DHANAMANJURI UNIVERSITY

MANIPUR

SYLLABUS
FOR
FOUR YEARS B.Sc. ZOOLOGY HONOURS
BASED ON NEW EDUCATION POLICY 2020

2022

COURSE STRUCTURE OF FOUR YEARS B.Sc. ZOOLOGY HONOURS PROGRAMME

Semester	Core (DSC)	DSE	GE	AEC	SEC	Research/ Academic Project	VAC	Total Credits
I	**CZO-101:** Non-Chordates I: Protozoa to Pseudocoelomates (4 credits)		**GZO-101:** Animal Diversity (3 credits)	**AEC-001:** English Communi-cation-I (2 credits)	**SZO-001:** Sericulture (2 credits)		**VAC-001/002/003/004** (2 credits)	22
			GZO-102: Practical based on GZO-101(1 credit)					
	CZO-102: Principles of Ecology (4 credits)							
	CZO-103: Practical based on **CZO-101** & **CZO-102** (4 credits)							
II	**CZO-104:** Non-Chordates II: Coelomates (4 credits)		**GZO-103:** Applied Zoology (3 credits)	**AEC-020:** Environm-ental Studies-I (2 credits)	**SZO-002:** Apiculture (2 credits)		**VAC-002** (2 credits)	22
			GZO-104: Practical based on GZO-103(1 credit)					
	CZO-105: Taxonomy, Zoogeography & Palaeontology (4 credits)							
	CZO-106: Practical based on **CZO-104** & **CZO-105** (4 credits)							
First Exit Point #								**44**
III	**CZO-207:** Diversity of Chordates (4 credits)		**GZO-205:** Aquatic Biology (3 credits)	**AEC-011:** English Communi-cation-II (2 credits)	**SZO-003:** Aquarium Fish Keeping (2 credits)		**VAC-003** (2 credits)	22
			GZO-206: Practical based on GZO-205(1 credit)					
	CZO-208: Cell Biology (4 credits)							
	CZO-209: Practical based on **CZO-207** & **CZO-208** (4 credits)							
IV	**CZO-210:** Comparative Anatomy of Vertebrates (4 credits)		**GZO-207:** Food, Nutrition & Health (3 credits)	**AEC-021:** Environm-ental Studies-II (2 credits)	**SZO-004:** Vermicultur e and Vermicom-posting (2 credits)		**VAC-004** (2 credits)	22
			GZO-208: Practical based on GZO-207(1 credit)					
	CZO-211: Animal Physiology I (4 credits)							
	CZO-212: Practical based on **CZO-210** & **CZO-211**							

	(4 credits)							
Second Exit Point ##								**88**
V	**CZO-313:** Animal Physiology II (4 credits)	**EZO-001:** Biochemistry II (3 credits)	**GZO-309:** Human Physiology (3 credits)		**SZO-005:** Integrated Paste Manageme-nt (2 credits)			22
		EZO-002: Practical based on EZO-001 (1 credit)	**GZO-310:** Practical based on GZO-309(1 credit)					
	CZO-314: Biochemistry I (4 credits)							
	CZO-315: Practical based on **CZO-313** & **CZO-314** (4 credits)							
VI	**CZO-316:** Molecular Biology (4 credits)	**EZO-003:** Fish & Fisheries (3 credits)	**GZO-311:** Animal Biotechnology (3 credits)		**SZO-006:** Medical Diagnostics (2 credits)			22
		EZO-004: Practical based on EZO-003 (1 credit)	**GZO-312:** Practical based on GZO-311(1 credit)					
	CZO-317: Principles of Genetics (4 credits)							
	CZO-318: Practical based on **CZO-316** & **CZO-317** (4 credits)							
Third Exit Point ###								**132**
VII	**CZO-419:** Developmental Biology (3 credits)	**ZSE-005:** Evolutionary Biology (3 credits)				Research/ Academic Project (6 credits)		22
	CZO-420: Practical based on **CZO-419** (1 credit)	**ZSE-006:** Practical based on ZSE-005 (1 credit)						
		ZSE-007 Applied Zoology & Ethology (3 credits)						
		ZSE-008: Practical based on ZSE-007 (1 credit)						
		ZSE-009: Biological Techniques (3 credits)						
		ZSE-010: Practical based on ZSE-009 (1 credit)						
VIII	**CZO-421:** Immunology (3 credits)	**ZSE-011:** Animal Biotechnology (3 credits)						22
	CZO-422: Practical based on **CZO-421** (1 credit)	**ZSE-012:** Practical based on ZSE-011 (1 credit)				Research/ Academic Project (6 credits)		
		ZSE-013:						

		Computational Biology (3 credits)						
		ZSE-014: Practical based on ZSE-013 (1 credit)						
		ZSE-015: Biostatistics (3 credits)						
		ZSE-016: Practical based on ZSE-015 (1 credit)						
Last Exit Point ####								**176**

Abbreviations:
DSC (Discipline Specific Course); ZOO (Zoology); DSE (Discipline Specific Elective); ZSE (Zoology Specific Elective); GE (Generic Elective); GEZ (Generic Elective Zoology); AEC (Ability Enhancement Course); SEC (Skill Enhancement Course); SZO (Skill Enhancement in Zoology); VAC (Value Addition Course)

Students can leave the University at this **First Exit Point** and they will be awarded **Undergraduate Certificate in Zoology** and the total credits required for the two semesters (1^{st} & 2^{nd}) is **44.**

Students can leave the University at this **Second Exit Point** and they will be awarded **Undergraduate Diploma in Zoology** and the total credits required for the four semesters (1^{st}, 2^{nd}, 3^{rd} & 4^{th}) is **88.**

Students can leave the University at this **Third Exit Point** and they will be awarded **Bachelor of Science in Zoology Honours (3 years)** and the total credits required for the six semesters (1^{st}, 2^{nd}, 3^{rd}, 4^{th}, 5^{th} & 6^{th}) is **132.**

Students after eight semesters will be awarded **Bachelor of Science in Zoology Honours with Research/Academic Project (4 years)** and the minimum total credits required is **176.**

@ Pool of subjects for Value Addition Course:

a. NSS
b. NCC
c. Yoga
d. Sports
e. Music (Folk/Classical)

SEMESTER I

CZO-101
[NON-CHORDATES I: PROTOZOA TO PSEUDOCOELOMATES]

No. of Credits: 4
Total marks: 100

Unit 1: Protozoa and Metazoa **20 lectures/30 marks**

1. General characteristics and Classification of Protozoa up to classes with examples
2. Nutrition and Reproduction in *Euglena viridis*, *Amoeba proteus* and *Paramecium caudatum*
3. Life cycle and pathogenicity of *Plasmodium vivax* and *Entamoeba histolytica*
4. Locomotion and Reproduction in Protozoa
5. Evolution of symmetry and segmentation in Metazoa

Unit 2: Porifera **7 lectures/13 marks**

1. General characteristics and Classification of Porifera up to classes with examples
2. Canal system and skeleton of sponges

Unit 3: Cnidaria **13 lectures/17 marks**

1. General characteristics and Classification of Cnidaria up to classes with examples
2. Metagenesis in *Obelia*
3. Polymorphism in Cnidaria
4. Corals and coral reefs

Unit 4: Ctenophora **4 lectures/10 marks**

1. General characteristics and Evolutionary significance of Ctenophora

Unit 5: Platyhelminthes **8 lectures/15 marks**

1. General characteristics and Classification of Platyhelminthes up to classes with examples
2. Life cycle and pathogenicity of *Fasciola hepatica* and *Taenia solium*

Unit 6: Nemathelminthes (Aschelminthes) **8 lectures/15 marks**

1. General characteristics and Classification of Nemathelminthes up to classes with examples
2. Life cycle and pathogenicity of *Ascaris lumbricoides* and *Wuchereria bancrofti*
3. Parasitic adaptations in helminthes

Note: Classification shall be followed from "Barnes, R.D. (1982). *Invertebrate Zoology*, V Edition"

SUGGESTED READINGS

1. Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, 8th Edition. Holt Saunders International Edition.
2. Kotpal, R.L. (2015). *Modern Text Book of Zoology*. 10th Edn. Rastogi Publications, Meerut.
3. Jordan, E.L. and Verma, P.S. (2017). *Invertebrate Zoology*. 20th Edn. S. Chand & Company Ltd., New Delhi.
4. Marshall & Williams (1995). *Parker & Haswell Text Book of Zoology, Invertebrates*. Vol.1 7th Edn. A.I.T.B.S. Publishers & Distributors, Delhi
5. Barnes, R.D. (1982). *Invertebrate Zoology*, V Edition. Holt Saunders International Edition.
6. Barrington, E.J.W. (1979). *Invertebrate Structure and Functions*. II Edition, E.L.B.S. and Nelson.

[***All the books shall be of latest editions***]

CZO-102
[PRINCIPLES OF ECOLOGY]

No. of Credits: 4
Total marks: 100

Unit 1: Introduction to Ecology **6 lectures/15 marks**

1. History of Ecology, Autecology and Synecology
2. Levels of organization
3. Laws of limiting factors
4. Study of physical factors

Unit 2: Population **24 lectures/30 marks**

1. Unitary and Modular populations
2. Unique and group attributes of population: density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion
3. Exponential and logistic growth, equation and patterns, r and k strategies/selections
4. Population regulation: density-dependent and independent factors
5. Population interactions, Gause's Principle with laboratory and field examples, Lotka-Volterra equation for competition and Predation, functional and numerical responses

Unit 3: Community **12 lectures/20 marks**

1. Community characteristics: species richness, dominance, diversity, abundance, vertical stratification
2. Ecotone and edge effect
3. Ecological succession with one example
4. Theories pertaining to climax community

Unit 4: Ecosystem **14 lectures/20 marks**

1. Types of ecosystems with one example in detail
2. Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains
3. Food web and Energy flow through the ecosystem
4. Ecological pyramids and Ecological efficiencies
5. Nutrient and biogeochemical cycle with reference to Nitrogen cycle
6. Human modified ecosystem

Unit 5: Applied Ecology **4 lectures/15 marks**

1. Ecology in Wildlife Conservation and Management with special reference to Manipur
2. Captive breeding, biotechnological intervention, Sanctuaries and National parks of India, Biosphere reserves, Ramsar sites.
3. Biodiversity: concept, types, biodiversity hotspots; IUCN Redlist categories.

SUGGESTED READINGS

1. Kormondy, E.J. *Concepts of Ecology*. Prentice-Hall, India
2. Colinvaux, P. A. (1993). *Ecology*. II Edition. Wiley, John and Sons, Inc.
3. Krebs, C. J. (2001). *Ecology*. VI Edition. Benjamin Cummings.
4. Odum, E.P., (2008). *Fundamentals of Ecology*. Indian Edition. Brooks/Cole
5. Robert Leo Smith. *Ecology and field biology*, Harper and Row publisher
6. Ricklefs, R.E., (2000). *Ecology*. V Edition. Chiron Press.

[***All the books shall be of latest editions***]

CZO-103
[PRACTICAL BASED ON CZO-101 & CZO-102]

No. of Credits: 4
Total marks: 100

NON-CHORDATES

1. **Study of Permanent slides** **12 marks**
   Whole mount of *Euglena*, *Amoeba* and *Paramecium*; Binary fission and Conjugation in *Paramecium*; *Sycon* (T.S. and L.S.); Spongin fibrs; *Obelia* colony; T.S. of *Fasciola*; T.S. of *Taenia*; Scolex of *Taenia*; T.S. of *Ascaris* (male and female).

