VIMALA COLLEGE (AUTONOMOUS), THRISSUR

B.Sc. DEGREE PROGRAMME IN ZOOLOGY

UNDER CHOICE BASED CREDIT AND SEMESTER SYSTEM (CBCSSUG 2019)

SCHEME AND SYLLABUS

2019 ADMISSION ONWARDS

FIRST SEMESTER B.Sc. ZOOLOGY PROGRAMME

Table 6

ANIMALDIVERSITY: NON-CHORDATA PART- I

Code: ZOL1B01T

[DIVERSITY, ADAPTATIONS AND FUNCTIONAL ANATOMY OF PROTOZOANS AND ACOELOMATE AND PSEUDOCOELOMATE NON-CHORDATES]

[36 hours] [2 hours per week] [2 Credits]

COURSE OUTCOMES (COs)

COs	Course Outcome Statements
CO1	Describe the principles of classification and nomenclature (5 hrs)
CO2	Explain the five kingdom classification of living organisms (1 hr)
CO3	Understand the concepts of classification of animals (4 hrs)
CO4	Explain the classification with examples and characteristic features of kingdom Protista and describe the morphology and structural organization of *Paramecium* (6 hrs)
CO5	Describe the characteristic features of subkingdom Mesozoa (1 hr)
CO6	Explain the classification of phylum Porifera and elucidate the salient features of each class (3 hrs)
CO7	Describe the characteristic features of phylum Cnidaria and Ctenophora, illustrate the classification of phylum Cnidaria down to classes and explain the structural organization of *Obelia* (8 hrs)
CO8	Explain the salient features of phylum Platyhelminthes and illustrate its classification down to classes (3 hrs)
CO9	Explain the characteristic features and classification of super-phylum Aschelminthes and phylum Nematoda (3 hrs)
CO10	Elucidate the characters of Pseudocoelomate minor phyla Rotifera and Gastrotricha (2 hrs)

Question paper pattern for external examination

[Module 1-4: Short answer 5x2=10 marks, Paragraph 3x5=15 marks, Essay 1x10= 10 marks
Module 5-10: Short answer 7x2=14 marks, Paragraph 4x5=20 marks, Essay 1x10=10 marks]

Section A. CONCEPTS OF CLASSIFICATION OF ORGANISMS

MODULE 1. Principles of classification and nomenclature (5 hrs)

Systematics: natural and classical. Nomenclature: Binomial and Trinomial nomenclature; International rules of Zoological nomenclature (brief account);

Mention modern trends in systematics: Chemotaxonomy, Serotaxonomy, Cytotaxonomy, Evolutionary taxonomy, Numerical taxonomy (Phenetics), Cladistics (Phylogenetics), Molecular systematics, DNA barcoding.

[Short answers/paragraphs/Essays]

MODULE 2. Five kingdom classification of living organisms (1 hr)

Mention Cavalier-smith's eight kingdom classification also.

[Short answers/Paragraphs]

MODULE 3. Concepts of classification of animals (4 hrs)

Classification based on number of cells, tissue or organ system level of organization, development of germ layers, development of symmetry, development of coelom, segmentation, homology and analogy of organs and their origin, development of mouth and digestive tract (brief account).

[Short answers/Paragraphs]

Section B. CLASSIFICATION OF KINGDOM PROTISTA

MODULE 4. Kingdom: PROTISTA (6 hrs)

Characteristic features and classification of Kingdom Protista down to phyla. [*Salient features of the major groups of protists given below with notes on the examples cited*]

Phylum: Rhizopoda	e.g.*Entamoeba*
Phylum: Dinoflagellata	e.g.*Noctiluca*
Phylum:Parabasilia	e.g.*Trichonympha*
Phylum: Apicomplexa [=Sporozoa]	e.g. *Plasmodium*
Phylum: Ciliophora	e.g.*Vorticella.*

Type ***Paramecium***: Morphology and structural organization [as revealed by compound microscopy]; locomotion, nutrition, excretion, osmoregulation and reproduction; conjugation in detail.

[Short answers/Paragraphs/Essays]

Section C. KINGDOM: ANIMALIA

Salient features of the Major Phyla of animals and their diversity.

[*Habits, habitat,morphology, functional anatomy and life history of representative types (wherever specified) and classification of each phylum down to classes, except otherwise mentioned, and examples thereof: Study of animal diversity with typical examples from each class, with emphasis on ecological and adaptive features, economic importance and such other points of biological interest expected. Only very brief account of each example is to be studied.*]

MODULE 5. Subkingdom: MESOZOA (1 hr)

A brief account of Dicyemid (=Rhombozoans) mesozoans [e.g. *Dicyema*] and Orthonectid mesozoans [e.g. *Rhopalura*]

[Short answers/Paragraphs]

MODULE 6. Subkingdom: PARAZOA (3 hrs)

Phylum: PORIFERA

Classification down to classes and salient features of each class.

Class Calcarea (=Calcispongiae)	e.g.*Leucosolenia*
Class Demospongiae	e.g.*Spongilla*
Class Hexactinellida (=Hyalospongiae)	e.g.*Euplectella*

Give an account of canal system (Asconoid, Syconoid, Leuconoid and Rhagonoid); Mention amphiblastula, parenchymula and sponge gemmule.

[Short answers/Paragraphs/Essays]

MODULE 7. Subkingdom: METAZOA (8 hrs)

Phylum CNIDARIA [=COELENTERATA] (7 hrs)

Classification of the phylum down to classes and salient features of each class.

Class Hydrozoa	e.g.*Halistemma, Physalia*
Class Scyphozoa	e.g.*Rhizostoma*

Class Anthozoa e.g.*Adamsia, Zoanthus,* and *Madrepora*

Type ***Obelia***: Morphology and life cycle.
Polymorphism in cnidarians with special reference to siphonophores.

Phylum CTENOPHORA [=ACNIDARIA] (1 hr)

Unique features as exemplified by *Pleurobrachia*; mention cidippid larva.

[Short answers/Paragraphs/Essays]

MODULE 8. ACOELOMATA (3 hrs)

Phylum PLATYHELMINTHES

Classification down to classes and salient features of the following classes.

ClassTurbellaria	e.g.*Bipalium*
Class Trematoda	e.g.*Fasciola*
Class Cestoda	e.g.*Taenia*

Type ***Dugesia*** (Planaria):Structural organization, Digestive system, locomotion and reproduction.

[Short answers/Paragraphs/Essays]

MODULE 9. PSEUDOCOELOMATA (3 hrs)

Super Phylum: ASCHELMINTHES

Classification down to phyla; highlight the heterogeneous nature of animals of this group.

Phylum: NEMATODA

Characteristic features of *Ascaris*.
Examples: *Ancylostoma, Enterobius, Wuchereria*

[Short answers/Paragraphs/Essays]

MODULE 10. PSEUDOCOELOMATE MINOR PHYLA (2 hrs)

Salient features of the followingpseudocoelomate minor phyla:

Phylum **Gastrotricha**	e.g.*Chaetonotus*
Phylum **Rotifera**	e.g.*Brachionus*

[Short answers/Paragraphs]

Topics for assignments/seminars

(Topics allotted for assignments/ seminars should be considered for internal assessments only, and can be subdivided among students)

1. Nutrition in protozoans.
2. Reproduction in protozoans.
3. Parasitic protozoans of man.
4. Helminth parasites of man.
5. Reef building corals and coral reefs.

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- Barnes, R.S.K., Calow, P.P., Olive, P.J.W., Golding, D.W. & Spicer, J.I. (2009). *The Invertebrates: A Synthesis*, 3rd Edition. Wiley Blackwell Science, UK.
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SECOND SEMESTER B. Sc. ZOOLOGY PROGRAMME

ZOOLOGY CORE COURSE- II (Theory)

ANIMAL DIVERSITY: NON-CHORDATA PART – II

Code: ZOL2B02T

[DIVERSITY, ADAPTATIONS & FUNCTIONAL ANATOMY OF COELOMATE NON-CHORDATES]

[36 hours] [2 hours per week] [2 Credits]

COURSE OUTCOMES [COs]

COs	Course Outcome Statements
CO1	Explain the classification with examples and characteristic features of phylum Annelida and describe the morphology and structural organization of *Neanthes* (7 hrs)
CO2	Describe the distribution, peculiarities and affinities of phylum Onychophora (2 hrs)
CO3	Explain the classification of phylum Arthropoda;elucidate the salient features of each class and describe the morphology and structural organization of *Penaeus*(11 hrs)
CO4	Describe the characteristic features of phylum Mollusca, illustrate its classification down to classes and explain the structural organization of *Pila globosa* (8 hrs)
CO5	Explain the salient features of phylum Echinodermata and illustrate its classification down to classes (4 hrs)
CO6	Understand the salient features and affinities of phylum Hemichordata (1 hr)
CO7	Elucidate the characters of coelomate minor phyla Phoronida, Ectoprocta and Echiura (3 hrs)

Question paper pattern for external examination

[Module 1-3: Short answer 7x2=14 marks, Paragraph 4x5=20 marks, Essay 1x10= 10 marks
Module 4-7: Short answer 5x2=10 marks, Paragraph 3x5=15 marks, Essay 1x10=10 marks]

COELOMATA

MODULE 1. Phylum ANNELIDA (7 hrs)

Classification down to subclasses; salient features of the following classes and subclasses:

1. Class Polychaeta — e.g. *Arenicola*
2. Class Clitellata
   - Subclass Oligochaeta — e.g. *Megascolex*
   - Subclass Hirudinea — e.g. *Hirudinaria, Haemadipsa*

Type: ***Neanthes*** [Nereis]

[Morphology, body wall, digestive system, respiratory system, circulatory system, excretory system, sense organs and reproductive system. Mention Heteronereis stage and Trochophore larva.]

[Short answers/Paragraphs/Essays]

MODULE 2. Phylum ONYCHOPHORA (2 hrs)

Peripatus [distribution, peculiarities and affinities).

[Short answers/Paragraphs]

MODULE 3. Phylum ARTHROPODA (11 hrs)

Classification down to classes (mention the five subphyla and 16 arthropod classes); salient features of the following classes:

1. Class Trilobita	[brief account only]
2. Class Merostomata	e.g. *Limulus*
3. Class Arachnida	e.g. *Heterometrus* (*Palamnaeus*),*Heteropoda* (Huntsman spider, Order *Araneae*). Mention ticks and mites (Subclass *Acari*).
4. Class Chilopoda	e.g. *Scolopendra, Scutigera*
5. Class Diplopoda	e.g. *Spirostreptus, Julus*
6. Class Crustacea	e.g. *Sacculina, Eupagurus*
7. Class Insecta	e.g. *Lepisma, Mantis, Tabanus, Troides minos* (Southern Birdwing butterfly), *Papilio buddha* (Malabar Banded Peacock),*Apis*.

Type: ***Penaeus indicus*** [Prawn]

[Morphology, digestive system, respiratory system, blood vascular system, excretory system, nervous system, sense organs (statocyst, compound eye in detail), reproductive system and development] [Details of larval stages not expected].

[Short answers/Paragraphs/Essays]

MODULE 4. Phylum MOLLUSCA (8 hrs)

Classification down to classes; Mention Nudibranchs and *Nautilus*. Salient features of the following classes:

1. Class Aplacophora	e.g. *Chaetoderma*
2. Class Polyplacophora (=Amphineura)	e.g. *Chiton*
3. Class Monoplacophora	e.g. *Neopilina*
4. Class Gastropoda	e.g. *Turbinella*
5. Class Bivalvia (=Pelecypoda)	e.g. *Perna*
6. Class Scaphopoda	e.g. *Dentalium*
7. Class Cephalopoda (=Siphonopoda)	e.g. *Sepia*

Type: ***Pila globosa*** [Apple Snail]

[Morphology, digestive system, respiratory system, blood vascular system, excretory system, nervous system, sense organs (osphradium in detail) and reproductive system].

[Short answers/Paragraphs/Essays]

MODULE 5. Phylum ECHINODERMATA (4 hrs)

Classification down to classes [of extant forms only]; salient features of the following classes and brief account of examples:

1. Class Crinoidea	e.g. *Antedon*
2. Class Asteroidea	e.g. *Astropecten*
3. Class Ophiuroidea	e.g. *Ophiothrix*
4. Class Holothuroidea	e.g. *Holothuria*
5. Class Echinoidea	e.g. *Echinus*

Structural peculiarities of *Asterias* (star fish); water vascular system in detail.

[Short answers/Paragraphs/Essays]

MODULE 6. Phylum HEMICHORDATA (1 hr)

Balanoglossus: Salient features and affinities.

[Short answers/Paragraphs]

MODULE 7. COELOMATE MINOR PHYLA (3 hrs)

Salient features of the following coelomate minor phyla; mention examples specified [structure and life history not required).

