

Programme	B.Sc. Zoology				
Type of Course	Minor				
Semester	I				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total hours
	4	3		2	75
Pre-requisites	+2 /VHSC Biology or equivalent online courses				
Course objectives	The student develops understanding in the organization and functioning of ecosystems, the concept of population, population interactions, biogeochemical cycle, behavioural patterns of animals, their social organisation, etc.				

Course outcome

CO	CO statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe the various components of ecosystem along with their interactions and flow of energy in ecosystem and the importance of productivity of ecosystem, food chain and food web, and types of biogeochemical cycles and their importance [PSO2]	U	F&C	
CO2	Identify the terms related to population, biotic community, types of community interactions; the concepts of k and r species and Keystone species, characteristics of habitat and its types, policies and laws for environmental protection.. [PSO1]	R	F	
CO3	Describe innate behaviour and its components, concept of FAP, learned behaviour and its various types and examples, the concept of animal communication; the types of animal communication, emphasizing the relation between animal communication and social behaviour of animals. [PSO2]	U	F&C	
CO4	Describe sociobiology of different animals, the concept of social organisation in animals, and the concept of proximate factors[PSO2]	U	F&C	
CO5	Acquire skill in estimating ecological parameters like dissolved Oxygen, Carbondioxide, pH etc. . [PSO4]	Ap	C&P	
CO6	Compare the characteristics of different types of ecosystems, pattern of flow of materials and energy in ecosystem, etc.	U	F&C	
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)				
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Question paper pattern for external examination: Module 1 : short answer 3 x 3 = 9 marks, paragraph 1x 6 = 6 marks, Essay 1 x10 = 10 marks ; Module 2 : short answer 2 x 3= 6 marks, paragraph 2x 6 =12marks,; Module 3 : short answer 2 x 3= 6 marks, paragraph 3x 6 = 18 marks; Module 4 : short answer 3 x 3= 9 marks, paragraph 2 x 6 = 12 marks, Essay 1 x10 = 10 marks

Module 1. Ecosystem (12hrs)

Unit 1: Introduction, Ecosystem & Energetics.(02 hrs) Fundamentals of Environmental Sciences. Scope of Environmental Science. Ecology as an inter-disciplinary science, Sub division of Ecology- Autoecology, Synecology, Scope of Ecology.

Unit 2: Ecosystem-Concept, Structure and functions:(08 hrs) Structures - Biotic and Abiotic components. Functions - Energy flow in ecosystems & law of thermodynamics, energy flow models ,energy transfer & transformations.

Productivity of ecosystem- primary (GPP, NPP, NCP), secondary productivity, standing crop, material removed and production rate. Ecological efficiencies. Trophic structures and ecological pyramids.Trophic levels, food chains and food webs.

Unit 3: Biogeochemical cycles(02hrs) -Concept and Basic types. Gaseous cycle -carbon & nitrogen cycles, Sedimentary cycle- phosphorus cycle. Decomposition and transformation.

Module 2: Ecosystem classification and Habitat Ecology (11hrs)

Unit 1: Basics of Ecosystem classification(05 hrs): *Types of Ecosystem:* Desert (hot and cold), forest, rangeland, wetlands, lotic, lentic, estuarine (mangrove), Oceanic.*Biomes:* Concept, classification and distribution. Characteristics of different biomes (mention): Tundra, Taiga, Grassland, Deciduous forest biome, Highland Icy Alpine Biome, Chaparral, Savanna, Tropical Rain forest.

Unit 2: Habitat ecology: (06hrs)

Terrestrial ecology -Tropical wet evergreen, tropical dry deciduous forests- its characteristics. Faunal characteristics & adaptations.

Freshwater ecology- Lentic &lotic habitats- its characteristics. Faunal characteristics & adaptations.

Marine ecology- Biotic divisions and its characteristics. Pelagic realm-Plantonic& nektonic adaptations. Benthic realm-littoral & Abyssal adaptations. Adaptations of animals on sandy, muddy & rocky seashore.

Module 3: Population, Community and Habitat (10 hrs)

Unit 1: Population Ecology- (05hrs) Characteristics of population, - Biotic potential, concept of carrying capacity, population growth (S and J shaped curves) and regulations. Population fluctuations, dispersion and metapopulation. Concept of 'r' and 'k' species. Keystone species.

Unit 2: Community ecology: (03 hrs)Biotic community: Definition, community concept, types and interaction - predation, herbivory, parasitism and allelopathy.