2. **Study of museum specimens** **12 marks**
   Porifera: *Hyalonema, Euplectella,* and *Spongilla,*
   Cnidaria: *Physalia, Aurelia, Tubipora, Porpita, Metridium, Pennatula, Fungia,* and *Gorgonia*
   Platyhelminthes: *Fasciola hepatica*, *Taenia solium*, *Schistosoma*, and *Planaria*
   Nemathelminthes: *Ascaris*, *Wuchereria*, and *Trichinella*

3. **Examination of pond water collected from different places for diversity of Protozoa**. **10 marks**

4. **Submission of a Project Report on the life cycle of any helminth/coral/coral reefs**. **6 marks**

ECOLOGY

1. **Experiments** **30 marks**
   a. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided
   b. Determination of population density in a natural/hypothetical community by quadrate method and calculation of Shannon-Weiner diversity index for the same community
   c. Study of an aquatic ecosystem: Phytoplankton and zooplankton, Measurement of area, temperature, turbidity/penetration of light, determination of pH
   d. Estimation of dissolved oxygen content of pond water/any fresh water by Winkler's method
   e. Estimation of dissolved CO_2 content of pond water/any fresh water by Phenolphthalein method

2. **Report on a visit to National Park/Biodiversity Park/Wild life sanctuary** **10 marks**

LABORATORY RECORD BOOK **10 marks**

VIVA-VOCE **10 marks**

GZO-101
[ANIMAL DIVERSITY]

Number of Credits: 3
Total marks: 75

Unit 1. Phylum Protozoa, Porifera and Cnidaria **10 lectures/12 marks**

1. General characters of Protozoa; Life cycle of *Plasmodium vivax*
2. General characters of Porifera; Canal system in *Sycon*
3. General characters of Cnidaria; Polymorphism in Hydrozoa

Unit 2. Phylum Platyhelminthes, Nemathelminthes and Annelida **10 lectures/12 marks**

1. General characters of Platyhelminthes; Life cycle of *Taenia solium*
2. General characters of Nemathelminthes; Parasitic adaptations in helminthes
3. General characters of Annelida; Metamerism in annelids

Unit 3. Phylum Arthropoda, Mollusca and Echinodermata **12 lectures/15 marks**

1. General characters of Arthropoda; Social life in insects
2. General characters of Mollusca; Pearl Formation
3. General characters of Echinodermata; Water Vascular system in Starfish

Unit 4. Protochordata, Pisces and Amphibia **13 lectures/16 marks**

1. Salient features of Protochordata
2. Osmoregulation and Migration in fishes
3. General characters of Amphibia
4. Adaptations for terrestrial life of amphibians; Parental care in Amphibia

Unit 5. Reptilia, Aves and Mammalia **15 lectures/20 marks**

1. Origin of reptiles; Terrestrial adaptations in reptiles
2. Origin of birds; Flight adaptations in birds
3. Origin and Ancestry of mammals; Dentition in mammals

SUGGESTED READINGS

1. Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, VIII Edition. Holt Saunders International Edition.
2. Jordan, E.L. and Verma, P.S. (2017). *Invertebrate Zoology*. 20th Edn. S. Chand & Company Ltd., New Delhi.
3. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science
4. Young, J. Z. (2004). *The Life of Vertebrates*. III Edition. Oxford university press.
5. Pough H. *Vertebrate life,* VIII Edition, Pearson International
6. Marshall A.J., Parker, T.J. & Haswell, W.A.: *Text Book of Zoology*, 7th Edn. 1995, Vol. 2. A.I.T.B.S. Publishers & Distributors, Delhi
7. Kotpal, R.L.: *Modern Text Book of Zoology, Vertebrates*. 2nd Edn. 1998. Rastogi Publications, Meerut.
8. Jordan, E.L. and Verma, P.S. (2017). *Chordate Zoology*. 20th Edn. S. Chand & Company Ltd., New Delhi.

[All the books shall be of latest editions]

GZO-102
[PRACTICAL BASED ON GZO-101]

No. of Credits: 1
Total marks: 25

1. **Study of Permanent slides** **2 marks**
   Amoeba (W. M.), *Euglena* (W.M.), and *Paramecium* (W.M.); *Sycon* (T.S. and L.S.); T.S. of *Ascaris* (male and female); T.S. of earthworm through pharynx, gizzard & typhlosolar region; Bipinnaria and Pluteus larva.

2. **Study of museum specimens** **8 marks**
   Porifera: *Sycon* and *Euplectella*
   Cnidaria: *Physalia, Aurelia, Tubipora,* and *Metridium*
   Platyhelminthes: *Fasciola hepatica*, and *Taenia solium*
   Nemathelminthes: *Ascaris* and *Wuchereria*
   Annelida: *Aphrodite, Nereis,* and *Hirudinaria*
   Arthropoda: *Peripatus*, *Cancer*, *Limulus*, *Scolopendra*, *Julus*, *Periplaneta*
   Mollusca: *Chiton, Dentalium, Loligo, Sepia,* and *Octopus*
   Echinodermata: *Asterias*, *Ophiothrix, Echinus,* and *Antedon*
   Protochordates: *Balanoglossus* and *Branchiostoma*
   Cyclostomata: *Petromyzon*
   Fishes: *Pristis, Hippocampus, Torpedo,* and *Labeo*
   Amphibia: *Ichthyophis/Ureotyphlus, Salamandra, Rhacophorus,* and *Hyla*
   Reptilia: *Uromastix*, *Hemidactylus, Chameleon, Draco, Vipera, Naja,* and *Bungarus*
   Aves: Model of *Archaeopteryx*, *Columba, Corvus,* and *Passer*
   Mammalia: Bat, *Pteropus*, *Rattus*

3. **Preparation of temporary slides/mounting** **3 marks**
   Septal and pharyngeal nephridia of earthworm; Placoid, cycloid and ctenoid scales; *Obelia* colony

4. **Dissections** **4 marks**
   a. Digestive and Nervous system of Cockroach
   b. Afferent and efferent branchial system of *Scoliodon*

5. **Laboratory Record Book** **3 marks**

6. **Viva Voce** **5 marks**

SZO-001
[SERICULTURE]

Number of Credits: 2
Total marks: 50

Unit 1: Introduction **5 lectures/8 marks**

1. Sericulture: Definition, History and Present status; Silk route
2. Types of silkworms, Distribution and Races
3. Exotic and indigenous races
4. Mulberry and non-mulberry Sericulture

Unit 2: Biology of Silkworm **5 lectures/8 marks**

1. Life cycle of *Bombyx mori*
2. Structure of silk gland and secretion of silk

Unit 3: Rearing of Silkworms **10 lectures/18 marks**

1. Selection of mulberry variety and establishment of mulberry garden
2. Rearing house and rearing appliances
3. Disinfectants: Formalin, bleaching powder, RKO
4. Silkworm rearing technology: Early age and Late age rearing
5. Types of mountages
6. Spinning, harvesting and storage of cocoons

Unit 4: Pests and Diseases **5 lectures/8 marks**

1. Pests of silkworm: Uzi fly, dermestid beetles and vertebrates
2. Pathogenesis of silkworm diseases: Protozoan, viral, fungal and bacterial
3. Control and prevention of pests and diseases

Unit 5: Entrepreneurship in Sericulture **5 lectures/8 marks**

1. Prospects of Sericulture in India: Sericulture industry in different states with special reference to Manipur, employment, potential in mulberry and non-mulberry sericulture.
2. Knowledge on practical set up of Sericulture farm for employability.

SUGGESTED READINGS

1. *Manual on Sericulture*; Food and Agriculture Organisation, Rome 1976
2. *Handbook of Practical Sericulture*: S.R. Ullal and M.N. Narasimhanna CSB, Bangalore
3. *Silkworm Rearing and Disease of Silkworm*, 1956, Ptd. By Director of Ptg., Stn. & Pub. Govt. Press, Bangalore
4. *Appropriate Sericultural Techniques*; Ed. M. S. Jolly, Director, CSR & TI, Mysore.
5. *Handbook of Silkworm Rearing: Agriculture and Technical Manual-1*, Fuzi Pub. Co. Ltd., Tokyo, Japan1972.
6. *Manual of Silkworm Egg Production*; M. N. Narasimhanna, CSB, Bangalore 1988.
7. *Silkworm Rearing*; Wupang—Chun and Chen Da-Chung, Pub. By FAO, Rome 1988.
8. *A Guide for Bivoltine Sericulture*; K. Sengupta, Director, CSR & TI, Mysore 1989.
9. *Improved Method of Rearing Young age silkworm*; S. Krishnaswamy, reprinted CSB, Bangalore, 1986.

[All the books shall be of latest editions]

SEMESTER II

CZO-104
[NON-CHORDATES II: COELOMATES]

No. of Credits: 4
Total marks: 100

Unit 1: Introduction to Coelomates **4 lectures/10 marks**

1. Evolution of coelom and metamerism

Unit 2: Annelida **8 lectures/15 marks**

1. General characteristics and classification of Annelida up to classes with examples
2. Excretion in Annelida

Unit 3: Arthropoda **17 lectures/25 marks**

1. General characteristics and classification of Arthropoda up to classes with examples
2. Vision and Respiration in Arthropoda
3. Metamorphosis in Insects
4. Social life in bees and termites

Unit 4: Onychophora **4 lectures/10 marks**

1. General characteristics and Evolutionary significance of Onychophora

Unit 5: Mollusca **15 lectures/20 marks**

1. General characteristics and classification of Mollusca up to classes with examples
2. Respiration in Mollusca
3. Torsion and detorsion in Gastropods
4. Pearl formation in bivalves
5. Evolutionary significance of trochophore larva

Unit 6: Echinodermata **12 lectures/20 marks**

1. General characteristics and classification of Echinodermata up to classes with examples
2. Water-vascular system in Asteroidea
3. Larval forms in Echinodermata
4. Affinities of Echinoderms with Chordates

Note: Classification shall be followed from "Ruppert and Barnes (2006) *Invertebrate Zoology*, 8th edition, Holt Saunders International Edition"

SUGGESTED READINGS

1. Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, 8th Edition. Holt Saunders International Edition.
2. Kotpal, R.L. (2015). *Modern Text Book of Zoology*. 10th Edn. Rastogi Publications, Meerut.
3. Jordan, E.L. and Verma, P.S. (2017). *Invertebrate Zoology*. 20th Edn. S. Chand & Company Ltd., New Delhi.
4. Marshall & Williams (1995). *Parker & Haswell Text Book of Zoology, Invertebrates*. Vol.1 7th Edn. A.I.T.B.S. Publishers & Distributors, Delhi
5. Barnes, R.D. (1982). *Invertebrate Zoology*, V Edition. Holt Saunders International Edition.
6. Barrington, E.J.W. (1979). *Invertebrate Structure and Functions*. II Edition, E.L.B.S. and Nelson.

[***All the books shall be of latest editions***]

CZO-105
[TAXONOMY, ZOOGEOGRAPHY & PALAEONTOLOGY]

No. of Credits: 4
Total marks: 100

Unit 1: Introduction to Taxonomy **20 lectures/30 marks**

1. History of Taxonomy; Principles and Methods of Taxonomy.
2. Definition and Basic concepts of Microtaxonomy, Systematics, and New Systematics.
3. Theory and Practice of Biological Classification.
4. Concepts of Species, Binominal and Trinominal Nomenclatures.

Unit 2: New Trends in Taxonomy **10 lectures/20 marks**

1. Concept of conventional and newer trends in Taxonomy: Chemotaxonomy and Cytotaxonomy.
2. Basic concepts of Molecular taxonomy, Modern methods in identification of species & phylogeny.
3. Basic concepts of International Code of Zoological Nomenclature (ICZN).

Unit 3: Zoogeography **15 lectures/25 marks**

1. Background, Continental drift and Glaciations.
2. Zoogeographical regions of the world with characteristic fauna with special reference to Indian sub-continent of Oriental region, Marine realm and its division and characteristics.
3. Barriers in animal distribution and Discontinuous distribution.

Unit 4: Palaeontology **15 lectures/25 marks**

1. Fossils and fossilizations, Types of fossils, and Formation of fossils.
2. Dating of fossils, Interpretation of Fossil records, and Significance of fossils.
3. Geological time scales and associated fauna.
4. Williston' Rule and Cope's Rule.

SUGGESTED READINGS

1. Kapoor, V.C. Theory and Practice of Animal Taxonomy. Oxford-IBH Publishing Co., New Delhi, Mumbai and Kolkata.
2. Hubbs, C.L. Zoogeography. Ayer Co Pub, Reprint Edotion
3. Mayer Ernst. Principles of Systematic Zoology. McGRAW Hill International Edn.
4. Simpson, G.C. Principles of Animal Taxonomy. Oxford-IBH Publishing Co., New Delhi, Mumbai and Kolkata.
5. International Code of Zoological Nomenclature (ICZN), 1999. Natural History Museum, Cromwell Road, London SW7 5BD-UK (www.iczn.org).
6. Darlington, P.J. The Zoogeography: The geographical distribution of animals. Wiley Publication, New York.
7. Illies, J. Introduction to Zoogeography. Macmillan.

