup>rd</sup> edition  
W.A. Benjamin Inc., London.
- 4) Lehninger, A.L., 1984. Principles of Biochemistry. CBS Publishers and Distributors,  
New Delhi.
- 5) Carr, K.E., and P.G. Toner 1982. Cell Structure. Churchill Livingstone, London.
- 6) Dupraw, E.J., 1968. Cell and Molecular Biology. Academic Press New York.
- 7) Ambrose, E.J., and D.M. Easty 1970. Cell Biology. Addison, Wesley Publishing  
Company. London.

- 8) Watson, D., A. Baker. P. Bell, A.Gann, M. Levine, R. Losick, 2004. Molecular Biology of the Gene. "Peasson Education (Singapore) Pvt. Ltd. India Branch" 482. F.I.E. Patpargani Delhi - 110 092.
- 9) De Robertis E.D.D and De. Robertis E.M.F. 1980. Cell and Molecular Biology. Holt - Sunders International (8<sup>th</sup> Edition).
- 10) Gupta. P.K., 2003, Cell and Molecular Biology Rastogi Publication, Meerut, India.

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**COURSE TITLE** : **GENETICS AND EVOLUTION**  
**COURSE CODE** : **BZOOS-52**  
**COURSE CREDIT** : **4**  
**SEMESTER** : **V**

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## **COURSE OBJECTIVES**

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While studying the Genetics and Evolution course, the student shall be able to:

**CO-1** Discuss the basis of mendelian inheritance and mendelian laws.

**CO-2** Describe the process of linkage and crossing over with the help of morgans experiments.

**CO-3** Explain the cytoplasmic inheritance and gene regulation with the concept of lac operon.

**CO-4** Elucidate the concept of mutation and chromosomal aberrations.

**CO-5** Discuss the theories of evolution with supporting experimental proofs.

### **BLOCK –I INTRODUCTION TO GENETICS**

Unit -1. Introduction to Genetics – Basis of Mendelian inheritance and Mendelian laws

Unit -2. Interaction of Genes – Complementary Factors, Inhibitory and Lethal Factors

Unit -3. Multiple Alleles – Blood Groups and their Inheritance in Human

### **BLOCK –II LINKAGE AND CROSSING OVER**

Unit -4. Linkage and Crossing Over – *Drosophila*: Morgan’s Experiments

Unit -5. Cytological Evidence for Crossing Over

Unit -6. Sex determination and sex linkage in *Drosophila* and Man

Unit -7. Non-Disjunction and Gynandromorphs

### **BLOCK –III CYTOPLASMIC INHERITANCE**

Unit -8. Cytoplasmic Inheritance, Maternal Effect on *Limnaea* (shell coiling)

Unit -9. Fine structure of Gene – Cistron – Recon, Muton

Unit -10. Gene Regulation – Operon concept – Lac Operon

### **BLOCK –IV MUTATION**

Unit -11. Mutation

Unit -12. Chromosomal Aberrations – examples from Human

Unit -13. Applied Genetics – Animal Breeding – Heterosis, Inbreeding, Outbreeding, Outcrossing, Hybrid Vigour

Unit -14. Population Genetics, Hardy Weinberg Law

Unit -15. Gene Frequency, Factors Affecting Gene Frequency

### **BLOCK –V THEORIES OF EVOLUTION**

Unit -16. Theories of Lamarck, Darwin and Devries

Unit -17. Modern concept of natural selection – Variation – isolation – speciation

Unit -18. Living fossils

Unit -19. Evolution of man - biological and cultural - Distribution of animals

Unit -20. Zoogeographical realms

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### **COURSE LEARNING OUTCOMES**

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After completion of the Genetics and Evolution, the student will be able to:

**CLO-1** Explain the ideas about Mendelian, non-Mendelian inheritance, genetic disorder, gene mutations and sex determination.

**CLO-2** Analysis about the linkage and crossing over.

**CLO-3** Describe the cytoplasmic inheritance of genes.

**CLO-4** Define the basic principles of mutation and chromosomal aberrations.

**CLO-5** Explain the theories of evolution.

### **REFERENCES:**

1. Verma, P.S. and V.K. Agarwal, 2013. Genetics, 8<sup>th</sup> edition, S. Chand & Co, New Delhi.
2. Higgins II, Best GJ and Jones J, 1996. Biotechnology – Principles and Application Black Well Scientific Publication Oxford, London.
3. Basu, S.B and M. 2008. Hossain. Principles of Genetics, Books and Allied (P) Ltd. Kolkata
4. Dubey, 2006. Text Book of Biotechnology S. Chand & Co. New Delhi
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6. Monroe. W. Strick Berger 2004 Genetics. Prentice Hall India Ltd., New Delhi.
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8. Colbert, E. H., M. Morales and E.C. Minkoff, 2011, Evolution of the Vertebrates.
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**COURSE TITLE** : **DEVELOPMENTAL BIOLOGY AND BIOTECHNOLOGY**  
**COURSE CODE** : **BZOOS-53**  
**COURSE CREDIT** : **4**  
**SEMESTER** : **V**

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### **COURSE OBJECTIVES**

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While studying the Developmental Biology and Biotechnology course, the student shall be able to:

- CO-1** Explain the process of gametogenesis, fertilization and parthenogenesis.
- CO-2** Define cleavage and illustrate the general principles and experimental works in cleavage.
- CO-3** Describe the embryonic adaptation, reproductive technology and bioethics.
- CO-4** Explain the recombinant DNA technology and human genome project.
- CO-5** Elucidate the animal cell culture techniques.

