



The Kelkar Education Trust's  
**Vinayak Ganesh Vaze College of Arts, Science & Commerce**  
**AUTONOMOUS**

Mithaghar Road, Mulund East, Mumbai-400081, India  
College with Potential for Excellence  
Phones :022-21631421, 221631423, 221631004 Fax : 022-221634262,  
e mail : vazecollege@gmail.com

---

---

**Syllabus for M. Sc. Part-1 Programme:**

**Zoology**

Syllabus as per Choice Based Credit System (NEP-2020)

**(June 2024 Onwards)**



**Submitted by**

**Department of Zoology**  
**Vinayak Ganesh Vaze College of Arts, Science and Commerce**  
Mithagar Road, Mulund ( East) Mumbai-400081. Maharashtra, India.

Tel: 022-21631004, Fax: 022-21634262

E-mail: [vazecollege@gmail.com](mailto:vazecollege@gmail.com) Website : [www.vazecollege.net](http://www.vazecollege.net)

The Kelkar Education Trust's  
Vinayak Ganesh Vaze College of Arts, Science & Commerce  
(AUTONOMOUS)

---

❖ Syllabus as per Choice Based Credit System (NEP 2020)

**Syllabus for Approval**

Sr. No.	Heading	Particulars
1	Title of Programme	M. Sc. Zoology Semester I and II
2	Eligibility for Admission	The B.Sc. degree examination of this university with Zoology 6 units or 3 units or degree of any other universities recognized as equivalent thereto.
3	Passing marks	Minimum D Grade or equivalent minimum marks for passing at the Graduation level.
4	Ordinances/Regulations (if any)	---
5	No. of Years/Semesters	One year/Two semester
6	Level	P.G. part - I : Level-6
7	Pattern	Semester
8	Status	Revised
9	To be implemented from Academic year	2023 - 2024

Date:

Signature:

BOS Chairperson: Dr. Vinod R. Ragade

.....

## Post Graduate Programs in Zoology

Year (2 Yr PG)	Level	Sem. (2 Yr)	Major	RM	OJT /FP	RP	Cum. Cr.	Degree	
			<b>Mandatory*</b>						
			<b>Electives Anyone</b>						
<b>1</b>	6.0	Sem-1	<b>For Zoology Animal physiology &amp; Oceanography Specialization</b>						
			Course 1 Credits 4 : Non-chordates Course 2 Credits 4 : Developmental biology-I Course 3 Credits 4 : Genetics and Evolution Course 4 Credits 2 : Practicals (Non-chordates + Developmental biology I)	<b>Credits 4 (2+2)</b> Course 1 : Frontiers in Zoology and Practicals : Zoology I  <b>OR</b> Course 2: Forensic Science and Environmental Biotechnology Practicals : Zoology I	4	--	--	22	PG Diploma (after 3 Year Degree)
		Sem-II	<b>For Zoology Animal physiology &amp; Oceanography Specialization</b>						
			Course 1 Credits 4: Chordates Course 2 Credits 4: Developmental biology-II Course 3 Credits 4: Biochemistry and Biotechnology Course 4 Credits 2: Practicals (Chordates + Developmental biology II)	<b>Credits 4 (2+2)</b> Course 1 : Instrumentation & Biophysics and Practicals : Zoology II <b>OR</b> Course 2: Diversity of life forms & applied zoology and Practicals : Zoology II	--	04	--	22	
<b>Cum. Cr. for PG Diploma</b>	<b>28</b>	<b>8</b>	<b>4</b>	<b>4</b>	<b>--</b>	<b>44</b>			
<b>Exit option: PG Diploma (44 Credits) after Three Year UG Degree</b>									

# Proposed Draft Syllabus for M.Sc. Zoology Semester I and II

## Choice Based Credit System (NEP 2020)

(To be implemented from the academic year, 2023-2024)

### Semester – I

#### Paper I - Non-Chordates

Course Code: VGVPSMZO101

Credits: 4

Unit	Content	Lecture
Unit I	<p><b>Digestion and Excretion</b></p> <p><b>I. General organization of digestive systems of Protostomes (Annelids, Arthropods and Molluscs) and Deuterostomes (Echinoderms and Hemichordates)</b></p> <p><b>II. Digestive Systems with Special emphasis on the organs or glands of :</b></p> <p>i. Annelids - Clamworm – Denticles or Paragnaths, Jaws</p> <p>ii. Arthropods - Prawn: Buccal cavity, Cardiac and Pyloric stomach, Hepatopancreas</p> <p>iii. Mollusca - Pila: Odontophore, Sub-radular organ, Radula, Oesophageal pouches, Cardiac and Pyloric chambers, Salivary gland, Hepatopancreas</p> <p>iv. Echinoderms - Starfish: Cardiac and Pyloric stomach, Intestinal Caeca, Digestive glands</p> <p>v. Hemichordates - Balanoglossus: Buccal Diverticulum, Digestive Pharynx, Post-branchial canal, Hepatic and posthepatic regions</p> <p><b>III. General organization of excretory systems of Protostomes (Annelids, Arthropods and Molluscs) and Deuterostomes (Echinoderms and Hemichordates)</b></p> <p><b>IV. Excretory Systems with special emphasis on the organs or glands of:</b></p> <p>i. Annelids Clam worm: Coiled Nephridia</p> <p>ii. Arthropods Prawn: Antennal glands or Green glands or Maxillary glands, Bladder, Renal sac</p> <p>iii. Molluscs Pila: Organ of Bojanus, anterior Renal chamber, posterior Renal chamber</p> <p>iv. Echinoderms Starfish: Water Vascular System, Coelomocytes, Intestinal caeca</p> <p>v. Hemichordates Balanoglossus: Glomerulus or Proboscis gland</p>	15 Hrs

<p><b>Unit II</b></p>	<p><b>Respiration and Circulation</b></p> <p><b>I. General organization of respiratory systems of Protostomes (Annelids, Arthropods and Molluscs) and Deuterostomes (Echinoderms and Hemichordates)</b></p> <p><b>II. Respiratory Systems with Special emphasis on the organs/structures or glands of:</b></p> <p>i. Annelids - Clam worm: Parapodia, Body wall</p> <p>ii. Arthropods - Prawn: Branchiostegites, Branchiae, Epipodite</p> <p>iii. Molluscs - Pila: Ctenidium, Pulmonary sac</p> <p>iv. Echinoderms - Starfish: Dermal papulae, Tube Feet</p> <p>v. Hemichordates - Balanoglossus: Gill slits, Branchial sac, Gill pores</p> <p><b>III. General organization of circulatory systems of Protostomes (Annelids, Arthropods and Molluscs) and Deuterostomes (Echinoderms and Hemichordates)</b></p> <p><b>IV. Circulatory systems with special emphasis on the organs/ structures or glands of:</b></p> <p>i. Annelids - Clam worm: Dorsal blood vessel, Ventral blood vessel, Transverse vessels</p> <p>ii. Arthropods - Prawn: Heart and Blood lacunae</p> <p>iii. Molluscs - Pila: Pericardium, Heart</p> <p>iv. Echinoderms - Starfish: Perihaemal sinuses, Axial gland</p> <p>v. Hemichordates - Balanoglossus: Central Sinus (Heart), Dorsal vessel, Ventral vessel</p>	<p><b>15 Hrs</b></p>
-----------------------	---	----------------------

<b>Unit III</b>	<p><b>Nervous System, Chemical Coordination and Reproductive System</b></p> <p><b>I. General organization of Nervous systems &amp; Chemical Coordination in Protostomes (Annelids, Arthropods and Molluscs) and Deuterostomes (Echinoderms and Hemichordates)</b></p> <p><b>II. Nervous system &amp; Chemical Co-ordination with special emphasis on the organs/structures or glands of:</b></p> <p>i. Annelids - Clam worm: Corpora pedunculata , Giant fiber, Circumpharyngeal ganglion, Peristomial cirri, Nuchal organ, pigmented Retinal cells</p> <p>ii. Arthropods - Prawn: Brain, Circum-oesophageal commissure, Compound eyes, Chromatophore, Statocysts, Tactile setae, Olfactory setae, Tangoreceptors, Chemoreceptors, Proprioceptors, Sinus gland X organ complex, Y organ</p> <p>iii. Molluscs - Pila: Cerebral Ganglia, Buccal Ganglia, Pleuro-pedal Ganglionic Mass, Supra Intestinal Ganglion, Visceral Ganglion, Osphradium, Tentacles, Statocysts, Eyes, Mechanoreceptors, Photoreceptors, Temperature receptors, Chemoreceptors</p> <p>iv. Echinoderms - Starfish: Ectoneural nervous system, Langer's nerve, Eyes, Terminal tentacles, Neurosecretory cells</p>	<b>15 Hrs</b>
-----------------	--	---------------

v. Hemichordates - Balanoglossus: Epidermal Plexus, Preoral ciliary organ, Neurosecretory cells

**III. General organization of reproductive systems in Protostomes (Annelids, Arthropods and Molluscs) and Deuterostomes (Echinoderms and Hemichordates)**

**IV. Reproductive systems with special emphasis on the organs/structures or glands in:**

i. Annelids - Clam worm: Gonads – Testes and Ovaries (Temporary)

ii. Arthropods - Prawn: Male – Testes, Vasa deferentia, Vesicula Seminalis; Female – Ovaries, Oviducts

iii. Molluscs - Pila: Male – Testes, Vasa efferentia, Vasa deferens, Vesicula seminalis, Hypobranchial glands; Female – Ovary, Oviduct, Receptaculum seminis, Uterus, Vagina, Hypobranchial gland

iv. Echinoderms - Starfish: Male / Female gonads

v. Hemichordates - Balanoglossus: Saccular gonads



<b>Unit IV</b>	<p><b>Paleontology and Phylogeny</b></p> <p><b>I. Fossils of:</b></p> <p>i. Annelids: <i>Serpula</i> and <i>Glomerula</i> spp. found in South India</p> <p>ii. Arthropods: Trilobites found in Kashmir, Insects trapped in amber found in Western India</p> <p>iii. Molluscs: Molluscs fossils found in Kutchh, Chhattisgarh and Jammu – <i>Palmerella kutchensis</i>, <i>Cimomia forbesi</i>, <i>Lamellidens</i></p> <p>iv. Echinodermata: <i>Gongrochanus</i> spp. found in South India, Echnoid fossils found in India.</p> <p>v. Hemichordata: Graptolite fossils</p> <p><b>II. Phylogenetic affinities of Annelida, Arthropoda, Mollusca, Echinodermata and Hemichordata</b></p> <p>i. Phylogenetic relationships of Trochophore larva</p> <p>ii. Similarities and differences between Annelids and Molluscs</p> <p>iii. Phylogeny of Arthropods – Monophyletic theory and polyphyletic theory</p> <p>iv. Phylogeny of Echinoderms – Asterozoan hypothesis and Cryptosyringid hypothesis</p> <p>v. Affinities of Annelida with Hemichordata</p> <p>vi. Affinities of Echinodermata with Hemichordata</p> <p><b>III. Construction of Phylogenetic Tree</b></p> <p>i. Genetic distance</p> <p>ii. Rooting trees</p>	<b>15 Hrs</b>
----------------	--	---------------

	<p><b>IV. Phylogenetic Tree Building Methods</b></p> <p>i. Distance-Based Methods: UPGMA Method, Neighbour Joining Method (NJ), Weighted Neighbour Joining (Weighbour), Fitch-Margoliash (FM) and Minimum Evolution (ME) Methods</p> <p>ii. Character-based Methods: Maximum parsimony (MP), Maximum Likelihood (ML)</p>	
	<b>Total No. of Lectures</b>	<b>60</b>

**References based on Course 1 - Non chordates (VGVPSMZ0101)**

1. Invertebrates – Protozoa to Echinodermata, Author: Ashok Verma, Publisher- Narosa Publishing House.
2. Invertebrate Zoology, Authors: E. L Jordan and P. S. Verma, Publisher: S. Chand and Company Ltd.
3. Invertebrate Zoology 3rd edition, Author: Paul A. Meglitsch and Fredrick R. Schram, Publisher – Oxford University Press.
4. Introduction to General Zoology Vol. I, Author: Korak Kanti Chaki, Gautam Kundu and Supriti Sarkar, New Central Book Agency (P) Ltd.
5. Introduction to General Zoology Vol. II, Author: Korak Kanti Chaki, Gautam Kundu and Supriti Sarkar, New Central Book Agency (P) Ltd.
6. Modern Text Book of Zoology: Invertebrates, Author: R. L. Kotpal.
7. Invertebrate Zoology by N.C Nair, S. Leelavathy, et al.
8. Textbook of Zoology: Invertebrates Vol I 7/e by Haswell.
9. Textbook of Invertebrate Zoology by Dev Bhattacharya.
10. Invertebrates by Richard C. Brusca, Wendy Moore, Stephen M. Shuster.
11. Invertebrate Zoology: A Functional Evolutionary Approach, Authors: Richard Fox, Robert D. Barnes, Edward E. Ruppert.
12. An Introduction to Mollusca by G. S. Sandhu and Harshvardhan Bhaskar, Campus Book International.
13. An Introduction to Echinodermata by G. S. Sandhu and Harshvardhan Bhaskar, Campus Book International.
14. Principles of Invertebrate Paleontology by N. Shrock.
15. Palaeontology Invertebrate by Henry Woods.
16. Phylogenetic Trees Made Easy: A How-to Manual by Barry G. Hall.
17. Invertebrate Zoology by P. S. Dhama and J. K. Dhama.
18. Practical Zoology by K. C. Ghose
19. Practical Zoology – Invertebrate by S. S. Lal.