[***All the books shall be of latest editions***]

CZO-106
[PRACTICAL BASED ON CZO-104 & CZO-105]

No. of Credits: 4
Total marks: 100

NON-CHORDATES

1. **Dissections** **10 marks**
   a. Digestive system, septal nephridia and pharyngeal nephridia of Earthworm
   b. Digestive and Nervous system of Cockroach

2. **Study of permanent slides** **6 marks**
   Trochophore larva of *Nereis*; T.S. of earthworm through pharynx, gizzard & typhlosolar region; mouth parts of mosquito/housefly; T.S. of gills of *Pila*

3. **Study of museum specimens** **12 marks**
   Annelida: *Aphrodite, Nereis, Heteronereis, Sabella, Chaetopterus* and *Hirudinaria*
   Arthropoda: *Limulus*, *Palamnaeus, Palaemon, Daphnia*, *Balanus*, *Sacculina*, *Cancer*, *Eupagurus*, *Scolopendra*, *Julus*, *Bombyx*, Queen Termite and *Apis*
   Onychophora: *Peripatus*
   Mollusca: *Chiton, Dentalium, Pila, Helix, Unio, Ostrea, Pinctada, Sepia, Loligo* and *Octopus*
   Echinodermata: *Pentaceros*/*Asterias, Ophiura, Clypeaster, Echinus, Cucumaria* and *Antedon*

4. **Preparation of temporary slides** **6 marks**
   Mouth parts of Cockroach/mosquito; *Obelia* colony; Parapodia of *Nereis*; Radula of Pila

5. **Submission of a Project Report on larval forms (insect/crustacean, mollusc and echinoderm)** **6 marks**

TAXONOMY, ZOOGEOGRAPHY & PALAEONTOLOGY

1. Study of diversity of species in pond water collected from different places (at least two) through description and nomenclature. **10 marks**

2. Identification of species using dichotomous keys in: **10 marks**
   a. Two local fishes [*Puntius sophore* (phabounga) and *Amblypharyngodon mola* (mukanga)]
   b. Two local insects [*Locusta migratoria* (grasshopper) and *Periplaneta americana* (cockroach)]

3. Temporary slide preparation from collected species/specimens (at least four). **8 marks**

4. Study of different Eras/Periods of Geological Time Scale based on charts and models. **6 marks**

5. Field collection and submission of report. **6 marks**

LABORATORY RECORD BOOK **10 marks**

VIVA-VOCE **10 marks**

GZO-103
[APPLIED ZOOLOGY]

Number of Credits: 3
Total marks: 75

Unit 1: Medical Parasitology **8 lectures/10 marks**

1. Life cycle and pathogenicity of *Entamoeba histolytica* and *Trypanosoma gambiense*
2. Life cycle and pathogenicity of *Ascaris lumbricoides* and *Wuchereria bancrofti*

Unit 2: Sericulture, Apiculture and Lac culture **17 lectures/20 marks**

1. Sericulture: Species diversity, life history, rearing methods, diseases, economic utility of tasar and mulberry silkworms
2. Sericulture in Manipur: prospects and challenges
3. Apiculture: Species diversity, life history, rearing methods, economic utility of bees
4. Lac culture: Life cycle of *Laccifer lacca*; Economic utility of lac insects

Unit 3: Fish and Fisheries **15 lectures/18 marks**

1. Fisheries: Culture and Capture fisheries; Inland fisheries
2. Fishes of commercial value: food, medicinal and ornamental
3. Pisciculture techniques: Extensive and intensive fish culture, hybridization and hypophysation, integrated fish farming with special reference to Manipur

Unit 4: Aquaculture **12 lectures/15 marks**

1. Potential scope of Aquarium Fish Industry as a Cottage Industry; Sustainable aquaculture
2. Preparation and maintenance of fish aquarium
3. Brood stock management
4. Role of water quality in aquaculture

Unit 5: Animal Husbandry and Poultry Farming **8 lectures/12 marks**

1. Preservation and artificial insemination in cattle
2. Induction of early puberty and synchronization of estrus in cattle
3. Principles of poultry breeding; Processing and preservation of eggs

SUGGESTED READINGS

1. Cheng, T.C.: *General Parasitology*, Academic Press College Division, Harcourt Brace Javanovich, Publishers Orlando, Florida (2nd Edition, 1986).
2. Smyth, J.D.: *Animal Parasitology*, Cambridge University Press (3rd Edition, 1993).
3. Ichhpujani R.L. and R. Bhatia: *Medical Parasitology*, Jaypee Brother Medical Publishers (P) Ltd. New Delhi.
4. Jhingran, V.G.: *Fish & Fisheries of India,* 3rd. En. Today & Tomorrow Book Agency, New Delhi.
5. G.S. Shukla and V.B. Upadhyay : *Economic Zoology*, Rastogi Publications, Shivaji Road, Meerut
6. David, B.V. and Anantha Kiishnan, T.N.: *General and Applied Entomology*, Tata-Mcgraw-Hill, New Delhi.
7. Dandin, S.B. et al. *Handbook of Sericulture Technologies*. Central Silk Board, Bangalore.

[All the books shall be of latest editions]

GZO-104
[PRACTICAL BASED ON GZO-103]

Number of Credits: 1
Total marks: 25

1. **Experiments** **12 marks**
   a. Study of *Entamoeba histolytica*, *Trypanosoma gambiense, Ascaris lumbricoides* and *Wuchereria bancrofti* through permanent slides/photomicrographs/specimens.
   b. Study of stages of life history of honey bee/silk moth/fish.
   c. Morphological differences among different castes of honey bee.
   d. Taxonomic identification of some common indigenous fishes.
   e. Water quality criteria for Aquaculture: Assessment of pH, Conductivity, Total solids, Total dissolved solids.
2. **Submission of Project Report on a visit to any fish farm/apiculture center/sericulture center** **5 marks**
3. **Laboratory Record Book** **3 marks**
4. **Viva Voce** **5 marks**

SZO-002
[APICULTURE]

Number of Credits: 2
Total marks: 50

Unit 1: Biology of Bees **6 lectures/10 marks**

1. History, Classification and Biology of Honey Bees
2. Social Organization of Bee Colony

Unit 2: Rearing of Bees **10 lectures/15 marks**

1. Artificial Bee rearing (Apiary), Beehives – Newton and Langstroth
2. Bee Pasturage
3. Selection of Bee Species for Apiculture
4. Bee Keeping Equipment
5. Methods of Extraction of Honey (Indigenous and Modern)

Unit 3: Diseases and Enemies **5 lectures/10 marks**

1. Bee Diseases and Enemies
2. Control and Preventive measures

Unit 4: Bee Economy **3 lectures/5 marks**

1. Products of Apiculture Industry and its Uses (Honey, Bees Wax, Propolis), Pollen, etc.

Unit 5: Entrepreneurship in Apiculture **6 lectures/10 marks**

1. Bee Keeping Industry – Recent Efforts, Modern Methods in employing artificial
2. Beehives for cross pollination in horticultural gardens

SUGGESTED READINGS

1. Prost, P. J. (1962). *Apiculture*. Oxford and IBH, New Delhi.
2. Bisht D.S., *Apiculture*, ICAR Publication.
3. Singh S., *Beekeeping in India*, Indian council of Agricultural Research, New Delhi.

[All the books shall be of latest editions]

SEMESTER III

CZO-207
[DIVERSITY OF CHORDATES]

No. of Credits: 4
Total marks: 100

Unit 1: Introduction, Hemichordata, Urochordata and Cephalochordata **20 lectures/30 marks**

1. General characteristics and Classification of Chordata upto Classes with examples.
2. General characteristics of Hemichordata, Urochordata and Cephalochordata with examples.
3. Retrogressive metamorphosis in Urochordata; Affinities of *Balanoglossus* and *Branchiostoma*.
4. Dipleurula concept and the Echinoderm theory of origin of chordates.
5. Advanced features of vertebrates over Protochordata (Hemichordata, Urochordata and Cephalochordata).

Unit 2: Agnatha and Pisces **10 lectures/20 marks**

1. General characteristics and Classification of Cyclostomata upto Classes with examples.
2. General characteristics and Classification of Chondrichthyes and Osteichthyes upto Orders with examples.
3. Migration, Osmoregulation and Parental care in fishes.

Unit 3: Amphibia and Reptilia **15 lectures/25 marks**

1. Origin of Tetrapoda (Evolution of terrestrial ectotherms).
2. General characteristics and Classification of Amphibia upto Orders with examples.
3. Parental care in Amphibians.
4. General characteristics and Classification of Reptilia upto Orders with examples.
5. Anatomical peculiarities and affinities of *Sphenodon*.
6. Poison apparatus and biting mechanism in snakes.

Unit 4: Aves and Mammalia **15 lectures/25 marks**

1. General characteristics and Classification of Aves upto Orders with examples.
2. General account on *Archaeopteryx*.
3. Fight adaptation and Migration in birds; Perching mechanism in birds.
4. General characteristics and Classification of Mammalia upto Orders with examples.
5. Origin of mammals; General characteristics and Classification of Prototheria, Metatheria and Eutheria with examples.
6. Dentition and Placentation in mammals.

Note: Classification shall be followed from Young, J.Z. (2004)

SUGGESTED READINGS

1. Marshall, A.J., Parker, T.J. & Haswell, W.A.: Text Book of Zoology, 7th Edn. 1995,Vol. 2. A.I.T.B.S. Publishers & Distributors, Delhi.
2. Kotpal, R.L.: *Modern Text Book of Zoology, Vertebrates*. 2nd Edn. 1998. Rastogi Publications, Meerut.
3. Jordan, E.L. and Verma, P.S. (2017). *Chordate Zoology*. 20th Edn. S. Chand & Company Ltd., New Delhi.
4. Sinha, Adhikari & Ganguli. *Biology of Animals*, Volume 2. New Central Book Agency (P) Ltd., Kolkata.
5. Young, J.Z.: *The life of Vertebrates*. 3rd Edn. 2004. Oxford University Press, New York
6. Pough, H. *Vertebrate life*, 7th Edn., Pearson International.

[All the books shall be of latest editions]

CZO-208
[CELL BIOLOGY]

No. of Credits: 4
Total marks: 100

Unit 1: Introduction to Cells and Plasma membrane **15 lectures/25 marks**

1. Prokaryotic and Eukaryotic cells
2. Virus, Viroid, Mycoplasma, and Prions
3. Fluid Mosaic model of plasma membrane
4. Transport across membranes: Active and Passive transport, Osmosis
5. Cell junctions: Tight junctions, Desmosomes, Gap junctions

Unit 2: Endomembrane System, Mitochondria and Peroxisomes **15 lectures/25 marks**

1. Structure and functions of Endoplasmic reticulum, Golgi apparatus, and Lysosomes
2. Mitochondria: Structure, Semi-autonomous nature, Endosymbiotic hypothesis
3. Role of Mitochondria in cellular respiration
4. Structure and functions of Peroxisomes (uricosomes)

Unit 3: Cytoskeleton and Nuclear Organization **15 lectures/25 marks**

1. Structure and functions of Microtubules, Microfilaments and Intermediate filaments
2. Structure and functions of nuclear envelope and nucleolus
3. Euchromatin and Heterochromatin
4. Nucleosomes as basic units of eukaryotic chromosomes

Unit 4: Cell Division and Cell Signalling **15 lectures/25 marks**

1. Mitosis and Meiosis
2. Cell cycle and its regulation
3. GPCR and Role of second messenger (cAMP)

SUGGESTED READINGS

1. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. 6th Edition. John Wiley and Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. 8th Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. 5th Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). *The World of the Cell*. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
5. Bruce Alberts, A. Johnson, J. Lewis, D. Morgan, M. Raff, K. Roberts, P. Walter: *Molecular Biology of the cell*, 6th Edn, 2015; Publisher: Garland Science, Taylor & Francis Group, New York
6. H. Lodish, D. Baltimore & others: *Molecular Cell Biology*, 5th Edn, 2006, Publisher: W.H. Freeman and Company, New York.

[***All the books shall be of latest editions***]

CZO-209
[PRACTICAL BASED ON CZO-207 & CZO-208]

No. of Credits: 4
Total marks: 100

DIVERSITY OF CHORDATES

1. **Dissections** **12 marks**

Scoliodon

a. Afferent & Efferent branchial system
b. Internal ear (to be taken out)
c. IX & X cranial nerves

Frog/toad

a. Brain (to be taken out)
b. Arterial and Venous system
c. IX & X cranial nerves

2. **Study of museum specimens** **12 marks**

Hemichordata: *Balanoglossus*
Urochordata: *Ascidia, Herdmania*
Cephalochordata: *Amphioxus (Branchiostoma)*
Cyclostomata: *Petromyzon, Myxine*
Chondrichthyes: *Torpedo, Sphyrna, Pristis, Chimaera*
Osteichthyes: *Hippocampus, Echeneis, Exocoetus, Syngnathus, Anguilla, Anabas*
Amphibia: *Ichthyophis*, *Salamandra, Hyla, Rhacophorus, Alytes, Necturus*
Reptilia: *Hemidactylus, Mabuia, Chelone, Chameleon, Calotes, Kachuga, Draco, Naja, Bungarus, Viper, Varanus, Uromastix, Ophiosaurus, Hydrophis*
Aves: *Psittacula, Columba, Passer, Corvus, Milvus*
Mammalia: *Ornithorhynchus & Echidna* (models), *Pteropus*

3. **Study of bones** **16 marks**

Toad/Frog: Skull, lower jaw, pectoral & pelvic girdles, vertebrae
Calotes: Skull, lower jaw
Pigeon: Skull, lower jaw, cervical vertebrae, ribs, pectoral & pelvic girdles, furcula
Rabbit: Skull, lower jaw, pectoral & pelvic girdles, forelimbs & hindlimbs

CELL BIOLOGY

Experiments **40 marks**

a. Preparation of temporary/permanent stained squash of animal tissues/onion root tips to study various stages of mitosis
b. Preparation of temporary/permanent stained squash of animal tissues (e.g., grasshopper testes) to study various stages of meiosis.
c. Preparation of permanent slide to show the presence of Barr body in human female blood cells/cheek cells.
d. Demonstration of DNA by Feulgen reaction
e. Demonstration of DNA and RNA by Methyl Green-Pyronin (MGP)
f. Demonstration of Mucopolysaccharides by PAS (Periodic Acid-Schiff) reaction

Laboratory Record Book **10 marks**

Viva Voce **10 marks**

GZO-205
[AQUATIC BIOLOGY]

No. of Credits: 3
Total marks: 75

Unit 1: Aquatic Biomes **15 lectures/18 marks**

1. Brief introduction to aquatic biomes
2. Freshwater ecosystem (lakes, wetlands, streams and rivers), estuaries, intertidal zones, oceanic pelagic zone, marine benthic zone and coral reefs.