1. Phylum **Phoronida** e.g. *Phoronis*
2. Phylum **Ectoprocta** [**Bryozoa]** e.g. *Bugula*
3. Phylum **Echiura** e.g. *Bonellia*

[Short answers/Paragraphs]

Topics for Assignments/Seminars

(*Topics allotted for assignments/ seminars should be considered for internal assessments only, and can be subdivided among students*).

1] Larval forms in Crustacea and their significance.
2] Metamorphosis in insects.
3] Social organization in insects.
4] Economic importance of molluscans.
5] Insect vectors of human diseases.

REFERENCES

- Anderson, D. T. (2001). *Invertebrate Zoology*. 2nd edition. University of Michigan, Oxford University Press (Indian Edition. 2006).
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THIRD SEMESTER B. Sc. ZOOLOGY PROGRAMME

ZOOLOGY CORE COURSE – III (Theory)

ANIMAL DIVERSITY: CHORDATA PART - I

CODE: ZOL3B03T

[TAXONOMY, DIVERSITY, STRUCTURAL ANATOMY AND ADAPTATIONS OF CHORDATES]

[54 hours] [3 hours per week] [3 credits]

COURSE OUTCOMES [COs]

COs	Course Outcome Statements
CO1	Explain the characteristics of chordates and outline classification of the phylum Chordata (2 hrs)
CO2	Describe the salient features and affinities of subphylum Urochordata and its classification down to classes; elucidate the morphology and structural organization of *Ascidia* (5 hrs)
CO3	Explain the salient features and affinities of subphylum Cephalochordata with reference to *Branchiostoma* (4 hrs)
CO4	Describe the salient features of subphylum Vertebrata, illustrate its classification down to classes and elucidate the characteristics of division Agnatha (3 hrs)
CO5	Enumerate the salient features of superclass Pisces and illustrate its classification down to orders and the morphology and structural organization of *Mugil cephalus* (12 hrs)
CO6	Describe the salient features and affinities of class Amphibia and its classification up to orders; explain the morphology and organ systems of *Hoplobatrachus tigerinus* (13 hrs)
CO7	Elucidate the characteristic features of the class Reptilia and its classification down to orders; describe the morphology and organ systems of *Calotes versicolor* (15hrs)

Question paper pattern for external examination

[Module 1-3: Short answer 4x2=8 marks, Paragraph 2x5=10
Module 4-7: Short answer 8x2=16 marks, Paragraph 5x5=25 marks, Essay 2x10=20 marks]

MODULE 1. Introduction [**2 hrs**]

Chordate characters (fundamental, general and advanced); chordates versus non-chordates; diversity of chordates; outline classification down to classes; salient features of each subphylum.

[Short answers/Paragraphs]

[*Type studies with special emphasis on morphologyand various functional systems such as integumentary, digestive, respiratory, circulatory, excretory, nervous and reproductive systems. Also mention the evolutionary significance*]

MODULE 2.Subphylum UROCHORDATA [Tunicata] [**5 hrs**]

Classification of the subphylum down to classes. Affinities of urochordates with cephalochordates and vertebrates.

Class Ascidiacea e.g. *Herdmania*
Class Larvacea e.g. *Oikopleura*
Class Thaliacea e.g. *Doliolum*

Type: ***Ascidia*** [Morphology and retrogressive metamorphosis]; add a note on neoteny and paedogenesis.

[Short answers/Paragraphs]

MODULE 3.Subphylum CEPHALOCHORDATA [**4 hrs**]

Type: ***Branchiostoma*** [=Amphioxus]

Morphology and anatomical features; digestive system in detail; primitive,

degenerate and specialized features [affinities and systematic position to be emphasized).

[Short answers/Paragraphs]

MODULE 4. Subphylum VERTEBRATA [3 hrs]

Salient features of subphylum vertebrata and its outline classification down to classes.

Division 1. AGNATHA

Characters, classificationdown to classes and examples: *Myxine; Petromyzon* [mention Ammocoetes larva]

[Short answers/Paragraphs]

Division 2. GNATHOSTOMATA

MODULE 5. Superclass PISCES [12 hrs]

Classification of Pisces down to orders; salient features of the following extent groups:

Class Chondrichthyes [Cartilaginous fishes]

Subclass Selachii e.g.*Scoliodon, Trygon*

Subclass Holocephali e.g.*Chimaera*

Class Osteichthyes [Bony fishes]

Subclass **Sarcopterygii**

1. Order Crossopterygii [Coelacanths] e.g. *Latimeria*
2. Order Dipnoi [Lung fishes] e.g. *Neoceratodus, Protopterus, Lepidosiren* (Add a note on the distribution of lung fishes).

Subclass **Actinopterygii**

1. Superorder Chondrostei e.g. *Acipenser*
2. Superorder Holostei e.g. *Amia, Lepidosteus*
3. Superorder Teleostei [Spiny-rayed fishes] e.g. *Sardinella, Rastrelliger*

Type: ***Mugil cephalus*** (Grey Mullet)

[Morphology, body wall, digestive system, respiratory system, circulatory system, excretory system, sense organs (neuromast organ in detail) and reproductive system].

Sub-terranean fishes from Kerala: *Aenigmachanna Gollum* (Gollum Snakehead), *Kryptoglanis shajii, Horaglanis krishnai* (Blind Catfish) & *Monopterus digressus* (Blind cave eel). Mention recent addition to ornamental fish trade - *Sahyadria denisonii* (Miss Kerala).

[Short answers/Paragraphs/Essays]

Super class **TETRAPODA**

MODULE 6. Class AMPHIBIA [13 hrs]

Classification of Amphibia down to orders with examples [of extant forms only].

Subclass **Stegocephalia** (extinct)

Subclass **Lissamphibia**

1. Order Apoda (=Gymnophiona) e.g.*Ichthyophis, Uraeotyphlus*
2. Order Caudata (=Urodela) e.g.*Necturus, Ambystoma*, mention Axolotl larva.

3. Order Anura (=Salientia) e.g.*Duttaphrynus, Rhacophorus*

Type: ***Hoplobatrachus tigerinus*** (Indian Bullfrog)

[Morphology, body wall, skeletal system,digestive system, respiratory system, circulatory system, excretory system, sense organs and reproductive system].

Mention about the diversity of bush frogs, dancing frogs and night frogs in Western Ghats and the discovery of *Nasikabatrachus sahyadrensis* (Purple frog).

[Short answers/Paragraphs/Essays]

MODULE 7. Class REPTILIA [15 hrs]

Classification of class Reptilia down to orders and salient features of thefollowing orders (only extant forms):

Subclass I - **Anapsida**

1. Order Cotylosauria [stem reptiles] e.g.*Hylonomus*
2. Order Chelonia [common turtles, tortoises etc.] e.g. *Melanochelys, Chelone*

SubclassII - **Diapsida**

1. Order Rhynchocephalia e.g. *Sphenodon*
2. Order Squamata
   - Suborder Lacertilia (Lizards) e.g. *Chamaeleo, Hemidactylus*
   - Suborder Ophidia (Snakes)

Common venomous and non-venomous snakes of Kerala: a] *Python molurus* b]*Ptyas mucosus* c] *Gongylophis* (= *Eryx*) *conicus* d] *Indotyphlops braminus* e] *Bungarus caeruleus* f] *Naja naja* g] *Daboia russellii* *h] Ophiophagus hannah*

Identification key for venomous and non-venomous snakes.

3. Order Crocodilia e.g. *Crocodylus, Gavialis*

[Mention the extinct subclasses **Euryapsida**, **Parapsida** and **Synapsida** (mammal-like reptiles) and mention the origin of mammals from synapsids].

Type: ***Calotes versicolor*** (Garden Lizard)

[Morphology, body wall, skeletal system (exclude skull bones), digestive system, respiratory system, circulatory system, excretory system, sense organs and reproductive system].

[Short answers/Paragraphs/Essays]

Topics for Assignments/Seminars

(*Topics allotted for assignments/ seminars should be considered for internal assessments only, and can be subdivided among students*)

1. Migration of fishes.
2. Parental care in fishes.
3. Parental care in amphibians.
4. Snake venom: nature; composition; antivenin; poly antivenins; prophylaxis.
5. Accessory respiratory organs in fishes.
6. Economic importance of fishes.

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FOURTH SEMESTER B. Sc. ZOOLOGY PROGRAMME

ZOOLOGY CORE COURSE-IV (Theory)

ANIMAL DIVERSITY: CHORDATA PART-II

Code: ZOL4B04T

[TAXONOMY, DIVERSITY, STRUCTURAL ANATOMY AND ADAPTATIONS OF CHORDATES – AVES AND MAMMALS]

[54 hours] [3 hours per week] [3 credits]

COURSE OUTCOMES [COs]

COs	Course Outcome Statements
CO1	Describe the classification of class Aves down to orders, salient features of each order with suitable examples (11 hrs)
CO2	Describe the external characters and functional systems of *Columba livia* (14 hrs)
CO3	Enumerate the salient features and classification of class Mammalia down to orders with suitable examples (11 hrs)
CO4	Elucidate the external characters and functional systems of *Oryctolagus cuniculus* (14 hrs)
CO5	Compare the circulatory, excretory and nervous systems of vertebrates (4 hrs)

Question paper pattern for external examination

[Module 1-2: Short answer 5x2=10 marks, Paragraph 3x5=15 marks, Essay 1x10= 10 marks
Module 3-4: Short answer 5x2=10 marks, Paragraph 3x5=15 marks, Essay 1x10=10 marks
Module 5: Short answer 2x2=4 marks, Paragraph 1x5=5 marks]

CLASS: AVES [25 hrs]

MODULE 1. Classification of Aves [11 hrs]

Classification of class Aves down to the orders specified; mention at least one example for each order.

Subclass **Archaeornithes** **[2 hrs]**

1. Order Archaeopterygiformes e.g. *Archaeopteryx lithographica* – a brief account on its discovery and evolutionary significance.

Subclass **Neornithes** **[2 hrs]**

Super order **Palaeognathae** [=Ratitae]

2. Order Casuariiformes e.g. *Casuarius* (Cassowary)
3. Order Dinornithiformes [=Apterygiformes] e.g. *Apteryx* (Kiwi)
4. Order Rheiformes e.g. *Rhea*
5. Order Struthioniformes e.g. *Struthio* (Ostrich)

Super order **Neognathae** [=Carinatae] **[7 hrs]**

6. Order Galliformes [pheasants, quail, turkeys, grouse] e.g. *Pavo cristatus*
7. Order Anseriformes [screamers, water fowls] e.g. *Anas poecilorhyncha*
8. Order Passeriformes [perching birds] e.g. *Passer domesticus*
9. Order Piciformes [woodpeckers, barbets, honeyguides] e.g. *Dinopium*
10. Order Coraciiformes [kingfishers & allies] e.g. *Alcedo atthis*
11. Order Apodiformes [swifts, humming birds] e.g. *Apus nipalensis*
12. Order Strigiformes [owls] e.g. *Bubo*
13. Order Cuculiformes [cuckoos, roadrunners, turacos] e.g. *Eudynamys*
14. Order Psittaciformes [parrots, lories, cockatoos]
15. Order Gruiformes [cranes, rails, coots, bustards]

e.g. *Psittacula krameri*
e.g. *Ardeotis nigriceps*

16. Order Charadriiformes [plovers, gulls, terns, auks, sand pipers] e.g. *Tringa*
17. Order Columbiformes [pigeons, doves, dodoes, sand grouse] e.g. *Columba*
18. Order Falconiformes [diurnal birds of prey – falcons, hawks] e.g. *Mylvus*
19. Order Ciconiiformes [herons, storks, ibis, spoon bills] e.g. *Ardeola grayii*
20. Order Pelecaniformes [pelicans, cormorants] e.g. *Pelecanus*
21. Order Sphenisciformes [Impennae] e.g. *Aptenodytes* (penguin)
22. Order Phoenicopteriformes [flamingos] e.g. *Phoenicopterus*

Recent Extinctions: Passenger Pigeon [*Ectopistes migratorius*), Dodo [*Raphus cucullatus*], Pink-headed Duck [*Rhodonessa caryophyllacea*], Elephant Bird [*Aepyornis*].

Rediscovery of Jerdon's Courser [*Cursorius bitorquatus*] & Forest Owlet [*Athene blewitti*].

[Short answers/Paragraphs/Essays]

MODULE 2. Type: ***Columba livia*** (Rock Pigeon) **[14 hrs]**

[External characters, integumentary system (structure of feather in detail – exclude development of feather), skeletal system (skull excluded), digestive system, respiratory system, circulatory system, excretory system, sense organs and reproductive system].

[Short answers/Paragraphs/Essays]

CLASS: MAMMALIA [25 hrs]

MODULE 3. **Classification of Mammalia [11 hrs]**

Classification of class Mammalia down to the orders cited with examples specified.