### **BLOCK –I GAMETOGENESIS**

Unit -1. Spermatogenesis and oogenesis

Unit -2. Comparative study of Invertebrate, Vertebrate sperms and eggs

Unit -3. Polarity and symmetry of eggs

Unit -4. Fertilization: Mechanism, physiology and theories

Unit -5. Parthenogenesis - Artificial parthenogenesis and its significance

### **BLOCK –II CLEAVAGE**

Unit -6. Cleavage - Factors influencing cleavage-Fate map - Blastulation and Gastrulation

Unit -7. General principles - physiology and comparative study in Amphioxus, Frog and Chick  
- Experimental works of Speerman and Mangold

Unit -8. Development of brain and eye in Frog

Unit -9. Regeneration in Invertebrates

### **BLOCK –III EMBRYONIC ADAPTATIONS**

Unit -10. Embryonic adaptations: Embryonic membranes and their functions in chick - placentation in mammals

Unit -11. Puberty - Menstrual cycle - contraception-family welfare

Unit -12. Reproductive technology: Artificial insemination - IVF - Embryo-transfer - Test tube

babies

Unit -13. Bioethics

### **Block – IV RECOMBINANT DNA TECHNOLOGY**

Unit -12. Recombinant DNA technology

Unit -13. Basic techniques of Genetic Engineering - Gene libraries

Unit -14. Human Genome project

### **BLOCK –V ANIMAL CELL CULTURE**

Unit -15. Animal cell culture fundamental facilities and applications, media preparations

Unit -16. Types of cell culture

Unit -17. Ccytotoxicity and cell viability

Unit -18. Transgenic animals

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### **COURSE LEARNING OUTCOMES**

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After completion of the Developmental Biology and Biotechnology, the student will be able to:

- CLO-1** Describe the concept of gametogenesis.
- CLO-2** Explain the general principle and pattern of cleavage and blastulation.
- CLO-3** Describe the embryonic adaptations of chick.
- CLO-4** Describe the basic recombination techniques in genetic engineering
- CLO-5** Develop the fundamental facilities and applications animal cell culture.

### **REFERENCES:**

1. Balinsky, B.I., 1981. Introduction to Embryology Saundeers, Philadelphia.
2. Berril & Corp, 1983. Developmental Biology. Mc Graw Hill Book Company, New York.
3. Verma, P.S., V.K. Agarwal and Tyagi, 1995. Chordate Embryology, S. Chand & Co., New Delhi.
4. Majumdar, N.N. 1990. Text book of Vertebrate Embryology. Tata McGraw-Hill Publishing Company Ltd., New Delhi.
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**COURSE TITLE : ELECTIVE – I AQUACULTURE**  
**COURSE CODE : BZOOSE-51**  
**COURSE CREDIT : 4**  
**SEMESTER V**

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## **COURSE OBJECTIVES**

While studying the Aquaculture course, the student shall be able to:

- CO-1** Define aquaculture and explain the scopes and designing the aquaculture ponds.
- CO-2** Explain the various forms of culture system and integrated farming.
- CO-3** Elucidate the culture of carps, pearl oyster and prawns.
- CO-4** Discuss factors involved in fish disease management and formulating fish feeds.
- CO-5** Explain fish harvesting and marketing.

## **BLOCK – I IMPORTANCE OF AQUACULTURE**

Unit -1. Importance of aquaculture – Over exploitation of wild fish stocks – advantages of aquaculture

Unit -2. Aquaculture production trends in the world and in India

Unit -3. Scope for aquaculture in India

Unit -4. Basic fish farm design: selection of site, grow - out and nursery ponds

## **BLOCK – II CULTIVABLE SPECIES**

Unit -5. Cultivable species of fishes, crustaceans, molluscs and algae

Unit -6. Culture systems: Extensive, intensive and semi-intensive culture, composite fish culture

Unit -7. Integrated farming

Unit -8. Advantages of polyculture, monoculture and monosex

## **BLOCK – III CULTURE OF CARP, OYSTER AND PRAWN**

Unit -9. Culture of carp species –oyster culture: pearl oyster

Unit -10. Prawn culture: the problems in penaeid prawn (shrimp) culture due to socio-economic and environmental problems

Unit -11. Freshwater prawn culture

Unit -12. Potential for ornamental fish culture

Unit -13. Common species for ornamental fish culture

#### **BLOCK – IV FISH DISEASE MANAGEMENT**

Unit -14. Fish disease management: Common bacterial, viral, fungal, protozoan and crustacean diseases, their symptoms and treatment

Unit -15. Water quality maintenance

Unit -16. Importance and composition of feeds; types of feed: wet and dry feeds

#### **BLOCK – V MARKETING**

Unit -17. Marketing the products: Marketing the fish to local markets and for export

Unit -18. Harvesting and transport

Unit -19. Canning and freezing

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#### **COURSE LEARNING OUTCOMES**

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After completion of the Aquaculture, the student will be able to:

**CLO-1** Explain the concepts and importance of fisheries.

**CLO-2** Discuss about freshwater fish culture and marine aquaculture like Oyster, Shrimp, etc.,

**CLO-3** Comparative analysis of aquaculture.

**CLO-4** Describe the techniques of fish culture and disease managements.

**CLO-5** Explain the fish marketing and quality control norms.

#### **REFERENCES:**

1. **RATH, R.K.** (2000) Freshwater Aquaculture. Scientific Publishers (India), Jodhpur.
2. **JHINGRAN, A.V.G.** (1991) Fish and Fisheries of India. Hindustan Publishing Co., New Delhi.
3. **BARADACH, J.E. J.H. RYTHER & WO M.C. LARNEY** (1972) Aquaculture. The Farming and Husbandry of Freshwater and Marine Organisms. Wiley Inter Science, New York.