Unit 2: Freshwater Biology **20 lectures/25 marks**

1. Lakes: Origin and classification, Lake as an Ecosystem, Lake morphometry, Physico–chemical Characteristics of lake: Light, Temperature, Thermal stratification, Dissolved Solids, Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity; dissolved gases (Oxygen, Carbon dioxide). Nutrient Cycles in Lakes: Nitrogen, Sulphur and Phosphorous.
2. Streams: Different stages of stream development, Physico-chemical environment, Adaptation of hill-stream fishes.

Unit 3: Marine Biology **10 lectures/12 marks**

1. Salinity and density of Sea water
2. Continental shelf, Adaptations of deep sea organisms, and Sea weeds.

Unit 4: Management of Aquatic Resources **15 lectures/20 marks**

1. Causes of pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills
2. Eutrophication, Management and conservation (legislations)
3. Sewage treatment, Water quality assessment- BOD and COD.

SUGGESTED READINGS

1. Anathakrishnan : *Bioresources Ecology*. 3rd Edition
2. Goldman : *Limnology*, 2nd Edition
3. Odum and Barrett : *Fundamentals of Ecology*, 5th Edition
4. Pawlowski: *Physicochemical Methods for Water and Wastewater Treatment*, 1st Edition

[All the books shall be of latest editions]

GZO-206
[PRACTICAL BASED ON GZO-205]

Number of Credits: 1
Total marks: 25

Experiments **17 marks**

1. Determine the area of a lake using graphimetric and gravimetric method.
2. Identify the important macrophytes, phytoplanktons and zooplanktons present in a lake ecosystem.
3. Determine the amount of Turbidity/transparency, Dissolved Oxygen, Free Carbon dioxide, Alkalinity (carbonates & bicarbonates) in water collected from a nearby lake/ water body.
4. Instruments used in limnology (Secchi disc, Van Dorn Bottle, Conductivity meter, Turbidity meter, PONAR grab sampler) and their significance.
5. A Project Report on a visit to a Sewage treatment plant/Marine bioreserve/Fisheries Institutes.

Laboratory Record Book **3 marks**

Viva Voce **5 marks**

SZO-003
[AQUARIUM FISH KEEPING]

No. of Credits: 2
Total marks: 50

Unit1: Introduction to Aquarium Fish Keeping **5 lectures/8 marks**

1. The potential scope of Aquarium Fish Industry as a Cottage Industry.
2. Exotic and Endemic species of Aquarium Fishes

Unit 2: Biology of Aquarium Fishes **10 lectures/18 marks**

1. Common characters and sexual dimorphism of Fresh water and Marine Aquarium fishes such as Guppy, Molly, Sword tail, Gold fish, Angel fish, Blue morph, Anemone fish and Butterfly fish

Unit 3: Food and feeding of Aquarium fishes **5 lectures/8 marks**

1. Use of live fish feed organisms
2. Preparation and composition of formulated fish feeds

Unit 4: Fish Transportation **5 lectures/8 marks**

1. Live fish transport - Fish handling, packing and forwarding techniques.

Unit 5: Maintenance of Aquarium **5 lectures/8 marks**

1. General Aquarium maintenance – budget for setting up an Aquarium Fish Farm as a Cottage Industry

SUGGESTED READINGS

1. Dawes, J.A. (1984). *The Freshwater Aquarium*. Roberts Royee Ltd. London
2. Walter James (2021). *Freshwater Aquarium for Beginners*.
3. Martin, A. Moe (2009). *Marine Aquarium Handbook*.
4. N. Arumugam, K.V. Jayashree, C.S. TharaDevi. *Home Aquarium and Ornamental fish culture*. Saras Publications.

[All the books shall be of latest editions]

SEMESTER IV

CZO-210
[COMPARATIVE ANATOMY OF VERTEBRATES]

No. of Credits: 4
Total marks: 100

Unit 1: Integumentary and Skeletal System **16 lectures/25 marks**

1. Structure, functions and derivatives of integument in different vertebrates
2. Overview of axial and appendicular skeleton; Jaw suspension
3. Visceral arches

Unit 2: Digestive and Respiratory System **16 lectures/25 marks**

1. Alimentary canal and associated glands; Dentition
2. Skin, gills, lungs, air sacs and swim bladder
3. Accessory respiratory organs in fishes

Unit 3: Circulatory and Urinogenital System **14 lectures/25 marks**

1. General plan of circulation; Evolution of heart and aortic arches
2. Succession of kidney; Evolution of urinogenital ducts
3. Types of mammalian uteri

Unit 4: Nervous System and Sense organs **14 lectures/25 marks**

1. Comparative account of brain
2. Autonomic nervous system; Spinal cord; Cranial nerves in mammals
3. Classification of receptors
4. Brief account of visual and auditory receptors in man

SUGGESTED READINGS

1. Kardong, K.V. (2005) *Vertebrates' Comparative Anatomy, Function and Evolution*. IV Edition. McGraw-Hill Higher Education.
2. Kent, G.C. and Carr R.K. (2001). *Comparative Anatomy of the Vertebrates*. IX Edition. McGraw-Hill International Edition, Singapore.
3. Hilderbrand, M and Gaslow G.E. *Analysis of Vertebrate Structure*, John Wiley and Sons
4. Walter, H.E. and Sayles, L.P; *Biology of Vertebrates*, Khosla Publishers.
5. Young, J.Z.: *The life of Vertebrates*. 3rd Edn. 2004. Oxford University Press, New York.
6. Kotpal, R.L.: *Modern Text Book of Zoology, Vertebrates*. Rastogi Publications, Meerut.
7. Jordan, E.L. and Verma, P.S. (2017). *Chordate Zoology*. 20th Edn. S. Chand & Company Ltd., New Delhi.

[All the books shall be of latest editions]

CZO-211
[ANIMAL PHYSIOLOGY I]

(Physiology should be with special reference to mammal/man)

No. of Credits: 4
Total marks: 100

Unit 1: Tissues **10 lectures/15 marks**

1. Structure, classification, location and function of epithelial and connective tissues.
2. Ultra structure of skeletal muscle.
3. Structure and functions of nervous tissues.

Unit 2: Physiology of Digestion **10 lectures/15 marks**

1. Structural organization of gastrointestinal tract and associated glands.
2. Digestion and absorption of carbohydrates, proteins and lipids.
3. Absorption of water, minerals and vitamins.
4. Hormonal and nervous regulation of gastrointestinal functions.

Unit 3: Physiology of Respiration **8 lectures/15 marks**

1. Histology of trachea and lung; Pulmonary ventilation.
2. Transport of oxygen and carbon dioxide; Carbon monoxide poisoning.
3. Respiratory volumes and capacities.
4. Respiratory pigments of animals.

Unit 4: Renal Physiology **8 lectures/15 marks**

1. Structure of kidney and its functional unit.
2. Mechanism of urine formation and micturition.
3. Role of kidney in acid-base balance.

Unit 5: Blood **12 lectures/20 marks**

1. Components of blood and their functions.
2. Structure and functions of haemoglobin.
3. Haemostasis: Blood clotting system and mechanism of blood coagulation, complement system and fibrinolytic system.
4. Haemopoiesis; ABO and Rh blood group; MN blood group.

Unit 6: Cardiovascular physiology **12 lectures/20 marks**

1. Structure of mammalian heart; coronary circulation.
2. Origin, conduction and regulation of heart beat; cardiac cycle; cardiac output and its regulation.
3. Frank Starling law of the heart; Electrocardiogram (ECG).
4. Blood pressure and its regulation.

SUGGESTED READINGS

1. Arthur C. Guyton and John E. Hall: *Text book of Medical Physiology*, 12th Edn. Elsevier Saunders.
2. Kim E. Barrett, Scott Boitano, Susan M. Barman and Heddwen L. Brooks: *Ganong's Review of Medical Physiology*, 23rd Edn. 2010. Tata McGraw Hill Education Private Limited, New Delhi.
3. Sembulingam, K. & Sembulingam, Prema. 7th Edn. 2016. *Essentials of Medical Physiology*. The Health Sciences Publisher, New Delhi, London, Philadelphia, Panama.
4. A.K. Jain: *Text book of Physiology, Vol. I & II*, 4th Edn. 2011. Avichal Publishing Company, New Delhi.

[All the books shall be of latest editions]

CZO-212
[PRACTICAL BASED ON CZO-210 & CZO-211]

No. of Credits: 4
Total marks: 100

COMPARATIVE ANATOMY

1. **Dissection** **16 marks**
   a. Aortic arches of fish
   b. Accessory respiratory organs of *Clarias*/*Anabas*
   c. Urinogenital system of Toad/Frog and Rat

2. **Study of permanent slides/photographs of placoid, cycloid and ctenoid scales of fishes** **12 marks**

3. **Study of bones** **12 marks**
   a. Disarticulated skeleton of *Varanus*
   b. Skull of herbivorous and carnivorous mammal
   c. Vertebrae of rabbit

ANIMAL PHYSIOLOGY

Histology **20 marks**

1. Study of permanent histological sections of mammalian Cartilage, Bone, Stomach, Small intestine, Liver, Trachea, Lung and Kidney.
2. Preparation of temporary mounts: Squamous epithelium, Skeletal muscle fibres/nerve cells.
3. Microtomy: Preparation of permanent slides of at least three mammalian tissues.

Physiology **20 marks**

1. Estimation of haemoglobin in our own blood by Sahli's method.
2. Enumeration of total erythrocytes in our blood by haemocytometry.
3. Enumeration of total leucocytes in our blood by haemocytometry.
4. Preparation and demonstration of haemin crystals (Teichmann's crystals).
5. Recording of blood pressure by using Sphygmomanometer.

Laboratory Record Book **10 marks**

Viva Voce **10 marks**

GZO-207
[FOOD, NUTRITION AND HEALTH]

No. of Credits: 3
Total marks: 75

Unit 1: Basic concept of Food and Nutrition: **10 lectures/12 marks**

1. Food Components and food-nutrients
2. Concept of a balanced diet
3. Nutrient requirements and dietary pattern for various age groups: adults, pregnant and nursing mothers, infants, school children, adolescents and old-aged groups.

Unit 2: Nutritional Biochemistry: **15 lectures/ 20 marks**

1. Carbohydrates, Lipids, Proteins: Definition, Classification, dietary source and biological significance.
2. Vitamins: Classification, dietary source and biological functions.
3. Minerals: Iron, calcium, phosphorus, iodine, selenium and zinc (biological functions).

Unit 3: Health: **20 lectures/ 23 marks**

1. Introduction to health: Definition and concept of health as per WHO
2. Major Nutritional Deficiency diseases: Protein Energy Malnutrition (Kwashiorkor and Marasmus); Vitamin deficiency disorders, Iron deficiency disorders, Iodine deficiency disorders (their causes, symptoms, treatment, prevention and government programmes, if any).
3. Life style related diseases: hypertension, diabetes mellitus and obesity (their causes and prevention through dietary and lifestyle modifications).
4. Social/public health problems: smoking, alcoholism, drug dependence, Acquired Immuno Deficiency Syndrome and COVID-19 (their causes, treatment and prevention).
5. Common ailments: cold, cough and fever (their causes and treatment).

Unit 4: Food Hygiene: **15 lectures/ 20 marks**

1. Potable water: sources and methods of purification at domestic level
2. Food and water borne infections: Bacterial infection (Cholera, typhoid fever, dysentery), Viral infection (Hepatitis and Poliomyelitis), Protozoan infection (amoebiasis, malaria, giardiasis), Parasitic infection (taeniasis and ascariasis).
3. Brief account of food spoilage: Causes of food spoilage and their preventive measures

SUGGESTED BOOKS

1. Mudambi, SR and Rajagopal, MV. *Fundamentals of Foods, Nutrition and Diet Therapy*; Fifth Ed; 2007; New Age International Publishers
2. Srilakshmi B. *Nutrition Science*; 2002; New Age International (P) Ltd. Srilakshmi B. Food Science; Fourth Ed; 2007; New Age International (P) Ltd.
3. Swaminathan M. *Handbook of Foods and Nutrition*; Fifth Ed; 1986; BAPPCO.
4. Bamji MS, Rao NP, and Reddy V. *Text Book of Human Nutrition*; 2009; Oxford & IBH Publishing Co. Pvt Ltd.
5. Wardlaw GM, Hampl JS. *Perspectives in Nutrition*; Seventh Ed; 2007; McGraw Hill.
6. Lakra P, Singh MD. *Textbook of Nutrition and Health*; First Ed; 2008; Academic Excellence.
7. Manay MS, Shadaksharaswamy. *Food-Facts and Principles*; 1998; New Age International (P) Ltd. Gibney et al. Public Health Nutrition; 2004; Blackwell Publishing

[All the books shall be of latest editions]

GZO-208
[PRACTICAL BASED ON GZO-207]

No. of Credits: 1
Total marks: 25

Experiments **17 marks**

1. To detect adulteration in a) Ghee b) Sugars c) Tea leaves and d) Turmeric
2. Estimation of Lactose in milk
3. Estimation of Ascorbic acid in food by titration method
4. Estimation of Calcium in food by titration method
5. Study of the stored grain pests from slides/photograph (*Sitophilus oryzae*, *Trogoderma granarium*, *Callosobruchus chinensis* and *Tribolium castaneum*): their identification, habitat and food sources, damage caused and control. Preparation of temporary mounts of the above stored grain pests.
6. Project:

   Undertake computer aided diet analysis and nutrition counselling for different age groups.