Unit 3 :Overview of Environmental Laws in India(02hrs)

National Water Policy, 2002; National Environmental Policy, 2006; The Plastic Waste Management Rules, 2016; The Solid Waste Management Rules, 2016; The e-waste (Management) Rules 2016.

Module 4: Animal Behaviour (12hrs)

Unit 1: Foundations of Ethology(02hrs)-Introduction and historical development of ethology, Key figures in ethological approach, its scope and relation with other branches of biology.

Unit 2: Innate/Stereotyped behaviour (02hrs)- orientation -taxes, kinesis, simple reflexes, instincts, Fixed action patterns (FAPs) and releaser stimuli. Examples of instinctive behaviours in different species.

Unit 3: Acquired behaviour/Learned behaviour (02hrs): Habituation, Conditioned reflex, latent learning, Imprinting, Habituation and Trial and error and learning with suitable example.

Unit 4.: Types of communication (03 hrs) 1.Visual 2.Auditory3.Tactile 4.Chemical with suitable examples.

Unit 5: Sociobiology (03hrs) Social organization in Animals :Termites and Elephants.

Proximate factors.

Module 5: PRACTICALS (1 CREDIT, 30 Hrs)

MANDATORY EXPERIMENTS

22. Estimation of dissolved oxygen in water sample using winklers method (Pond water, well-water, Tap water). Discuss the ecological significance of dissolved oxygen in water.
23. Identify soil micro-organisms in soil samples collected from different localities-by floatation process & Berlese funnel method. Discuss the ecological significance of soil characteristics.
24. Demonstration of Phototaxis by earthworm
25. Demonstration of alarm pheromones in ants

Of the remaining experiments any 4 can be selected by the Institution from the following list. Two experiments other than the listed should be selected by the Supervising teacher and introduced to the students.

26. Estimation of dissolved CO₂ in water sample (Pond water, well-water, Tap water). Discuss the ecological significance of dissolved CO₂ in water.
27. Estimation of PH of water (Pond water, well-water, Tap water) Discuss the ecological significance of PH characteristics.
28. Locomotory behavior of dipteran larvae on different types of substrata
29. Determination of salinity of water
30. Determination of moisture content in different types of soil (sand, clay, laterite, etc.)
31. Estimation of water holding capacity of different types of soil.(sand, clay, laterite, etc.)

Field study: A). Conduct a field trip to assess the biodiversity of a chosen ecosystem- by preparation of food chains and food web. Add a note on its significance, B) A visit to natural habitat of wild animals or birds, or zoo, aviary etc, and observation of behaviour patterns of those animals; and submit a detailed field study report at the time of semester end practical examination.

REFERENCES:

ENVIRONMENTAL BIOLOGY

- Odum, E. P. & Barrett. G. W. 2004- Fundamentals of Ecology 5th Ed. -Brooks/ Cole 624pp

- Goyal, M. K, 2020: .Essential Environment - Shri Vinod Pusstak Mandir 351pp
- Miller, G. T. & Spoolman, S.. 2010 Environmental Science 13 Ed. Brooks/ Cole 452pp
- Miller, G. T. Jr 2017 . Living in the Environment - Brools/ Cole 832pp
- Molles. M. 2015 - Ecology: Concepts and Applications McGraw-Hill Education 592pp
- Townsend, C. R. Begon, M. and Harpe, J. L. 2008 Essentials of Ecology John Willey & Sons 532pp.
- Cunningham, W. P & Cunningham, M. A Principles of Environmental Science McGraw-Hill Education 410pp

ANIMAL BEHAVIOUR

- Dugatkin, L. A. 2020 Principles of Animal Behavior 4th Ed. - University of Chicago Press 576pp
 - Manning, O.2016 Introduction to Animal behaviour South Asia Ed, 6th Ed. Cambridge University Press, India 456pp
 - Mathur, R. 2022 Animal Behaviour -Visionias 676pp
 - Alcock, J. 2005 Animal Behavior - SP Oxford University Press 556pp
- Mapping of COs with PSOs and POs :**

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1		3					3						
CO 2	3						3						
CO 3		3					3						
CO 4		3					3						
CO 5				3					3				
CO 6		3					3						

INTRODUCTORY HUMAN PHYSIOLOGY

Programme	B.Sc. Zoology				
Type of Course	Minor				
Semester	II				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total hours
	4	3		2	75
Pre-requisites	+2 /VHSC <u>Biology</u> or the following online courses 7. https://www.coursera.org/learn/physiology 8. https://learn.utoronto.ca/programs-courses/courses/2159-basic-human-physiology 9. https://www.classcentral.com/classroom/youtube-anatomy-physiology-45834 10. https://www.ivyroses.com/Revise/AnatomyPhysiology/index.php 11. https://www.medicalnewstoday.com/articles/organs-in-the-body#organ-systems 12. https://www.cartercenter.org/resources/pdfs/health/ephti/library/lecture_notes/health_science_students/physiologypti.pdf				
Course objectives	The student develops understanding in the organization and functioning of human physiological systems and will be able to perform simple experiments related to it.				