**Semester – I**  
**Paper II - Developmental Biology - I**  
**Course Code: VGVPSMZO102**  
**Credits: 4**

Unit	Content	Lecture
Unit I	<p><b>Fertilization and Early Development in Non-chordates</b></p> <p><b>I. Concept and Mechanism of Fertilization</b></p> <p>i. Types of reproduction – Asexual and sexual</p> <p>ii. Fertilization – Concept and types</p> <p>iii. Mechanism of fertilization - Capacitation of sperm - Recognition of sperm and egg - Acrosome reaction - Activation of egg - Fusion of egg and sperm cell membrane - Amphimixis</p> <p><b>II. Molecular Events of Fertilization</b></p> <p>i. Species specific recognition of gametes – Fertilizin and antifertilizin interaction, Binding protein</p> <p>ii. Prevention of polyspermy – Fast and slow block</p> <p>iii. Calcium as initiator of cortical granule reaction</p> <p>iv. Activation of egg metabolism with respect to Sea urchin</p> <p><b>III. Formation of Germ Layers and Coelom Formation</b></p> <p>i. Post Fertilization events: Overall view of Cleavage, Blastulation, Gastrulation</p> <p>ii. Formation of Germ layers – Diploblastic, Triploblastic</p> <p>iii. Coelom formation in Protostomes and Deuterostomes</p>	15 Hrs
Unit II	<p><b>Basic concepts of embryonic development in non-chordates</b></p> <p><b>I. Fate map and cell lineages: potency and commitment</b></p> <p><b>II. Competence and induction</b></p> <p><b>III. Mosaic and regulative development</b></p> <p><b>IV. Cell specification:</b></p> <p>i. Autonomous specification</p> <p>ii. Conditional specification</p> <p>iii. Syncytial specification</p>	15 Hrs

<b>Unit III</b>	<p><b>Early Development in non-chordates</b></p> <p><b><i>I. Development of Caenorhabditis elegans</i></b></p> <p>i. Pattern of cleavage</p> <p>ii. Anterior-posterior axis formation</p> <p>iii. Dorsal-Ventral axis formation</p> <p>iv. Cell specification (Autonomous and Conditional)</p>	<b>15 Hrs</b>
-----------------	--	---------------

	<p>v. Process of gastrulation</p> <p><b>II. Early Development in <i>Drosophila melanogaster</i>:</b></p> <p>i. Pattern of cleavage</p> <p>ii. Blastulation</p> <p>iii. Process of gastrulation</p> <p>iv. Anterior-posterior pattern formation by morphogenetic protein gradient</p> <p>v. Dorsal-ventral pattern formation by morphogenetic protein gradient</p> <p>vi. Patterns of homeotic gene expression: Homeo selector gene complexes (Hom-C, homeotic gene complex) – Antennapedia and bithorax complexes and their functional domains, Realistor genes: distal less and wingless genes.</p>	
<b>Unit IV</b>	<p><b>Special Aspects in Reproduction and Development in non-chordates</b></p> <p><b>I. Sexual Reproduction in Protozoa - Conjugation in Paramecium sp. - Syngamy in flagellates</b></p> <p><b>II. Metagenesis in Obelia sp.</b></p> <p><b>III. Polyembryony in Fasciola sp.</b></p> <p><b>IV. Regeneration in Hydra (Morphallactic) and Planaria (Totipotency)</b></p> <p><b>V. Parthenogenesis in Aphids</b></p> <p><b>VI. Metamorphosis in insects – Indirect Development</b></p> <p>i. Types of insect metamorphosis</p> <p>ii. Eversion and differentiation of imaginal disc</p> <p>iii. Hormonal control of insect metamorphosis</p> <p>iv. Study of life cycle of Blow fly-applications in forensics</p> <p>v. Larval forms of non-chordates: Amphiblastula larva (Porifera), Planula (Coelenterata), Echinopluteus (Echinodermata) and Tornaria (Hemichordata)</p> <p><b>VII. Pheromones in invertebrates and their role as sex attractants and in Integrated Pest Management (IPM)</b></p>	<b>15 Hrs</b>
	<b>Total No. of Lectures</b>	<b>60</b>

**References based on Course 2 - Developmental biology – I (VGVPSMZOP102)**

1. Developmental Biology – Scott F. Gilbert – 8th Edition, Sinauer Associates Inc., 2006
2. Principles of Development – L. Wolpert – 4th Edition, Oxford University Press, 2011.
3. Essential Developmental Biology- J.M.W. Slack – 2nd Edition, Blackwell Publishing, 2006
4. Modern Text Book of Zoology- Invertebrates by R.L .Kotpal, Rastogi Pub,10th Edn, 2013.
5. An Introduction to Embryology by B. I. Balinsky, CBS College Pub, 5th Edn, 1981.
6. Biology of the Invertebrates by Jan A. Pechenik, Tata McGraw- Hill, 4thEdn, 2000.
7. Invertebrate Zoology by P. S. Dhami and J. K. Dhami, R. Chand and Co.3rd Rev.Edn,1974
8. General and Applied Entomology by B. V. David and T. N. Ananthakrishnan, Tata McGraw- Hill, 2nd Edn, 2004.
9. Modern Entomology by D. B. Tembhare, Himalaya Publishing House,1st Edn,1997



**Semester – I**  
**Paper III - Genetics and Evolution**  
**Course Code: VGVPSMZO103**  
**Credits: 4**

Unit	Content	Lecture
<b>Unit I</b>	<p><b>Introduction to evolutionary genetics</b></p> <p><b>I. Cytochrome ‘c’</b></p> <ul style="list-style-type: none"> <li>i. Structure of Cytochrome ‘c’ and couple cytochrome ‘c’</li> <li>ii. Cytochrome ‘c’ in eukaryotes. Example Primates</li> <li>iii. Cox gene 1.1.4 Molecular basis of haemoglobin gene structure. Haemoglobin as a model of evolution</li> </ul> <p><b>II. Sex Determination and Evolution of Sex Chromosome</b></p> <ul style="list-style-type: none"> <li>i. Theory of evolution of sex chromosome</li> <li>ii. Evolution of sex chromosomes from autosomes</li> <li>iii. Biology of Y chromosome</li> <li>iv. Molecular level of sex determination in mammals</li> <li>v. Sex based gene expression</li> <li>vi. T6sRNA</li> </ul> <p><b>III. Cytoplasmic Inheritance/Extra-nuclear Inheritance</b></p> <ul style="list-style-type: none"> <li>i. Introduction – human mitochondrial genetics</li> <li>ii. Paternal and maternal mtDNA inheritance in humans</li> <li>iii. mtDNA mutations and human diseases</li> <li>iv. Salient feature of cytoplasmic inheritance</li> </ul> <p><b>IV. Selfish Gene</b></p> <ul style="list-style-type: none"> <li>i. Introduction and definition</li> <li>ii. Individual altruism and genetic egoism</li> <li>iii. Green beard effect</li> </ul>	<b>15 Hrs</b>

<b>Unit II</b>	<p><b>Molecular Genetics</b></p> <p><b>I. Gene Library</b></p> <ul style="list-style-type: none"> <li>i. Molecular analysis of gene and gene products</li> <li>ii. Types – Genomic Library, cDNA Library</li> <li>iii. Construction of genomic library – human antibody gene library</li> <li>iv. Applications of gene library</li> </ul> <p><b>II. Types of Genes:</b></p> <p>Definition – Multigenes, Repeated genes, Single copy gene, House-keeping gene (constitutive gene), Luxury gene (non-constitutive gene), Pseudogene, Jumping gene</p>	<b>15 Hrs</b>



(Transposons), Overlapping gene, Structural gene, Processed gene, Split gene ,  
Regulatory gene

i. Multi-gene Families and Types:

a) Split Genes or Interrupted genes – Introduction, Structure of split genes,  
Discovery and theory of split genes, Evolution of split genes

b) Pseudogenes

c) Selfish gene

ii. Overlapping Gene

**III. Mapping units**

i. Types –genetic mapping and physical mapping

ii. Detection of linkages

iii. Construction of linkage maps in diploids and their characteristics

iv. Coefficient of coincidence

v. Outline of other types of gene mapping

**IV. Gene cloning**

i. Definition and strategies of gene cloning

ii. Techniques in gene cloning

iii. Applications of gene cloning in DNA analysis in research

**V. Population genetics**

i. Population genetics in DNA typing

ii. Mutation – Selection balance

iii. Parallelism between random drift and inbreeding

<b>Unit III</b>	<p><b>Evolution – Anthropology</b></p> <p><b>I. Racial distribution of Primates and Homo sapiens</b></p> <p>i. Racial distribution of primates - Distribution of Prosimians (Lemurs, Lorises, Galagos), Distribution of Anthropoids (Monkeys and Apes)</p> <p>ii. Divergence of Homo sapiens from Anthropoid</p> <p><b>II. Racial distribution of Homo sapiens</b></p> <p>i. Biological races in humans - Caucasoid (White) race, Negroid (Black) race, Capoid (Bushmen/Hottentots) race, Mongoloid (Oriental /Amerindian) race, Australoid (Australian Aborigine and Papuan) race</p> <p>ii. Human genetic diversity protein-based polymorphism (Blood groups, Alu polymorphism), craniometrics</p> <p><b>III. Importance of Human Genetic Biodiversity</b></p> <p>i. Applications – Anthropological, Medical, Cultural</p> <p>ii. Parasites and human co-evolution</p>	<b>15 Hrs</b>

	<p>iii. Ectoparasites co-evolution with humans (Head Louse, Scabies, Mite)</p> <p>iv. Endoparasites co-evolution with humans (Liver fluke, Tapeworm, Ascaris, Sickle cell Individuals as an example of coevolution with malarial parasite)</p> <p><b>IV. Altruism and Evolution</b></p> <p>i. Altruism – Intraspecies and Interspecies, Cooperation and its evolution in human</p> <p>ii. Altruism and evolution in domesticated wild animals</p> <p>iii. Group selection and kin selection</p> <p>iv. Domestication and behavioral changes</p> <p><b>V. Hybrid Evolution</b></p> <p>i. Natural Hybrids – Origin and evolution of animal hybrids, Insects, Snails, Fish, Frog, Lizard</p> <p>ii. Hybrid Speciation</p> <p>iii. Artificial Hybrids – Hybrid optimization – Bee Colony</p> <p>iv. Artificial cells in hybrids to create – Dzo, Mule, Hinny, Liger, Wholpin, Leopon, Zorse</p>	
<p><b>Unit IV</b></p>	<p><b>Evolution &amp; Fossils</b></p> <p><b>I. Human evolution</b></p> <p>i. Human evolutionary history and placing humans on tree of life</p> <p>ii. Genomics and humanness; current issues in human evolution</p> <p>iii. Brief Accounts of Parapithecus spp., Propliopithecus spp., Dryopithecus spp., Ramapithecus spp., Australopithecus spp., Kenyanthropus spp., Homo spp., Neanderthal, Cromagnon and Modern man</p> <p>iv. Concept of neutral evolution, molecular divergence and molecular clock</p> <p><b>II. Fossil dating</b></p> <p>i. Geological time scale – Eras, Periods and Epochs</p> <p>ii. Major events in evolutionary time scale</p> <p>iii. Significance of fossils and fossilization</p> <p>iv. Fossil dating – Types: Absolute and Relative Dating</p> <p>v. Process of C-14 Carbon dating</p> <p><b>III. Frozen zoo</b></p> <p>i. Concept of frozen zoo to save endangered species</p> <p>ii. Techniques to create offspring from cells of endangered species, nuclear transfer, mixing cells, creating sperms and eggs</p> <p>iii. Current status of frozen zoo</p>	<p><b>15 Hrs</b></p>