Subclass Prototheria **[2 hr]**

Infraclass **Ornithodelphia** [egg-laying mammals]

1. Order Monotremata e.g. *Ornithorhynchus* [Platypus], *Tachyglossus* [= *Echidna*]

Subclass Theria **[2 hr]**

Infraclass **Metatheria** [marsupials]

2. Order Marsupialia e.g. *Didelphis* [Opossum], *Macropus* [Kangaroo]

Infraclass **Eutheria** [true placental mammals] **[7 hrs]**

3. Order Edentata e.g. *Bradypus* (Sloth), *Dasypus* (Armadillo) *Myrmecophaga* (Spiny ant-eater)
4. Order Pholidota e.g. *Manis* (Pangolin/ Scaly ant-eater)
5. Order Lagomorpha [rabbits and hares] e.g. *Lepus nigricollis*(Indian Hare)
6. Order Rodentia e.g. *Funambulus, Ratufa*(Giant squirrel)
7. Order Soricimorpha [shrews, moles] e.g. *Suncusmurinus, Crocidura*
8. Order Erinaceomorpha e.g. *Paraechinus micropus* (Indian Hedgehog)
9. Order Chrysochloridea e.g. Golden mole of South Africa
10. Order Dermoptera [colugos] e.g.*Cynocephalusvolans* (flying lemur)
11. Order Chiroptera

12. Order Primates — e.g. *Loris, Macaca, Gorilla, Pongo, Hylobates, Homo*

13. Order Carnivora — e.g. *Phoca* (Seal), *Odobenus* (Walrus), *Panthera sp.*, *Viverriculaindica* (Civet), *Lutrogale* (Otter),

Cuon alpinus (Wild dog).

14. Order Cetacea e.g. *Physeter* (Sperm whale), *Delphinus* (Dolphins), *Phocaena* (Porpoise), *Balaenoptera* (Baleen whale]

15. Order Artiodactyla e.g. *Sus scrofa cristatus* (Wild Boar), *Bos gaurus* (Gaur), *Giraffa* (Giraffe), *Hemitragus* [Tahr], *Rusa* (=*Cervus) unicolor* (Sambar deer), *Axis axis* (Spotted deer), *Moschiola* (Mouse deer), *Antilope cervicapra* (Blackbuck).

16. Order Perissodactyla e.g. *Equus caballus* (Horse), *Rhinoceros*

17. Order Sirenia e.g. *Trichechus* (Manatee), *Dugong*

18. Order Proboscidea e.g. *Elephas maximus indicus* [Indian elephant], *Elephas maximus borneensis* [Borneo pigmy elephant], *Loxodonta africana* [African savanna elephant] and *Loxodonta cyclotis* [African forest elephant].

19. Order Hyracoidea e.g. Hyrax (Coney)

20. Order Tubulidentata e.g. *Aardvark*

[Short answers/Paragraphs/Essays]

MODULE 4. Type*: **Oryctolagus cuniculus*** (European Rabbit) **[14 hrs]**

[External features, integumentary system, skeletal system (dentition in detail – skull excluded), digestive system, respiratory system, circulatory system (exclude arterial and venous systems), excretory system, sense organs and reproductive system].

[Short answers/Paragraphs/Essays]

MODULE 5. Comparative Anatomy [4 hrs]

Compare the circulatory, excretory and nervous systems of vertebrates.

[Short answers/Paragraphs]

Topics for Assignments/ Seminars

(*Topics allotted for assignments/ seminars should be considered for internal assessments only, and can be subdivided among students*)

1. Aquatic mammals and their adaptations
2. Dentition in mammals [adaptations related to food)
3. Endangered mammals of Kerala
4. Flying mammals
5. Migration in birds
6. Flight adaptations in birds
7. Flightless birds

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B. Sc. ZOOLOGY PROGRAMME

ZOOLOGY [CORE COURSE] PRACTICAL – I: ANIMAL DIVERSITY

Code: ZOL4B05P

[Practical I*A+ I*B+ I*C+ I*D]

[144 hours] [2 hrs per week] [Spread over first 4 semesters] [4 Credits]

COURSE OUTCOMES [COs]

COs	Course Outcome Statements
CO1	Identify and describe specified protists and acoelomate & pseudocoelomate non-chordates and perform the culture of selected protists; understand the histological features of coelenterate, platyhelminth and nematode. (36 hrs)
CO2	Identify and describe specified coelomate non-chordates and the transverse sections of annelids; Perform mounting of the specified organs of selected non-chordates. (36 hrs)
CO3	Identify and describe specified chordates and specified bones of chordates; Prepare key for identification of venomous snakes; Perform mounting and dissection of specified organ systems of chordates. (36 hrs)
CO4	Identify and describe selected vertebrates and specified bones of vertebrates.(36 hrs)

FIRST SEMESTER B. Sc. DEGREE PROGRAMME

CORE COURSE PRACTICAL- I*A

ANIMAL DIVERSITY: NONCHORDATA Part - I

[36 hours] [2 hrs per week]

[Students are expected to make sketches with notes, while they study the specimens in the laboratory/field itself. The record must carry sketches with notes of all specimens, mountings and dissections. Emphasis must be on scientific accuracy and not on beauty of sketches.]

MODULE 1. [36 hrs]

Section A. Study of the following Non-chordate specimens:

(Choose useful and harmful forms from different habitats. All animals intended for type study are to be included. Slides / museum preparations are to be used; charts / models may be used in exceptional cases. Students are expected to identify the specimens by their generic names and assign them to the respective phyla and classes).

1. **Protists**: *Amoeba, Noctiluca, Ceratium, Entamoeba, Trichonympha, Paramecium* [any 4]
2. **Poriferans**: *Leucosolenia/Scypha* or *Spongilla,* Sponge gemmule, spicules
3. **Cnidarians**: Sedentary hydrozoans: *Hydra, Obelia, Obelia* medusa [any 2]
   Pelagic hydrozoans: *Physalia/Velella*
   Pelagic scyphozoan: *Aurelia/ Rhizostoma*
   Common anthozoans: *Adamsia, Edwardsia, Madrepora, Fungia, Tubipora Gorgonia* [any 3]
4. **Platyhelminths**: Free living flat worm: *Bipalium Dugesia*
   Parasitic flat worms: *Fasciola/Taenia solium*
5. **Aschelminths**: Parasitic round worms: *Ascaris*/*Ancylostoma*/*Wuchereria*
6. **Minor Phyla** : *Sipunculus/Bonellia* or any other specimen
7. **Local Biodiversity Record**: Observe water samples from the locality for live protists and make a field note.

8. Demonstration of culture methods of Protists[*Amoeba*/*Euglena*/*Paramecium*].

Section B. Histology

Transverse sections of a coelenterate [*Hydra*], a platyhelminth [*Dugesia*] and a nematode (*Ascaris* male & female).

SECOND SEMESTER B. Sc. DEGREE PROGRAMME

CORE COURSE PRACTICAL– I*B

ANIMAL DIVERSITY: NON-CHORDATA Part– II

[36 hours] [2 hrs per week]

MODULE 2. [36 hrs]

Section A. Study of the following Coelomate Non-chordate specimens:

1. **Annelids** : Polychaetes: *Aphrodite, Chaetopterus, Arenicola, Tomopteris* [any 2]

Common earthworm: *Megascolex / Pheretima*

Leech: *Hirudinaria, Heamadipsa, Branchellion* [any 2]

2. **Arthropods**: Items of evolutionary / taxonomic importance - *Limulus, Streptocephalus* [any 1]

Common fouling barnacle – *Lepas / Balanus*

Parasitic crustaceans– *Sacculina, Cymothoa, Argulus* [any 2]

Crustacean of the sandy shore– *Emerita / Albunea*

Symbiotic crustacean - *Eupagurus*

Economically important crustacean - *Penaeus, Scylla* [any 1]

Vectors – *Cyclops, Aedes, Musca, Xenopsylla* [any 2]

Insect pests – *Lepisma*, termite queen,

Pest of paddy, pest of coconut, pest of stored grains [any 5]

Aquatic insects – *Belostoma, Nepa, Ranatra* [any 2]

Predatory insect - Dragonfly, Ant-lion, *Mantis* [any 1]

Insect which camouflages - *Carausius /Phyllium*

Common myriapods – *Scolopendra/Scutigera, Julus/ Spirostreptus/Jonespeltis* [any 2]

Common arachnids – *Palamnaeus/ Buthus*,

Spider/ tick/mite [any 2]

3. **Molluscs**: Inter tidal mollusks – *Chiton, Patella, Haliotis, Onchidium, Aplysia* [any 2]

Ornamental gastropods –*Cypraea, Murex, Turbinella* [any 2]

Poisonous gastropod – *Conus*

Pelecypods of economic importance – *Perna, Pinctada, Teredo, Ostrea* [any 2]

Scaphopod - *Dentalium*

Cephalopods of economic/evolutionary importance - *Sepia, Loligo, Octopus, Nautilus* [any 3]

4. **Echinoderms**: *Antedon, Asterias, Ophiothrix, Cucumaria, Echinus,* cake urchin, hearturchin

[any 3]

5. **Hemichordate:** *Balanoglossus*

6. **Onychophoran:** *Peripatus* (Evolutionary significance)

7. **Local Biodiversity Record**: Observation of butterflies/dragonflies or any other Non-chordate group of the locality and prepare a field note.

Section B. Histology

Compare TS of any two annelids [*Neanthes*/ Earth worm/ Leech].

Section C. Mountings

1. Earthworm : Setae (a few loose setae) [Minor]
2. *Neanthes*: Parapodium [Minor]
3. *Penaeus* : Appendages [Minor]
4. Cockroach : Salivary apparatus [Major]
5. Honeybee/ plant bug: Mouth parts [Minor]

Section D. Dissections (Digital versions to be downloaded or procured as per UGC guidelines)

1. *Penaeus* : Nervous system [Major]
2. Cockroach : Nervous system [Major]

THIRD SEMESTER B. Sc. ZOOLOGY PROGRAMME

CORE COURSE PRACTICAL- I*C

ANIMAL DIVERSITY: CHORDATA Part - I

[36 hours] [2 hrs per week]

[Students are expected to make sketches with notes, while they study the specimens in the laboratory and field. The record must carry notes of all specimens, mountings and dissections. Emphasis must be on scientific aspects. The record sheets related to part I and part II must be bound together to get a single Record.]

MODULE 3. [36 hrs]

Section A. Study of the following Chordate specimens:

(Students are expected to identify the specimens by their generic names and assign them to the respective phyla /classes/ orders)

1. **Urochordates** : *Ascidia*, ascidian tadpole, *Salpa, Doliolum* [any 2]

2. **Cephalochordates** : *Branchiostoma*

3. **Agnathans** : *Myxine, Petromyzon,* Ammocoetes larva [any 1]

4. **Fishes** :

a. Common elasmobranchs - *Chiloscyllium, Stegostoma, Sphyrna, Pristis, Trygon, Narcine, Astrapes* [any 3]

b. Common edible fishes (marine) - *Sardinella, Rastrelliger, Cynoglossus, Parastromateus, Trichiurus,Cybium, Thunnus* [any 3]

c. Common edible fishes (Inland) - *Etroplus, Mugil, Wallagonia, Tilapia, Catla, Cirrhina, Labeo, Cyprinus* [any 3]

d. Fishes with special adaptive features - *Hippocampus, Belone, Hemiramphus, Exocoetus, Tetraodon, Pterois, Ostracion,*

Heteropneustes, Clarias, Arius, Anabas, Channa, Echeneis, Antennarius, Amphisile, Anguilla [any 5]

5. **Amphibians**: Common amphibians - *Duttaphrynus, Euphlyctis, Rhacophorus, Ambystoma*, Axolotl larva, *Ichthyophis*/*Uraeotyphlus* [any 3]

6. **Reptiles** :

a. Common lizard - *Hemidactylus, Calotes, Mabuya (Eutropis)* [any 1]

b. Lizards with special adaptations - *Draco, Chamaeleo, Phrynosoma* [any 2]

c. Non venomous snakes - *Ptyas, Gongylophis, Lycodon, Indotyphlops* [any 2]

d. Venomous snakes - *Naja, Daboia, Bungarus, Echis* [any 2]

e. Water snake – *Hydrophis / Enhydris* / *Xenochrophis*

f. Arboreal snake – *Dendrelaphis / Python / Ahaetulla*

7. Key for identification of venomous and non-venomous snakes.

8. **Local Biodiversity Record**: Observe fishes/amphibians or any other vertebrate group (any one group) of the locality in their natural habitat and prepare a field note.

Section B. Histology

1. *Branchiostoma* - T. S. through pharyngeal region

Section C. Mountings

1. Sardine: Cycloid scale [Minor]
2. Shark: Placoid scale [Minor]
3. Shark/Frog/*Calotes*: Brain [Minor] - Demonstration only.

Section D. Dissections (Digital versions to be downloaded or procured as per UGC guidelines)

1. Mullet/ Sardine: Alimentary canal (Major)
2. Shark: IX and X cranial nerves on one side (Major) – Demonstration only.
3. Frog: V cranial nerve - branches, root and ganglion on one side (Major) Demonstration only
5. Frog/*Calotes*: Arterial system on one side (demonstration only).