   OR

   Identify nutrient rich sources of foods (fruits and vegetables), their seasonal availability and price

   OR

   Study of nutrition labelling on selected foods

Laboratory Record Book **3 marks**

Viva Voce **5 marks**

SZO-004
[VERMICULTURE AND VERMICOMPOSTING]

No. of Credits: 2
Total marks: 50

Unit 1: Introduction **5 lectures/8 marks**

1. Definition, History, Economic importance and Scope of vermiculture.
2. Methodology adapted for maintenance and fertility of earthworms used for vermicomposting.

Unit 2: Biology of Earthworm and Environment **10 lectures/18 marks**

1. Morphology and life cycle of earthworm.
2. Types of earthworms used in vermiculture.
3. Ecological parameters of natural enemies of earthworm and preventive measures.

Unit 3: Vermicomposting Technology **10 lectures/18 marks**

1. Tools and techniques in earthworm culture.
2. Requirements of vermicomposting, Types of vermicomposting and Techniques of vermicomposting.
3. Work experience by visiting a vermiculture farm.

Unit 4: Composition and Application of Vermicompost **5 lectures/6 marks**

1. Chemical composition and nature of vermicompost.
2. Application and use of vermicompost in organic farming.

SEMESTER V

CZO-313
[ANIMAL PHYSIOLOGY II]

(Physiology should be with special reference to mammal/man)

No. of Credits: 4
Total marks: 100

Unit 1: Muscle Physiology **10 lectures/20 marks**

1. Properties of skeletal muscles.
2. Molecular mechanism of muscle contraction; Energy source during muscle contraction.
3. Muscle fatigue and Cori cycle.

Unit 2: Nerve Physiology **10 lectures/20 marks**

1. Resting membrane potential; Origin of action potential and its propagation across the myelinated and unmyelinated nerve fibres.
2. Types of synapse; Synaptic transmission and neuromuscular junction.
3. Reflex arc and reflex action with specific examples.

Unit 3: Sense organs **8 lectures/10 marks**

1. Structure of human eye; Physiology of vision.
2. Structure of human ear; Physiology of hearing.
3. Physiology of smell and taste.

Unit 4: Endocrinology **20 lectures/30 marks**

1. Introduction to endocrine glands; Classification of hormones; Hormonal Feedback mechanism.
2. Mechanism of hormone (epinephrine/protein & steroid) action.
3. Functions of hormones of hypothalamus, pituitary, pineal, thyroid, parathyroid, thymus, adrenal, pancreas, testis and ovary.
4. Functions of gastrointestinal hormones and hormones of heart, kidney and placenta.

Unit 5: Reproductive system **12 lectures/20 marks**

1. Human male and female reproductive system.
2. Adolescence and puberty.
3. Menstrual cycle.
4. Methods of contraception in male and female.

SUGGESTED READINGS

1. Arthur C. Guyton and John E. Hall: *Text book of Medical Physiology*, 12th Edn. Elsevier Saunders.
2. Kim E. Barrett, Scott Boitano, Susan M. Barman and Heddwen L. Brooks: *Ganong's Review of Medical Physiology*, 23rd Edn. 2010. Tata McGraw Hill Education Private Limited, New Delhi.
3. Sembulingam, K. & Sembulingam, Prema. 7th Edn. 2016. *Essentials of Medical Physiology*. The Health Sciences Publisher, New Delhi, London, Philadelphia, Panama.
4. A.K. Jain: *Text book of Physiology, Vol. I & II*, 4th Edn. 2011. Avichal Publishing Company, New Delhi.

[All the books shall be of latest editions]

CZO-314
[BIOCHEMISTRY I]

No. of Credits: 4
Total marks: 100

Unit 1: Chemical bonds in Biochemistry & Bioenergetics **10 lectures/20 marks**

1. Electrostatic interactions, hydrogen bonds, Van der Waals interactions & hydrophobic interactions.
2. Entropy and the laws of Thermodynamics; ATP as Universal Currency of free energy.

Unit 2: Carbohydrates, Proteins and Lipids **20 lectures/30 marks**

1. Structure, classification and biological significance of carbohydrates and lipids.
2. Structure, classification and general properties of amino acids; Physiological importance of essential and non-essential amino acids.
3. Structure, classification and biological significance of proteins; Denaturation of proteins.

Unit 3: Vitamins and Minerals **8 lectures/10 marks**

1. Classification, dietary source and physiological functions of vitamins.
2. Macronutrients and micronutrients: dietary source and physiological functions.

Unit 4: Nucleic acids **10 lectures/15 marks**

3. Structure of different constituents of nucleotides; Denaturation and Renaturation of DNA.
4. Types of DNA and RNA; Complementarity of DNA; Hypo-hyperchromaticity of DNA.

Unit 5: Enzymes **12 lectures/25 marks**

1. Introduction and classification of enzymes; Mechanism of enzyme action; Enzyme kinetics.
2. Factors affecting rate of enzyme-catalyzed reactions; Derivation of Michaelis-Menten equation.
3. Lineweaver-Burk plot; Multi-substrate reactions; Enzyme inhibition.

SUGGESTED READINGS

1. Stryer, L: *Biochemistry*, W.H. Freeman & Co, New York, 2012.
2. Michael M. Cox and David L. Nelson: *In Lehninger Principles of Biochemistry*, 5th Edn.2010; W.H. Freeman and Company, New York.
3. Victor W. Rodwell, David A. Bender, Kathleen M Botham, Peter J. Kennelly, P. Anthony Weil: *Harper's Illustrated Biochemistry*, 30th Edn. 2015; Mc Graw Hill Education.
4. Satyanaraya, U: *Biochemistry*, 3rd Edn. 2006; Books and Allied (P) Ltd., Kolkata.
5. Vasudevan DM, Sreekumari S: *Text Book of Biochemistry*, 5th Edn.2007; Jaypee Brothers, New Delhi.
6. A.C. Dev: *Text Book of Biochemistry*
7. Bruce Alberts, A. Johnson, J. Lewis, D. Morgan, M. Raff, K. Roberts, P. Walter: In *Molecular Biology of the cell*, 6thEdn, 2015; Publisher: Garland Science, Taylor & Francis Group, New York.

[All the books shall be of latest editions]

CZO-315
[PRACTICAL BASED ON CZO-313 & CZO-314]

No. of Credits: 4
Total marks: 100

General Physiology **14 marks**

1. Recording of simple muscle twitch with electrical stimulation.
2. Recording of effect of temperature on simple muscle twitch.
3. Demonstration of unconditioned reflex action (e.g., knee jerk reflex).

Endocrinology & Reproduction

1. Dissection and display of endocrine glands of Rat/Mice/Guinea pig **10 marks**
2. Study of permanent histological sections of mammalian pituitary, thyroid, pancreas and adrenal. **8 marks**
3. Study of permanent histological sections of mammalian testis, ovary, uterus, fallopian tube, prostate and seminal vesicle. **8 marks**

Biochemistry **40 marks**

1. Qualitative test of carbohydrates, proteins and lipids in the given solutions.
2. Study of activity of salivary amylase under optimum conditions.
3. Estimation of total protein in the given solution by Lowry's method.
4. Paper chromatography of amino acids.
5. Demonstration of protein separation by SDS-PAGE.

Laboratory Record Book **10 marks**

Viva Voce **10 marks**

EZO-001
[BIOCHEMISTRY II]

No. of Credits: 3
Total marks: 75

Unit 1: Overview of Metabolism **10 lectures/12 marks**

1. Concepts of Metabolism, catabolism, anabolism and amphibolism.
2. Compartmentalization of metabolic pathways, Shuttle systems and membrane transporters.
3. Use of reducing equivalents and cofactors.
4. Intermediary metabolism and regulatory mechanisms.

Unit 2: Carbohydrate metabolism **16 lectures/20 marks**

1. Sequence of reactions and regulation of Glycolysis, Citric acid cycle, Pentose phosphate pathway, Gluconeogenesis, Glycogenesis and Glycogenolysis.

Unit 3: Lipid metabolism **14 lectures/17 marks**

1. β-oxidation and ω-oxidation of saturated fatty acids with even and odd number of carbon atoms.
2. Biosynthesis of palmitic acid; Ketogenesis.

Unit 4: Protein metabolism **10 lectures/13 marks**

1. Catabolism of amino acids: Transamination, Deamination and Urea cycle.
2. Fate of C-skeleton of glucogenic and ketogenic amino acids.

Unit 5: Oxidative Phosphorylation **10 lectures/13 marks**

1. Redox systems.
2. Electron-Transfer Reactions in mitochondria and ATP synthesis.
3. Inhibitors and un-couplers of Electron Transport System.

SUGGESTED READINGS

1. Stryer, L: *Biochemistry*, W.H. Freeman & Co, New York, 2012.
2. Michael M. Cox and David L. Nelson: *In Lehninger Principles of Biochemistry*, 5th Edn.2010; W.H. Freeman and Company, New York.
3. Victor W. Rodwell, David A. Bender, Kathleen M Botham, Peter J. Kennelly, P. Anthony Weil: *Harper's Illustrated Biochemistry*, 30th Edn. 2015; Mc Graw Hill Education.
4. Satyanaraya, U: *Biochemistry*, 3rd Edn. 2006; Books and Allied (P) Ltd., Kolkata.
5. Vasudevan DM, Sreekumari S: *Text Book of Biochemistry*, 5th Edn.2007; Jaypee Brothers, New Delhi.
6. A.C. Dev: *Text Book of Biochemistry*

[All the books shall be of latest editions]

EZO-002
[PRACTICAL BASED ON EZO-001]

No. of Credits: 1
Total marks: 25

Experiments **17 marks**

1. Estimation of blood glucose concentration by Anthrone/Glucose oxidase-peroxidase method.
2. Detection of SGOT and SGPT in human serum.
3. Qualitative determination of serum cholesterol.
4. Study of enzymatic activity of trypsin and lipase.
5. Determination of serum alkaline phosphatase.

Laboratory Record Book **3 marks**

Viva Voce **5 marks**

GZO-309
[HUMAN PHYSIOLOGY]

No. of Credits: 3
Total marks: 75

Unit 1: Tissues **10 lectures/15 marks**

1. Structure, classification, location and function of epithelial and connective tissues.
2. Ultra structure of skeletal muscle.
3. Structure and functions of nervous tissues.

Unit 2: Nerve and Muscle Physiology **10 lectures/15 marks**

1. Structure of a neuron; Resting membrane potential, Graded potential, Origin of Action potential and its propagation in myelinated and non-myelinated nerve fibres.
2. Ultra-structure of skeletal muscle; Molecular and chemical basis of muscle contraction.

Unit 3: Digestion and Respiration **10 lectures/15 marks**

1. Physiology of digestion and absorption of carbohydrates, proteins and lipids.
2. Pulmonary ventilation; Respiratory volumes and capacities
3. Transport of Oxygen and Carbon dioxide in blood

Unit 4: Excretion and Cardiovascular Physiology **15 lectures/15 marks**

1. Structure of nephron; Mechanism of Urine formation; Counter-current Mechanism
2. Composition of blood; Mechanism of blood coagulation
3. Structure of Heart; Origin and conduction of the cardiac impulse
4. Cardiac cycle

Unit 5: Reproduction and Endocrine Glands **15 lectures/15 marks**

1. Male reproductive System; Hormonal control of spermatogenesis
2. Female reproductive System: Hormonal control of oogenesis and menstrual cycle
3. Structure and function of pituitary, thyroid, parathyroid, pancreas and adrenal

SUGGESTED READINGS

1. Arthur C. Guyton and John E. Hall: *Text book of Medical Physiology*, 12th Edn. Elsevier Saunders.
2. Kim E. Barrett, Scott Boitano, Susan M. Barman and Heddwen L. Brooks: *Ganong's Review of Medical Physiology*, 23rd Edn. 2010. Tata McGraw Hill Education Private Limited, New Delhi.
3. Sembulingam, K. & Sembulingam, Prema. 7th Edn. 2016. *Essentials of Medical Physiology*. The Health Sciences Publisher, New Delhi, London, Philadelphia, Panama.
4. A.K. Jain: *Text book of Physiology, Vol. I & II*, 4th Edn. 2011. Avichal Publishing Company, New Delhi.

[All the books shall be of latest editions]

GZO-310
[PRACTICAL BASED ON GZO-309]

No. of Credits: 1
Total marks: 25

Histology **5 marks**

1. Study of permanent histological sections of mammalian Cartilage, Bone, Stomach, Small intestine, Liver, Lung and Kidney.
2. Preparation of temporary mounts: Squamous epithelium, Skeletal muscle fibres/nerve cells.

Physiology **12 marks**

1. Determination of ABO and Rh blood group in own blood.
2. Estimation of haemoglobin in our own blood by Sahli's method.
3. Enumeration of total erythrocytes in our blood by haemocytometry.
4. Preparation and demonstration of haemin crystals (Teichmann's crystals).