	<b>Total No. of Lectures</b>	<b>60</b>
--	------------------------------	-----------

### References based on Course 3 - Genetics and Evolution (VGVPSMZO103)

1. Morphology of the primates and human evolution R.P Srivastava.
2. Animal behavior by S. Prasad.
3. Text of Animal Behaviour by H.S Gundevia.
4. Animal behavior Saras publication Kenneth Oakley, Title of book.
5. Fossil in Earth Sciences by Anis kumar Ray.
6. Evolution Donal R. Prothero.
7. Principals of paleontology David M. Raup, Stanley.
8. Fossil Records, John Morris.
9. General genetics by Winchester.
10. Molecular Biology of gene by Watson et al. Vol I & II.
11. Genetics by Strickberger.
12. Molecular Biology by Friefelder.
13. Genetics by P.K. Gupta.
14. Molecular cell biology by Darnell, Lodish and Baltimore (Scientific American books).
15. Evolution by Savage.
16. Process of organic evolution by Stebbings.
17. Evolution of vertebrates by Colbert Concepts of Genetics, 9th edition (2008), William S. Klug, Michael R. Cummings, Charlotte Spencer, and Michael A. Palladino, Publisher Benjamin Cummings.
18. Genes IX, 9th edition (2008), Benjamin Lewin, Publisher-Jones and Barlett Publishers Inc.
19. Principles of Genetics, 4th edition, (2006), Snustad D. Peter and Simmons J. Micheal, Publisher -John Wiley and Sons. Inc.
20. Genetics, (1999), Daniel J. Fairbanks, W. Ralph Andersen Publisher- Brooks/Cole Pub Co.
21. Principles of Genetics, 8th edition (1991), Eldon J. Gardner, D.P. Snustad, M.J. Simmons, and D. Peter Snustad Publisher-John Wiley and Sons. Inc.
22. Microbial Genetics, (1987), David Freifelder, Publisher-Jones & Bartlett.
23. General Genetics, (1985), Leon A. Snyder, David Freifelder, Daniel L. Hartl Publisher Jones and Bartlett.
24. Genetics, 3rd edition, Monroe W. Strickberger, (1968), Publisher – Macmillan Publishing Co.



**Semester – I**  
**Practical based on Non-Chordates**  
**Course Code: VGVPSMZOP101**  
**Credits: 2**

<b>Practicals based on Non chordates VGVPSMZOP101</b>	
<b>Sr No.</b>	<b>List of Experiments</b>
<b>1</b>	A. Study of Fossils: a. Annelids: Serpula and Glomerula spp. b. Arthropods: Trilobites, Insects trapped in amber c. Molluscs: Palmerella kutchensis, Cimomia forbesi, Lamellidens d. Echinodermata: Gongrochanus spp., Goniocidaris e. Hemichordata: Graptolite fossils
<b>2</b>	Construction of a phylogenetic tree.
<b>3</b>	Making of fossil casts with Shaadu Clay / Muddy soil
<b>4</b>	Field visit to observe invertebrates in their natural habitat and accordingly the modifications of various systems.
<b>5</b>	Field visit to study fossils to places such as museums, Institutions, quarries, archeological sites.
<b>12</b>	To study larvae of Non-Chordates: i. Porifera – Amphiblastula, ii. Cnidaria (Coelenterata) – Planula, iii. Annelida and Molluscs– Trochophore, iv. Mollusca – Glochidium, v. Crustacea – Nauplius, Zoea, Mysis, Megalopa vi. Echinodermata – Auricularia, Echinopluteus , vii. Hemichordata – Tornaria

**SEMESTER I**  
**Practical I - Practical based on Non-Chordates**  
**(Practical Paper Pattern)**

<b>Duration: 5 hours</b>	<b>Marks: 50</b>
Q.1 Identify and Describe the larvae: a) Porifera/ Cnidaria (Coelenterata) b) Annelida/ Molluscs c) Crustacea d) Echinodermata/ Hemichordata	<b>12 marks</b>
Q.2. Identify and Describe the Fossils: a. Annelids/ Arthropods b. Molluscs c. Echinodermata/ Hemichordata	<b>09 marks</b>
Q.3 Construct a phylogenetic tree from the given data.	<b>08 marks</b>
Q.4 Making of fossil casts with Shaadu Clay / Muddy soil and viva based on it.	<b>06 marks</b>
Q.5. Field Report	<b>05 marks</b>
Q.6. Viva voce based on Theory.	<b>05 marks</b>
Q.7 Journal.	<b>05 Marks</b>

**Semester – I**  
**Practical based on Developmental Biology I**  
**Course Code: VGVPSMZOP101**  
**Credits: 2**

<b>Practicals based on Developmental Biology I- VGVPSMZOP102</b>	
<b>Sr No.</b>	<b>List of Experiments</b>
<b>1.</b>	To Isolate DNA from the given blood sample.
<b>2.</b>	To culture <i>Paramecium</i> to study the Conjugation and Binary fission in <i>Paramecium</i> .
<b>3</b>	To observe the Kappa particles in <i>Paramecium</i> cultured in laboratory.
<b>4</b>	To culture <i>Drosophila</i> due to study its life cycle.
<b>5</b>	To study germ layers: i. Diploblastic – T.S. of body wall of sponges and cnidarians (coelenterates) ii. Triploblastic acoelomate – T.S. of body wall of Platyhelminthes iii. Triploblastic pseudocoelomate– T.S. of body wall of Ascaris iv. Triploblastic coelomate –T. S. of body wall of earthworm
<b>6</b>	Study of syndromes – Cockeye syndrome (CS), Proteus syndrome, Muenke syndrome
<b>7</b>	Problems on gene mapping and mitotic index
<b>8</b>	To study gemmule formation in a sponge.
<b>9</b>	To study Life cycle of Butterfly / Moth (Insecta).



**SEMESTER I**  
**Practical II- Practical based on Developmental Biology I**  
**(Practical Paper Pattern)**

<b>Duration: 5 hours</b>	<b>Marks: 50</b>
<b>Major Question:</b> Q.1 Isolate DNA from the given blood sample.	<b>10 marks</b>
<b>Minor Question:</b> Q.2. Culture <i>Paramecium</i> to study the Conjugation and Binary fission in <i>Paramecium</i> .  <b>OR</b> Q.2 Observe the Kappa particles in <i>Paramecium</i> cultured in laboratory. <b>OR</b> Q.2 Culture <i>Drosophila</i> due to study its life cycle.	<b>08 marks</b>
<b>Q.3 Identify and Describe:</b> a) Germ layers b) Germ layers/ Gemmule c) Triploblastic pseudocoelomate/ triploblastic coelomate d) Life cycle of Butterfly/ Moth e) Study of syndromes	<b>15 marks</b>
Q. 4 Problems on gene mapping and mitotic index	<b>07 marks</b>
Q.4. Viva voce based on Theory.	<b>05 marks</b>
Q.5 Journal.	<b>05 Marks</b>



**Semester I**  
**OE: Frontiers in Zoology**  
**Course Code: VGVPSSELZO101**  
**Credits: 4**

Unit	Content	Lecture
<b>Unit I</b>	<p><b>Frontiers In Zoology</b>  <b>Astrobiology And Chronobiology</b></p> <p><b>I. General aspects of Astrobiology, Status of Research in Astrobiology and Future perspectives, factors determining habitability on planets; extremophiles</b></p> <p><b>II. Biosignatures of life in exoplanet atmosphere</b></p> <p><b>III. Search for life on Mars; search for extraterrestrial intelligence</b></p> <p><b>IV. Introduction to Chronobiology - Definition and meaning</b></p> <p><b>V. Biological rhythms</b>  i) Introduction  ii) Types - Circadian rhythms, Tidal rhythms, Lunar rhythms, Semilunar rhythms, Circannual rhythms</p> <p><b>VI. Structure of Biological Clock in Insects and Vertebrates; Biological Clock function</b></p> <p><b>VII. Relevance of Biological Clocks for Human Welfare</b>  i) Chronomedicine  ii) Chronotherapy</p> <p><b>VIII. Molecular mechanisms controlling the circadian rhythm (Noble Prize winning work, 2017)</b></p>	<b>15 Hrs</b>
<b>Unit II</b>	<p><b>Modern Techniques in Medical Field</b></p> <p><b>I. Physical Aspects of Medical Imaging</b>  i) Laser beam in Biology and Medical Field  ii) Medical lasers (Carbon Dioxide Laser, Nd: YAG Laser)  iii) Applications of lasers in therapy and diagnosis.</p> <p><b>II. Principle and applications of major medical imaging techniques</b>  i) Radiography  ii) Echocardiography (2D and 3D Echo)  iii) Computed Tomography Scan (CT Scan)  iv) Magnetic Resonance Imaging (MRI)</p> <p><b>III. Radioisotope Imaging: Introduction and applications</b></p> <p><b>IV. DNA barcoding technique and its applications</b></p> <p><b>V. Molecular Cytogenetic Techniques and their Applications</b>  i) Fluorescence <i>in-situ</i> Hybridization (FISH)  ii) Genomic <i>in-situ</i> Hybridization (GISH)  iii) Flow Cytometry  iv) Automated karyotyping  v) Chromosome painting</p>	<b>15 Hrs</b>

<p><b>Unit III</b></p>	<p><b>Biological Psychology And Neurobiology Of Stress And Emotion</b></p> <p><b>I. Introduction and general features of emotions</b></p> <p><b>II. Neuronal basis of emotion</b></p> <p><b>III. Types of emotions:</b> Definition and management- Fear, Frustration, Joy/ Happiness, Sadness, Embarrassment, Guilt, Shame, Anger, Love, Inspiration</p> <p><b>IV. Measurement of emotions:</b> Self-report, Behavioral observations, Physiological measure</p> <p><b>V. Role of brain regions in emotions:</b> Limbic system, Amygdala, Cortex, Hypothalamus, Midbrain Periaqueductal Grey, Neurochemicals involved in emotions</p> <p><b>VI. Concept of Stress, Measurement of stress, Characterizing stress:</b> Signs of stress, Types of stressors</p> <p><b>VII. Stress and the Hypothalamus:</b> Pituitary- Adrenal Axis (HPA Axis)</p> <p><b>VIII. Remedial measures to combat psychological stress and negative emotions</b></p>	<p><b>15 Hrs</b></p>
<p><b>Unit IV</b></p>	<p><b>Climatic Change And Sustainability</b></p> <p><b>I. Climatic Change</b> i) Introduction ii) Indicator species of climate change iii) Vulnerability and adaptations</p> <p><b>II. Greenhouse effect</b> i) Greenhouse gases ii) Increase in greenhouse gas concentrations iii) Global warming potential of greenhouse gases</p> <p><b>III. Intergovernmental Panel on Climate Change [IPCC]: Objectives and functioning</b></p> <p><b>IV. United Nations Framework Convention on Climate Change (UNFCCC) - Salient Features and Objectives</b> i) Kyoto protocol ii) Doha Amendment iii) Emission trading / Carbon Trading</p> <p><b>V. Sustainable Development</b> i) Introduction and goals ii) Sustainable habitat - Green building, Griha rating norms</p> <p><b>VI. Green Audit:</b> Introduction and Types - Energy audit, Waste disposal audit, Water audit, Carbon audit</p> <p><b>VII. Impact of climatic change on terrestrial and aquatic organisms</b></p> <p><b>VIII. Case studies on Climatic Change and Global Warming:</b> Kerala Floods, Impact of highway and road construction on animal survival, Impact of urbanization: Dhaka - Bangladesh</p>	<p><b>15 Hrs</b></p>
	<p style="text-align: right;"><b>Total No. of Lectures</b></p>	<p><b>60</b></p>