#### **Weblink**

1. <https://youtu.be/W6lDgj5YwZg?list=RDQMdmfTkfmmGJE>
2. <https://youtu.be/zat-USX5Sf4>
3. <https://youtu.be/dFQYLBd1bU4>
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5. [https://youtu.be/cqh\\_mEJbkU8](https://youtu.be/cqh_mEJbkU8)
6. <https://youtu.be/h0HdUPRj-sQ>
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**COURSE TITLE : ANIMAL PHYSIOLOGY**  
**COURSE CODE : BZOOS-61**  
**COURSE CREDIT : 6**  
**SEMESTER VI**

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## **COURSE OBJECTIVES**

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While studying the Animal Physiology course, the student shall be able to:

- CO-1** Explain the process of metabolism, nutrition, food requirement and metabolic pathway of carbohydrate and proteins.
- CO-2** Describe respiration, transportation of gases, cardiac cycle and cardiac rhythm.
- CO-3** Define excretion and discuss the mechanism of urine formation, osmoconformers and muscle mechanism.
- CO-4** Explain nervous system, nervous tissue, neuron, receptors and phonoreceptors.
- CO-5** Describe endocrine glands and disorders caused due to abnormal secretion of endocrine hormones.

### **BLOCK –I METABOLISM**

Unit -1. Nutrition and Food requirements

Unit -2. Carbohydrates and Proteins

Unit -3. Fats, Minerals and Vitamins

Unit -4. Digestive enzymes and their role in digestion

Unit -5. Metabolism - metabolic pathways with reference to carbohydrates

### **BLOCK –II RESPIRATION**

Unit -6. Respiration and Respiratory pigments and functions

Unit -7. Transport of gases ( $\text{CO}_2 + \text{O}_2$ ) - Respiratory quotient - Circulation: Types, Composition, Properties and Functions of blood

Unit -8. Human - cardiac cycle - cardiac rhythm

### **BLOCK –III EXCRETION**

Unit -9. Excretion - kinds of excretory products

Unit -10. Mechanism of urine formation in mammals - hormonal regulation of excretion - Regulatory mechanisms

Unit -11. Osmoconformers – Osmoregulators

Unit -12. Muscles - Types of muscles - Muscle proteins - mechanism of muscle contraction

### **BLOCK –IV NERVOUS SYSTEM**

Unit -13. Nervous tissue - Neuron - Structure, types of neurons. Nerve Impulse - Synapse - Synaptic transmission of impulses - Neuro-transmitters

Unit -14. Receptors - Photoreceptor - mammalian eye - structure of retina - visual pigments - Physiology of vision

Unit -15. Phonoreceptors - Mammalian ear-Physiology of organ of Corti

### **BLOCK –V ENDOCRINE GLANDS**

Unit -16. Endocrine glands - structure, secretions and functions in vertebrates

Unit -17. Pituitary, hypothalamus, thyroids, parathyroid, adrenal, thymus, islets of Langerhans

Unit -18. Sex organs and hormones of insects and crustaceans.

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### **COURSE LEARNING OUTCOMES**

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After completion of the Animal Physiology, the student will be able to:

- CLO-1** Explain the concepts of digestion and metabolic pathways.
- CLO-2** Comparative analysis respiratory pigments and circulation.
- CLO-3** Describe the different kind excretory products.
- CLO-4** Differentiate the structure and types of muscles and explain the nervous system.
- CLO-5** Analyse the structure and functions of endocrine glands.

### **REFERENCES:**

1. Sambasivaiah, Kamalakara Rao and Augustine Chellappa, 1990. A Text book of Animal Physiology and Ecology, S. Chand & Co., Ltd., New Delhi.
2. Parameswaran, Anantakrishnan and Ananthasubramaniam, 1975. Outlines of Animal Physiology, S. Viswanathan Printers & Publishers Pvt. Ltd., Chennai.
3. William S. Hoar, 2004. General and Comparative Physiology, Prentice Hall of India Pvt. Ltd., New Delhi - 110 001.
4. Prosser, C.L. Brown 1985. Comparative Animal Physiology.

### **Weblink**

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5. <https://youtu.be/9j6BpanhpKY>
6. <https://youtu.be/pDr6DDRHvUY>
7. [https://youtu.be/C\\_LiAEjuIIc](https://youtu.be/C_LiAEjuIIc)
8. <https://youtu.be/qYDiL2PNOoc>

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**COURSE TITLE** : **ENVIRONMENTAL BIOLOGY AND BIOCHEMISTRY**  
**COURSE CODE** : **BZOOS-62**  
**COURSE CREDIT** : **4**  
**SEMESTER** : **VI**

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### **COURSE OBJECTIVES**

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While studying the Environmental Biology and Biochemistry course, the student shall be able to:

**CO-1** Explain various bio-geo chemical cycles.

**CO-2** Describe population ecology, community, wildlife management and natural resource management.

**CO-3** Discuss the environmental degradation, ethics and laws of environment and role of governmental agencies for environmental monitoring.