Course outcomes (CO)

CO	CO statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe the structural and functional organization of human body[PSO2]	U	F&C	
CO2	Explain the mechanism of transport and exchange of respiratory gases and its control[PSO2]	U	F&C	
CO3	Identify different components of blood and various blood groups; cardiovascular problems[PSO1]	R	F	
CO4	Compare the different types of neurons; Explain mechanism of nerve impulse transmission; the ultrastructure of skeletal muscles and biochemical events and energetics involved in muscle contraction, the need of physical exercise in good physical and physiological condition[PSO3]	U	F&C	
CO5	Acquire skill in estimating and enumerating blood parameters; calculating BMI, measuring the respiratory volumes, etc. [PSO4]	Ap	C&P	
CO6	Explain the mechanism of excretion and its hormonal control; enumerate common renal disorders in man.[PSO2]	U	F&C	

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Question paper pattern for external examination: Module 1 : short answer 1 x 3 = 3marks, paragraph 1 x 6 = 6 marks; Module 2 : short answer 3 x 3= 9 marks, paragraph 2 x 6 = 12 marks, Essay 1 x10 = 10 marks; Module 3 : short answer 3 x 3= 9marks, paragraph 2 x 6 = 12 marks Essay 1 x10 = 10 marks ; Module 4 : short answer 3 x 3= 9 marks, paragraph 3 x 6 = 18 marks.

Module 1: Unit 1: Introduction to human physiology :(3 hrs)

Branches of human physiology, Components of body system, Human body systems and functions, vital and non vital organs, Levels of physiological regulation: Intracellular, local and extrinsic regulation. Homeostasis, Anthropometry, BMI and its significance.

Module 2: Physiology of Respiration & Circulation (18 hrs)

Unit 1: Respiration (8 hrs) : Measures of lung volume : Vital capacity, tidal volume, residual volume etc., Structure, types and functions of hemoglobin, Transport of oxygen and carbon dioxide in blood, factors influencing transport of gases, Oxygen dissociation curves and the factors influencing it; Carbon monoxide poisoning; Nervous and chemical control of respiration, Respiratory problems in new born babies and old age, COVID associated problems, COPD, Problems and adaptations at high altitude.

Unit 2: Circulation (10 hrs)

Pace maker and conducting system, Components of blood and their functions; Haemostasis, Biochemical pathway of Blood coagulation: Clotting factors, Disorders of blood clotting,

Haemopoiesis; ESR, Haemoglobinopathies, Blood groups: Rh factor, ABO and MN; Blood transfusion and agglutination, Apherisis, ECG, Cardiovascular problems: Hyper and hypotension, Artherosclerosis, Bradycardia and tachycardia, Myocardial infarction, Angina pectoris, Cardiac arrest.

Module 3: Physiology of Excitation (12 hrs)

Unit 1: Nervous system (5 hrs): Structure and types of neurons, Propagation of nerve impulse, myelinated and non-myelinated nerve fibers, Types of synapse and synaptic transmissions; Saltatory conduction, Neurotransmitters, synaptic delay, synaptic fatigue, numbness, tingling, tickling .

Unit 2: Muscular system (7 hrs) : Types of muscles; Ultra structure of skeletal muscle; Physiology and biochemistry of muscle contraction:- Sliding filament theory, physiological changes, Muscular relaxation, Energy for muscular contraction, Neuromuscular junction; muscle twitch; summation, tetanus and Rigor mortis. Sports Physiology - Aims and its benefits, Effect of sports on physical health, Benefits of exercise, Physical ergonomics.