## References based on OE - Frontiers in Zoology (VGVPSSELZO101)

1. Animal Behaviour (Ethology) by Dr. V. K. Agarwal, S. Chand and Company Ltd. New Delhi.
2. Chronobiology Biological Timekeeping: Jay. C. Dunlap, Jennifer. J. Loros, Patricia J. De Coursey (ed). 2004, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.
3. Insect Clocks, by D.S. Saunders, C.G.H. Steel, X., afopoulou (ed.) R.D. Lewis. (3rd Ed) 2002 Baren and Noble Inc. New York, USA.
4. Biological Rhythms: Vinod Kumar (ed.2002) Narosa Publishing House, Delhi/ SpringerVerlag, Germany.
5. Molecular mechanisms controlling the circadian rhythm by Michael Rosbash, Michael W. Young & Jeffrey C. Hall, (Nobel Prize winner 2017).
6. Principles and techniques of practical biochemistry Ed. B. L. Williams and amp; K. Wilson, Arnold Publishers.
7. Medical Imaging Physics by W. R. Hendee, E.R. Ritenour, Wiley-Liss, 2002.
8. An Introduction to The Principles of Medical Imaging, Guy, D. ffytche, Imperial College Press, 2008.
9. Medical Instrumentation applications and design by John G. Webster.
10. Biomedical Instrumentation Technology and applications by Khandpur. McGraw – Hill.
11. Biomedical Instrumentation systems by Shakti Chatterjee.
12. HandBook of Bio-Medical Instrumentation by R. S. Khandpur, McGraw Hill Publishing Co. Ltd.2003.
13. Biomedical Instrumentation and Measurements Leslie Cromwell, Fred J. Weibell, Erich A.Pfeiffer, Pearson Education.
14. Bio-Medical Instrumentation by M. Arumugam, Anuradha Agencies
15. Lasers and Optical Fibers in Medicine by Katzir A.: Academic Press, Inc. 1993.
16. Techniques in life science by Tembhare.
17. Biological Psychology 3rd edition, by Frederick Toates, Prentice Hall, Pearson Education Limited.
18. Biological Psychology, 10th Edition, James V. Kalat, North Carolina State University, 2009, 2007Wadsworth, Cengage Learning.
19. Introduction to Psychology, 9th edition, James Kalat North Carolina State University, Wadsworth, Cengage Learning.
20. Neurobiology – Gordon M. Sheperd.
21. Principles of Neural Science – E. Kandel and others.
22. Essentials of Neural Science and Behaviour – E. Kandel and others.
23. Elements of Molecular Neurobiology – C U M Smith.
24. Fundamentals of Ecology and Environment, Second edition by Pranav Kumar and Usha Mina, Pathfinder Publication New Delhi, India.
25. Elements of Ecology by Smith TM and Smith RL (2009), 7th ed. San Francisco CA: Pearson Benjamin Cummings.



**Semester I**  
**OE: Forensic Science and Environmental Biotechnology**  
**Course Code: VGVPSSELZO102**  
**Credits: 4**

Unit	Content	Lecture
<b>Unit I</b>	<p><b>Forensic Science and Environmental Biotechnology</b></p> <p><b>Forensic Science</b></p> <p><b>I. Forensic Entomology:</b>  Basics of forensic entomology. Different Insects of forensic importance. Collection of entomological evidence during death investigations.</p> <p><b>II. Forensic Serology:</b>  Nature and importance of biological evidence. Composition and Functions of Blood and Semen. Types and identification of microbial organisms of forensic significance.  Examinations of Biological Evidence: Identification of Blood, Semen, Saliva and Urine through preliminary and confirmatory crystal examinations.</p> <p><b>III. Forensic Toxicology:</b>  Toxicological analysis and chemical intoxication tests, Postmortem Interval, Clinical toxicology, Dose-response relationship, Lethal dose 50, Lethal concentration 50 and Effective dose 50.  Collection and preservation of viscera, blood and urine for various poison cases  Identification and Analysis of Biocides and Heavy metals in body fluids</p>	<b>15 Hrs</b>
<b>Unit II</b>	<p><b>Methods In Field Zoology</b></p> <p><b>I. Methods of estimating population density of animals, ranging through direct, indirect and remote observations</b></p> <p><b>II. Sampling methods in the study of behavior;</b></p> <p><b>III. Different techniques of sampling – simple random sampling, stratified random sampling</b></p> <p><b>IV. Ethnzoology and its applications</b></p> <p><b>V. Habitat characterization: ground and remote sensing methods.</b></p> <p><b>VI. Aerial counts and Satellite Imagery</b></p> <p><b>VII. Measuring Abundance: Transects and Quadrats for faunal diversity</b></p> <p><b>VIII. Underwater and Foreshore Surveying</b></p>	<b>15 Hrs</b>

<p><b>Unit III</b></p>	<p><b>Environmental Biotechnology</b></p> <p><b>I. Role of environmental biotechnology; Scope for use, Market for environmental biotechnology, modalities and local influences.</b></p> <p><b>II. Integrated approach in environmental biotechnology;</b> Immobilisation, Degradation or Monitoring of Pollutants from a Biological Origin, Metabolic Pathways of Particular Relevance to Environmental Biotechnology</p> <p><b>III. Nanofiltration for water purification</b></p> <p><b>IV. Green Nanotechnology – Nanomaterials for resolving environmental problems</b></p> <p><b>V. Biofuel- Biodiesel, Biogas, Ethanol production</b></p> <p><b>VI. Genetically modified organisms (GMO) and Biosafety:</b> Impact of GMO on the environment</p>	<p><b>15 Hrs</b></p>
------------------------	---	----------------------

	<b>VII. Biosensors to detect environmental pollutants</b> <b>VIII. Case study: Current advances in Environmental Biotechnology</b>	
<b>Unit IV</b>	<b>Applied Ecology</b> <b>I. Environmental pollution and anthropogenic activities;</b> <b>II. Global warming and Greenhouse gases;</b> <b>III. Global Climatic change: Causes, consequences and mitigation</b> <b>IV. Eutrophication and Biomagnification</b> <b>V. Bioremediation: Types, Techniques and its applications</b> <b>VI. Algal bloom and its impact in the environment</b> <b>VII. Xenobiotic; Ecological management in toxicological evaluation.</b> <b>VIII. Microplastic biodegradation</b>	<b>15 Hrs</b>
	<b>Total No. of Lectures</b>	<b>60</b>

**References Based on OE - Forensic Science And Environmental Biotechnology (VGVPSELZO102)**



1. R.K. Murray, D.K. Granner, P.A. Mayes and V.W. Rodwell, Harper's Biochemistry, APPLETON & Lange, Norwalk (1993).
2. David B. Rivers; Gregory A. Dahlem: The Science of Forensic Entomology, 2nd Edition, September 2002, ISBN: 978-1-119-64061-5.
3. Damien Charabidze and Daniel Martín-Vega; From Laboratory Studies to Court Evidence: Challenges in Forensic Entomology, 2021. <https://doi.org/10.3390/books978-3-0365-1707-0>.
4. R. Saferstein, Forensic Science Handbook, Vol. III, Prentice Hall, New Jersey (1993).
5. G.T. Duncan and M.I. Tracey, Serology and DNA typing in, Introduction to Forensic Sciences, 2nd Edition, W.G. Eckert (Ed.), CRC Press, Boca Raton (1997).
6. Sunshine I; Year book of Toxicology, CRC Press Series, USA.
7. Michael J. Deverlanko et al: HandBook of Toxicology CRC Press, USA.
8. Robert J. Flanagan, Andrew A. Taylor, Ian D. Watson, Robin Whelpton Fundamentals of Analytical Toxicology, Wiley.
9. Rosner B.A., 2011, Fundamentals of Biostatistics, Cengage Learning
10. Remote Sensing of the Environment – An earth resource perspective: J. R. Jensen; Pearson Education.
11. Remote Sensing, Principles and interpretation: Floyd F. Sabins Jr., W.H. Freeman & Company, New York, 2nd Ed., 1987.
12. Odum, EP. 1987: Basic ecology, Sounders college publications, Philadelphia.
13. Environmental Biotechnology: Alan Scragg
14. Environmental Biotechnology: Bimal Bhattachraya and Ritu Banerjee
15. Encyclopedia of Bioethics, Stephen G. Post (3rd edition)
16. R. M. Atlas and R. Bartha - 1998 - Microbial Ecology - Fundamentals and applications. Addison Wesley Longman, Inc.
17. R.M. Maier, I.L. Pepper and C.P. Gerba 2010, Environmental Microbiology Academic Press.
18. Rastogi & Sani, Microbes and Microbial Technology, 2011, pp 29-57, Molecular Techniques to Assess Microbial Community Structure, Function, and Dynamics in the Environment,
19. A K Bej and M H Mahbubani, Applications of the polymerase chain reaction in environmental Microbiology. Genome Res. 1992 1: 151-159.
20. Wastewater engineering: Treatment and reuse. Metcalf and Eddy, Tata McGraw Hill Publishing Co. Ltd. 4th Ed.
21. Environmental management. H. V. Jadhav, Vipul Prakashan, 2002
22. Environmental microbiology. P. D. Sharma. Alpha Science International 2005 ed.
23. Mills, D.H. (1972) An introduction to freshwater Ecology. Liver & Boyd, Edinburg.
24. Sawyer, C.N. and McCarty, P.L. and Parkin, G.F. "Chemistry for Environmental Engineers", 4th

Edition, McGraw Hill, New Delhi, 1994

25. Environmental Monitoring and Instrumentation, Bucholtz, F., (1997) Optical Society of America, Washington D.C.
26. Environmental Sampling Analysis: A Practical Guide, Xieith, L.H., Boca Raton, F.L. (1991), Lewis Publication.
27. Climate Change and Biodiversity; By Thomas E. Lovejoy, Lee Jay Hannah Published by Yale University Press, 2006 ISBN 0300119801, 80300119800 418 pages.

**Practicals based on Semester I - OE (VGVPSSELZOP101)**

<b>Sr. No.</b>	<b>List of Experiments</b>
1	Determination of concentration of iron as a pollutant from sample / sample solution by – Redox titration or spectrophotometric method.
2	Detection of heavy metals from given sample: a) Zinc b) Lead c) Copper
3	Extraction of fluid from evidence collected from crime scenes.
4	Survey method of Quadrat and Line Transect method for Field Study in Zoology
5	Recycling and purification of waste water effluents
6	Identification of photographs with respect to chronobiology. a) Structure of biological clock in insects b) Structure of biological clock in vertebrates
7	Identification of photographs of different imaging techniques
8	Study of gross anatomical regions of the brain involved in stress and emotion.
9	Study of animals as indicators for climate change and global warming a) Green turtle b) Birds – Sparrow c) Polar bear d) Coral reef e) Butterflies
10	Identification of SCUBA Apparatus
11	Environment Audit report (Green Audit / Review of EIA of a Selected Area)
12	Visit to nearby Barcoding laboratory / imaging center /Visit to Industries and Field work report pertaining to Environmental Biotechnology, Applied Ecology and submission of report
13	Assignment or report submission on pulse rate after stress.