**CO-4** Explain classification, structure and functions of basic biomolecules.

**CO-5** Classify enzymes and explain the mechanism of action of enzymes.

### **BLOCK –I BIO-GEO CHEMICAL CYCLES**

Unit -1. Bio-geo chemical cycles

Unit -2. Gaseous cycle and sedimentary cycle (phosphates and sulphur)

Unit -3. Intra specific and inter specific animal association with abiotic factors

### **BLOCK –II POPULATION ECOLOGY**

Unit -4. Population Ecology: definition - characteristics – natality, mortality, age distribution, population growth forms, population fluctuation

Unit -5. Community – ecological succession - Conservation

Unit -6. Wild life management: preservation – sanctuaries, national parks

Unit -7. Natural resources management: renewable and non-renewable energy

### **BLOCK –III ENVIRONMENTAL DEGRADATION**

Unit -8. Environmental degradation - deforestation, urbanization, population explosion and other environmental hazards

Unit -9. Depleting natural resources and relationship between poverty and environmental degradation

Unit -10. Environmental ethics and laws

Unit -11. Role of Governmental agencies for environmental monitoring

### **BLOCK- IV INTRODUCTION TO BIOCHEMISTRY**

Unit -12 Introduction to Biochemistry

Unit- 13. Proteins: Classification – Globular and fibrous proteins – Structure and functions

Unit -14. Carbohydrates: Mono, oligo and polysaccharides – Structure and functions

Unit -15. Lipids: Classification, structure, properties and functions

Unit -16. Amino Acids: Structure and classification and functions

### **BLOCK -V ENZYME**

Unit -17. Enzymes - naming - Classification – Properties

Unit -18. Mechanism of action of enzymes

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### **COURSE LEARNING OUTCOMES**

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After completion of the Environmental Biology and Biochemistry, the student will be able to:

- CLO-1** Comparative analysis of Bio-geo chemicals. Laws and types of ecosystem.
- CLO-2** Explain the concepts of population ecology.
- CLO-3** Elaborate the environmental degradations.
- CLO-4** Examine the biomolecular receptors and biochemical pathways of cells.
- CLO-5** Describe the various cascade of metabolic processes and enzyme classification and mechanism.

### **REFERENCES:**

1. Clark, G.L. 1954, Elements of Ecology, John Wiley & Sons Inc., New York, London.
2. Eugene P. Odum, 1971. Fundamentals of Ecology, Saunders International Student Edition, W.B. Saunders Company, Philadelphia London, Toronto.
3. Verma, P.S and Agarwal 1986, Environmental Biology, S. Chand & Co Ltd., New Delhi.
4. Richard. 1971, Manual of Wild life Conservation, Wildlife Society, Washington.
5. Saha, T.K. 2014. Ecology and Environmental Biology, Books and Allied (P) Ltd. Kolkata.
6. Lehninger, L. Albert, David, L. Nelson, Michael, M. Cox (1993). Principles of Biochemistry, CBS Publishers and Distributors, Delhi.
7. Stryer, L (1988), Biochemistry, W.H. Freeman and Company, New York.

8. Cooper, T.G. 1977, The Tools of Biochemistry, Wiley Interscience Publication, John Wiley and Sons, New York.

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2. <https://youtu.be/k6sJtdLxurs>
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16. [https://youtu.be/15Fezs8uG\\_c](https://youtu.be/15Fezs8uG_c)
17. [https://youtu.be/-fy8-owt6sk?list=PLRpz4J5dUMCf0Jk8oojz\\_5TuaXtPNLmX](https://youtu.be/-fy8-owt6sk?list=PLRpz4J5dUMCf0Jk8oojz_5TuaXtPNLmX)

**COURSE TITLE** : **IMMUNOLOGY AND MICROBIOLOGY**  
**COURSE CODE** : **BZOOS-63**  
**COURSE CREDIT** : **4**  
**SEMESTER** : **VI**

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### **COURSE OBJECTIVES**

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While studying the Immunology and Microbiology course, the student shall be able to:

- CO-1** Explain the basic of immunology and types of immunity and graft rejection.
- CO-2** Classify the immunoglobulins and explain its structure, functions and deficiency syndromes.
- CO-3** Define and classify microbes and explain its structure.
- CO-4** Describe the bacterial culture and bacterial culture techniques.
- CO-5** Discuss the causative agents, mode of transmission, control, prevention and treatment for various human diseases.