Module:4 -Physiology of Digestion and Excretion (12 hrs):

C) Digestion (6 hrs): Structural organization and functions of gastrointestinal tract and associated glands; Hormonal control of digestion. Nutrition in pregnancy. Nutritional disorders: Cachexia, Bulmia Nervosa, Anorexia nervosa, obesity, flatulence, Peptic ulcer; physiological causes of vomiting and hiccups

D) Excretion (6 hrs): Ornithine cycle, Juxta glomerulus apparatus, Urine formation and Counter current mechanism, Hormonal and enzymatic control of urine formation. Role of kidney in osmoregulation, Abnormal constituents of human urine and its significance: Glycosuria, Albuminuria, Haematuria, Ketonuria, Haemoglobinuria, Uraemia, Pyuria. Dialysis.

Module 5: PRACTICALS (1 CREDIT, 30 Hrs)

MANDATORY EXPERIMENTS

1. Determination of ABO Blood group
2. Detection of Abnormal constituents of urine (Glucose, Protein, Ketone bodies)
3. Determination of Lung volume, tidal volume etc. by using Spirometer
4. Examination of sections of mammalian oesophagus, stomach, duodenum, ileum, rectum, liver, trachea, lung, kidney, Types of Muscles, (Virtual Model/Slide)

Of the remaining experiments any 4 can be selected by the Institution from the following list. Two experiments other than the listed should be selected by the Supervising teacher and introduced to the students.

5. Estimation of haemoglobin using Sahli's haemoglobinometer
6. Preparation of haemin crystals
7. Calculation of BMI
8. Recording of blood pressure using a sphygmomanometer
9. Demonstration of Blood clotting time
10. Demonstration enzymatic activity of Amylase, Protease and lipase
11. Recording of simple muscle twitch

Field study: A) Visit to Anatomy Museum B) Visit to Diagnostic centres, and submission of detailed field study report at the time of semester end practical examination.

Virtual Labs (Suggestive sites)

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

<https://zoologysan.blogspot.com>

www.vlab.iitb.ac.in/vlab

www.onlinelabs.in

**ANIMAL DIVERSITY, REPRODUCTIVE BIOLOGY AND DEVELOPMENTAL
BIOLOGY**

CO	CO statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Enumerate the salient features and examples of Phylum - Rhizopoda, Dinoflagellata, Apicomplexa, Porifera, Cnidaria, Platyhelminthes, Nematoda, Annelida, Arthropoda, Onychophora, Mollusca, Echinodermata, and the structural organization of <i>Penaeus</i> sp.	U	F&C	
CO2	Describe the characteristic features and classification of phylum Chordata with examples and, the structural organization of <i>Oryctolagus cuniculus</i>	U	F&C	
CO3	Explain the structural and functional features of human reproductive system and the process of fertilization, pregnancy, gestation, placentation, parturition and lactation in humans, Assisted Reproductive technologies and Pre Natal Diagnostic techniques	U	F&C	
CO4	Enumerate the types of eggs and cleavage, the different types of blastula, morphogenetic movements during gastrulation and germ layers and their derivatives	U	F&C	
CO5	Perform experiments like mounting of specialized organs of selected non-chordates and chordates, and dissections of specimens by standard laboratory protocols	Ap	C&P	
CO6	Prepare field study report on observing local biodiversity	C	C&P	

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Module 1 Protists and Non-chordates (12hrs)

Unit 1: Kingdom Protista (2 hrs) - General characters.;

Phylum Dinoflagellata: e.g. *Noctiluca*

Phylum Ciliophora: e.g. *Vorticella*

Phylum Apicomplexa: e.g. *Plasmodium* (exclude life cycle)

Unit 2: Kingdom Animalia Part I : Non-chordata(10hrs)

Salient features of phyla, classification down to classes (7 hrs)

Phylum Porifera: e.g. *Leucosolenia*

Phylum Cnidaria: e.g. *Obelia*, *Sea anemone*

Phylum Platyhelminthes: e.g. *Fasciola*

Phylum Nematoda: e.g. *Ascaris*

Phylum Annelida: e.g.: *Hirudinaria*

Phylum Arthropoda: e.g.: *Limulus*, *Sacculina*, *Eupagurus*

Type: *Penaeus* sp. Morphology, digestive system, excretory system, sense organs (statocyst and compound eye), reproductive system (Exclude details of larval stages) (3 hrs)

Phylum Onychophora: e.g.: *Peripatus*

Phylum Mollusca: e.g. *Perna*, *Teredo*, *Pinctada*

Phylum Echinodermata: e.g. *Asterias*, *Holothuria*

MODULE 2. Kingdom Animalia Part II : Chordata (12hrs)

Unit 1: Chordata Classification (8hrs)

Salient features, Mention classes)