**Practical based on Electives- Frontiers in Zoology (VGVPSSELZOP101)  
(Practical Paper Pattern)**

<b>Duration: 5 hours</b>	<b>Marks: 50</b>
<b>Major Question:</b> Q.1 Determination of concentration of iron as a pollutant from sample / sample solution by – Redox titration or spectrophotometric method. <b>OR</b> Q.1 Detection of heavy metals from given sample: a) Zinc b) Lead c) Copper	<b>12 marks</b>
<b>Minor Question:</b> Q.2 Extraction of fluid from evidence collected from crime scenes. <b>OR</b> Q. 2 Survey method of Quadrat and Line Transect method for Field Study in Zoology	<b>08 marks</b>
Q.3 Identify and Describe: a) Chronobiology b) Imaging Techniques c) Indicator animals for climate change and global warming d) SCUBA apparatus	<b>12 marks</b>
Q.4. Environment Audit Report <b>OR</b> Q.4 Report on visit to Barcoding laboratory/ Imaging Center/ Visit to Industries	<b>08 marks</b>
Q.4. Viva voce based on Theory.	<b>05 marks</b>
Q.5 Journal.	<b>05 Marks</b>



**Semester I**  
**Research Methodology**  
**Course Code: VGVPSRMZO101**  
**Credits: 4**

Unit	Content	Lecture
<b>Unit I</b>	<p><b>Principles of Scientific Research</b></p> <p><b>I. Basic concepts of research</b></p> <p>i. Definition</p> <p>ii. Characteristics of research (controlled, rigorous, systematic, valid and verifiable, empirical and critical)</p> <p>iii. Objectives of research</p> <p>iv. *Types of research: a) Pure and applied b) Structured and unstructured c) Descriptive, correlational, explanatory, exploratory, historical, comparative and experimental</p> <p><b>II. Formulating research problem</b></p> <p>i. Reviewing literature: Using library, computerized searches, evaluating literature</p> <p>ii. Developing a research problem: Importance, sources, considerations, steps, defining a problem, formulate objectives</p> <p>iii. Identifying variables: Introduction, types of variables, measurement scales</p> <p>iv. *Hypothesis: Definition, function, characteristics, types (H<sub>0</sub>, H<sub>A</sub>), Principles of hypothesis, framing hypothesis, errors in hypothesis, research question versus research hypothesis, hypothesis versus non-hypothesis research</p> <p><b>III. Research design</b></p> <p>i. Definition and purpose</p> <p>ii. Characteristics of good research design</p> <p>iii. Sampling strategy and sampling size determination, eliminating extraneous variables</p> <p>iv. *Types of study design: study designs in quantitative research (cross-sectional, before and after, longitudinal, retrospective, prospective, retrospective-prospective, experimental, non-experimental, quasi-experimental)</p>	<b>15 Hrs</b>

<b>Unit II</b>	<b>Data Management and Analysis</b> <b>I. Methods of data collection</b> i. Primary sources ii. Secondary sources <b>II. Data Classification and Presentation</b> i. *Classification of data (Geographical, Chronological, Qualitative, Quantitative)	<b>15 Hrs</b>
	ii. Tabulation of data (one-way table, two-way table, complex table) iii. Type of charts (Line, Column, Scatter plot, Box plot, Heat Map) <b>III. Concepts of Measurements</b> i. Univariate (standard deviation, variance, quartiles) ii. Bivariate (correlation and regression) iii. Multivariate (ANOVA: one-way, two-way) iv. Level of significance and p-value v. *Normal distribution, Skewness, Kurtosis, Outliers <b>IV. Testing of Hypothesis</b> i. Null hypothesis, Alternative hypothesis ii. Type 1 and Type 2 Errors iii. *Testing of Hypothesis (single population mean, two population means) iv. One-tailed and Two-tailed tests <b>V. *Parametric and Non-parametric tests</b> i. Parametric tests: t test, z test, F test ii. Non-parametric tests: Chi-square test, Mann-Whitney test, Kruskal-Wallis test, Friedman Test, Wilcoxon signed- rank test	
<b>Unit III</b>	<b>Scientific Communication</b> <b>I. Research planning</b> i. *Project Proposal and research funding agencies –Research grants, scholarships and funding (CSIR, DBT, DST, DST- INSPIRE Fellowship, ICMR, INSA, BRNS, MoEFCC, UGC-RFSMS, Fulbright Fellowships for Indian students, Lady Tata Memorial Trust, EPA, Bill and Melinda Gates Foundation, Wellcome Trust, Erasmus Mundus) ii. Use of reference management software (MS Word / Zotero / Mendeley) iii. Scientific writing –Thesis and Dissertation <b>II. *Documentation for approval from Institutional Animal Ethics Committee (IAEC) and Institutional Biosafety Committee (IBSC)</b> i. Documents for registration, renewal and reconstitution of IAEC as per CPCSEA guidelines	<b>15 Hrs</b>

<ul style="list-style-type: none"><li>ii. Proposal layout for permission from IAEC for use of animals in research</li><li>iii. Proposal layout based on recombinant DNA safety guidelines from IBSC</li><li>iv. Proposal layout for use of transgenic animals in research</li></ul> <p><b>III. Publications and Research Journals</b></p> <ul style="list-style-type: none"><li>i. *Types of research journals</li><li>ii. Impact factors of Journals</li><li>iii. Predatory Journals</li></ul>	
---	--



	<p>iv. Review process – benefits and drawbacks of single blind, double blind and open peer review process</p> <p>v. Understanding “h – index” and “i10 – index”</p> <p>vi. SCOPUS, Google Scholar, Web of Science</p> <p>vii. Process to obtain ISSN and ISBN</p>	
<b>Unit IV</b>	<p><b>Model organisms and their applications</b></p> <p><b>I. Introduction: Concept key features and importance of model organisms</b></p> <p><b>II. Earthworm</b></p> <p>i. Biology and genome</p> <p>ii. *Model for studies on regeneration</p> <p><b>III. <i>Caenorhabditis elegans</i></b></p> <p>i. Body plan of the worm, genetics, genome, cultivation, advantages and limitations</p> <p>ii. *Techniques used for genetic modification, Mutant characterization, discovery of RNAi</p> <p><b>IV. <i>Daphnia</i> sp.</b></p> <p>i. Genome, epigenetic phenotypic variation</p> <p>ii. Advantage and limitations</p> <p>iii. *Model for studies in toxicology</p> <p><b>V. <i>Drosophila melanogaster</i></b></p> <p>i. Genome, advantages and limitations</p> <p>ii. *Model for cytogenetics, development, neuroscience, human diseases and therapeutic drug discovery</p> <p><b>VI. <i>Danio rerio</i> (Zebra fish)</b></p> <p>i. Genome, advantages and limitations</p> <p>ii. *Insights on embryology, ageing and toxicology</p> <p><b>VII. <i>Mus musculus</i> (Mouse)</b></p> <p>i. Genomics, advantages and limitations</p> <p>ii. *Model for studies on physiology, development, ageing, human diseases (Cancer and Diabetes) and behaviour research</p> <p>iii. Transgenic and germ line transgenic mouse models, genetically engineered mouse models (GEMMs): Knock-In and Knock-out mouse models</p>	<b>15 Hrs</b>
	<b>Total No. of Lectures</b>	<b>60</b>



## References based on Research Methodology (VGVPSRMZO101)

1. Graduate research – A guide for students in Life Sciences. 2nd edition. Robert V. Smith
2. Research methods for Biosciences. 3rd edition. Debbie Holmes, Peter Moody, Diana Dine, Laurence Trueman
3. Experimental designs for Life Sciences. 4th edition. Graeme D., Ruxton and Nick Colegrave
4. Research methodology – Step by Step Guide for Beginners. 3rd edition. Ranjit Kumar
5. Research methodology – Tools and techniques, Bridge Centre 2015
6. The practice of statistics in life sciences – Brigitte Baldi and David Moore, W. H. Freeman.
7. Mahajan's methods in Biostatistics for Medical students and Research Workers – Bratati Banerjee, Jaypee Publishers.
8. Biostatistics: Basic concepts and methodology – Wayne Daniel and Chad Cross, Wiley.
9. Statistics for people who (think they) hate statistics – Neil J. Salkind, SAGE Publications.
10. Discovering Statistics using IBM SPSS Statistics – Andy Field, SAGE Publications.
11. IBM SPSS Statistics Step by Step – Darren George and Paul Mallery, Taylor & Francis.
12. Statistics for Ecologists using R and Excel – Mark Gardener, Pelagic Publishing.
13. Thesis and Dissertation Writing in a Second Language a handbook for supervisors – Brian Paltridge and Sue Starfield, Routledge Publishers.
14. The process of research writing – Steven Krause – Eastern Michigan University.
15. Animal – Use Research IAEC Project Proposal & animal imports Guidelines – NCBS Animal Care and Resource Center.
16. Academic Writing and Publishing – A Practical Handbook – James Hartley.
17. How to Improve Your Journal and Have Greater Impact – James Testa – Thomson Reuters.
18. Introduction to Genetic Analysis: Griffiths, Wessler, Lewontin, Carroll. WH Freeman Company, New York.
19. Biology. E. P. Solomon, L. R. Berg, D. W. Martin, Thompson Brooks/Cole.
20. Bier, E. 2005. Drosophila, the Golden Bug, Emerges as a Tool for Human Genetics. Nature Reviews Genetics 6: 9-23.
21. <https://beckerguides.wustl.edu/authors/hindex>
22. <https://www.elsevier.com/en-in/reviewers/what-is-peer-review>
23. <https://www.thehindu.com/sci-tech/science/what-is-a-predatoryjournal/article21039351.ece>
24. Fly: <http://flybase.bio.indiana.edu:82/>
25. Worm: <http://www.expasy.ch/cgi-bin/lists?celegans.txt>
26. Zebrafish: [http://www.ncbi.nlm.nih.gov/genome/guide/D\\_reio.html](http://www.ncbi.nlm.nih.gov/genome/guide/D_reio.html)
27. Mouse: <http://www.informatics.jax.org/>



**Semester – II**  
**Paper I - Chordates**  
**Course Code: VGVPSMZO201**  
**Credits: 4**

<b>Unit</b>	<b>Content</b>	<b>Lecture</b>
<b>Unit I</b>	<p><b>Protochordates and Agnatha</b></p> <p>I. Protochordates</p> <p>i. Origin and ancestry of Protochordates, similarities and differences with Invertebrates and Chordates</p> <p>ii. Comparison of characteristics between subphyla</p> <p><b>Urochordates and Cephalochordates</b></p> <p>II. Urochordates</p> <p>i. Life history of Herdmania and its phylogenetic affinities</p> <p>III. Cephalochordates</p> <p>i. General features and phylogenetic affinities</p> <p>ii. Life history of Branchiostoma</p> <p>IV. Ostracoderm</p> <p>i. Salient features and biological significance</p> <p>ii. Interrelationship and affinities with fish</p> <p>V. Cyclostomes</p> <p>i. Resemblance with Cephalochordates, Vertebrates and differences from Fishes</p> <p>ii. Life history of Petromyzon</p>	<b>15 Hrs</b>

<p><b>Unit II</b></p>	<p><b>Phylogeny of Chordates</b></p> <p>I. Ancestry of Chordates</p> <p>II. Pisces</p> <p>i. General characters of Dipnoi and affinities with Fishes, Elasmobranchs and Amphibia</p> <p>ii. Origin of air bladder and its relationship with tetrapod lungs</p> <p>iii. Deep sea adaptations of fishes</p> <p>iv. Origin of fins</p> <p>III. Amphibia</p> <p>i. Origin of Tetrapods</p> <p>ii. Pedomorphosis</p> <p>iii. Adaptive radiation in amphibians Lemospondyli and</p>	<p><b>15 Hrs</b></p>
-----------------------	---	----------------------

	<p>Lissamphibia</p> <p>IV. Reptilia</p> <p>i. Origin of Reptiles and affinities with Amphibia</p> <p>ii. Terrestrial adaptations in Reptiles</p> <p>V. Aves</p> <p>i. Origin of Birds and affinities with Reptiles</p> <p>ii. Adaptive radiation in Birds – Ratitae (Flightless Birds) and Carinatae (Flying Birds)</p> <p>iii. Origin of Flight – Theory of Cursorial and Arboreal origin</p> <p>VI. Mammalia</p> <p>i. Origin of Mammals</p> <p>ii. Phylogeny of terrestrial and aquatic mammals</p>	
<b>Unit III</b>	<p><b>Functional and Comparative Anatomy of Chordates</b></p> <p>I. Comparative Anatomy of:</p> <p>i. Chondrocranium</p> <p>ii. Splanchnocranium</p> <p>iii. Skull in different Vertebrates</p> <p>II. Evolution and Comparative Anatomy of Excretory System of Chordates</p> <p>i. Evolutionary development of Kidney – Archinephros, Pronephros, Mesonephros, Metanephros</p> <p>III. Comparative Anatomy of Nervous System in Vertebrates</p> <p>i. Brain</p> <p>ii. Sense organs – Eyes and Ears</p> <p>IV. Comparative Anatomy of Respiration</p> <p>i. Gills, Skin and Lungs</p> <p>V. Circulation: Heart and Aortic Arches</p> <p>VI. Male and female reproductive and urinary ducts of Vertebrates (Cyclostomes, Teleost, Elasmobranchs, Amphibia, Reptilia, Aves and Mammalia)</p>	<b>15 Hrs</b>

<b>Unit IV</b>	<p><b>Assorted Topics on Chordates</b></p> <p>I. Retrogressive metamorphosis in Ascidians</p> <p>II. Pisces - Evolutionary significance Crossopterygians, Placoderms, Migration, Lateral line sense organ and electric organs</p> <p>III. Amphibia – Evolutionary significance of Labyrinthodonts</p> <p>IV. Reptilia - Evolutionary significance of Dinosaurs, Venom apparatus and biting mechanism in snakes</p> <p>V. Aves – Migration, Flight adaptations</p>	<b>15 Hrs</b>
----------------	---	---------------

	VI. Mammalia - Dentition in mammals, Habitat diversification, Walking gait: Plantigrade, Digitigrade and Unguligrade, Comparative account of Jaw suspension	
	<b>Total No. of Lectures</b>	<b>60</b>