### **BLOCK –I BASICS OF IMMUNOLOGY**

Unit -1. Basics of immunology – antigen - antibody reaction

Unit -2. Types of immunity

Unit -3. Hypersensitivity and graft rejection

Unit -4. Lymphoid organs, cells of immune system and their role in immune response

### **BLOCK –II IMMUNOGLOBULINS**

Unit -5. Immunoglobulin: types, structure, physico-chemical and biological properties

Unit -6. Immunoprophylaxis - Immunization schedule for children

Unit -7. Immuno deficiency - AIDS, Immuno-techniques

### **BLOCK –III INTRODUCTION TO MICROBES**

Unit – 8. Classification of microbes

Unit – 9. Morphology and ultra structure of bacteria, fungi and viruses

### **BLOCK –IV BACTERIAL CULTURE**

Unit – 10. Bacterial culture techniques

Unit – 11. Bacterial growth curves and nutritional requirements

### **BLOCK V: HUMAN DISEASES**

Unit – 12. Causative agents, mode of transmission, control, prevention and treatment of Polio

Unit - 13. Causative agents, mode of transmission, control, prevention and treatment of Rabbits

Unit –13. Causative agents, mode of transmission, control, prevention and treatment of AIDS

Unit – 14. Causative agents, mode of transmission, control, prevention and treatment of Cholera

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## **COURSE LEARNING OUTCOMES**

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After completion of Immunology and Microbiology, the student will be able to:

- CLO-1** Explain the basics of immunology.
- CLO-2** Define the immunization schedule for children and immunoglobulin.
- CLO-3** Describe the types of microbes and their morphology.
- CLO-4** Classify the microorganisms and bacterial culture.
- CLO-5** Imparts the knowledge about communicable diseases.

## **REFERENCE**

1. Paul, W.E.M. 1989, Fundamental Immunology, Raven press, New York.
2. Kuby. J., 2008. Immunology. W.H. Free man and Co. New York.
3. Roitt. I, Brostoff, J. and Male. D., 2002. Immunology, Mosby, New York.
4. Richard, A. Golds, Thomas I, Kindt & Barbara. A. Osborne, Kuby 2000. Immunology, Freeman and Co. New York.
5. Pelczer, M.J. Reid, R.D. and Chan, E.C.S (1996), Microbiology, 5 Edn., Tata McGraw Hill Publishing Company Ltd., New Delhi.
6. Ananthanarayanan, T & Jayaram Paniker, C.K (2000), Text Book of Microbiology, Sixth Edition, Orient Longman Ltd., Madras.

## **Weblink**

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3. <https://youtu.be/zg61a3BoR8Y>
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5. <https://youtu.be/l3an3uhiHAW>

6. [https://youtu.be/3A9w\\_PUGd8Q](https://youtu.be/3A9w_PUGd8Q)
7. <https://youtu.be/AorQ3rSsWwY>

**COURSE TITLE** : **ELECTIVE –II ECONOMIC ZOOLOGY**  
**COURSE CODE** : **BZOOSE-61**  
**COURSE CREDIT** : **4**  
**SEMESTER** : **VI**

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### **COURSE OBJECTIVES**

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While studying the Economic Zoology course, the student shall be able to:

**CO-1** Explain the beneficiary and harmful insects along with their economic importance.

**CO-2** Define aquaculture and describe the principles, scopes, merits and demerits of aquaculture.

**CO-3** Explain the methods and techniques of apiculture.

**CO-4** Discuss the culturing techniques involved in sericulture.

**CO-5** Describe poultry farming disease management in poultry birds.

### **BLOCK –I BENEFICIAL AND HARMFUL INSECTS**

Unit -1. Beneficial and harmful insects, including insect vectors of human diseases (Mosquito and Lice)

Unit -2. Pests of sugar cane (*Pyrrilla perpusilla*)

Unit -3. Pests of Oil seed (*Achaea janata*)

Unit -4. Pests of Rice (*Sitophilus oryzae*)

### **BLOCK- II AQUACULTURE**

Unit -5. Aquaculture: Principles, definition and scope

Unit -6. Exotic fishes-their merits and demerits

Unit -7. Basic principles of different aquaculture system (Polyculture and integrated farming)

Unit -8. Culture of prawn

Unit -9. Pearl culture

### **BLOCK- III APICULTURE**

Unit -10. Apiculture: Development of Apiary in India

Unit -11. Types of honey bees

Unit -12. Modern methods of apiary management

Unit -13. Products and its uses

Unit -14. Problems and prospects



## **BLOCK- IV SERICULTURE**

Unit -15. Sericulture: Life history and rearing of *Bombyx mori*, harvesting & processing of cocoon, reeling and extraction of silk

Unit -16. Diseases of silkworms of *Bombyx mori* and control measures

## **BLOCK -V POULTRY FARMING**

Unit -17. Poultry: Fowl -Types of breeds

Unit -18. Rearing of Fowl

Unit -19. Disease management

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## **COURSE LEARNING OUTCOMES**

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After completion of the Economic Zoology, the student will be able to:

**CLO-1** Explain the basic concepts of insect vectors and comment on beneficial and harmful insects.

**CLO-2** Describe fish culture, prawn culture, apiculture etc.

**CLO-3** Discuss about rearing techniques and disease management of apiculture.

**CLO-4** Discuss about rearing techniques and disease management of sericulture.

**CLO-5** Elucidate the concepts and importance of poultry farming.

## **REFERENCES:**

1. **AYYAR, E.K. & T.N. ANANTHAKRISHNAN** (2000), Manual of Zoology Vol. I & II (Non – Chordata and Chordata), S. Viswanathan (Printers and Publishers) Pvt. Ltd., Chennai.
2. **SHUKLA & UPADHYAY** (2014) Economic Zoology, Fifth Edition. Rastogi Publication, Meerut, New Delhi.
3. **KOTPAL, R.L** (2000), Modern Textbook of Zoology, Rastogi Publications (2000) Meerut, New Delhi.