Section E. Osteology

1. Frog: Typical, 8th, 9 th Vertebrae,
2. Frog: Pectoral & Pelvic girdles
3. Snake Vertebra [show zygosphene and zygandrum]
4. Carapace and plastron of turtle/tortoise.

FOURTH SEMESTER B. Sc. ZOOLOGY PROGRAMME

CORE COURSE PRACTICAL- I*D

ANIMAL DIVERSITY: CHORDATA Part - II

[36 hours] [2 hrs per week]

MODULE 4. [36 hrs]

Section A. Study of the following Vertebrate specimens:

1. **Birds**:

a. Fossil bird - *Archaeopteryx*

b. Flightless bird - *Rhea, Struthio* [any 1]

c. Wetland birds - Jacana, Duck, Egret, Heron, Ibis, Stork [any 2]

d. Shore birds – Gulls, Plovers, Terns [any 1]
e. Migratory birds - Pelican, Crane, Flamingo [any 1]
f. Birds of Prey – Falcon, Eagle, Kite, Shikra, Owl [any 2]
g. Features and adaptations of: duck, parrot, king fisher, owl, kite and wood pecker [draw sketches of the beaks and feet of 4 birds)

2. Mammals:

a. Common insectivore – *Suncus,* Hedgehog [any 1]
b. Common rodent – *Rattus, Bandicoota, Funambulus* [any 1]
c. Common bat of Kerala – *Pteropus, Megaderma, Pipistrellus* [any 1]
d. Small Carnivore – Jungle Cat, *Herpestes*, Civet [any 1]
e. Primate – *Loris* or any other species

3. Local Biodiversity Record: Observe birds/mammals (any one group) of the locality in their natural habitat and prepare a field note.

Section B. Osteology

a. Pigeon/ Domestic Fowl: Cervical vertebra, Pectoral girdle and Sternum, Pelvic girdle with Synsacrum [mention the component bones].

b. Rabbit: Skull showing dentition, Atlas, axis, typical vertebra, scapula and pelvic girdle.

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FIFTH SEMESTER B.Sc. ZOOLOGY PROGRAMME

ZOOLOGY CORE COURSE- V [Theory]

CELL BIOLOGY AND GENETICS

Code: ZOL5B06T

[54 hours] [3 hours per week] [4 Credits]

COURSE OUTCOMES (COs)

COs	Course outcome Statements
CO1	Understand the principles and applications of various types of light microscopes, electron, Scanning-tunnelling and Atomic force microscope and illustrate the histological and histochemical processing of tissues (7 hrs)
CO2	Explain the basic structure of a eukaryotic cell and the structure and functions of plasma membrane, mitochondria, lysosome, cytoskeletal elements and interphase nucleus (12 hrs).
CO3	Illustrate the nucleosome organization of chromatin and higher order structures; structure of chromosomes and giant chromosomes (2 hrs).
CO4	Enumerate eukaryotic cell cycle and cell division by amitosis, mitosis and meiosis (4 hrs)
CO5	Explain the causes of transformation, characteristics of transformed cells and the role of protooncogenes and tumor suppressor genes in malignant transformation; mechanism and significance of apoptosis (2 hrs)
CO6	Enumerate allelic and non-allelic gene interactions; supplementary, complementary, polymeric, duplicate and modifying genes and polygenic inheritance (5 hrs).
CO7	Illustrate multiple allelism and solve problems related to blood group inheritance (4 hrs).
CO8	Explain characteristics of linkage groups and linkage map; crossing over and calculation of recombination frequency; sex-linked, sex-influenced and sex-limited characters; sex differentiation and disorders of sexual development (8 hrs).
CO9	Describe the mechanisms of sex determination including chromosomal, genic, haploid-diploid mechanisms; the hormonal and environmental influence on sex determination and gynandromorphism (3 hrs).
CO10	Explain mutagenesis, mutagens and chromosomal and gene mutations (3 hrs).
CO11	Enumerate the classification and grouping of human chromosomes; numerical and mutational human autosomal and sex chromosomal anomalies; polygenic human traits and genetic counseling (4 hrs).

Question paper pattern for external examination

[Module 1-5 Short answer 7x2=14 marks; Paragraph 4x5=20 marks; Essay2x10=20 marks; Module 6-11 Short answer 8x2=16 marks; Paragraph 4x5=20 marks; Essay2x10=20 marks]

Section A: CELL BIOLOGY (27 hrs)

MODULE 1. Techniques in Cell Biology (7 hrs)

Microscopy (4 hrs)

Light microscope: principles and uses; use of oil immersion objective. Types of light Microscopes: Bright-field, Phase contrast and Fluorescence microscope. Camera lucida: Principle and uses. Micrometry. Electron microscope: Principle, applications; advantages and disadvantages. Principles and applications of - Scanning Electron Microscope (SEM); Scanning-tunnelling microscope and Atomic force microscope.

Histological Techniques (2 hrs)

Preparation of materials for light microscopy (for temporary and permanent mounts): Fixation: common fixatives: buffered formalin, ethanol, Bouin's solution and Carnoy's fluid (mention composition). Processing of the fixed tissue: mention dehydration, infiltration, and embedding. Sectioning: Rotatory microtome (brief description), uses. Staining: Mention deparaffinization, hydration, staining, dehydration and mounting. Histological stains: Haematoxylin and Eosin. Vital stains: Neutral red and Janus green.

Histochemical Techniques (1 hr)

Mention the techniques for the demonstration of proteins (mercuric bromophenol blue method),carbohydrates (PAS) and lipids (Sudan)

[Short answers/Paragraphs]

MODULE 2. Structure of eukaryotic cell (12 hrs)

Plasma membrane (6 hrs)

Chemical composition and structure (unit membrane concept and fluid mosaic model), membrane lipids and membrane fluidity; significance of membrane fluidity; membrane proteins-integral proteins, peripheral proteins and lipid-anchored proteins; membrane carbohydrates.

Interactions between cells and their environment – extracellular space, glycocalyx, extracellular matrix - Mention basal lamina, collagen, fibronectin, proteoglycans and laminins.

Interaction of cells with other cells – cell adhesion molecules, selectins, immunoglobulins, integrins and cadherins. Modifications of the plasma membrane – microvilli, desmosomes, nexuses, tight junction and gap junction.

Functions: trans-membrane transport mechanisms – diffusion, osmosis, active transport, ion transport (channels), co-transport, bulk trans-membrane transport – exocytosis, endocytosis. Membrane receptors: Mention insulin receptor.

Mitochondria (2 hrs)

Ultra-structure; mitochondrial membranes; functions of mitochondria; Biogenesis of mitochondria.

Lysosomes (1 hr)

Structure and function; polymorphism in lysosomes, lysosomal enzymes. Concept of GERL (Golgi body – Endoplasmic Reticulum – Lysosome complex).

Cytoskeleton (1 hr)

Location, ultrastructure, biochemical composition and functions of microfilaments, intermediate filaments and microtubules.

Interphase nucleus (2 hrs)

General structure and functions; nucleo-cytoplasmic index; ultrastructure of nuclear membrane and nuclear pore complex (NPC), functions of NPC; Nucleoplasm - Composition and function; Nucleolus - Structure, composition, nucleolar organizer, nucleolar cycle and functions of nucleolus. Chromatin: Euchromatin and heterochromatin.

[Short answers/Paragraphs/Essays]

MODULE 3. Structure of chromatin (2 hrs)

Nucleosome organization and higher order structures; Chromosome structure; Giant chromosomes - Polytene chromosomes: structure, puffs and bands; Endomitosis; significance. Lamp brush chromosomes: structure, loops and significance.

[Short answers/Paragraphs]

MODULE 4. Cell Cycle & Cell division (4 hrs)

Cell Cycle: G1, S, G2 and M phases – Check points; G_0 phase. Cell division: Amitosis (brief account); Mitosis: description of all stages, cytokinesis and significance; Meiosis: description of all stages and significance. Role of centriole in animal cell division.

[Short answers/Paragraphs/Essays]

MODULE 5. Cancer and Apoptosis (2 hrs)

Characteristics of cancer cells; causes of transformation; protooncogenes and tumor suppressor genes and their role in transformation. Apoptosis, mechanism of apoptosis and its significance.

[Short answers/Paragraphs]

Section B: GENETICS (27 hrs)

MODULE 6. Interaction of genes (5 hrs)

Allelic interactions: incomplete dominance and co-dominance with examples. Non-allelic interactions: epistasis (inheritance of plumage colour in poultry), mention dominant and recessive epistasis. Supplementary genes (example: inheritance of comb pattern in poultry). Complementary genes, mention any one example.

Polymeric genes, mention one example. Duplicate genes, mention one example. Modifying genes. Atavism, Penetrance and Expressivity. Polygenic (quantitative) inheritance (example: skin colour in man).

[Short answers/Paragraphs]

MODULE 7. Multiple alleles (4 hrs)

Definition and characteristics; example: coat colour in rabbits. Blood group genetics: ABO blood group system; MN blood group and Bombay phenotype. Inheritance of Rh factor; mention erythroblastosis foetalis. Problems related to blood group inheritance (5 problems). Isoalleles, mention any one example.

[Short answers/Paragraphs/Essays]

MODULE 8. Linkage and Recombination (8 hrs)

Definition and characteristics of linkage groups, Morgan's work on *Drosophila*. Types of linkage: complete and incomplete - examples; Linkage groups.

Crossing over and recombination, Calculation of Recombination Frequency and Percentage; Linkage map, Map Distance; Mitotic Recombination (brief).

Sex-Linked Characteristics: Types of sex-linkage - X linked characters - Colour blindness and haemophilia in humans, holandric genes – hypertrichosis.

Dosage compensation – Barr body – Lyon hypothesis.

Sex-Influenced and Sex-Limited Characteristics.

Sex Differentiation: Testis-determining factor (TDF), Müllerian inhibition factor. Disorders of Sexual Development (short notes) - XX males and XY females, Point mutations in the *SRY* gene and testicular feminization.

[Short answers/Paragraphs/Essays]

MODULE 9. Sex determination (3 hrs)

Chromosomal mechanism of Sex-Determination: Male heterogametic and female heterogametic mechanism of sex determination. Genic Sex Determining Systems - Genic balance (ratio) theory of Bridges. Haploid-diploid mechanism of sex determination, honey bee as example.

Environmental Sex Determination: Example – *Bonellia*, Crocodile.

Hormonal influence on sex determination: Example - sex reversal in fowl and free martin in cattle; Gynandromorphism – types and causes. Intersex (brief).

[Short answers/Paragraphs/Essays]

MODULE 10. Mutations (3 hrs)

Chromosome mutations: numerical (euploidy and aneupoloidy) and structural changes (deletion, duplication, insertion, inversion, translocation).

Gene mutations: types- spontaneous, induced, somatic, gametic, forward and reverse. Types of point mutations- deletion, insertion, substitution, transversion and transition. Mutagenesis- Natural and artificial mutagenesis, Mutagenic agents: a) UV radiation and ionising radiation b) Base analogues, alkylating and intercalating agents.

[Short answers/Paragraphs/Essays]

MODULE 11. Human Genetics and Genetic counselling (4 hrs)

Classification and grouping of human chromosomes (Patau's scheme). Chromosomal anomalies and disorders: Autosomal - (Down's, Patau's, Edward's and Cri du Chat syndromes). Sex chromosomal - (Turner's and Klinefelter's syndromes). Gene mutations: Autosomal mutation - albinism, PKU, alkaptonuria, galactosemia, Tay-Sach's syndrome, Gaucher's disease, Sickle cell anaemia, thalassemia and brachydactyly. Sex chromosomal mutations: haemophilia, Lesch–Nyhan syndrome, dermal hypoplasia. Polygenic traits: cleft palate / lip, club foot and hydrocephaly. Eugenics, Euthenics and Euphenics.