### References based on Course 1 – Chordates (VGVPSMZO201)

1. Introduction to General Zoology, Volume II– K. K. Chaki, G. Kundu, S. Sarkar (NCBA)
2. Vertebrate Zoology– F. B. Mondal (Oxford IBH)
3. Modern TextBook of Vertebrates – R. L. Kotpal (Rastogi)
4. Alexander, R. M. The Chordata. Cambridge University Press, London.
5. Barrington, E. J. W. The biology of Hemichordata and protochordata. Oliver and Boyd, Edinburgh.
6. Kingsley, J. S. Outlines of comparative anatomy of vertebrates. Central Book Depot, Allahabad.
7. Kent, C. G. Comparative anatomy of vertebrates.
8. Smith, H. S. Evolution of chordate structure. Hold Rinehart and Winston Inc., New York.
9. Torrey, T. W. Morphogenesis of vertebrates. John Wiley and Sons Inc., New York.
10. Romer, A. S. Vertebrate Body, III Ed. W. B. Saunders Co., Philadelphia
11. Young, J. Z., Life of mammals, The Oxford University Press, London
12. Colbert, E. H., Evolution of the vertebrates. John Wiley and Sons Inc., New York.
13. Weichert, C. K. and Presch, W. Elements of Chordate anatomy. 4th Edn. McGraw Hill, Book Co., New York.
14. Montagna, W. Comparative anatomy. John Wiley and Sons Inc.
15. Andrews, S. M. Problems in vertebrate evolution. Academic Press, New York.
16. Waterman, A. J. Chordata structure and function. Macmillan Co., New York.
17. Lovtrup, S. The phylogeny of Vertebrate. John Wiley & Sons, London
18. Barbiur, T. Reptiles and Amphibians: Their habits and adaptations. Hongton Miffin Co., New York.
19. Smyth. Amphibia and their ways. The Macmillan Co., New York.
20. Jordan and Verma. Chordate Zoology, S. Chand Publication.



**Semester II**  
**Paper II - Developmental Biology – II**  
**Course Code: VGVPSMZO202**  
**Credits: 4**

Unit	Content	Lecture
<b>Unit I</b>	<p><b>Reproductive Systems in Chordates</b></p> <p>i. <b>Reproductive system</b> – Urochordata - Tunicate, Cephalochordata - Amphioxus, Cyclostomata – Petromyzon, Pisces – Catfish, Amphibia – Frog, Reptilia – Lizard, Aves – Pigeon, Mammalia – Human</p> <p>ii. Accessory Reproductive Glands – Human.</p>	<b>15 Hrs</b>
<b>Unit II</b>	<p><b>Physiology of Reproduction</b></p> <p><b>i. Morphogenesis and organogenesis in animals:</b> Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick; organogenesis, vulva formation in Caenorhabditis elegans; eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development-larval formation, metamorphosis; environmental regulation of normal development; sex determination.</p> <p><b>ii. Sperm capacitation, decapacitation</b> – molecular mechanism and Ovarian luteinization and mammary gland differentiation in human</p> <p><b>iii. Pheromones</b> – Pisces, Amphibia, Reptilia, Aves and Mammalia</p> <p><b>iv. Courtship behavior in</b> – Pisces, Amphibia, Reptilia, Aves, Mammalia</p>	<b>15 Hrs</b>
<b>Unit III</b>	<p><b>Developmental Biology –</b></p> <p><b>i. Gametogenesis, fertilization and early development:</b> Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals</p> <p><b>ii. Introduction to germ cells :</b> Germ cell migration in Zebrafish, Frogs, Lizard, Chick and Mouse</p> <p><b>iii. Stem cells –</b></p> <p>i. Embryonic stem cells, Induced Pluripotent stem cells, Adult stem cells</p> <p>ii. Regeneration Therapy – Cardiac, bone and neuronal regeneration</p> <p>iii. Cryopreservation of stem cells – Concept, tools, techniques and application</p> <p>iv. Induced breeding in fish – technique and applications.</p>	<b>15 Hrs</b>
<b>Unit IV</b>	<p><b>Animal Development –</b></p> <p><b>i. Environmental Cues and Impact on Development</b> - Predator Induced Polyphenism – Amphibian, Temperature and Sex – Fish, Turtle and Alligator</p> <p><b>ii. Teratogenesis</b> - Alcohol, Retinoic acid, Endocrine disruptors – Diethylstilbestrol, Plastics – Nonylphenol, Bisphenol A and Heavy metals as teratogens</p> <p><b>iii. Developmental constraints on evolution</b> – physical, morphogenetic and phyletic</p> <p>i. Modularity of development – Example – Duffy blood group substance and Stickleback fish</p> <p><b>iv. Aging and Senescence</b> – Causes, Consequences, and Therapeutics i. Environmental and epigenetic causes of aging – Plastics, Pesticides, Heavy metals</p> <p><b>v. Promoting Longevity:</b> Role of telomerase: an overview</p>	<b>15 Hrs</b>
	<b>Total No. of Lectures</b>	<b>60</b>

## References based on Course 2 - Developmental Biology II (VGVPSMZ0202)

1. Comparative embryology of the vertebrates 1 – 2 (1953) McGraw – Hill Book company, New York.
2. Comparative reproductive biology - Heide Schatter and Gheorghe Constantinescu – Blackwell Publishing.
3. Human reproductive system – Encyclopedia Britannica by Richard J. Harrison.
4. Animal Physiology – Withers.
5. Animal Physiology - Hoar
7. Gilbert, 9th Edition.
8. Animal Physiology - Giese
9. Chordates- Jordan and Verma
10. Chordates- Parker and Haswell
11. Chick embryology- Patten
12. Chordate Zoology- Kotpal
13. Chordate Zoology- P. S. Dhami and J. K. Dham
14. Sex pheromones in amphibians-a review Vet.Med-Czech, 50,2005(9); 385-389
15. Developmental Biology- Gilbert

### E-resources

15. <http://www.eurekaselect.com/node/156190/related-ebooks>
16. <https://embryo.asu.edu/pages/sperm-capacitation>
17. <https://www.sciencedirect.com/book/9780124366435/handbook-of-stem-cells>
18. <https://ivf.net/ivf/a-textbook-of-in-vitro-fertilization-and-assisted-reproduction-the-bournhall-guide-to-clinical-and-o418.html>
19. <https://www.britannica.com/science/teratogenesis>
20. [https://link.springer.com/chapter/10.1007/978-3-642-45532-2\\_15](https://link.springer.com/chapter/10.1007/978-3-642-45532-2_15)
21. <https://www.elsevier.com/books/handbook-of-the-biology-of-aging/schneider/978-0-12-627871-2>
22. <https://www.whatisepigenetics.com/fundamentals/>





**Semester – II**  
**Paper III - Biochemistry and Biotechnology**  
**Course Code: VGVPSMZO203**  
**Credits: 4**

Unit	Content	Lecture
<b>Unit I</b>	<p><b>Fundamentals of Biochemistry</b></p> <p><b>I. Water as the Basic Molecule of Life</b></p> <ul style="list-style-type: none"> <li>i. Structure of atoms, molecules and chemical bonds</li> <li>ii. Molecular structure and solvent properties of water, tetrahedral geometry, hydrogen bond, thermal properties of water and their biological significance</li> <li>iii. Ionization of water, Ion product of water (K<sub>w</sub>), Concept of pH, Dissociation of weak acids and weak bases, Henderson-Hasselbalch Equation, Titration curves of strong and weak acids, concept of buffer, buffers in biological systems</li> </ul> <p><b>II. Biological Macromolecules</b></p> <ul style="list-style-type: none"> <li>i. Central role of Carbon</li> <li>ii. Common ring structure, Chirality, and Isomerization in biomolecules</li> <li>iii. Composition, structure of monomers and polymers, functions of carbohydrates, lipids, proteins, nucleic acids and vitamins</li> </ul> <p><b>III. Interactions of Macromolecules</b></p> <ul style="list-style-type: none"> <li>i. Stability of Proteins and Nucleic Acids; Stabilizing Interactions such as Vander Waals, Electrostatic, Hydrogen Bonding, Hydrophobic Interactions</li> <li>ii. Conformation of proteins: Ramachandran plot, secondary structure, domains, motif and folds, hydropathy index of amino acids, isoelectric point (p<sub>i</sub>) of proteins</li> <li>IV. Complex biomolecules <ul style="list-style-type: none"> <li>i. Glycoproteins: blood group determinants</li> <li>ii. Complex Lipids: Phospholipids, Sphingolipids, Gangliosides, Sterols and Waxes</li> <li>iii. Lipoproteins: classification and functions of chylomicrons, VLDL, LDL, HDL, and free fatty acid albumin complex.</li> </ul> </li> </ul>	<b>15 Hrs</b>

<p><b>Unit II</b></p>	<p><b>I. Biochemical Thermodynamics</b></p> <ul style="list-style-type: none"> <li>i. Laws of thermodynamics, free energy, entropy, enthalpy, exergonic and endergonic reactions</li> <li>ii. Biological oxidation: Electron transport chain in mitochondria; oxidative phosphorylation – mechanism, uncoupling of oxidative phosphorylation and its significance</li> <li>iii. Free radicals, Antioxidants and Antioxidant system</li> </ul> <p><b>II. Carbohydrate and Lipid Metabolism</b></p> <ul style="list-style-type: none"> <li>i. Glycolysis and its energetics</li> <li>ii. Gluconeogenesis: Reaction sequence from pyruvate, gluconeogenesis from amino acids, glycerol, propionate and lactate</li> <li>iii. Glycogen metabolism: Glycogenesis, Glycogenolysis</li> <li>iv. Significance of the pathways: Hexose Monophosphate (HMP) Shunt as a multifunctional pathway; uronic acid pathway; glyoxalate cycle</li> </ul>	<p><b>15 Hrs</b></p>
-----------------------	--	----------------------

	<p>v. Fatty acid metabolism: Oxidation of saturated even and odd carbon atom, and unsaturated fatty acids, metabolism of cholesterol</p> <p><b>III. Regulation of Metabolism</b></p> <p>i. Regulation of metabolic flux by genetic mechanisms: Control of enzyme synthesis, constitutive and inducible enzymes; induction and repression of enzymes (lac operon and trp operon)</p> <p>ii. Regulation of metabolism by extracellular signals: nutrient supply, nutrient transport, endocrine control, neural control</p> <p><b>IV. Amino acid and Nucleic acid Metabolism</b></p> <p>i. Nitrogen metabolism: Protein turnover, amino acid pool, nitrogen balance</p> <p>ii. Metabolism of Amino acids: Transamination, Deamination, Urea cycle</p> <p>iii. Formation of amino acids from Pyruvate, TCA cycle intermediates, Acetyl CoA</p> <p>iv. Nucleic Acid metabolism: De novo synthesis: synthesis of purine and pyrimidine nucleotides; Salvage Pathway; Catabolism of purine and pyrimidine nucleotides.</p>	
<b>Unit III</b>	<p><b>Organization of genome in prokaryotes and eukaryotes</b></p> <p>i. C-value paradox and genome size.</p> <p>ii. DNA replication in prokaryotes and eukaryotes</p> <p>iii. Transcription and translation in prokaryotes &amp; eukaryotes, Transcription level control, Translational level control, post-translational control</p> <p><b>Control of gene expression in Prokaryotes &amp; Eukaryotes-</b></p> <p>i. Lac operon,</p> <p>ii Trp operon</p> <p>iii. Small regulatory RNAs, small nuclear ribonucleoproteins (snRNPs)</p> <p>iv. Gene silencing, miRNA, RNA silencing pathways and DNA methylation, RNA processing</p> <p><b>Methods in Biotechnology</b></p> <p>Cloning using plasmid pUC18, pUC19, blue-white screening, cloning in bacteriophage, cosmid, BAC and YAC vectors, Chromosome walking, RAPD, AFLP, Microarrays</p>	<b>15 Hrs</b>