## **Weblink**

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2. [https://youtu.be/DQxwoK\\_mvBg](https://youtu.be/DQxwoK_mvBg)
3. <https://youtu.be/IKzkUBu1KIk>
4. <https://youtu.be/bz57wCVGJO0>
5. <https://youtu.be/hgrq4zmSUOw>
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**COURSE TITLE** : **CORE PRACTICAL –III, CELL BIOLOGY, GENETICS, EVOLUTION, DEVELOPMENT BIOLOGY & BIOTECHNOLOGY**

**COURSE CODE** : **BZOOS-P3**

**COURSE CREDIT** : **4**

**SEMESTER** : **VI**

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### **COURSE OBJECTIVES**

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While studying the Core Practical -III course, the student shall be able to:

**CO-1** Learners gain knowledge about various principles, procedures and biological functions of Microscope.

**CO-2** Gather practical knowledge on the human blood grouping and its important.

**CO-3** Analysis the evolutionary changes of organs.

**CO-4** Hands on training about the mounting of buccal epithelium.

**CO-5** Analysis the slides/ museum specimens of different stages of chick embryo

### **CELL BIOLOGY**

1. Use of Microscope, Camera Lucida, Stage and Ocular Micrometers
2. Mounting of buccal epithelium
3. Mitosis in onion root tip squash

### **GENETICS**

1. Observation of common mutants of *Drosophila*
2. Human blood grouping

### **EVOLUTION**

1. Calculating gene frequencies and genotype frequencies in the light of Hardy-Weinberg Law in human/other populations
2. Calculation of frequencies of recessive and dominant genes in a population
3. Calculation of Hetrozygotes and Homozygotes in a population
4. Study of Evidences:
  - i) Analogous and Homologous organs

- ii) Connecting links (*Peripatus*, *Archaeopteryx* and *Limulus*)
  - iii) Embryological evidences
5. Study of Adaptation:
- i) Aquatic ii) Terrestrial iii) Aerial/Volant iv) Cursorial v) Desert

## **DEVELOPMENT BIOLOGY AND BIOTECHNOLOGY**

Study of prepared slides/museum specimens

1. Sections of testis and ovary (Mammalian)
2. Slides of mammalian sperm and ovum
3. Study of egg types
4. Study of cleavage stages – blastula and gastrula of frog
5. Slides of different stages of chick embryo-18 Hours (primitive streak stage), 24 hours, 48 hours, 72 hours and 96 hours
6. Placenta of sheep, pig and man
7. Plasmids
8. Transgenic animals

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## **COURSE LEARNING OUTCOMES**

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After completion of the Core Practical -III, the student will be able to:

- CLO-1** Explain the principles, procedures and biological functions of Microscope.
- CLO-2** Elaborate complete procedure of mounting of buccal epithelium.
- CLO-3** Identify the salient features of human blood grouping.
- CLO-4** Comparative analysis of evolutionary evidences.
- CLO-5** Identify the slides/ museum specimens of different stages of chick embryo.

## **WEBLINK**

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4. <https://youtu.be/g9ld8XkQJhA>
5. <https://youtu.be/6HIJhp2RkD8>
6. [https://youtu.be/\\_7wxUPUSpbM](https://youtu.be/_7wxUPUSpbM)

7. <https://youtu.be/6bSJ9NE-2Pg>
8. <https://youtu.be/GWm-viFOQtQ>

**COURSE TITLE** : **CORE PRACTICAL –IV, IMMUNOLOGY, ANIMAL PHYSIOLOGY AND ENVIRONMENTAL BIOLOGY**  
**COURSE CODE** : **BZOOS-P4**  
**COURSE CREDIT** : **4**  
**SEMESTER** : **VI**

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### **COURSE OBJECTIVES**

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While studying the Core Practical -IV course, the student shall be able to:

- CO-1** Gain the knowledge about immunological techniques.
- CO-2** Gain - biochemical analysis of various human samples.
- CO-3** Gather histological techniques.
- CO-4** Learners gain skill about quantification of various ecological parameters.
- CO-5** Basic concept of plankton study.

### **IMMUNOLOGY AND MICROBIOLOGY**

1. Study of WIDAL test – Qualitative and quantitative
2. **Study of prepared slides of histology:**
  - a) Thymus b) Spleen c) Bone marrow d) Lymph node

### **ANIMAL PHYSIOLOGY**

1. Study of activity of human salivary amylase in relation to pH and temperature
2. Estimation of oxygen consumption in a fish with reference to body weight
3. Detection of nitrogenous waste products in fish tank water, bird excreta and mammalian urine
4. Blood smear preparation – Observation on RBA and various cell types
5. Study of prepared slides of histology:

Columnar epithelium, Ciliated epithelium, Glandular epithelium, Cardiac muscle, Striated muscle, Non-striated muscle, Neuron

### **ENVIRONMENTAL BIOLOGY**

1. Estimation of dissolved oxygen, salinity and CO<sub>2</sub> in water samples
2. Plankton study - Fresh water

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## COURSE LEARNING OUTCOMES

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After completion of the Core Practical -IV, the student will be able to:

- CLO-1** Explain the principles of widal test.
- CLO-2** Identify the histology slides of immunological organs
- CLO-3** Physiological analysis of salivary amylase.
- CLO-4** Comparative analysis of blood smear preparations.
- CLO-5** Estimation of Dissolved oxygen, Salinity and CO<sub>2</sub> in water samples

### WEBLINK

1. <https://youtu.be/dfIOQ8hXUbA>
2. [https://youtu.be/nUjK4n3\\_1C8](https://youtu.be/nUjK4n3_1C8)
3. <https://youtu.be/iaqxTaXit9M>
4. <https://youtu.be/KSs0SMfERuA>
5. <https://youtu.be/frtln5ZoeNQ>
6. <https://youtu.be/mDsTyRIH-Ec>

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## Allied Zoology: I (Botany and Chemistry Majors)

<b>COURSE TITLE</b>	<b>:</b>	<b>ANIMAL DIVERSITY</b>
<b>COURSE CODE</b>	<b>:</b>	<b>BOTANY : BBOT-1A</b> <b>CHEMISTRY : BCHYA-11</b>
<b>COURSE CREDIT</b>	<b>:</b>	<b>4</b>

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### **COURSE OBJECTIVES**

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While studying the Core Practical -IV course, the student shall be able to:

- CO-1** Explain about classification of invertebrate organisms.
- CO-2** Elaborate study about the paramecium and earthworm.
- CO-3** Elaborate the Lamellidens and Sea star.
- CO-4** Basic concept of various physiological, anatomical structures of animals.
- CO-5** Analysis the biological concepts of birds and mammals.

### **BLOCK- I CLASSIFICATION OF MAJOR INVERTEBRATE ORGANISMS**

Unit -1. Classification of major Invertebrate organisms

Unit -2. Phylum chordata up to classes

Unit -3. Class characteristics and diversity with suitable examples

### **BLOCK- II *PARAMOECIUM, EUGLENA, OBELIA, FASCIOLA HEPATICA AND EARTHWORM***

Unit -4. Detailed study of *Paramoecium*

Unit -5. Detailed study of *Euglena*

Unit -6. Detailed study of *Obelia*

Unit -7. Detailed study of *Fasciola hepatica*

Unit -8. Detailed study of Earthworm

### **BLOCK- III *PRAWN, LAMELLIDENS AND SEA STAR***

Unit -9. Detailed study of Prawn

Unit -10. Detailed study of Lamellidens

Unit -11. Detailed study of sea star

## **BLOCK- IV SHARK, FROG AND CALOTES**

Unit – 12. Detailed study of external features, digestive system, respiratory system, circulatory system, urinogenital system and brain of shark

Unit -13. Detailed study of external features, digestive system, respiratory system, circulatory system, urinogenital system and brain of frog

Unit. 14. Detailed study of external features, digestive system, respiratory system, circulatory system, urinogenital system and brain of calotes

## **BLOCK- V PIGEON AND RABBIT**

Unit – 15. Detailed study of external features, digestive system, respiratory system, circulatory system, urinogenital system and brain of pigeon

Unit- 16. Detailed study of external features, digestive system, respiratory system, circulatory system, urinogenital system and brain of rabbit

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## **COURSE LEARNING OUTCOMES**

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After completion of the Core Practical -IV, the student will be able to:

- CLO-1**        Classify the major invertebrate and Chordates.
- CLO-2**        Detail about paramecium, euglena, obelia, fasciola hepatica and earthworm.
- CLO-3**        Explain the Prawn, Lamellidens and Sea star.
- CLO-4**        Comparative study of digestive system, respiratory system, circulatory system, urinogenital system and brain of Shark, Frog and Calotes.
- CLO-5**        Elaborate the circulatory system, urinogenital system and brain of Pigeon and Rabbit.

### **Reference:**

1. Ekambaranatha Ayyar, M. and T.N. Ananthakrishnan, 1992. Manual of Zoology Vol. 1 (Invertebrata), parts I and II.S. Viswanathan (Printers and Publishers) Pvt. Ltd; Madras.
2. Jordan, E.L. and P.S. Verma, 1993. Ivertebrate Zoology, 12th Edition. S. Chand and Co. Ltd, New Delhi.
3. Kotpal, R.L. 1988 - 1992 Protozoa, Porifera, Coelenterata, Helminthes, Arthropoda, Mollusca, Echinodermata. Rastogi Publications, Meerut.
4. Jordan E.L. and P.S. Verma 1995. Chordata Zoology and Elements of Animal Physiology. S. Chand and Co., New Delhi.



## **WEBLINK**

1. <https://youtu.be/I1o7wqYhez8>
2. <https://youtu.be/P4SnQb2gLLM>
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4. <https://youtu.be/nopltRU9Drw>
5. <https://youtu.be/wMMzjhUpaIE>
6. <https://youtu.be/kuQ4paSrRvA>
7. <https://youtu.be/i5ExoUsa18I>

## **ALLIED ZOOLOGY -II**

**COURSE TITLE : ECONOMIC ZOOLOGY**

**COURSE CODE : BOTANY : BBOT-2A**

**CHEMISTRY : BCHYA-12**

**COURSE CREDIT : 4**

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### **COURSE OBJECTIVES**

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While studying the Economic Zoology course, the student shall be able to:

**CO-1** Explain the beneficiary and harmful insects along with their economic importance.

**CO-2** Define aquaculture and describe the principles, scopes, merits and demerits of aquaculture.

**CO-3** Explain the methods and techniques of apiculture.

**CO-4** Discuss the culturing techniques involved in sericulture.

**CO-5** Describe poultry farming disease management in poultry birds.

### **BLOCK I BENEFICIAL AND HARMFUL INSECTS**

Unit -1. Beneficial and harmful insects, including insect vectors of human diseases (Mosquito and Lice)

Unit -2. Pests of sugar cane (*Pyrrilla perpusilla*)

Unit -3. Pests of oil seeds (*Achaea janata*)

Unit -4. Pests of rice (*Sitophilus oryzae*)

### **BLOCK II AQUACULTURE**

Unit -5. Aquaculture: Principles, definition and scope

Unit -6. Exotic fishes - their merits and demerits

Unit -7. Basic principles of different aquaculture system (Polyculture and integrated farming)

Unit -8. Culture of prawn

Unit -9. Pearl culture

### **BLOCK III APICULTURE**

Unit -10. Apiculture: Development of apiary in India

Unit -11. Types of honey bees

Unit -12. Modern methods of apiary management

Unit -13. Products and its uses

Unit -14. Problems and prospects

#### **BLOCK IV SERICULTURE**

Unit -15. Sericulture: Life history and rearing of *Bombyx mori*, harvesting & processing of cocoon, reeling and extraction of silk

Unit -16. Diseases of silkworms of *Bombyx mori* and control measures

#### **BLOCK V POULTRY FARMING**

Unit -17. Poultry: Fowl -Types of breeds

Unit -18. Rearing of Fowl

Unit -19. Disease management

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#### **COURSE LEARNING OUTCOMES**

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After completion of the Economic Zoology, the student will be able to:

**CLO-1** Explain the basic concepts of insect vectors and comment on beneficial and harmful insects.

**CLO-2** Describe fish culture, prawn culture, apiculture etc.

**CLO-3** Discuss about rearing techniques and disease management of apiculture.

**CLO-4** Discuss about rearing techniques and disease management of sericulture.

**CLO-5** Elucidate the concepts and importance of poultry farming.

#### **REFERENCES:**

1. **AYYAR, E.K. & T.N. ANANTHAKRISHNAN** (2000), Manual of Zoology Vol. I & II (Non – Chordata and Chordata), S. Viswanathan (Printers and Publishers) Pvt. Ltd., Madras.
2. **SHUKLA & UPADHYAY** (2014) Economic Zoology, 5<sup>th</sup> Edition, Rastogi Publication, Meerut, New Delhi.
3. **KOTPAL, R.L** (2000), Modern Textbook of Zoology, Rastogi Publications (2000) Meerut, New Delhi.

#### **Weblink**

1. [https://youtu.be/FjB\\_4qwqnWA](https://youtu.be/FjB_4qwqnWA)
2. [https://youtu.be/DQxwoK\\_mvBg](https://youtu.be/DQxwoK_mvBg)
3. <https://youtu.be/IKzkUBu1KIk>
4. <https://youtu.be/bz57wCVGJ00>

5. <https://youtu.be/hgrq4zmSUOw>
6. <https://youtu.be/1EhRqb2myII>

## Mapping

### Core Courses (CC)

Programme Outcomes	BZ O-11	BZ O-12 A	BZ O-21	BZ O-22 A	BZ O-23 P	BZ O-31	BZ O-32 A	BZ O-41	BZ O-42 A	BZ O-43 P	BZ O-51	BZ O-52	BZ O-53	BZ O-61	BZ O-62	BZ O-63	BZ O-65 P	BZ O-66 P
Core competency	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Critical thinking	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Analytical reasoning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Research-skills	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Teamwork	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

### Discipline Specific Elective Courses (DSE)

Programme Outcomes	BZOE- 54	BZOE- 64
Additional Academic Knowledge	✓	✓
Problem-solving	✓	✓
Additional analytical skills	✓	✓
Additional Research-skills	✓	✓

### Generic Elective Courses (GEC)

Programme Outcomes	NME
Additional Academic Knowledge	✓
Exposure beyond discipline	✓
Problem-solving	✓
Analytical reasoning	✓

### Skill Enhancement Course (SEC)

<b>Programme Outcomes</b>	<b>BZOE- 54</b>	<b>BZOE-64</b>
Additional Knowledge enhancement	✓	✓
Exposure beyond discipline	✓	✓
Analytical reasoning	✓	✓
Digital Literacy	✓	✓
Moral and ethical awareness	✓	✓

### Ability Enhancement Course (AEC)

<b>Programme Outcomes</b>	<b>BZ O-11</b>	<b>BZ O-12 A</b>	<b>BZ O-21</b>	<b>BZ O-22 A</b>	<b>BZ O-23 P</b>	<b>BZ O-31</b>	<b>BZ O-32 A</b>	<b>BZ O-41</b>	<b>BZ O-42 A</b>	<b>BZ O-43 P</b>	<b>BZ O-51</b>	<b>BZ O-52</b>	<b>BZ O-53</b>	<b>BZ O-61</b>	<b>BZ O-62</b>	<b>BZ O-63</b>	<b>BZ O-65 P</b>	<b>BZ O-66 P</b>	<b>BZ O-E-54</b>	<b>BZ O-E-64</b>
Additional Academic Knowledge	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Psychological skills	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Problem-solving	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