Laboratory Record Book **3 marks**

Viva Voce **5 marks**

SZO-005
[INTEGRATED PASTE MANAGEMENT]

No. of Credits: 2
Total marks: 50

Unit 1: Introduction **5 lectures/10 marks**

1. Definition, principles and concepts of pest management
2. Importance of pest management as an environmentally sound practice based on economic, ecological and sociological consequences.
3. Study of major factors that influence on pest population**.**

Unit 2: Pesticide classification and biotechnological intervention **5 lectures/10 marks**

1. Classification and formulation of pesticides.
2. Methods to minimize the toxic effects of pesticides.

Unit 3: Pest control tactics and strategies **15 lectures/20 marks**

1. Series of pest control tactics and strategies toward more sustainable agriculture, natural resources, and urban and rural health and well-being.
2. Pest management in a multi-faceted approach, incorporating the use of biological, cultural, physical, chemical, behavioural, genetic, and other control tactics to suppress populations of pests.

Unit 4: Laboratory protocol **5 lectures/10 marks**

1. To explore several aspects of pest management, including ecological influences, field sampling, video tape overviews of IPM programs, simulation "modelling," and economic thresholds.

* *For laboratory sessions, students will expose to both the expectations and limitations of the applications of the principles of pest management to pest problems.*

SUGGESTED READINGS

1. Norris, Caswell-Chen, and Kogan, Concepts in Integrated Pest Management (2003).
2. Metcalf and Luckmann. Introduction to Insect Pest Management [3rd ed.] [1994].
3. Koul, O., Dhaliwal, G.S., and Cuperus, G.W., 2004, Integrated Pest Management: Potential, Constraints and Challenges, CABI Publishing.

[All the books shall be of latest editions]

SEMESTER VI

CZO-316
[MOLECULAR BIOLOGY]

No. of Credits: 4
Total marks: 100

Unit 1: Nucleic acids **22 lectures/30 marks**

1. Historical background about nucleic acids
2. Double helix model of DNA; Mechanism of DNA replication in prokaryotes and eukaryotes
3. Mechanism of DNA repair
4. RNA: major types, structure and functions
5. Riboswitches, RNA interference (RNAi), microRNAs (miRNAs), small interfering RNAs (siRNAs)

Unit 2: Biosynthesis of Proteins **20 lectures/30 marks**

1. Structure of prokaryotic RNA polymerase
2. Mechanism of transcription in prokaryotes and eukaryotes
3. Genetic code; alterations in Standard genetic code in mitochondria
4. Ribosome structure and mechanism of translation in prokaryotes and eukaryotes
5. Difference between prokaryotic and eukaryotic protein biosynthesis

Unit 3: Post-transcriptional and post-translational modifications **8 lectures/20 marks**

1. Eukaryotic mRNA processing
2. Concepts of split genes (introns and exons) and spliceosomes
3. Post-translational modification of proteins

Unit 4: Regulation of Gene expression **10 lectures/20 marks**

1. Lac Operon and trp Operon model
2. Concepts of regulation of gene expression in eukaryotes
3. Gene silencing and Genetic imprinting

SUGGESTED READINGS

1. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. 6th Edition. John Wiley and Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. 8th Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. 5th Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). *The World of the Cell*. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
5. Bruce Alberts, A. Johnson, J. Lewis, D. Morgan, M. Raff, K. Roberts, P. Walter: *Molecular Biology of the cell*, 6th Edn, 2015; Publisher: Garland Science, Taylor & Francis Group, New York
6. H. Lodish, D. Baltimore & others: *Molecular Cell Biology*, 5th Edn, 2006, Publisher: W.H. Freeman and Company, New York.

[All the books shall be of latest editions]

CZO-317
[PRINCIPLES OF GENETICS]

No. of Credits: 4
Total marks: 100

Unit 1: Mendelian Genetics and its Extension **12 lectures/20 marks**

1. The birth of Genetics
2. Mendel's Principles of Segregation and Independent Assortment
3. Concepts of Back cross, Test cross and Trihybrid cross
4. Extensions of Mendelian Principles: Incomplete dominance, Co-dominance, Supplementary genes, Complementary genes, Duplicate genes, Epistasis, Pleiotropy (lethal genes) and Multiple alleles.
5. Polygenic inheritance with suitable examples; Simple numerical based on it.

Unit 2: Linkage, Crossing over and Chromosome Mapping **12 lectures/20 marks**

1. Linkage: Definition, Theories of linkage, Types of linkage with specific examples and crosses.
2. Crossing over: Definition, Cytological basis of crossing over, Molecular mechanism of crossing over including models of recombination.
3. Factors affecting recombination frequency.
4. Two factor and three factor crosses.
5. Linkage map (chromosome map); Interference and Coincidence.
6. Somatic cell hybridization.

Unit 3: Sex-linked, sex-influenced and sex-limited inheritance, & Sex Determination **12 lectures/20 marks**

1. Sex-linked recessive traits and their mode of inheritance with special reference to colour blindness & haemophilia in man and white eye in *Drosophila*.
2. Sex-influenced inheritance and sex-limited inheritance.
3. Historical background about discovery of sex-chromosomes.
4. Mechanism of sex-determination in *Drosophila* and man.
5. Intersex and gynandromorphs in *Drosophila*.

Unit 4: Mutation **6 lectures/10 marks**

1. Types of mutation; chromosome mutation (classification with suitable examples), gene mutation (classification).
2. Molecular basis of mutation in relation to UV light and chemical mutagens.
3. Detection of mutations: ClB method, attached X method.

Unit 5: Extra-chromosomal Inheritance **7 lectures/10 marks**

1. Criteria for extra-chromosomal inheritance.
2. Antibiotic resistance in *Chlamydomonas*.
3. Mitochondrial mutations in *Saccharomyces*.
4. Infective heredity in *Paramecium* and maternal effects.

Unit 6: Recombination and Transposable Genetic Elements **11 lectures/20 marks**

1. Conjugation, Transformation and Transduction.
2. Complementation test in Bacteriophage.
3. Transposons in bacteria and human.
4. Ac-Ds elements in maize and P elements in *Drosophila*.

SUGGESTED READINGS

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). *Principles of Genetics*. VIII Edition. Wiley India.
2. Snustad, D.P., Simmons, M.J. (2009). *Principles of Genetics*. V Edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). *Concepts of Genetics*. X Edition. Benjamin Cummings.
4. Russell, P. J. (2009). *Genetics- A Molecular Approach.* III Edition. Benjamin Cummings.
5. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. *Introduction to Genetic Analysis*. IX Edition. W. H. Freeman and Co., New York, USA.
6. B.D. Singh. *Fundamentals of Genetics*. Kalyani Publishers, Delhi, Kolkata, Madras
7. Sinnott, Dunn & Dobzhansky. *Principles of Genetics*. Tata McGraw-Hill Publishing Company

[All the books shall be of latest editions]

CZO-318
[PRACTICAL BASED ON CZO-316 & CZO-317]

No. of Credits: 4
Total marks: 100

MOLECULAR BIOLOGY

Experiments **40 marks**

1. Preparation of liquid broth medium (LB) and raise culture of *E. coli*
2. Preparation of solid broth medium (SB) and growth of *E. coli* by spreading and streaking technique
3. Demonstration of antibiotic sensitivity/resistance test of *E. coli* to antibiotic pressure and interpretation of results
4. Quantitative estimation of salmon sperm/calf thymus DNA using spectrophotometer
5. Quantitative estimation of RNA using Orcinol reaction
6. Study and interpretation of electron micrographs/photographs showing:
   a. DNA replication
   b. Transcription
   c. Split genes

GENETICS

Experiments **40 marks**

1. Study of Mendelian Inheritance and gene interactions (Non-Mendelian Inheritance) using suitable examples. Verify the results using Chi-square test.
2. Study of Linkage maps based on data from conjugation, transformation and transduction.
3. Study of Linkage maps based on data from *Drosophila* crosses.
4. Study of Human Karyotypes (normal and abnormal).
5. Pedigree analysis of some human inherited traits.

Laboratory Record Book **10 marks**

Viva Voce **10 marks**

EZO-003
[FISH & FISHERIES]

No. of Credits: 3
Total marks: 75

Unit 1: Introduction and Classification **6 lectures/6 marks**

1. Introduction and General description of fish.
2. Account of systematic classification of fishes (upto classes).
3. Classification of fishes based on feeding habit, habitat and mode of reproduction.

Unit 2: Morphology and Physiology of fishes **18 lectures/20 marks**

1. Types of fins and their modifications; Locomotion in fishes; Hydrodynamics.
2. Types of scales, Use of scales in classification and determination of age of fish.
3. Gills and gas exchange; Swim Bladder: Types and role in respiration, buoyancy.
4. Osmoregulation in fishes with special reference to Elasmobranchs.
5. Reproductive strategies in fishes; Reproductive strategies r & k
6. Electric organs; Bioluminescence; Mechanoreceptors.
7. Schooling, Parental care and Migration in fishes.

Unit 3: Fisheries **12 lectures/15 marks**

1. Inland and Marine Fisheries.
2. Environmental factors influencing the seasonal variations in fishes.
3. Fishing crafts and Gears; Depletion of fisheries resources.
4. Application of remote sensing and GIS in fisheries.
5. Fisheries law and regulations

Unit 4: Aquaculture **20 lectures/30 marks**

1. Sustainable Aquaculture; Extensive, semi-intensive and intensive culture of fish.
2. Pen and cage culture; Polyculture; Composite fish culture.
3. Brood stock management; Induced breeding of fish; Management of finfish hatcheries.
4. Preparation and maintenance of fish aquarium; Preparation of compound diets for fish.
5. Role of water quality in aquaculture.
6. Fish diseases: Bacterial, viral and parasitic.
7. Preservation and processing of harvested fish, Fishery by-products

Unit 5: Fish in Research **4 lectures/4 marks**

1. Transgenic fish, Zebrafish as a model organism in fish research.
2. Fish in biomedical research.

SUGGESTED READINGS

1. Q Bone and R Moore, *Biology of Fishes*, Talyor and Francis Group, CRC Press, U.K.
2. D. H. Evans and J. D. Claiborne, *The Physiology of Fishes*, Taylor and Francis Group, CRC Press, UK von der Emde, R.J. Mogdans and B.G. Kapoor. *The Senses of Fish: Adaptations for the Reception of Natural Stimuli*. Springer, Netherlands.
3. Chandy, M. *Fishes*. National Book Trust India.
4. Jingran, V.G. *Fish & Fisheries of India*. Hindustan Publishing Corporation India.
5. Langler, K.F. Ichthyology (2nd Edn.) John Wiley & Sons, New York.
6. Nickolsky, G.V. *The Ecology of Fishes*. Academic Press, London.
7. C.B.L. Srivastava, *Fish Biology*, Narendra Publishing House.
8. J.R. Norman, *A history of Fishes*, Hill and Wang Publishers.

9. S.S. Khanna and H.R. Singh, *A text book of Fish Biology and Fisheries*, Narendra Publishing House.
10. Pandey & Shukla. Fish & Fisheries. Rastogi Publications.

[All the books shall be of latest editions]

EZO-004
[PRACTICAL BASED ON EZO-003]

No. of Credits: 1
Total marks: 25

Experiments **14 marks**

1. Morphometric and meristic characters of fishes.
2. Study of different types of fish scales (through permanent slides/ photographs).
3. Study of crafts and gears used in Fisheries.
4. Water quality criteria for Aquaculture: Assessment of pH, free CO_2, dissolved O_2 and alkalinity.
5. Study of air breathing organs in *Channa, Heteropneustes, Anabas* and *Clarias.*
6. Demonstration of induced breeding in fishes (video).
7. Demonstration of parental care in fishes (video).

Project Report on a visit to any fish farm/ pisciculture unit/Zebrafish rearing Lab. **3 marks**

Laboratory Record Book **3 marks**

Viva Voce **5 marks**

GZO-311
[ANIMAL BIOTECHNOLOGY]

No. of Credits: 3
Total marks: 75

Unit 1: Introduction **8 lectures/10 marks**

1. Historical background of Biotechnology
2. Definition, Scope and Perspectives of Biotechnology

Unit 2: Molecular Techniques in Gene manipulation **22 lectures/30 marks**

1. Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC, MAC and Expression vectors (characteristics).
2. Restriction enzymes: Definition, Types and Functions.
3. Transformation techniques: Calcium chloride method and electroporation
4. Construction of genomic and cDNA libraries and screening by colony and plaque hybridization
5. Southern, Northern and Western blotting
6. DNA sequencing: Sanger method
7. Polymerase Chain Reaction; DNA Finger Printing and DNA micro array

Unit 3: Genetically Modified Organisms **18 lectures/20 marks**

1. Production of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection.
2. Applications of transgenic animals: Production of pharmaceuticals, production of donor organs, knock out mice.
3. Production of transgenic plants: *Agrobacterium* mediated transformation.
4. Applications of transgenic plants: insect and herbicide resistant plants.

Unit 4: Culture Techniques and Applications **12 lectures/15 marks**

1. Culture media and reagents for Animal cell and Tissue culture.
2. Basic techniques of mammalian cell culture; Expression of cloned genes in mammalian cells.
3. Molecular diagnosis of genetic diseases (Cystic fibrosis and Sickle cell anaemia).
4. Production of human insulin and human growth hormone using rDNA technology.
5. rDNA technology and gene therapy.