Subphylum Urochordata e.g. *Ascidia*

Subphylum Cephalochordata e.g. *Branchiostoma*

Subphylum Vertebrata:

Division I: Agnatha: e.g. *Petromyzon*

Division II: Gnathostomata

Super class: Pisces

Class: Chondrichthyes: e.g. *Narcine*

Class: Osteichthyes: e.g. *Echeneis*, *Hippocampus*, *Scomberomorus*, *Brama*,

Sahyadriadenisonii (Miss Kerala)

Super class: Tetrapoda

Class Amphibia: e.g. *Ichthyophis*, *Salamandra*, *Rhacophorus*, *Duttaphrynus*, Mention *Nasi*

kabatrachussahyadrensis

Class Reptilia: e.g. *Chamaeleo*, *Chelone*, *Naja*, *Bungarus*, *Daboia*

Class Aves: e.g. *Columba*

Class Mammalia e.g. *Pteropus*

Unit 2: Chordata Type: *Oryctolagus cuniculus* (4 hrs)

External features, skeletal system, digestive system, sense organs and nervous system. [Exclude skin, skull bones, respiratory system, circulatory system, autonomous nervous system and endocrine system].

Section B: REPRODUCTIVE BIOLOGY AND DEVELOPMENTAL BIOLOGY

Module 3. Human Reproductive system and Reproductive Biology (7hrs)

Unit 1: Male reproductive system (1 hr)- Structure of testis, semen production and composition.

Unit 2: Female reproductive system (2hrs) - Structure of ovary and graafian follicle, ovulation. Mention corpus haemorrhagicum, corpus luteum and corpus albicans. Accessory reproductive organs. Secondary sexual characteristics. Menstrual cycle and its hormonal control.

Unit 3: Gametogenesis (2 hrs) - Spermatogenesis and oogenesis.

Unit 4: Fertilization (2hrs) - Fertilization and anti-fertilization, capacitation, agglutination, sperm penetration, activation of egg and amphimixis. Physiological and biochemical changes during and after fertilization. Pregnancy, Gestation, Placentation, parturition and lactation.

Unit 5: Infertility and Assisted reproductive techniques (4hrs)- Infertility: Causes and problems in male and female; Infertility management: collection, preservation and storage of semen and ova, artificial insemination; Cryopreservation and embryo transfer: Collection, care and preservation of embryos; In vitro fertilization (IVF) and embryo transfer: Major

steps; Test tube babies; Assisted Reproductive Techniques (ART): GIFT, ZIFT, ICSI, oocyte donation and embryo donation; surrogacy

Unit 1- Prenatal diagnosis (2 hours) Different methods: Ultrasonography, amniocentesis, chorionic villus sampling and alpha-foetoprotein estimation; female foeticide: ethical issues and laws (Mention PNDDT Act)

MODULE 4. Developmental Biology (8hrs)

Unit 1: Introduction to Embryology (1 hr) -Embryology v/s Developmental biology. Mention phases in development. Cell differentiation, totipotency, pluripotency, de-differentiation and redifferentiation.

Unit 2: Types of eggs (2 hrs) -Classification of eggs with examples based on: Amount of yolk (micro-, meso- & macrolecithal); Distribution of yolk (iso-, centro- and telolecithal); Presence or absence of shell (cleidoic & non cleidoic); Types of development (determinate and indeterminate). Egg membranes: primary, secondary and tertiary; functions of egg envelopes.

Unit 3: Cleavage and Blastulation (2hrs) - Types of cleavage with examples based on: Plane of cleavage (Meridional, Vertical, Equatorial and Latitudinal); Amount of yolk (Holoblastic and Meroblastic); Types of development (Determinate and Indeterminate); Pattern of arrangement of blastomeres (Radial and Spiral). Different types of blastula.

Unit 4: Gastrulation (3hrs) -

Basic Cell movements (Morphogenetic movements) in gastrulation (Invagination, Involution, Ingression, Delamination and Epiboly-Brief account only). Germ layers and derivatives.