<p><b>Unit IV</b></p>	<p><b>Applications of Biotechnology</b></p> <p><b>I. Industrial Biotechnology</b></p> <p>i. Microbial fermentation, Microbial growth kinetics, Design of a fermenter, Organisms used in large scale fermentation.</p> <p>ii. Production of antibiotics – Cephalosporin, erythromycin; amino acids – proline, glutamate; vitamins – cyanocobalamin, riboflavin; Aspartame and Taxol</p> <p><b>II. Medical Biotechnology:</b></p> <p>Molecular approaches in diagnosis and treatment</p> <p>i. Peptide vaccines: synthetic drugs (engineered proteins)</p> <p>ii. Genetic immunization: Antisense DNA, Therapeutic ribozymes</p> <p>iii. Anti-idiotypic vaccine for cancer treatment</p> <p>iv. Monoclonal antibodies (mAbs) and their therapeutic applications</p> <p>v. HIV therapeutic agents</p> <p>vi. Production of biopharmaceuticals from transgenic animals – Human Tissue Plasminogen Activator (hTPA) and <math>\alpha</math>-1Antitrypsin (AAT)</p> <p>vii. Pharmacogenomics and Nutrigenomics: An overview and applications</p> <p><b>III. Agricultural Biotechnology</b></p>	<p><b>15 Hrs</b></p>
-----------------------	--	----------------------

	<p>i. Plant Tissue culture methods–Broad outline and applications of Pollen culture &amp; Protoplast culture</p> <p>ii. <i>Bacillus thuringiensis</i> based bio-pesticides, genetic engineering of herbicide resistance trait in crops, genetic engineering of <math>\beta</math>-carotene biosynthetic pathway in golden rice</p> <p>iii. Genetic engineering of biological nitrogen fixation (Nitrogenase cluster and hydrogenase genes), Genetic engineering drought/salinity tolerance trait in crops</p>	
	<b>Total No. of Lectures</b>	<b>60</b>

<b>References based on Course 2 - Biochemistry And Biotechnology (VGVPSMZO203)</b>
--

1. Puri, Dinesh (2014). Textbook of Medical Biochemistry (3rd Edition).
2. Bhagavan N. V. and Chung-Eun Ha (2015). Essentials of Medical Biochemistry (2<sup>nd</sup> Edition).
3. Harper's Illustrated Biochemistry.
4. Satyanarayana U. and Chakrapani (2014). Biochemistry.
5. Outlines of Biochemistry, (5th Edition) – 2006 – Eric E. Conn, Paul K. Stumpf, Georg Bruening.
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.
9. Smith (1983), Principles of Biochemistry, (7th Edition), Mc Graw Hill (Mammalian Biochemistry), New York.
10. Voet, D. & Voet, J (1995), Biochemistry, John Wiley and Sons, New York.
11. Basic Concepts in Biochemistry – Hiram F Gilbert – McGraw Hill Publications.
12. Fundamentals of Biochemistry – J L Jain, Sunjay Jain, Nitin Jain – S. Chand.
13. Molecular Biology of the Cell – Alberts et al., - Garland Science.
14. Molecular Biology of the Gene – Watson et al., Benjamin Publications.
15. Genes VIII – Benjamin Lewin – Oxford Press.
16. Molecular Biology – Freifelder – Narosa Publication House. Biotechnology
17. Molecular Cell Biology (5th Edition) – Lodish, Berk, Matsudaira, Kaiser, Krieger, Scott, Zipursky, Darnell – WH Freeman.
18. Cell & Molecular Biology: Concepts & Experiments (6th Edition) – Gerald Karp.
19. iGenetics – A molecular approach (3rd Edition) – Peter J Russell – Pearson Education Inc.
20. Molecular Biotechnology – Principles and applications of recombinant DNA (3rd Edition) Bernard R Glick & Jack J Pasternak – ASM Press.
21. Principles of Fermentation Technology (2nd Edition) – Peter F Stanbury, Allan Whitaker,

Stephen J Hall – Elsevier Publications.

22. Basic Biotechnology (3rd Edition) – Colin Ratledge & Bjorn Kristiansen – Cambridge University Press.

23. Medical Biotechnology – S. N. Jogdand – Himalaya Publishing House.

24. Microbial Biotechnology (2nd Edition) – Alexander Glazer & Hiroshi Nikaido – Cambridge University Press.

25. Plant Tissue Culture: Theory and Practice – S. S. Bhojwani & M. K. Razdan – Elsevier.

26. Molecular Biology and Biotechnology– KG Ramawat & Shaily Goyal – S. Chand.

27. Aspartame Information Center. [www.aspartame.org](http://www.aspartame.org)

28. Genetic engineering of taxol biosynthetic genes in *Saccharomyces cerevisiae*. a. *Biotechnology and Bioengineering* 93(2): 212-24 • February 2006

29. Textbook of Biotechnology – H K Das – Wiley India Publication.

E-resources

30. The Golden Rice Project <http://www.goldenrice.org/>



<b>Practicals based on Course 1 – Chordates (VGVPSMZOP201)</b>	
<b>Sr No.</b>	<b>List of Experiments</b>
<b>1</b>	Museum specimens / Photographs / Pictures / Slides: i. Protochordates: Study of Doliolum, Herdmania, Ascidia, Botryllus ii. Adaptive radiation in Reptiles-Turtles, Crocodile, Tuatara, Snakes and Lizards iii. Adaptive radiation in Mammals – Talpa (mole), Tarsius, Armadillo, Camel and Sperm whale
<b>2</b>	Comparative anatomy of digestive system in vertebrates
<b>3</b>	Comparative study of Pelvic and Pectoral girdle in vertebrates
<b>4</b>	Types of jaw suspension in vertebrates- Autodiastylic, Holostylic, Amphistylic and Autostylic.
<b>5</b>	Types of vertebrae – Acoelous, Procoelus, Opisthocoelus, Amphicoelus, Amphiplatins, Heterocoelus, Axis and atlas vertebrae
<b>6</b>	Pigeon – Study / Virtual dissection of i. Flight muscles, ii. Digestive system, iii. Respiratory system, iv. Circulatory system v. Excretory system
<b>7</b>	Field visit to national Park / Sanctuary / Museum / Zoo or any other suitable ecosystem to study vertebrates.
<b>8</b>	Isolation and determination of glycogen in the given tissue (liver / skeletal muscle / kidney) by Anthrone method.
<b>9</b>	Restriction digestion of the given DNA sample and separation of the fragments by agarose gel electrophoresis
<b>10</b>	Southern blotting technique (assembly of the sandwich/ mechanical blotting).



<b>Practical based on Chordates</b>	
<b>(Practical Paper Pattern)</b>	
<b>Duration: 5 hours</b>	<b>Marks: 50</b>
<b>Major Question:</b> Q.1 Isolation and determination of glycogen in the given tissue (liver / skeletal muscle / kidney) by Anthrone method. <p style="text-align: center;"><b>OR</b></p> Q.1 Restriction digestion of the given DNA sample and separation of the fragments by agarose gel electrophoresis <p style="text-align: center;"><b>OR</b></p> Q.1 Southern blotting technique (assembly of the sandwich/ mechanical blotting).	<b>15 marks</b>
<b>Minor Question:</b> Q.2. Comparative anatomy of digestive system in vertebrates <p style="text-align: center;"><b>OR</b></p> Q. 2 Pigeon – Study / Virtual dissection of i. Flight muscles, ii. Digestive system, iii. Respiratory system, iv. Circulatory system v. Excretory system	<b>08 marks</b>
Q.3 Identify and Describe: a) Protochordates b) Adaptive radiation in Reptiles c) Adaptive radiation in Mammals d) Types of jaw suspension in vertebrates e) Pelvic and Pectoral girdle in vertebrates f) Types of vertebrae	<b>12 marks</b>
Q.4. Field Report	<b>05 marks</b>
Q.4. Viva voce based on Theory.	<b>05 marks</b>
Q.5 Journal.	<b>05 Marks</b>

<b>Practicals based on Course 1 - Developmental biology II (VGVPSMZOP202)</b>	
<b>Sr No.</b>	<b>List of Experiments</b>
<b>1</b>	Identification of fish developmental stages–egg, larva, juvenile (fry, fingerling and adult).
<b>2</b>	Measurement of fish ova diameter using an Oculometer.
<b>3</b>	Study of metamorphosis in Amphibia.
<b>4</b>	Histology of male and female accessory reproductive glands – Human – Prostate gland, Bulbourethral gland and placenta [Permanent slides]

5	Study of stem cells from chick embryos – staining and identification of cells.
6	Quantitative estimation of proteins from the given sample using Bradford method.
7	Determination of glucose by Benedict's quantitative reagent (Titrimetric method)
8	Visit to Fish Breeding Centre and Report Submission

<b>SEMESTER II</b> <b>Practical based on Developmental Biology II</b> <b>(Practical Paper Pattern)</b>	
<b>Duration: 5 hours</b>	<b>Marks: 50</b>
<b>Major Question:</b> Q.1 Quantitative estimation of proteins from the given sample using Bradford method.  <b>OR</b> Q.1 Determination of glucose by Benedict's quantitative reagent (Titrimetric method)	<b>15 marks</b>
<b>Minor Question:</b> Q.2. Measurement of fish ova diameter using an Oculometer.  <b>OR</b> Q. 2 Study of stem cells from chick embryos: Staining and identification of cells.	<b>08 marks</b>
Q.3 Identify and Describe: a) Fish developmental stages b) Metamorphosis in Amphibia c) Histology of male and female accessory reproductive glands	<b>12 marks</b>
Q. 4 Report on Visit to Fish Breeding Centre	<b>05 marks</b>
Q. 5. Viva voce based on Theory.	<b>05 marks</b>
Q.6 Journal.	<b>05 Marks</b>



**Semester – II**  
**OE - Instrumentation & Biophysics**  
**Course Code: VGVPSSELZO201**  
**Credits: 4**

Unit	Content	Lecture
<b>Unit I</b>	<p><b>Instrumentation - I</b></p> <p>I. Centrifugation</p> <p style="padding-left: 20px;">i. Basic Principles of sedimentation</p> <p style="padding-left: 20px;">ii. Types, Care &amp; Safety aspects of centrifuge</p> <p style="padding-left: 20px;">iii. Preparative centrifugation</p> <p style="padding-left: 20px;">iv. Analytical centrifugation</p> <p>II. Microscopy:</p> <p style="padding-left: 20px;">i. The light microscope</p> <p style="padding-left: 20px;">ii. Optical sectioning</p> <p style="padding-left: 20px;">iii. Imaging living cells and tissues</p> <p style="padding-left: 20px;">iv. Measuring cellular dynamics</p> <p style="padding-left: 20px;">v. The electron microscope (EM)</p> <p style="padding-left: 20px;">vi. Image archiving</p> <p>III. Mass Spectrometric Techniques:</p> <p style="padding-left: 20px;">i. Ionization</p> <p style="padding-left: 20px;">ii. Mass analysers and Detectors</p> <p style="padding-left: 20px;">iii. Structural information by tandem mass spectrometry</p> <p style="padding-left: 20px;">iv. Analyzing protein complexes</p> <p style="padding-left: 20px;">v. Computing and database analysis</p> <p>IV. Electrophoretic techniques</p> <p style="padding-left: 20px;">i. General principles</p> <p style="padding-left: 20px;">ii. Electrophoresis of proteins</p> <p style="padding-left: 20px;">iii. Electrophoresis of nucleic acids</p> <p style="padding-left: 20px;">iv. Capillary electrophoresis</p> <p style="padding-left: 20px;">v. Microchip electrophoresis</p>	<b>15 Hrs</b>

<b>Unit II</b>	<b>Instrumentation - II</b> I. Chromatographic techniques i. Principles of chromatography ii. High-performance liquid chromatography iii. Adsorption chromatography iv. Partition chromatography v. Ion-exchange chromatography vi. Gas chromatography	<b>15 Hrs</b>
----------------	---	---------------

	<p>II. Spectroscopic techniques: I</p> <ul style="list-style-type: none"> <li>i. Ultraviolet and visible light spectroscopy</li> <li>ii. Fluorescence spectroscopy</li> <li>iii. Luminometry</li> <li>iv. Circular dichroism spectroscopy</li> <li>v. Light scattering</li> <li>vi. Atomic spectroscopy</li> </ul> <p>III. Spectroscopic techniques: II</p> <ul style="list-style-type: none"> <li>i. Infrared and Raman spectroscopy</li> <li>ii. Surface plasmon resonance</li> <li>iii. Electron paramagnetic resonance</li> <li>iv. Nuclear magnetic resonance</li> <li>v. X-ray diffraction</li> <li>vi. Small-angle scattering</li> </ul> <p>IV. Radioisotope techniques</p> <ul style="list-style-type: none"> <li>i. The nature of radioactivity</li> <li>ii. Detection and measurement of radioactivity</li> <li>iii. Other practical aspects of counting of radioactivity and analysis of data</li> <li>iv. Safety aspects</li> </ul>	
--	---	--