SUGGESTED READINGS

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). *Principles of Genetics*. VIII Edition. Wiley India.
2. Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. *An Introduction to Genetic Analysis*. W. H. Freeman and Co., New York, USA.
3. Brown, *T.A. Molecular Biology Labfax II; Gene Cloning and DNA Analysis.* Academic Press, California, USA.
4. Glick, B.R. and Pasternak, J.J. (2009). *Molecular Biotechnology - Principles and Applications of Recombinant DNA*. IV Edition, ASM press, Washington, USA.
5. B.D. Singh. *Biotechnology*. Kalyani Publishers, Delhi, Kolkata, Madras
6. Das, H.K. *Text book of Biotechnology*. Wiley India Pvt. Ltd. New Delhi

[All the books shall be of latest editions]

GZO-312
[PRACTICAL BASED ON GZO-311]

No. of Credits: 1
Total marks: 25

Experiments **14 marks**

1. Isolation of DNA from any living cell/tissue/organism.
2. Digestion of plasmid DNA by restriction enzyme.
3. Construction of circular and linear restriction map from the data provided.
4. Calculation of transformation efficiency from the data provided.
5. To study the following techniques through photographs and/or video:
   a. Southern Blotting
   b. Northern Blotting
   c. Western Blotting
   d. DNA Sequencing (Sanger's method)
   e. Polymerase Chain Reaction (PCR)
   f. DNA Fingerprinting

Submission of Project Report on Animal cell culture **3 marks**

Laboratory Record Book **3 marks**

Viva Voce **5 marks**

SZO-006
[MEDICAL DIAGNOSTICS]

No. of Credits: 2
Total marks: 50

Unit 1: Introduction **2 lectures/3 marks**

1. Definition and scope of medical diagnostics.
2. Importance of medical diagnostics.

Unit 2: Diagnostic Methods used for Blood analysis **9 lectures/16 marks**

1. Composition of blood
2. Total Erythrocyte Count by haemocytometry
3. Total Leucocyte Count by haemocytometry and Differential Leucocyte Count (D.L.C.) using Leishman's stain.
4. Erythrocyte Sedimentation Rate (E.S.R).
5. Packed Cell Volume (P.C.V.)/Haematocrit value

Unit 3: Diagnostic Methods Used for Urine Analysis **3 lectures/5 marks**

1. Physical and Chemical characteristics of urine
2. Microscopical examination of urine.
3. Abnormal constituents of urine

Unit 4: Non-infectious Diseases **5 lectures/8 marks**

1. Causes, types, symptoms, complications, diagnosis and prevention of Diabetes mellitus (Type I and Type II).
2. Hypertension (Primary and secondary).
3. Testing of blood glucose using Glucometer/Kit.

Unit 5: Infectious Diseases **3 lectures/5 marks**

1. Causes, types, symptoms, diagnosis and prevention of Tuberculosis and Hepatitis.

Unit 6: Tumours **5 lectures/8 marks**

1. Types (Benign/Malignant); Metastasis.
2. Detection, diagnosis and treatment of Cancer.
3. Prevention of cancer as per World Cancer Research Fund.

Unit 7: Medical imaging **3 lectures/5 marks**

1. X-Ray and Ultrasonography
2. PET, MRI and CT scan

SUGGESTED READINGS

1. Park, K. (2007), *Preventive and Social Medicine*, B.B. Publishers
2. Godkar P.B. and Godkar D.P. *Textbook of Medical Laboratory Technology*, II Edition, Bhalani Publishing House
3. Cheesbrough M., *A Laboratory Manual for Rural Tropical Hospitals, A Basis for Training Courses*
4. Guyton A.C. and Hall J.E. T*extbook of Medical Physiology*, Saunders
5. Robbins and Cortan, *Pathologic Basis of Disease*, VIIIEdition, Saunders
6. Prakash, G. (2012), *Lab Manual on Blood Analysis and Medical Diagnostics*, S. Chand and Co. Ltd.

[All the books shall be of latest editions]

SEMESTER VII

CZO-419
[DEVELOPMENTAL BIOLOGY]

No. of Credits: 3
Total marks: 75

Unit 1: Introduction **6 lectures/10 marks**

1. Historical perspectives and basic concepts.
2. Landmark Theories of Embryology.
3. Differentiation and Growth.
4. Cytoplasmic determinants and asymmetric cell division.

Unit 2: Gametogenesis, Fertilization & Parthenogenesis **18 lectures/20 marks**

1. Spermatogenesis in mammals, factors affecting spermatogenesis.
2. Oogenesis and vitellogenesis, Egg maturation, Egg membrane formation, Polarity of egg and ooplasmic segregation.
3. Fertilization and Parthenogenesis.

Unit 3: Animal egg, Early stages of development and Foetal membranes **20 lectures/25 marks**

1. Types of animal eggs, Planes & Pattern of cleavage.
2. Blastulation and gastrulation in frog and Chick.
3. Germ layers and their derivatives and homologies.
4. Fat maps & cell lineage, Structure and development of extra-embryonic membranes.
5. Concepts on implantation in human, Placenta and its types, Physiology of placenta.

Unit 4: Organogenesis, Tissue interactions & Metamorphosis **16 lectures/20 marks**

1. Organogenesis of central nervous system, sense organs, heart and kidney.
2. Tissue interactions (inductions) in development.
3. Metamorphosis: Retrogressive and Progressive; Hormonal regulation of metamorphosis in Anura and Insecta.
4. Organizer concept.

SUGGESTED READINGS

1. Balinsky, B.I.: An introduction to Embryology, W.B. Saunders-Toppan Co. Japan.
2. Rastogi, V. B. and M.S. Jayaraj: Developmental Biology, Kedarnath Ramnath, Meerut.
3. Verma, P.S. and Agarwal, V.K.: Chordate Embryology, S. Chand & Co. Ltd., New Delhi.
4. Gilbert, S.F. Developmental Biology, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
5. Lewis Wolpert. Principles of Development, Oxford University Press.

[All the books shall be of latest editions]

CZO-420
[PRACTICAL BASED ON CZO-419]

No. of Credits: 1
Total marks: 25

Experiments **17 marks**

1. Study of different developmental stages of frog: whole mount/section of cleavage, blastula, gastrula and neurula.
2. Study of different developmental stages of chick: whole mount of 18, 24, 33, 36, 43, 48 and 72 hours of incubation.
3. Study of sections of blastula and gastrula of chick.
4. Study of different sections of placenta (photomicrograph/slides).

Laboratory Record Book **3 marks**

Viva Voce **5 marks**

ZSE-005
[EVOLUTIONARY BIOLOGY]

No. of Credits: 3
Total marks: 75

Unit 1: Introduction **5 lectures/10 marks**

1. Theories of Biogenesis (Life from Life), Biochemical or Chemosynthetic origin of life, Biogeny (Biological Evolution), Evolution of eukaryotic organelles.
2. Historical perspective of Evolutionary Biology.
3. Basic concepts of Organic Evolution.

Unit 2: Evidences of Evolution **15 lectures/15 marks**

1. Evidences from Anatomy, Embryology, Physiology, Biochemistry, Genetics and Molecular Biology.
2. Evidences from Taxonomy and Palaeontology.

Unit 3: Theories of Evolution **10 lectures/10 marks**

1. Lamarckism, Darwinism & Neo-Darwinism.
2. Modern Synthetic Theory of Evolution.
3. Neutral Theory of Evolution.

Unit 4: Population Genetics, Genetic Drift, Gene Flow & Speciation **10 lectures/15 marks**

1. Hardy-Weinberg Equilibrium.
2. Random Genetic Drift (Sewall Wright Effect).
3. Gene Flow and Population.
4. Species Concept, Speciation, Modes of Speciation (Sympatric, Allopatric, Parapatric & Alloparapatric Speciation).

Unit 5: Mechanisms of Evolution **10 lectures/10 marks**

1. Variation: Definition, Types, Sources, Role of variation in evolution.
2. Mutation: Definition, Types, Causes, Role of mutation in evolution.
3. Role of Isolating mechanisms in mutation.
4. Role of Reproductive Isolation in Evolution.

Unit 6: Adaptations and Zoogeography **10 lectures/15 marks**

1. Definition of Adaptation, kinds of Adaptation (Adaptive radiation & Convergence) & Causes of Adaptation.
2. Structural Adaptations: Aquatic, Deep sea, Terrestrial, Volant, Desert & Cave Adaptations).
3. Colouration and Mimicry in animals.
4. Zoogeographical regions of the world.

SUGGESTED READINGS

1. Lull, R.S. Organic evolution. Light and Life Publisher.
2. Rastogi, Veer Bala. Organic Evolution. Meditech, A division of Scientific International Pvt. Ltd.
3. Ridley, M. Evolution, Blackwell publishing
4. Hall, B.K. and Hallgrimson, B. Evolution, Jones and Barlett Publishers.
5. Campbell, N.A. and Reece J.B. Biology, Pearson, Benjamin, Cummings.
6. Douglas, J. Futuyma. Evolutionary Biology. Sinauer Associates.
7. Snustad. S. Principles of Genetics.

[All the books shall be of latest editions]

ZSE-006
[PRACTICAL BASED ON ZSE-005]

No. of Credits: 1
Total marks: 25

Experiments **17 marks**

1. Study of fossils from models/pictures.
2. Study of homology and analogy from suitable specimens.
3. Study and verification of Hardy-Weinberg Law by Chi square analysis.
4. Study of structural modifications in animals (*Hippocampus, Gara, Remora, Rhacophorus, Draco and Pteropus*) for adaptation.

Laboratory Record Book **3 marks**

Viva Voce **5 marks**

ZSE-007
[APPLIED ZOOLOGY & ETHOLOGY]

No. of Credits: 3
Total marks: 75

APPLIED ZOOLOGY

Unit 1: Medical Parasitology **8 lectures/10 marks**

1. Life cycle and pathogenicity of *Entamoeba histolytica* and *Trypanosoma gambiense*
2. Life cycle and pathogenicity of *Ascaris lumbricoides* and *Wuchereria bancrofti*

Unit 2: Sericulture, Apiculture and Lac culture **10 lectures/15 marks**

1. Sericulture: Species diversity, life history, rearing methods, diseases, economic utility of tasar and mulberry silkworms.
2. Sericulture in Manipur: prospects and challenges.
3. Apiculture: Species diversity, life history, rearing methods, economic utility of bees.
4. Lac culture: Life cycle of *Laccifer lacca*; Economic utility of lac insects.

Unit 3: Fish and Fisheries **12 lectures/12 marks**

1. Fisheries: Culture and Capture fisheries; Inland fisheries.
2. Fishes of commercial value: food, medicinal and ornamental.
3. Pisciculture techniques: Extensive and intensive fish culture, hybridization and hypophysation, integrated fish farming with special reference to Manipur.

Unit 4: Aquaculture **12 lectures/13 marks**

1. Potential scope of Aquarium Fish Industry as a Cottage Industry; Sustainable aquaculture.
2. Preparation and maintenance of fish aquarium.
3. Brood stock management.
4. Role of water quality in aquaculture.

Unit 5: Animal Husbandry and Poultry Farming **8 lectures/10 marks**

1. Preservation and artificial insemination in cattle.
2. Induction of early puberty and synchronization of estrus in cattle.
3. Principles of poultry breeding; Processing and preservation of eggs.

ETHOLOGY **10 lectures/15 marks**

1. Concepts of Ethology; Types of animal behavior: Learning behavior in animals.
2. Communication in Insects; Parental care in fishes.
3. Courtship behavior in fishes and birds; Migration in insects, fishes and birds.
4. Biological Rhythm and Circadian Rhythm

SUGGESTED READINGS

1. Cheng, T.C.: *General Parasitology*, Academic Press College Division, Harcourt Brace Javanovich, Publishers Orlando, Florida (2nd Edition, 1986).
2. Smyth, J.D.: *Animal Parasitology*, Cambridge University Press (3rd Edition, 1993).
3. Ichhpujani R.L. and R. Bhatia: *Medical Parasitology*, Jaypee Brother Medical Publishers (P) Ltd. New Delhi.
4. Jhingran, V.G.: *Fish & Fisheries of India,* 3rd. En. Today & Tomorrow Book Agency, New Delhi.
5. G.S. Shukla and V.B. Upadhyay: *Economic Zoology*, Rastogi Publications, Shivaji Road, Meerut
6. David, B.V. and Anantha Kiishnan, T.N.: *General and Applied Entomology*, Tata-Mcgraw-Hill, New Delhi.
7. Dandin, S.B. et al. *Handbook of Sericulture Technologies*. Central Silk Board, Bangalore.
8. Mathur, R. Animal Behavior. Rastogi Publications, Meerut.
9. Aubrey Manning and Marian Stamp Dawkins. An Introduction to Animal Behavior. Cambridge University Press.

[All the books shall be of latest editions]

ZSE-008
[PRACTICAL BASED ON ZSE-007]

Number of Credits: 1
Total marks: 25

Experiments **10 marks**

1.

a. Study of *Entamoeba histolytica*, *Trypanosoma gambiense, Ascaris lumbricoides* and *Wuchereria bancrofti* through permanent slides/photomicrographs/specimens.
b. Study of stages of life history of honey bee/silk moth/fish.
c. Morphological differences among different castes of honey bee.
d. Taxonomic identification of some common indigenous fishes.
e. Water quality criteria for Aquaculture: Assessment of pH, Conductivity, Total solids, Total dissolved solids.