[Short answers/Paragraphs]

Topics for assignments/seminars

(Topics allotted for assignments/ seminars should be considered for internal assessments only, and can be subdivided among students)

1. Ribosomes: structure and functions
2. Golgi bodies: structure and functions
3. Cytoplasmic or extra nuclear inheritance:
   a) Shell coiling in *Limnaea*
   b) Endo-symbionts like kappa particle and sigma**.**
4. Mendel's experiments on pea plants
5. Mendel's laws of inheritance

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Module 6-11 (Genetics)

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FIFTH SEMESTER B.Sc. ZOOLOGY PROGRAMME

ZOOLOGY CORE COURSE- VI [Theory]

BIOTECHNOLOGY, MICROBIOLOGY AND IMMUNOLOGY

Code: ZOL5B07T

[72 hours] [4 hours per week] [4 Credits]

COURSE OUTCOMES (COs)

COs	Course Outcome statements
CO1	Illustrate the steps in genetic engineering and animal cell culture (12 hrs)
CO2	Explain transfection methods, transgenic animals and ethical issues of transgenic animals (5 hrs)
CO3	Enumerate the applications of biotechnology (7 hrs)
CO4	Understand the biological diversity of microbial forms and the various techniques for handling microbes in the laboratory (8 hrs)
CO5	Enumerate the basic structure and life cycle of bacteria and virus (8 hrs)
CO6	Understand the industrial and medical importance of microorganisms (8 hrs)
CO7	Describe different types of immunity and the cells and organs of the immune system (6 hrs)
CO8	Explain antigen, antibody, immunity and major histocompatibility complex (9 hrs)
CO9	Enumerate autoimmune and immunodeficiency diseases and immunology of tumor and organ transplantation (9 hrs)

Question paper pattern for external examination

[Module 1-3 Short answer 3x2=6 marks; Paragraph 2x5=10 marks; Essay2x10=20 marks;
Module 4-6 Short answer 6x2=12 marks; Paragraph 3x5=15 marks; Essay1x10=10 marks
Module 7-9 Short answer 6x2=12 marks; Paragraph 3x5=15 marks; Essay 1x10=10 marks]

Section A: BIOTECHNOLOGY (24 hrs)

MODULE 1: Genetic Engineering and Animal cell culture (12 Hrs)

Genetic Engineering **(10 hrs)**

Concept and scope of biotechnology – Mention branches of biotechnology. Introduction to the concept of Recombinant DNA Technology: Cloning vectors (Plasmid, pBR322, Phages, Cosmids, Virus vectors, YAC vector and Bac vector).

Enzymes: Type II Restriction endonucleases, polynucleotide kinase, exonuclease, terminal transferase, reverse transcriptase and DNA ligase.

Construction of Recombinant DNA: Preparation of vector and donor DNA, Joining of vector DNA with the donor DNA, Introduction of recombinant DNA into the host cell and selection of transformants (brief account).

Animal Cell Culture **(2 hrs)**

Cell culture media (Natural and Defined), Preparation and Sterilization, Primary cell culture, Cell Lines, Pluripotent Stem Cells, Cryopreservation of cultures. Somatic cell fusion and HAT selection of hybrid clones – production of monoclonal antibodies.

[Short answers/Paragraphs/Essays]

MODULE 2: Transgenic Organisms (5 hrs)

Transfection Methods: (Chemical treatment, Electroporation, Lipofection, Microinjection, Retroviral vector method, Embryonic stem cell method and Shot Gun Method). Transgenic Animals: (Fish, Pig, Sheep, Rabbit, Mice, Goat and

Insects), Knock Out Mice. Human Cloning and Ethical Issues of transgenic Animals.

[Short answers/Paragraphs/Essays]

MODULE 3: Applications of Biotechnology (7hrs)

Molecular diagnosis of genetic diseases (Cystic Fibrosis, Huntington's Disease and Sickle Cell Anemia). Vaccines and Therapeutic agents, Recombinant DNA in Medicines (Recombinant Insulin and Human Growth Hormone).

Human gene therapy (gene therapy for severe combined immune deficiency).

Enzymes in detergents and leather industries, Heterologous protein production, Biofiltration, Bioremediation, Bioleaching, Molecular pharming and Bioreactors.

Molecular markers (brief account) RFLP, RAPD, VNTR, SNPs and their uses.

[Short answers/Paragraphs/Essays]

Section B: MICROBIOLOGY (24 hrs)

MODULE 4: Introduction and Methods in Microbiology (8 hrs)

Introduction (1 hr)

Microbial Diversity: Archaebacteria, Eubacteria, Prochlorophyta, Algae, Fungi, Protozoa, Viruses, Viroids, Prions, Mycoplasma and Rickettsias

Methods in Microbiology (7 hrs)

Sterilization: Physical and Chemical methods - Dry and Moist Heat, Pasteurization, Radiation, Ultrasonication. Disinfection, Sanitization, Antiseptics, Sterilants and Fumigation. Preparation of culture media: Selective, Enrichment and Differential media. Plating techniques and Isolation of pure colonies. Staining: Simple staining, Negative staining and Gram staining. Culture preservation techniques: Refrigeration, Deep freezing, Freezing under liquid Nitrogen and Lyophilisation.

[Short answers/Paragraphs]

MODULE 5: Basic Concepts in Bacteriology and Virology (8 hrs)

Bacteria: Structure of a typical Bacterium, Different types of bacterial culture (Batch, Synchronous, Arithmetic), Bacterial growth: Growth phases, Methods of growth determination.

Basic Concepts of Virology: General characteristics and classification of viruses. Bacteriophages: Diversity, lytic and lysogenic Phages (Lambda and P1 Phage), Applications of bacteriophages. Oncogenic Viruses. Prevention and control of Viral diseases: Antiviral compounds, Interferons and viral vaccines.

[Short answers/Paragraphs/Essays]

MODULE 6: Industrial and Medical Microbiology (8 hrs)

Industrial Microbiology (4 hrs)

Bioengineering of microorganisms for industrial purposes: Microbial production of industrial products (micro-organisms involved, media, fermentation conditions, downstream processing and uses) - citric acid, ethanol, wine, penicillin, glutamic acid, riboflavin, enzymes (amylase, cellulase, protease, lipase, glucose isomerase, glucose oxidase). Bioinsecticides (Bt) and Steroid biotransformation.

Medical Microbiology **(4 hrs)**

Normal microflora of the human body: skin, throat, gastrointestinal tract and urogenital tract. Diseases caused by: (with reference to causative agent, symptoms and mode of transmission).

a) Bacteria: anthrax, tuberculosis, typhoid, whooping cough, pneumonia, cholera, gonorrhea, and syphilis.

b) Viruses: polio, chicken pox, herpes, hepatitis, rabies, dengue, AIDS and chikungunya.

c) Protozoa: malaria, kala-azar and toxoplasmosis.

d) Fungi: dermatomycoses and opportunistic mycoses

Bacterial drug resistance.

[Short answers/Paragraphs/Essays]

Section C: IMMUNOLOGY (24 hrs)

MODULE 7: Cells and organs of immune system (6 hrs)

Introduction **(1 hr)**

Immunity: Natural and acquired, active and passive, immunization, vaccines, mechanisms of innate immunity - barriers, inflammation, phagocytosis.

Cells of the immune system **(3 hrs)**

B- cells, T – cells, NK cells, monocytes, macrophages, neutrophils, basophils, eosinophils, mast cells, and dendritic cells (APCs).

Organs of the immune system **(2 hrs)**

Lymphoid organs: Primary (thymus, bone marrow) and secondary (lymph nodes, spleen).

[Short answers/Paragraphs]

MODULE 8: Antigens, antibodies, immunity and MHC (9 hrs)

Antigens **(3 hrs)**

Types, factors for immunogenecity, exogenous antigens, endogenous antigens, adjuvant, haptens, epitopes, antigen-antibody reaction - precipitation reaction, agglutination reaction, agglutination inhibition reaction.

Immunoglobulins **(2 hrs)**

Structure, classification and biological functions. Mention immunoglobulin gene families – κ and λ light chain families and the heavy chain family.

Immunity **(2 hrs)**

Types of Immunity: humoral and cell mediated immunity, primary and secondary response, generation of cytotoxic T- cells (CTLs), NK cell mediated cytotoxicity, ADCC and cytokines (brief).

Major Histocompatability Complex **(2 hr)**

MHC, HLA, Class I MHC, Class II MHC molecules and structure. Mention Class III MHC.

[Short answers/Paragraphs/Essays]

MODULE 9: Autoimmune and Immunodeficiency diseases, Tumor and transplantation immunology (9 hrs)

Autoimmune diseases (2 hrs)

Auto immune diseases: Systemic (SLE, multiple sclerosis and rheumatoid arthritis). Organ specific-(Hashimoto's thyroiditis, Grave's disease, Myasthenia gravis)

Immunodeficiency disease (3 hrs)

Primary (Bruton's Disease, Di-George syndrome and SCID)

Secondary (AIDS) – Clinical course of HIV – acute infection, seroconversion, window period, chronic latent phase - lymph adenopathy and crisis phase. Mention anti-retroviral therapy (ART)

Tumor immunology (2 hrs)

Malignant transformation of cells, tumor antigens, immune response to tumor antigens.

Transplantation Immunology (2 hrs)

Transplantation Antigens, Various organ transplantation (liver, kidney, heart, skin), Xenotransplantation

[Short answers/Paragraphs/Essays]

Topics for assignments/seminars

(Topics allotted for assignments/ seminars should be considered for internal assessments only, and can be subdivided among students)

1. Microbiological analysis of drinking water
2. Biogas plant
3. Social acceptance of biotechnology
4. Biofertilizers
5. DNA vaccines
6. Immunity and malnutrition

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Module 4-6 (Microbiology)

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Module 7-9 (Immunology)

- Abul K. Abbas, Andrew H. Lichtman & Shiv Pillai (2017) *Cellular & Molecular Immunology* 8th Edtion, Paperback ISBN: 9780323479783, Elsevier, 608 pages
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- David Male, Jonathan Brostoff, David Roth and Ivan Roitt (2013) *Immunology*, 8th Edition, ISBN: 9780323080583, Elsevier, 482 pages
- Helen Chapel, Mansel Haeney, Siraj Misbah & Neil Snowden (2014) *Essentials of Clinical Immunology* 6th Edition, ISBN: 978-1-118-47295-8, Wiley Blackwell, 376 pages
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FIFTH SEMESTER B.Sc. ZOOLOGY PROGRAMME

ZOOLOGY CORE COURSE- VII [Theory]

BIOCHEMISTRY AND MOLECULAR BIOLOGY

Code: ZOL5B08T

[72 hours] [4 hours per week] [4 Credits]

COURSE OUTCOMES (COs)

COs	Course Outcome statements
CO1	Understand the elements of biological importance and the non-covalent interactions that stabilize biomolecules (1 hr).
CO2	Describe the classification, types, structure, reactions and biological roles of carbohydrates, and diabetes Type I and II (6 hrs)
CO3	Enumerate the properties and classification of amino acids and their standard abbreviations; hierarchial levels of protein structure, classification, separation, purification and sequencing of proteins (7 hrs).
CO4	Explain the classification and functions of lipids and fatty acids; chemistry and structure of nucleic acids and sequencing of DNA (7 hrs)
CO5	Understand the classification, nomenclature and properties of enzymes; enzyme action, co-enzymes, cofactors, isozymes, ribozymes and allosteric enzymes (3 hrs)
CO6	Explain glycolysis, Kreb's cycle, glycogenesis, glycogenolysis, gluconeogenesis, HMP pathway; amino acid and fatty acid oxidation and oxidative phosphorylation (12 hrs).
CO7	Describe the mechanism of DNA duplication and the role of enzymes (4 hrs).
CO8	Understand the concept of gene and gene expression; genetic code and wobble hypothesis (6 hrs).
CO9	Explain the mechanism of transcription and post-transcriptional modification of hnRNA (7 hrs).
CO10	Enumerate the processes of translation and post-translational modification and targeting of peptides (7 hrs).
CO11	Describe the regulation of *trp* operon, C-value, repetitive DNA, satellite DNA, selfish DNA, overlapping genes, pseudogenes, cryptic genes, transposons and retrotransposons (8 hrs).
CO12	Explain the structure and life cycle of bacteriophages and the gene transfer mechanisms in bacteria (4 hrs).

Question paper pattern for external examination

[Module 1-6 Short answer 7x2=14 marks; Paragraph 4x5=20 marks; Essay 2x10=20 marks; Module 7-12 Short answer 8x2=16 marks; Paragraph 4x5=20 marks; Essay 2x10=20 marks]

BIOCHEMISTRY (36 hrs)

MODULE 1. Introduction (1 hr)

Elements of biological importance; non-covalent bonds that stabilize biomolecules – Hydrogen bonds, hydrophobic interactions and Van der Waals Interactions.

[Short answer questions]

MODULE 2. Carbohydrates (6 hrs)

Monosaccharides: Aldoses and ketoses, trioses, tetroses, pentoses and hexoses; glyceraldehyde, dihydroxyacetone, ribose, deoxyribose, ribulose, glucose and fructose. Cyclization of pentoses and hexoses, optical activity and mutarotation, inversion and invert sugar, monosaccharides as reducing agents, Osazones.

Disaccharides: Glycosidic bond, reducing and non-reducing disaccharides, maltose and sucrose as examples.

Polysaccharides: Starch and glycogen, amylose and amylopectin, homo and heteropolysaccharides.

Biological functions of carbohydrates; Mention diabetes Type I and II.

[Short answers/Paragraphs]

MODULE 3. Amino acids, peptides and protein (7 hrs)

Proteinogenic amino acids, abbreviations (three letter and single letter) of the standard amino acids, structure and classification and general properties of amino acids, isoelectric point, peptide bonds, nonstandard amino acids.

Peptides and proteins: Classification of proteins - simple, conjugated and derived. Structure of proteins: primary, secondary, tertiary and quaternary structure. Denaturation of proteins.

Separation and purification of proteins: Paper chromatography, column chromatography, ion exchange chromatography, size exclusion chromatography, affinity chromatography and high - performance liquid chromatography (Brief account only). Polyacrylamide Gel Electrophoresis.