<b>Unit III</b>	<b>Biophysics - I</b> <ol style="list-style-type: none"> <li>I. Physico-chemical Techniques to study biomolecules <ol style="list-style-type: none"> <li>i. Hydration of macromolecules</li> <li>ii. Role of friction</li> <li>iii. Diffusion</li> <li>iv. Sedimentation</li> <li>v. Ultracentrifuge</li> <li>vi. Viscosity</li> <li>vii. Rotational Diffusion - Flow birefringence measurement and electric birefringence</li> <li>viii. Light Scattering</li> <li>ix. Small angle X-ray scattering</li> </ol> </li> <li>II. Molecular Modeling <ol style="list-style-type: none"> <li>i. Generating the model</li> <li>ii. Building the structure of H<sub>2</sub>O<sub>2</sub></li> <li>iii. Building the protein structure</li> <li>iv. Building the nucleic acid structure</li> <li>v. Displaying and altering the generated model</li> </ol> </li> </ol>	<b>15 Hrs</b>
-----------------	--	---------------

	<ul style="list-style-type: none"> <li>vi. Optimizing the Model</li> <li>III. Signal Transduction <ul style="list-style-type: none"> <li>i. Mode of Transport</li> <li>ii. Signal Transduction in cell</li> </ul> </li> <li>IV. Physical aspects of Hearing <ul style="list-style-type: none"> <li>i. Ear</li> <li>ii. Elementary acoustics</li> <li>iii. Theories of hearing</li> </ul> </li> </ul>	
<b>Unit IV</b>	<p><b>Biophysics - II</b></p> <ul style="list-style-type: none"> <li>I. Biomechanics of muscular system <ul style="list-style-type: none"> <li>i. Striated muscles</li> <li>ii. Contractile Proteins</li> <li>ii. Mechanical Properties of Muscles</li> <li>iii. Contraction mechanism</li> <li>iv. Role of Calcium ions</li> </ul> </li> <li>II. Biomechanics of cardiovascular system <ul style="list-style-type: none"> <li>i. Blood pressure</li> <li>ii. Electrical activity during heartbeat</li> <li>iii. Electrocardiography</li> <li>iv. Duplicate Publications</li> <li>v. Suggesting bogus reviewers</li> </ul> </li> <li>III. Neurobiophysics <ul style="list-style-type: none"> <li>i. Synapse</li> <li>ii. Physics of membrane potential</li> <li>iii. Membrane potential due to diffusion</li> <li>iv. Voltage clamp</li> </ul> </li> <li>IV. Sensory Mechanisms - The Eye <ul style="list-style-type: none"> <li>i. The visual receptors</li> <li>ii. Electrical activity and visual generator potential</li> <li>ii. Optical Defects of the eye</li> <li>iii. Neural Aspect of vision</li> <li>iv. Visual Communications, Bioluminescence</li> </ul> </li> </ul>	<b>15 Hrs</b>
	<b>Total No. of Lectures</b>	<b>60</b>

**References based on OE- Instrumentation and Biophysics (VGVPSELZO201)**

1. Wilson, K. and Walker, J. (2010) Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, Cambridge
2. Modern experimental biochemistry, second edition by Rodney F Boyer. Benjamin-Cummings Publishing, Redwood City, CA. 1993
3. Plummer, M.U. and Plummer, D.T. (1988) Introduction to Practical Biochemistry. Tata McGraw-Hill Education, Noida.
4. Vasanta Pattabhi and N Gautam. Biophysics. 2002. Kluwer academic publishers, Dordrescht
5. Paata J. Kervalishvili. Applied Biophysics. Georgian Technical University. Tbilisi 2021





**OE - Diversity of life forms & Applied zoology**

**Course Code: VGVPSSELZO202**

**Credits: 4**

<b>Unit</b>	<b>Content</b>	<b>Lecture</b>
<b>Unit I</b>	<b>Diversity of life forms</b>  I. Principles & methods of taxonomy: Concepts of species and hierarchical taxa, biological nomenclature, classical & quantitative methods of taxonomy of plants, animals and microorganisms.  II. Levels of structural organization: Unicellular, colonial and multicellular forms. Levels of organization of tissues, organs & systems. Comparative anatomy, adaptive radiation, adaptive modifications.  III. Outline classification of plants, animals & microorganisms: Important criteria used for classification in each taxon. Classification of plants, animals and microorganisms. Evolutionary relationships among taxa.  IV. Natural history of Indian subcontinent: Major habitat types of the subcontinent, geographic origins and migrations of species. Common Indian mammals, birds. Seasonality and phenology of the subcontinent.  V. Organisms of health & agricultural importance: Common parasites and pathogens of humans, domestic animals and crops.  VI. Organisms of conservation concern: Rare, endangered species. Conservation strategies.	<b>15 Hrs</b>

<b>Unit II</b>	<p><b>Applied Marine Zoology</b></p> <p>I. Biochemical composition of raw and preserved fish.</p> <p>II. Fish protein concentrate, fish maws, isinglass, oils (body and liver), chitin, chitosan, Fish/ Prawn pickle and chutney, fish wafers, surimi, imitation products.</p> <p>III. Bioactive Compounds</p> <p>a) Sea as treasure house of new chemicals</p> <p>b) Bioactive metabolites from sponges and bacteria</p> <p>c) Bioactive toxins and eutrophication</p> <p>IV. Commercial uses of seaweeds</p> <p>a) Uses of seaweeds as food: Nori (Porphyra), Kombu (Laminaria), Arame (Eisenia), Dulse (Palmaria)</p> <p>b) Liquid Seaweed Fertilizer</p> <p>c) Seaweed as source of Biofuel</p> <p>d) Seaweed in cosmetics</p>	<b>15 Hrs</b>
----------------	--	---------------

	<p>V. Methods of evaluating freshness and quality of fish and prawn (Organoleptic, Microbial and Chemical)</p> <p>VI. Mechanisms of spoilage (Hyperemia, rigor mortis, Autolysis, Rancidity)</p> <p>VII. Methods of preservation– Icing, Drying, Salting, Canning, Pickling, Freezing</p>	
<b>Unit III</b>	<p><b>Applied Zoology - I</b></p> <p>I. Apiculture, sericulture, lac culture, carp culture, pearl culture, prawn culture, vermiculture.</p> <p>II. Major infectious and communicable diseases (malaria, filaria, tuberculosis, cholera and AIDS) their vectors, pathogens and prevention.</p> <p>III. Cattle and livestock diseases, their pathogens (helminthes) and vectors (ticks, mites, Tabanus, Stomoxys).</p> <p>IV. Pests of sugarcane (<i>Pyrilla perpusiella</i>) oil seed (<i>Achaea janata</i>) and rice (<i>Sitophilus oryzae</i>).</p> <p>V. Human genetic disease and genetic counseling.</p>	<b>15 Hrs</b>
<b>Unit IV</b>	<p><b>Applied Zoology - II</b></p> <p>II. Microbial fermentation and production of small and macromolecules.</p> <p>III. Application of immunological principles, vaccines, diagnostics. Tissue and cell culture methods for animals.</p> <p>IV. Transgenic animals, molecular approaches to diagnosis and strain identification.</p> <p>V. Genomics and its application to health and agriculture, including gene therapy.</p> <p>VI. Bioresources and uses of biodiversity.</p> <p>VII. Breeding in plants and animals, including marker – assisted selection.</p>	<b>15 Hrs</b>
	<b>Total No. of Lectures</b>	<b>60</b>

<b>References based on Diversity of Life Forms &amp; Applied Zoology</b>
--

1. Verma, P.S., Agarwal, V.K. (1999). Cell biology genetics molecular biology evolution and ecology . New Delhi: S.Chand Co.(pvt) Ltd..
2. Jordan EL & Verma PS. Invertebrate Zoology. S Chand Publications, New Delhi
3. Jordan EL & Verma PS. Chordate Zoology. S Chand Publications, New Delhi
4. Lal P. Indica: A Deep Natural History of the Indian Subcontinent. Penguin Random House India; Illustrated edition (7 December 2016)
5. Marketing Management – Philip Kotler.
6. Operations Research Theory and Application, Third edition, Sharma J. K.: Macmillan India Ltd.
7. Pollution and Toxicology, Venugopalan, V.K.: CAS in Marine Biology.
8. Prawn and Prawn Fisheries – Kurian & Sebastian.
9. Textbook of Marine Pollution - Prakesh P.
10. The Oceans – Svedrup, H.V. et al, Asian Publishing House.
11. Molecular biotechnology : principles and applications of recombinant DNA. Bernard R. Glick and Jack J. Pasternak, Cheryl L. Patten. 4th ed. United State
12. Biotechnology - B. D. Singh, Kalyani Publishers

<b>Practicals based on OE (VGVPSELZOP201)</b>	
<b>Sr. No.</b>	<b>List of Experiments</b>
<b>1</b>	Separation of amino acids by 2D Paper chromatography
<b>2</b>	Separation of pigments by column chromatography
<b>3</b>	To determine viscosity of a given tissue fluid using Ostwald's Viscometer
<b>4</b>	Separation of proteins by SDS-PAGE from the given sample.
<b>5</b>	Construct a phylogenetic tree from the given data
<b>6</b>	Identify the animal and comment on its conservation status
<b>7</b>	Extraction of collagen from fish scales
<b>8</b>	Interpretation of Electrocardiogram (ECG) and associated abnormalities.
<b>9</b>	Preparation of prawns pickle and fish by-products and its report submission.
<b>10</b>	Evaluate the fish quality by organoleptic method
<b>11</b>	Extraction and quantification of total lipids from seaweeds.
<b>12</b>	Pedigree analysis of genetic disorders

**Practical based on Diversity of life forms & Applied Zoology  
(Practical Paper Pattern)**

<b>Duration: 5 hours</b>	<b>Marks: 50</b>
<b>Major Question:</b> Q.1 Separation of amino acids by 2D Paper chromatography <b>OR</b> Q.1 Separation of pigments by column chromatography <b>OR</b> Q.1 To determine viscosity of a given tissue fluid using Ostwald's Viscometer	<b>15 marks</b>
<b>Minor Question:</b> Q.2. Separation of proteins by SDS-PAGE from the given sample. <b>OR</b> Q. 2 Extraction of collagen from fish scales <b>OR</b> Q.2 Evaluate the fish quality by organoleptic method <b>OR</b> Q. 2 Extraction and quantification of total lipids from seaweeds.	<b>08 marks</b>
<b>Q 3.</b> Pedigree analysis of genetic disorders <b>OR</b> Q. 3 Construct a phylogenetic tree from the given data	<b>04 arks</b>
Q.4 Identification a) Animal and its Conservation status b) Interpretation of Electrocardiogram (ECG) and associated abnormalities.	<b>08 marks</b>
Q.5 Report on Preparation of prawns pickle and fish by-products and its report submission.	<b>05 marks</b>
Q.6. Viva voce based on Theory.	<b>05 marks</b>
Q.7 Journal.	<b>05 Marks</b>

## Syllabus Prepared by:

<p>1. <b>Dr. Vinod R. Ragade:</b> Chairperson, Syllabus Committee Head, Dept. of Zoology &amp; Associate Professor, KET'S V. G. Vaze College (Autonomous), Mulund East, Mumbai.</p>
<p>2. <b>Dr. Preetha Achary,</b> Assistant Professor, Dept. of Zoology, KET'S V. G. Vaze College (Autonomous), Mulund East, Mumbai.</p>
<p>3. <b>Ms. Veena Menon,</b> Assistant Professor, Dept. of Zoology, KET'S V. G. Vaze College (Autonomous), Mulund East, Mumbai.</p>
<p>4. <b>Dr. Abhay Morajkar,</b> Assistant Professor, Dept. of Zoology, KET'S V. G. Vaze College (Autonomous), Mulund East, Mumbai.</p>
<p>5. <b>Mr. Akshay Bagwe,</b> Assistant Professor, Dept. of Zoology, KET'S V. G. Vaze College (Autonomous), Mulund East, Mumbai.</p>
<p>6. <b>Dr. Sarika Bansode,</b> Assistant Professor, Dept. of Zoology, KET'S V. G. Vaze College (Autonomous), Mulund East, Mumbai.</p>
<p>7. <b>Dr. Prachi Dandge,</b> Assistant Professor, Dept. of Zoology, KET'S V. G. Vaze College (Autonomous), Mulund East, Mumbai.</p>