2. Study on learning behaviour in animals (habituation, imprinting, motivation and drive) **7 marks**

Laboratory Record Book **3 marks**

Viva Voce **5 marks**

ZSE-009
[BIOLOGICAL TECHNIQUES]

Number of Credits: 3
Total marks: 75

Unit 1: **10 lectures/15 marks**

1. Principle and use of pH meter and centrifuge machine.
2. Microscopy: Principles and applications of Bright field, Dark field, Phase contrast and Electron microscopes.

Unit 2: **20 lectures/20 marks**

1. Principles and applications of Paper and Thin layer chromatography.
2. Elementary knowledge of High Performance Liquid Chromatography (HPLC).

Unit 3: **20 lectures/25 marks**

1. Principles and applications of Agarose and Polyacrylamide gel electrophoresis (PAGE).
2. Principles and applications of Colorimeter, UV- visible spectrophotometer and Flame photometer.

Unit 4: **10 lectures/15 marks**

1. Elementary knowledge of Enzyme-Linked Immunosorbent Assay (ELISA).
2. Basics of Polymerase Chain Reaction (PCR).

SUGGESTED READINGS

1. Wilson, K. and Goulding, K.H.: A Biologist Guide to Principles and Techniques of Practical Biochemistry, ELBS Ed.
2. Wilson, K. & Walker, J.: Practical Biochemistry (2003), Cambridge University Press.
3. Plummer, D.T.: An Introduction to Practical biochemistry (3rd Ed. 2003), Tata-McGraw-Hill Publ. Co., New Delhi.
4. Robert, B: Introduction to Instrumental Analysis (Latest Ed.), McGraw Hill International Publ.
5. Boyer: Modern Experimental Biochemistry and Molecular Biology (2nd Ed. 1993), Benjamin/Cumin.

[All the books shall be of latest editions]

ZSE-010
[PRACTICAL BASED ON ZSE-009]

Number of Credits: 1
Total marks: 25

Experiments **17 marks**

1. Operation of compound microscope using 10X, 40X and 100X objectives including oil immersion technique.
2. Measurement of the size of cell/small organism using stage micrometer and oculometer.
3. Demonstration of the use of centrifuge machine.
4. Demonstration of the use of Spectrophotometer.
5. Demonstration of the use of ELISA reader.

Laboratory Record Book **3 marks**

Viva Voce **5 marks**

SEMESTER VIII

CZO-421
[IMMUNOLOGY]

No. of Credits: 3
Total marks: 75

Unit 1: Introduction **5 lectures/10 marks**

1. Historical perspective of Immunology.
2. Scope, Prospect and Importance of Immunology.
3. Cells and organs of the Immune System.

Unit 2: Immunity **15 lectures/20 marks**

1. Definition, Types (Innate and Acquired Immunity; Passive and Active Immunity) and Mechanism of Immunity.
2. Cell mediated and Humoral Immunity.
3. Maturation, activation and differentiation of B- & T- lymphocytes.

Unit 3: Antigens and Antibodies **10 lectures/15 marks**

1. Antigenicity and Immunogenicity; Immunogens, Adjuvants and haptens.
2. Factors influencing immunogenicity; B- & T- Cell epitopes.
3. Structure and functions of different classes of immunoglobulins.
4. Antigen-antibody interactions.

Unit 4: Antigen presentation and Major Histocompatibility Complex (MHC) **10 lectures/10 marks**

1. Structure and functions of MHC molecules.
2. Endogenous and exogenous pathways of antigen processing and presentation.

Unit 5: Cytokines **10 lectures/10 marks**

1. Types and functions of Cytokines.
2. Therapeutic cytokines.

Unit 6: Complement System, Hypersensitivity and Vaccines **10 lectures/10 marks**

1. Components and pathways of complement activation.
2. Gell and Coombs' classification and brief description of various types of hypersensitivities.
3. Types of vaccines and recent approaches in vaccine production.

SUGGESTED READINGS

1. Roitt, I.M.: Essential Immunology, ELBS Edition.
2. Paul, W.E.: Fundamentals of Immunology, Lippincott-Raven Pub., Philadelphia, New York.
3. Kuby: Immunology, W.H. Freeman, USA.
4. Lal, S.S.: Immunology, Rastogi Pub., Meerut, India (3rd ed., 2012).
5. Tizzard, I: Immunology.

[All the books shall be of latest editions]

CZO-422
[PRACTICAL BASED ON CZO-421]

Number of Credits: 1
Total marks: 25

Experiments **17 marks**

1. Study of permanent histological sections of spleen, thymus, tonsil, and lymph nodes.
2. Ouchterlony's double immuno-diffusion method.
3. Cell counting and viability test from splenocytes of farm bred animals/cell lines.
4. Determination of ABO and Rh blood group in own blood.
5. Demonstration of Immunoelectrophoresis.

Laboratory Record Book **3 marks**

Viva Voce **5 marks**

ZSE-011
[ANIMAL BIOTECHNOLOGY]

No. of Credits: 3
Total marks: 75

Unit 1: Introduction **8 lectures/10 marks**

1. Historical background of Biotechnology.
2. Definition, Scope and Perspectives of Biotechnology.

Unit 2: Molecular Techniques in Gene manipulation **22 lectures/30 marks**

1. Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC, MAC and Expression vectors (characteristics).
2. Restriction enzymes: Definition, Types and Functions.
3. Transformation techniques: Calcium chloride method and electroporation.
4. Construction of genomic and cDNA libraries and screening by colony and plaque hybridization.
5. Southern, Northern and Western blotting.
6. DNA sequencing: Sanger method.
7. Polymerase Chain Reaction; DNA Finger Printing and DNA micro array.

Unit 3: Genetically Modified Organisms **18 lectures/20 marks**

1. Production of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection.
2. Applications of transgenic animals: Production of pharmaceuticals, production of donor organs, knock out mice.
3. Production of transgenic plants: *Agrobacterium* mediated transformation.
4. Applications of transgenic plants: insect and herbicide resistant plants.

Unit 4: Culture Techniques and Applications **12 lectures/15 marks**

1. Culture media and reagents for Animal cell and Tissue culture.
2. Basic techniques of mammalian cell culture; Expression of cloned genes in mammalian cells.
3. Molecular diagnosis of genetic diseases (Cystic fibrosis and Sickle cell anaemia).
4. Production of human insulin and human growth hormone using rDNA technology.
5. rDNA technology and gene therapy.

SUGGESTED READINGS

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). *Principles of Genetics*. VIII Edition. Wiley India.
2. Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. *An Introduction to Genetic Analysis*. W. H. Freeman and Co., New York, USA.
3. Brown, *T.A. Molecular Biology Labfax II; Gene Cloning and DNA Analysis.* Academic Press, California, USA.
4. Glick, B.R. and Pasternak, J.J. (2009). *Molecular Biotechnology - Principles and Applications of Recombinant DNA*. IV Edition, ASM press, Washington, USA.
5. B.D. Singh. *Biotechnology*. Kalyani Publishers, Delhi, Kolkata, Madras
6. Das, H.K. *Text book of Biotechnology*. Wiley India Pvt. Ltd. New Delhi

[All the books shall be of latest editions]

ZSE-012
[PRACTICAL BASED ON ZSE-011]

No. of Credits: 1
Total marks: 25

Experiments **14 marks**

1. Isolation of DNA from any living cell/tissue/organism.
2. Digestion of plasmid DNA by restriction enzyme.
3. Construction of circular and linear restriction map from the data provided.
4. Calculation of transformation efficiency from the data provided.
5. To study the following techniques through photographs and/or video:
   a. Southern Blotting
   b. Northern Blotting
   c. Western Blotting
   d. DNA Sequencing (Sanger's method)
   e. Polymerase Chain Reaction (PCR)
   f. DNA Fingerprinting

Submission of Project Report on Animal cell culture **3 marks**

Laboratory Record Book **3 marks**

Viva Voce **5 marks**

ZSE-013
[COMPUTATIONAL BIOLOGY & BIOINFORMATICS]

No. of Credits: 3
Total marks: 75

Unit 1: Introduction to Bioinformatics **5 lectures/10 marks**

1. Importance, Goal, and Scope of Bioinformatics.
2. Genomics, Transcriptomics, Systems Biology, Functional Genomics, Metabolomics, & Molecular Phylogeny.
3. Applications and Limitations of Bioinformatics.

Unit 2: Biological Databases **10 lectures/18 marks**

1. Introduction to Biological databases; Primary, secondary and composite databases.
2. Nucleic acid databases (GenBank, DDBJ, EMBL and NDB); Protein databases (PIR, SWISS-PROT, TrEMBL, PDB).
3. Metabolic pathway database (KEGG, EcoCyc, and MetaCyc).
4. Small molecule databases (PubChem, Drug Bank, ZINC, CSD).

Unit 3: Data Generation and Data Retrieval **14 lectures/18 marks**

1. Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray).
2. Sequence submission tools (BankIt, Sequin, Webin).
3. Sequence file format (flat file, FASTA, GCG, EMBL, Clustal, Phylip, Swiss-Prot).
4. Sequence annotation; Data retrieval systems (SRS, Entrez).

Unit 4: Basic Concepts of Sequence Alignment **14 lectures/17 marks**

1. Scoring Matrices (PAM, BLOSUM), Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA).
2. Local and global alignment, pair wise and multiple sequence alignments.
3. Similarity, identity and homology of sequences.

Unit 5: Applications of Bioinformatics **7 lectures/12 marks**

1. Structural Bioinformatics (3-D protein, PDB).
2. Functional genomics (genome wide and high throughput approaches to gene and protein function).
3. Drug discovery method (Basic concepts).

SUGGESTED READINGS

1. Ghosh Z and Mallick B. (2008). Bioinformatics: Principles and Applications, Oxford University Press.
2. Pevsner J. (2009). Bioinformatics and Functional Genomics, II Edition, Wiley Blackwell.
3. Zvelebil, Marketa and Baum O. Jeremy (2008). Understanding Bioinformatics, Garland Science, Taylor and Francis Group, USA.

[All the books shall be of latest editions]

ZSE-014
[PRACTICAL BASED ON ZSE-013]

No. of Credits: 1
Total marks: 25

Experiments **17 marks**

1. Accessing biological databases.
2. Retrieval of nucleotide and protein sequences from the databases.
3. To perform pair-wise alignment of sequences (BLAST) and interpret the output.
4. Translate a nucleotide sequence and select the correct reading frame of the polypeptide from the output sequences.
5. Predict the structure of protein from its amino acid sequence.

Laboratory Record Book **3 marks**

Viva Voce **5 marks**

ZSE-015
[BIOSTATISTICS]

No. of Credits: 3
Total marks: 75

Unit 1: Introduction **10 lectures/10 marks**

1. Definition, history and scope of biostatistics.
2. Application of biostatistics in biological sciences.
3. Role of biostatistics in modern research.

Unit 2: Data collection and Sampling techniques **10 lectures/10 marks**

1. Census and Sample; Sample population and target population.
2. Sampling methods: Random (Probability) and Non-Random (Non-Probability or Deliberate) Sampling methods.

Unit 3: Frequency distributions and Representation of data **15 lectures/20 marks**

1. Methods of data presentation.
2. Diagrammatic and graphical representation of data (Bar diagram, Histogram, Pie chart, Pictogram, etc.).
3. Significance and types of frequency distributions.

Unit 4: Statistical measures of Variability (Dispersion) and Probability distributions **15 lectures/20 marks**

1. Computation of mean, median and mode from grouped and ungrouped data.
2. Computation of variance, standard deviation, standard error and their coefficient; Skewness and Kurtosis.
3. Concept of normal distribution.

Unit 5: Inferential Statistics and Hypothesis testing **10 lectures/15 marks**

1. Correlation and Regression; Student's t-test, Chi-square Test & F-Test.
2. Analysis of Variance (ANOVA): Definition and Types of ANOVA,

SUGGESTED READINGS

1. Zar, Jerrold H. (1999). Biostatistical Analysis, IV Edition, Pearson Education Inc and Dorling Kindersley Publishing Inc. USA.
2. Antonisamy, B., Christopher S. and Samuel, P. P. (2010). Biostatistics: Principles and Practice. Tata McGraw Hill Education Private Limited, India.
3. Pagana, M. and Gavreau, K. (2000). Principles of Biostatistics, Duxberry Press, USA.
4. Veer Bala Rastogi (2017). Biostatistics, Medtech, A division of Scientific International Pvt. Ltd., India.

[All the books shall be of latest editions]

ZSE-016
[PRACTICAL BASED ON ZSE-015]

No. of Credits: 1
Total marks: 25

Experiments **17 marks**

1. To learn graphical representations of statistical data with the help of computers (e.g., MS Excel).
2. To perform a "two-sample t- test" for a given set of data.
3. Computation and tests of significance for correlation and regression coefficients.
4. Statistical analysis of data using MS-Word.

Laboratory Record Book **3 marks**

Viva Voce **5 marks**