Sequencing of peptides: Sanger's method, Edman degradation procedure and Mass spectrometry (Brief account only)

[Short answers/Paragraphs/Essays]

MODULE 4. Lipids and Nucleic acids (7 hrs)

Lipids (2 hrs)

Classification and functions (simple, compound, derived and miscellaneous lipids).

Fatty acids: saturated and unsaturated; triglycerides; mention phospholipids; lecithins; cephalins; phosphoinositides; prostaglandins and cholesterol. Mention the clinical significance of lipid profile estimation.

Nucleic acids (5 hrs)

Chemistry and structure of purines and pyrimidines, structure of nucleotides (ATP, dATP and cAMP), Watson – Crick model of DNA, Different forms of DNA, secondary and tertiary structure of tRNA. Sequencing of DNA by Sanger's method. Mention Maxam-Gilbert sequencing.

[Short answers/Paragraphs/Essays]

MODULE 5. Enzymes and co-enzymes (3 hrs)

Classification, nomenclature and properties of enzymes; Active centre, mechanism and theories of enzyme action, enzyme inhibition, co-enzymes (NAD, FAD) and cofactors. Mention isozymes, ribozymes and allosteric enzymes.

[Short answers/Paragraphs/Essays]

MODULE 6. Metabolism of carbohydrates, proteins and lipids (12 hrs)

Glycolysis, Kreb's cycle, glycogenesis, glycogenolysis, gluconeogenesis and HMP pathway. Amino acid oxidation and production of urea. β-oxidation of fatty acids.

Brief account on redox reactions, redox potentials, electrochemical gradients, electron transport chain, oxidative phosphorylation, proton gradient and chemiosmotic synthesis of ATP.

[Short answers/Paragraphs/Essays]

MOLECULAR BIOLOGY (36 hrs)

MODULE 7. DNA Replication (4 hrs)

Semi-conservative and semi-discontinuous, priming of Okazaki fragments, primer removal and joining of Okazaki fragments, Meselson and Stahl experiment.

[Short answers/Paragraphs/Essays]

MODULE 8. Gene and genetic code (6 hrs)

Gene concept **(2 hrs)**

Classical and modern concepts, housekeeping and luxury genes. Gene action: gene expression and gene products; one gene one enzyme hypothesis; one gene one polypeptide hypothesis. Central dogma of molecular biology, reverse transcription and modified central dogma.

Genetic code **(4 hrs)**

Deciphering of genetic code, experiments of Nirenberg and Khorana, codon assignments, properties of the genetic code and wobble hypothesis.

[Short answers/Paragraphs/Essays]

MODULE 9. Transcription (7 hrs)

RNA polymerases of eukaryotes and prokaryotes; promoters, terminators, enhancers and silencers.

Transcription unit, mono and polycistronic transcription units; coupling of transcription with translation in bacteria.

Initiation, elongation and termination of transcription (brief account).

Post transcriptional modification of the primary transcript – hnRNA, capping, poly (A) tailing and splicing (brief account), spliceosomes.

[Short answers/Paragraphs/Essays]

MODULE 10. Translation (7 hrs)

Activation of amino acids and aminoacyl tRNA synthetases; role of tRNA as adaptor molecules in translation. Role of ribosomes and active centres of ribosomes. Initiation, elongation and termination of translation.

Post translational modification of the peptide chain: cleavage, formation of disulfide-bridges, acetylation, glycosylation, myristoylation, sulphation, hydroxylation, prenylation, nitrosylation, ubiquitination and SUMOylation.

Protein folding and role of molecular chaperones; Protein targeting (brief account)

[Short answers/Paragraphs/Essays]

MODULE 11. Regulation of gene expression and organization of genome(8 hrs)

Regulation of gene expression **(4 hrs)**

Operon organization of bacterial transcription units; *trp* operon and its regulation. Regulatory RNAs – ncRNAs, miRNAs, piRNAs, siRNAs and RNA interference. Mention CRISPR–Cas9 and targeted genome editing.

Organization of genome **(4 hrs)**

Sequence components of eukaryotic genome – non-repetitive, moderately repetitive and highly repetitive DNA; satellite DNA. Mention selfish DNA. C-value and C-value paradox. Overlapping genes, pseudogenes, cryptic genes, transposons and

retrotransposons. Human genome and human genome project (brief account). Mitochondrial and chloroplast genome (brief account).

[Short answers/Paragraphs/Essays]

MODULE 12. Genetics of bacteria and phages (4 hr)

Conjugation in bacteria. Transduction – generalized and specialized; sexduction.

Structure and life cycle of a bacteriophage; temperate and virulent phages; lysogeny and lysis.

[Short answers/Paragraphs]

Topics for assignments/seminar

(Topics allotted for assignments/ seminars should be considered for internal assessments only, and can be subdivided among students)

1. B-Complex vitamins as co-enzymes
2. Different types of eukaryotic RNAs
3. Biological functions of steroids
4. Lac operon and its regulation
5. Role of enzymes in DNA replication

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- David L. Nelson and Michael Cox (2017): Lehninger *Principles of Biochemistry* 7 th Edition, ISBN-10: 1-4641-2611-9, W.H. Freeman, 1172 pages
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- Bruce Alberts, Dennis Bray Karen Hopkin and Alexander D. Johnson (2013) Essential Cell Biology, 4th Edition, ISBN-10: 0853696470, Garland Publishing, 864 pages

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- Burns, G. W. & Bottino, P. J.(1989): *The Science of Genetics*. 6th Edition, ISBN 0023174005, Macmillan, 491 pages
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- Gardner, E. J., Michael J. Simmons and Peter Snustad (2006): *Principles of Genetics.* 8th Edition, ISBN-10: 8126510439, Wiley, 740 pages
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- Jocelyn E Krebs, Elliot S. Goldstein and Stephen T. Kilpatrick (2017) *Lewin,s GENES XII*, ISBN-10: 1284104494, Jones and Bartlett Publishers Inc, 838 pages
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- Nancy Craig, Rachel Green, Carol Greider, Gisela Storz, Cynthia Wolberger and Orna Cohen-Fix (2014): *Molecular Biology-Principles of genome function* 2nd Edition, ISBN-10: 0198705972, Oxford, 936 pages.
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FIFTH SEMESTER B.Sc. ZOOLOGY PROGRAMME

ZOOLOGY CORE COURSE- VIII [Theory]

METHODOLOGY IN SCIENCE, BIOSTATISTICS AND BIOINFORMATICS

Code: ZOL5B09T

[54 hours] [3 hours per week] [4 Credits]

COURSE OUTCOMES (COs)

COs	Course Outcome Statements
CO1	Explain science, its importance, disciplines and the major steps in formulating a hypothesis, various hypothesis models, theory, law and importance of animal models, simulations and virtual testing (6 hrs)
CO2	Illustrate the principles and procedures in designing experiments and elaborate the requirements for carrying out experiments (4 hrs)
CO3	Describe the ethical concerns in practicing science (5 hrs)
CO4	Understand the Scope and role of statistics; methods and procedures of sampling; Construction of tables, charts and graphs (5 hrs)
CO5	Calculate central tendency and measures of dispersion and application of its knowledge on hypothesis testing as well as in problem solving (10 hrs)
CO6	Enumerate major biological databases and database search engines (8 hrs)
CO7	Perform DNA and protein sequence analysis, including sequence alignment and sequence similarity search using BLAST, FASTA, CLUSTAL W and CLUSTAL X (4 hrs)
CO8	Understand molecular phylogenetics and tools and methods for construction of phylogenetic trees (3 hrs)
CO9	Explain genome sequencing technologies, functional genomics, proteomic technologies and molecular docking and drug design (9 hrs)

Question paper pattern for external examination

[Module 1-3: Short answer 5x2=10 marks, Paragraph 2x5=10 marks, Essay 1x10= 10 marks
Module 4-5: Short answer 5x2=10 marks, Paragraph 2x5=10 marks, Essay 1x10=10 marks;
Module 6-9: Short answer 5x2=10 marks, Paragraph 4x5=20 marks, Essay 2x10 = 20 marks]

Section A: METHODOLOGY IN SCIENCE (15 hrs)

MODULE 1. Science, Scientific Studies and Methods (6 hrs)

Science and Scientific Studies

Science as a human activity; scientific attitude; Empiricism; Science disciplines; Interdisciplinary approach.

Scientific Methods

Major steps: Observation, Defining the problem, Collection of information, Formulation of a hypothesis, Experimentation, Analysis of the results and Conclusion based on interpretation of the results.

Methods in scientific enquiry: Inductive and deductive reasoning.

Hypothesis: Formulation of a hypothesis, different thought processes in developing hypothesis (analogy, induction, deduction and intuition), hypothetico-deductive model, testing hypothesis, auxiliary hypothesis, adhoc hypothesis.

Theories and laws in science; peer review; importance of models, simulations and virtual testing (brief account).

[Short answers/Paragraphs/Essays]

MODULE 2. Experimentation (4 hrs)

Types of experiments; design of an experiment: principles and procedures; necessity of units and dimensions; repeatability and replications; documentation of experiments; Planning of Experiments: design, selection of controls, observational and instrumental requirements; Test animals used in experiments.

[Short answers/Paragraphs/Essays]

MODULE 3. Ethics in Science and Animal Ethics (5 hrs)

Scientific information: Depositories of scientific information – primary, secondary and digital sources; Sharing of knowledge: transparency and honesty, Publications, Patents, Plagiarism.

Constitution of India Article 51A (g); Prevention of cruelty to animals Act of 1960 - Section 17.1(d), Committee for the purpose of control and supervision of experiments on animals (CPCSEA).

[Short answers/Paragraphs]

Section B: BIOSTATISTICS (15 Hrs)

MODULE 4. Introduction (5 hrs)

Definition; scope; role of statistics in life sciences; terminology and variables.

Sample and Sampling: Sample size, sampling errors, methods of sampling.

Collection/documentation of data of the experiments.

Classification of data; Presentation of data: Tabular, Graphical and Diagrammatic (histogram, frequency polygon and frequency curve; line diagram, bar diagram and pie diagram).

[Short answers/Paragraphs/Essays]

MODULE 5. Analysis and Interpretation of data (10 hrs)

Measures of central tendency: *(raw data, discrete series data, continuous series data- problems are to be discussed)*

a) Mean, b) Median and c) Mode.

Measures of Dispersion: *(raw data, discrete series data, continuous series data - problems to be discussed)*

a) Range, b) Mean deviation, c) Standard deviation, d) Standard error.

Hypothesis testing and Interpretation of results: *(problems to be discussed)*

a)'t' test, b) F- test - ANOVA

Significance of statistical tools in data interpretation; Statistics-based acceptance or rejection of hypothesis.

[Short answers/Paragraphs/Essays]

SECTION C: BIOINFORMATICS (24 hours)

MODULE 6. Introduction and Biological Databases (8 hrs)

Overview of bioinformatics, Scope and application of Bioinformatics.

Major Databases in Bioinformatics: Biological databases, Features of a good database. Classification format of biological databases.

Primary databases: Nucleotide sequence databases – Mention EMBL, DDBJ, Genbank; Protein sequence databases – Mention Swiss Prot, PIR, MIPS.

Structure databases: PDB, NDB.

Special databases – PROSITE, Pfam, CATH, OWL, PubMed.

Secondary databases: Mention PROSITE, PRINTS. Databases of patterns, motifs and profiles, EST databases, SNP databases.

Metabolite databases – Mention KEGG, EcoCyc.

*Database Search Engines***:** Entrez at NCBI of USA, SRS at EBI of England, STAG at DDBJ of Japan. Data retrieval with Entrez and SRS.

Sequence submission to NCBI.

[Short answers/Paragraphs/Essays]

MODULE 7. Sequence Analysis (4 hrs)

Web based and standalone tools for DNA and protein sequence analysis. Types of sequence alignment, methods of sequence alignment. Sequence similarity search – pair wise and multiple sequence alignments; BLAST, FASTA, CLUSTAL W, CLUSTAL X.

[Short answers/Paragraphs]

MODULE 8. Molecular Phylogenetics (3 hrs)

Basics of Phylogenetics; molecular evolution and molecular phylogenetics, cladistics and ontology. Gene Phylogeny versus species phylogeny. Phylogenetic tree construction methods and programmes. Forms of Tree representation.

[Short answer/Paragraphs]

MODULE 9. Genomics and Proteomics (9 hrs)

Genome sequencing technologies; Sanger capillary sequencing, Roche 454 (pyrosequencing), Illumina/Solexa, SOLiD System, Single molecule sequencing. Whole genome sequence assembly, annotation and analysis. Functional Genomics: Microarrays, SAGE, ESTs; Transcriptomics; Metabolomics. Metagenomics: Concept and applications.

Proteomics

Aims, strategies and challenges in proteomics. Brief account on proteomics technologies: 2D-electrophoresis, iso-electric focusing, LC/MS-MS, MALDI-TOF mass spectrometry, yeast 2-hybrid system. Protein-protein interactions: experimental and computational methods; structural proteomics. Deriving function from sequence databases.