Module 5: PRACTICALS (1 CREDIT, 30 Hrs)

MANDATORY EXPERIMENTS

1. Spotters

A. Animal Diversity

Phylum Dinoflagellata	: <i>Noctiluca</i>
Phylum Porifera	: <i>Leucosolenia</i>
Phylum Cnidaria	: <i>Obelia, Physalia,</i>
Phylum Platyhelminthes	: <i>Fasciola</i>
Phylum Nematoda	: <i>Ascaris</i>
Phylum Annelida	: <i>Hirudinaria.</i>
Phylum Arthropoda	: <i>Eupagarus, Limulus, Sacculina</i>
Phylum Onychophora	: <i>Peripatus</i>
Phylum Mollusca	: <i>Sepia, Pinctada, Perna</i>
Phylum Echinodermata	: <i>Asterias, Holothuria.</i>
Phylum Chordata	
Protochordates	: <i>Ascidia/ Branchiostoma.</i>
Cyclostomata	: <i>Petromyzon.</i>
Superclass: Pisces	: <i>Narcine, Echeineis, Hippocampus, Scomberomorus, Brama</i> (Any 3)
Class Amphibia	: <i>Ichthyophis, Axolotl larva, Rhacophorus</i> (Any 2)
Class Reptilia	: <i>Chamaeleo, Daboia, Bungarus</i>
Class Aves	: <i>Columba</i>
Class Mammalia	: <i>Pteropus</i> or any other Bat.

B. Osteology : Rabbit : Skull showing Dentition, Pectoral and Pelvic girdle

2. Mounting:

Penaeus: Appendages (minor)

Cockroach: Salivary apparatus (major).

Honeybee: Mouth parts (minor).

Shark: Placoid scales (minor).

3. Dissections :

Penaeus : Nervous system (major)

Sardinella : Alimentary canal (major)

4. Spotters – Developmental Biology

- Types of eggs (Insect, Amphioxus, frog, chick, and human- use slides/diagrams/models).
- Cleavage in frog (use slides / diagrams/models).
- Types of Blastula (use slides / diagrams/models).
- Gastrula of frog or any organism (use slides / diagrams/models).

II. Two experiments related to Reproductive biology or Developmental biology other than the listed should be designed by the Faculty and introduced/demonstrated to the students.

Field study: Explore the local Biodiversity and submit a diversity register of animals belonging to a minimum of **ten classes**, at the time of semester end practical examination.

Virtual Labs (Suggestive sites)

REFERENCES

- Buchsbaum, R., Buchsbaum, M., Pearse, J. & Pearse V. (2013). *Animals without Backbones: An Introduction to the Invertebrates*. University of Chicago Press, USA.
- Dhami, P. S. & Dhami, J. K.: *Invertebrate Zoology*. R. Chand & Co, New Delhi.
- Ekambaranatha Ayyar, M. & Ananthakrishnan, T. N. (1985). *A Manual of Zoology Vol. I [Part I & II]*, S. Viswanathan Pvt. Ltd., Madras
- Ekambaranatha Ayyar, M. & Ananthakrishnan, T. N. (2009) *Manual of Zoology, Chordata, Vol. II (Part I & II)*, ISBN-10: 8187156384, S. Viswanathan Pvt. Ltd., Madras.
- Jordan E.L. & Verma, P.S. (2010) *Chordate Zoology*, ASIN: B00QUYL0ZY, Kindle Edition, S. Chand & Co. 1092 pages
- Jordan E.L. & Verma, P.S. (2009) *Invertebrate Zoology, 15th Edition*, ISBN-10: 9788121903677, S. Chand & Co., 1127 pages
- Kotpal, R.L. (2014) *Modern Text Book of Zoology – Invertebrates*, ISBN, 10: 9350780402, Rastogi
- Verma, A. (2005). *Invertebrates: Protozoa to Echinodermata*. Alpha Science Intl., Oxford.
- Balinsky, B.I. (1981) *An Introduction to Embryology*, 5th Edition, *Embryology*, ISBN-4833700298 (International ed.), Saunders College Pub., 768 pages
- Berril N. J. (1971) *Developmental Biology*, ISBN 10: 0070050201, McGraw Hill
- Berry, A.K. (2008) *An introduction to Embryology*, Emkay publications.
- Bruce Carlson (2013) *Human embryology and Developmental Biology*, 5th Edition, eBook ISBN: 9780323279352, Saunders, 520 pages
- Michael J.F. Barresi (Author), Scott F. Gilbert (Author) (2019) *Developmental Biology*, 12th Edition, ISBN-10: 1605358223, Sinauer Associates, 888 pages
- Sastry K. V. & Vineetha Shukla (2018): *Developmental Biology*, 2nd Revised Edition, ISBN: 9789350781289372, Rastogi, 372 pages
- Verma, P.S. & Agarwal V.K. (2010): *Chordate Embryology*, ISBN-10: 9788121902618, S.Chand Pub., 667 pages