Cheminformatics

Molecular docking and drug design; Structural Bioinformatics in drug discovery

[Short answers/Paragraphs/Essays]

Topics for seminar/assignment

(Topics allotted for assignments/ seminars should be considered for internal assessments only, and can be subdivided among students)

1. Findings that changed the course of science.
2. Prepare a table showing the height of 20 students in a class. Calculate the mean height.

3. What are the mathematical properties of SD? How is it a better measure of Dispersion than range? Calculate the arithmetic mean and the SD of the frequency distribution obtained from a sample of data.
4. Report an experimental data in tabular / graphical form.
5. Viral genome database (ICTVdb, VirGen).
6. Bacterial Genomes database (Genomes OnLine Database –GOLD, Microbial Genome Database-MBGD).

REFERENCES

Module 1-3 (Methodology in Science)

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Module 4-5 (Biostatistics)

- Antonisamy B, Prasanna S. Premkumar and Solomon Christopher (2017) Principles and Practice of Biostatistics, ISBN-10: 8131248879, Elsevier, 390 pages
- Bailey, N. T. J (1995): *Statistical Methods in Biology*, 3rd Edition, CUP, 272 pages
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Module 6-9 (Bioinformatics)

- Anna Tramontano (2006): *Introduction to Bioinformatics*, ISBN-10: 1584885696, Chapman & Hall, 192 pages.
- Atwood and Parry-Smith (1999): *Introduction to Bioinformatics*. ISBN 9780582327887, Pearson Education Asia, New Delhi, 218 pages
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- Malcom Campbell and Laurie J. Heyer (2006): *Discovering Genomics, Proteomics and Bioinformatics*, 2nd Edition, ISBN 10: 9780805382198, Pearson, 464pages

B. Sc. ZOOLOGY PROGRAMME

ZOOLOGY [CORE COURSE] PRACTICAL – II

Code: ZOL6B15P

[Practical II*A + Practical II*B] [4 Credits]

PRACTICAL II*A: CELL BIOLOGY, GENETICS, BIOTECHNOLOGY, MICROBIOLOGY AND IMMUNOLOGY [72 hours] [4 hrs /week]

PRACTICAL II*B: BIOCHEMISTRY, MOLECULAR BIOLOGY, METHODOLOGY IN SCIENCE, BIOSTATISTICS & BIOINFORMATICS[72 hours] [4 hrs/week]

COURSE OUTCOMES [COs]

COs	Course Outcome Statements
CO1	Perform experiments in cell biology and genetics including demonstration of Barr body in buccal epithelial cells of man, polytene chromosome in the salivary glands of *D. Melanogaster* larva, mitotic division in onion root tip cells, micrometry of microscopic objects, prepare whole mounts of microscopic objects, and calculate mitotic and metaphase index from slides.
CO2	Enumerate the inheritance of major human genetic traits, pedigree chart, normal and abnormal human karyotypes, phenotypic differences of male and female Drosophila and solve problems on Monohybrid, dihybrid crosses, blood groups and sex-linked inheritance.
CO3	Understand electrophoresis, PCR, Northern blotting, Southern blotting and Western blotting, DNA sequencing and fingerprinting and isolation of genomic DNA.
CO4	Perform gram staining and preparation of culture media for bacteria and demonstrate bacterial motility by standard laboratory protocols.
CO5	Understand the detection of human blood groups and organs of immune system
CO6	Perform standard biochemical tests for the detection of reducing and nonreducing sugars, polysaccharides, proteins and lipids.
CO7	Understand the staining of mitochondria, tissue homogenization and isolation of nuclei, effect of colchicines of cell division, extraction of DNA and polyacrylamide and agaros egel electrophoresis
CO8	Solve basic problems in biostatistics and Bioinformatics

FIFTH SEMESTER B. Sc. ZOOLOGY PROGRAMME

PRACTICAL II*A

CELL BIOLOGY, GENETICS, BIOTECHNOLOGY, MICROBIOLOGY & IMMUNOLOGY [72 hrs] [4 hrs/week]

Section A: Cell Biology

1. Study of diversity of eukaryotic cells – methylene blue staining of buccal epithelium and striated muscle cells (Minor).
2. Temporary mount of buccal epithelial cells to observe Barr body (Major).
3. Mitosis: stages in onion (*Allium cepa*) root meristem by squash preparation (major).
4. Calculation of mitotic index and metaphase index in root meristem of *Allium cepa* (Major).
5. Study of the polytene chromosome of *Drosophila melanogaster* using salivary gland cells of 3 rd instar larva (Demonstration only).

6. Measurement of size of microscopic objects using ocular and stage micrometres (Major).
7. Tissues (permanent slides of epithelial tissues, smooth muscle, cartilage, bone).
8. Preparation of permanent whole mount (Demonstration).
9. Study of different stages of meiosis in grass hopper testes (Demonstration).
10. V staining of mitochondria using insect flight muscle/check ital epithelium/yeast (Minor)

Section B: Genetics

1. Scheme of Pedigree chart.
2. Study of inheritance of human traits: (use Pedigree charts). Blood groups, Eye colour.
3. Genetic problems on Monohybrid, dihybrid crosses; blood groups; sex-linked inheritance (minimum ten problems to be worked out).
4. Frequency of the following genetic traits in human: widow's peak, attached ear lobe, dimple in chin, hypertrichosis, colour blindness, PTC tasting.
5. Study through photographs of the Karyotype: Down's, Klinefelter's, Turner's and Edward's Syndrome.
6. Study of phenotypic characters in male and female *Drosophila*

Section C: Biotechnology

1. Study of the principle and applications of Electrophoretic apparatus.
2. PCR-Principle and applications.
3. Study of transgenic animals.
4. Southern blotting (Principle and methodology - using flowcharts/diagrams/by visiting a diagnostic Lab)

Section D: Microbiology

1. Gram staining for the identification of Gram positive and Gram negative bacteria (*Lactobacilius* and *Rhizobium)* (Major).
2. Bacterial motility by hanging-drop method (Demonstration).
3. Preparation of culture media for bacteria (Synthetic Media, Natural Media, Simple Media, Differential Media and Selective Media).
4. Methylene blue reduction test for assessing the quality of raw milk (Demonstration).
5. Preparation of a fungal smear – Lactophenol cotton blue staining & mounting (Minor)

Section E: Immunology

1. Identification of human blood groups (A B O and Rh).
2. Histological study of spleen, thymus and lymph nodes through slides/photographs.
3. ELISA (methodology of detection of biomolecules using flowcharts/diagrams/by visiting a diagnostic Lab)
4. Western blotting (methodology of detection of specific proteins using flowcharts/diagrams/by visiting a diagnostic Lab)

REFERENCES

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- Margaret J. Barch, Turid Knutsen and Jack L. Spurbeck (1997) *The AGT Cytogenetics Laboratory Manual*; ISBN-10: 0397516517, Lippincott
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PRACTICAL II*B

BIOCHEMISTRY, MOLECULAR BIOLOGY,
METHODOLOGY IN SCIENCE, BIOSTASTICS & BIOINFORMATICS

[(72 hrs) (4 hrs/week)]

Section A: Biochemistry

1. Detection of organic constituents (carbohydrates, proteins and lipids only) from sample solutions (Major)
   a) Detection of reducing sugar: Glucose/Fructose/Maltose [Fehling's test, Benedict's test, Moore's test, cupric sulphate test, rapid furfural test (any three) (Major).
   b) Detection of monosaccharides [Barfoed's test]
   c) Detection of non-reducing sugars: Sucrose [Hydrolysis test].
   d) Identification of functional groups of carbohydrates [Selivanoff's test]
   e) Detection of polysaccharides: Starch [Lugol's iodine test, confirmatory heating & cooling test].
   f) Detection of proteins: [Biuret test, Nitric acid test, Xanthoproteic test].
   g) Detection of lipids: [Sudan III or IV test, Spot test].
2. Preparation of Normal, molar and standard solutions and serial dilutions.
3. Separation of amino acids (or any other compounds) from a mixture by using paper chromatography (Demonstration).
4. Determination of concentration of unknown solutions using Photo electric colorimeter (Demonstration).

Section B: Molecular Biology (Any *four* items)

1. Cell fractionation and isolation of nucleus (demonstration).
2. Study of the effects of Colchicine on mitosis in the root meristem of *Allium cepa*.
3. Differential staining for DNA and RNA in human cheek epithelial cells (demonstration).
4. Poly acrylamide gel electrophoresis (Demonstration).
5. Agarose gel electrophoresis (Demonstration).

6. Isolation of DNA from animal tissues (Demonstration)
7. Isolation of RNA from animal tissues (Demonstration)

Section C: Methodology in Science, Biostatistics and Bionformatics

(Any 10 items of the following)

1. Design an experiment to prove a hypothesis by testing the specificity of the enzyme salivary amylase on starch.
2. Measure the size of given leaves / any sample of data and calculate the mean, median and mode (raw data, discrete series & continuous series).
3. Measure the size of given shells / any sample of data and represent it in a graphical form and interpret it.
4. Calculate the standard deviation of the given set of data (raw data, discrete series & continuous series). Enter the data in Excel, calculate SD and record the screen shots of steps and results.
5. Census the avian fauna / any fauna of two different areas and present the data in a suitable graphical form. Compare by t-test.
6. Construct a frequency curve with mean ± SD using suitable data. Draw the same in Excel or using any free software and record it.
7. Prepare a frequency polygon with mean ± SD utilizing appropriate data.
8. Draw a bar diagram with mean ± SD employing suitable data.
9. Construct a histogram with mean ± SD utilizing suitable data. Do the same with software
10. Draw a pie diagram using suitable data. Draw the same in Excel or using any free software.
11. Formulate a hypothesis of any scientific observation made by you.
12. Sequence retrieval from databases (demonstration).
13. Sequence similarity search using BLAST.
14. Multiple sequence alignment.
15. Construction of phylogenetic tree (Demonstration).
16. Docking studies (Demonstration).

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SYLLABUS

OPEN COURSES [ZOOLOGY] 1 TO 3

FIFTH SEMESTER B. Sc. ZOOLOGY PROGRAMME

ZOOLOGY OPEN COURSE- I (Theory)

REPRODUCTIVE HEALTH AND SEX EDUCATION

Code: ZOL5D01T

[54 hours] [3 hours per week] [3 credits]

COURSE OUTCOMES [COs]

COs	Course Outcome Statements
CO1	Understand the reproductive health, and importance of sex education for teen and youth. (2 hrs)
CO2	Explain the chromosomal mechanism of sex determination and sex chromosomal anomalies. (3 hrs)
CO3	Describe the structural and functional features of human reproductive system, fertilization, implantation, pregnancy, gestation, placenta, parturition and lactation. (17 hrs)
CO4	Explain the scope of reproductive technologies in infertility management and the assisted reproductive techniques. (10 hrs)
CO5	Understand the different methods of prenatal diagnosis and associated ethical issues (4 hrs)
CO6	Describe the different methods of fertility control. (4 hrs)
CO7	Understand the symptoms, mode of transmission, diagnosis and treatment of different sexually transmitted diseases and their socio economic dimensions. (7 hrs)
CO8	Describe sexual orientation, sexual abuse and myths (5 hrs)
CO9	Understand the ethical aspects of sex (2 hrs)

Question paper pattern for external examination

[Module 1-3: Short answer 4x2 = 8marks; Paragraph 3x5=15 marks; Essay 1x10 = 10 marks
Module 4-6: Short answer 3x2 = 6 marks; Paragraph 2x5=10 marks; Essay 1x10 = 10 marks
Module 7-9: Short answer 5x2 =10 marks; Paragraph 2x5=10 marks.]

MODULE 1. Introduction (2 hrs)

Definition; Reproductive health - problems and strategies; reproductive rights; importance of sex education for teen and youth.

[Short answers/Paragraphs]

MODULE 2. Sex determination and Chromosomal anomalies (3 hrs)

Chromosomal mechanism of sex determination; Barr body; twin studies; sex reversal; Sex chromosomal anomalies: Turner's syndrome and Klinefilter's syndrome.

[Short answers/Paragraphs]

MODULE 3. Human Reproduction (17 hrs)

Male reproductive system: Structure of testis, male accessory organs; Semen production and composition; ejaculation. Spermatogenesis.

Female reproductive system: Structure of human ovary; development of primary follicle; structure of graafian follicle; fallopian tubes; uterus; external genitalia; mammary glands. Ogenesis.

Menstrual cycle and hormonal control; brief account of fertilization, implantation, pregnancy, gestation, placenta, parturition and lactation (Brief account on hormonal control of lactation).

[Short answers/Paragraphs/Essays]

MODULE 4. Infertility and Assisted reproductive technologies (10 hrs)

Infertility: Causes and problems in male and female. Infertility management: semen collection, preservation and storage, artificial insemination, surrogacy. Cryopreservation and embryo transfer: Collection, care and preservation of embryos. *In vitro* fertilization (IVF) and embryo transfer: Major steps; Test tube babies. Assisted Reproductive Techniques (ART): GIFT, ZIFT, ICSI, oocyte donation and embryo donation.

[Short answers/Paragraphs/Essays]

MODULE 5. Prenatal Diagnosis (4 hrs)

Different methods: Ultrasonography, amniocentesis, chorionic villus sampling and alpha-foetoprotein estimation; female foeticide: ethical issues and laws (Mention– PNDT Act).

[Short answers/Paragraphs]

MODULE 6. Fertility Control (4 hrs)

Natural methods; artificial methods; chemical methods; hormonal methods; contraceptive devices; surgical contraception; abortion, legal termination of pregnancy.

[Short answers/Paragraphs/Essays]

MODULE 7. Sexually transmitted infectious diseases (7 hrs)

Symptoms, mode of transmission, diagnosis, treatment and prophylaxis of AIDS, syphilis, gonorrhea, herpes (genital), human papilloma virus and genital warts, hepatitis, gonococcal vulvo vaginitis, Trichomonal vaginitis. Mention the term venereal disease. Socio economic dimensions of STD.

[Short answers/Paragraphs]

MODULE 8. Sexual orientation, sexual abuse and myths (5 hrs)

Homosexuality and bisexuality (mention LGBT), oral sex, animal sex, cyber sex, sexual abuse, premarital and extramarital sex, sexual perversions, paraphilia, child abuse, prostitution, sexual hygiene, protection of children from sexual offences (POCSO) Act, 2012 (brief account only), sexual myths.

[Short answers/Paragraphs]

MODULE 9. Ethical aspects of sex (2 hrs)

Healthy relationship with opposite sex, role of counseling, gender discrimination in family and society.

[Short answers/Paragraphs]

Topics for Assignments/Seminars

(Topics allotted for assignments/ seminars should be considered for internal assessments only, and can be subdivided among students)

1. Sexual counseling
2. Marriage counseling
3. Population explosion and birth control
4. Functions of male and female hormones
5. Hormones of pregnancy

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- Robert T. Francoeur (1982): *Becoming a sexual person*, ISBN-10: 0471078484, John Wiley and Sons, 836 pages
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http://stayteen.org/sex-ed/article/why-sex-education-important

http://www.onlymyhealth.com/importance-sex-education-among-youth-1301382451

http://www.livestrong.com/article/246343-how-to-make-friends-with-the-opposite-sex/

http://stories.plancanada.ca/gender-discrimination-starts-at-home/

SIXTH SEMESTER B.Sc. ZOOLOGY PROGRAMME

ZOOLOGY CORE COURSE – IX [Theory]

PHYSIOLOGY AND ENDOCRINOLOGY

Code: ZOL6B10T

[54 hrs] [3 hours per week] [3 credits]

COURSE OUTCOMES [COs]

COs	Course Outcomes Statements
CO1	Describe the regulation of digestion in man, nutrition in pregnancy and infancy, nutritional disorders, balanced diet, starvation, fasting and obesity. (5 hrs)
CO2	Understand the mechanism of transport and exchange of respiratory gases and its neurophysiological control and physiological problems in diving mammals, new-born and aged individuals. (6 hrs)
CO3	Describe functions, composition, coagulation, transfusion, agglutination and clinical analysis of blood, haemoglobinopathies, types of heart and common cardio-vascular problems. (6 hrs)
CO4	Understand the osmoregulatory mechanisms in animals; excretion and its hormonal control and common renal disorders in man. (6 hrs)
CO5	Explain the ultrastructure of skeletal muscles and biochemical events and energetics of muscle contraction. (5 hrs)
CO6	Understand the different types of nerve cells, glial cells and nerve fibres, and the mechanism of nerve impulse transmission (6 hrs)
CO7	Understand the types, physiology and significance of bioluminescence, and the structure and functions of electric organs. (2 hrs)
CO8	Describe invertebrate neuro-endocrine organs and hormones, vertebrate endocrine glands, their hormones and functions (12 hrs)
CO9	Understand the concept of neurosecretion and the mode of action of peptide and steroid hormones. (6 hrs)

Question paper pattern for external examination

Module 1-7: Short answer 7x2 =14 marks; Paragraph 4x5 =20 marks; Essay 2x10 =20 marks
Module 8-9: Short answer 5x2 =10 marks; Paragraph 3x5 =15 marks.

Section A: PHYSIOLOGY (36 hours)

MODULE 1. Nutrition (5 hrs)

Regulation of digestive activity: Nervous and hormonal control; Ruminant digestion; Nutrition in pregnancy, infant nutrition, breast feeding, composition of breast milk; Importance of dietary fibres; Balanced diet; Nutritional disorders: anorexia, acidity, ulcer, flatulence; starvation, fasting and its significance; Obesity: causes and consequences.

[Short answers/Paragraphs]

MODULE 2. Respiration (6 hrs)

Gaseous exchange and transport of respiratory gases (brief account), Oxygen-Haemoglobin dissociation curve; Respiratory pigments, structure and properties of Hb; Neurophysiological control of respiration; Physiological problems in diving mammals, new-born and aged individuals.

[Short answers/Paragraphs/Essays]

MODULE 3. Circulation (6 hrs)

Blood: functions and composition; Coagulation of blood (Enzyme cascade theory); Clinical analysis of blood, ESR; Haemodynamics; Haemostasis, haemolysis and

jaundice, haemoglobinopathies; Blood transfusion and agglutination, aphaeresis.

Types of heart; ECG; Common cardio-vascular problems: Abnormal variations in BP, Tachycardia, Bradycardia, Myocardial infarction, heart failure, cerebral hemorrhage and cerebro-vascular accident.

[Short answers/Paragraphs/Essays]

MODULE 4. Osmoregulation and Excretion (6 hrs)

Osmoconformers and osmoregulators; Water conservation in desert forms; Osmotic and ionic regulation in terrestrial, fresh water and marine animals; Types of excretion, urea cycle; Human kidney: Urine formation with counter-current mechanism and hormonal regulation; Common renal disorders: haematuria, uremia, proteinuria, renal hypertension, nephritis, renal calculi, oedema, acidosis and alkalosis; Dialysis.

[Short answers/Paragraphs/Essays]

MODULE 5. Muscle Physiology (5 hrs)

Structure of vertebrate skeletal muscle: EM structure of Myofibrils and Myofilaments, contractile proteins; Mechanism of muscle contraction: Ultra structural changes (sliding filament theory); physiology, biochemistry and energetics of muscle contraction; energy sources, role of creatine phosphate, cori cycle; Muscle twitch, fatigue, tetany and rigor mortis.

[Short answers/Paragraphs/Essays]

MODULE 6. Nerve Physiology (6 hrs)

Different types of nerve cells; glial cells, giant nerve fibre of crustaceans and cephalopods; regeneration of medullary fibres, neurotrophins; Nerve impulse transmission, synapses and neuromuscular junctions, synaptic transmission (electrical and chemical), neurotransmitters.

[Short answers/Paragraphs/Essays]

MODULE 7. Bioluminescence and Bioelectricity (2 hrs)

Classification of bioluminescence: symbiotic, extracellular and intracellular; Physiology and significance of light production; Structure and functions of electric organs.

[Short answers/Paragraphs/Essays]

Section B: ENDOCRINOLOGY (18 hrs)

MODULE 8. Invertebrate and Vertebrate endocrinology (12 hrs)

Neuro- endocrine organs and hormones in crustaceans and insects.

Classification of hormones: Amine, peptide and steroid hormones; Endocrine glands in man (hypothalamus, pituitary, thyroid, parathyroid, pancreas, adrenal, thymus, pineal and gastro-intestinal): their hormones and functions (brief account); Hormonal disorders.

Hormones of reproduction: Testes, ovaries and placenta, their hormones and physiological effects; role of hormones in female sexual cycle; hormone related female and male sexual dysfunctions.

[Short answers/Paragraphs]

MODULE 9. Concept of neurosecretion and hormonal action (6 hrs)

Hypothalamus-hypophysial interactions, hypothalamus releasing and inhibiting hormones and their roles, Neuro-hormonal integration, Neuro-endocrine pathways, Regulation of hormone secretion.

Hormonal action :Hormone receptors; Mechanism of action of peptide and steroid hormones; mode of action of insulin and thyroxine; positive and negative feedback regulation.

[Short answers/Paragraphs]

Topics for assignments/seminars

(Topics allotted for assignments/ seminars should be considered for internal assessments only, and can be subdivided among students)

1. History, aim, scope and branches of Physiology.
2. Absorption of carbohydrates, proteins, and lipids.
3. Conducting system of the heart.
4. Composition and functions of lymph.
5. Gross and micro structure of human kidney.
6. Endocrine disorders in man : Cushing's disease, Addison's disease, diabetes mellitus, diabetes insipidus, dwarfism, gigantism, cretinism, myxedema and goitre.

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SIXTH SEMESTER B.Sc. ZOOLOGY PROGRAMME

ZOOLOGY CORE COURSE – X [Theory]

REPRODUCTIVE AND DEVELOPMENTAL BIOLOGY

Code: ZOL6B11T

[54 hrs] [3 hours per week] [3 credits]

COURSE OUTCOMES [COs]

COs	Course Outcome statements
CO1	Explain the reproductive strategies in invertebrates and vertebrates and structural and functional features of human reproductive system (6 hrs)
CO2	Describe process of fertilization, pregnancy, gestation, placentation, parturition and lactation in humans. (3 hrs)
CO3	Explain the scope of reproductive technologies in infertility management; prenatal diagnostic techniques and methods of fertility control (5 hrs)
CO4	Understand the phases and theories of development, and classification of eggs (3 hrs)
CO5	Enumerate the types of cleavage, arrangement of blastomeres, germ layers and their derivatives, cell lineage in Planocera and different types of blastula. (3 hrs)
CO6	Illustrate the early developmental process of egg in *Amphioxus*, frog, chick and man (22 hrs)
CO7	Explain the basics of cell differentiation and its genetic control, stem cells and applications of stem cell technology (3 hrs)
CO8	Describe parthenogenesis, types, and significance (2 hrs)
CO9	Explain fate map construction, Spemann's constriction experiments on amphibian embryos, organizers in development, embryonic induction, gradient experiments in sea urchin eggs, cloning experiments in sheep and teratogenesis (7 hrs)

Question paper pattern for external examination

Module 1-3: Short answer 2x2 =4 marks; Paragraph 3x5=15 marks.
Module 4-9: Short answer 10x2 =20 marks; Paragraph 4x5=20 marks; Essay 2x10=20 marks

SECTION A: REPRODUCTIVE BIOLOGY (14 hrs)

MODULE 1. Introduction and Human Reproductive system (6 hrs)

Introduction to Reproductive Biology (1 hr)

Importance and scope. Reproductive strategies in invertebrates and vertebrates; semelparity and iteroparity. Sex patterns; Mention sex reversal with examples.

[Short answers/Paragraphs]

Human Reproductive system (5 hrs)

Male reproductive system: structure of testis, semen production and composition. Female reproductive system: structure of ovary and graafian follicle, ovulation, mention corpus haemorrhagicum, corpus luteum and corpus albicans. Accessory reproductive organs.

Secondary sexual characteristics. Menstrual cycle and its hormonal control (brief account of oestrous cycle in mammals). Gametogenesis: spermatogenesis and oogenesis.

[Short answers/Paragraphs]

MODULE 2. Fertilization, Pregnancy, Gestation, Placentation, parturition and lactation (3 hrs)

Fertilization: Fertilizin and anti-fertilizin, capacitation, agglutination, sperm penetration, activation of egg and amphimixis. Physiological and biochemical

changes during and after fertilization. Pregnancy, Gestation, Placentation, parturition and lactation.

[Short answers/Paragraphs]

MODULE 3. Reproductive technologies (5 hrs)

Reproductive technologies (3 hrs)

Infertility and its management: Brief account of semen collection, preservation, storage, artificial insemination, surrogacy.

Cryopreservation and embryo transfer: Collection, care and preservation of embryos; *in vitro* fertilization and embryo transfer: major steps; Test tube babies.

Assisted Reproductive Techniques (ART): GIFT, ZIFT, ICSI, oocyte donation and embryo donation.

Prenatal Diagnosis (1 hr)

Different Prenatal Diagnostic techniques (invasive and non-invasive); Prevention of Female foeticide - ethical issues and laws (Mention–PNDT Act).

Fertility control (1 hr)

Natural methods, artificial methods, chemical methods, hormonal methods, surgical contraception, removal of gonads and uterus; abortion.

[Short answers/Paragraphs]

SECTION B: DEVELOPMENTAL BIOLOGY (40 hrs)

MODULE 4. Introduction and Types of eggs (3 hrs)

Introduction to Embryology (1 hr)

Historical Perspective (brief account): Mention phases in development. Theories: preformation, epigenesis, recapitulation and germplasm theory.

Types of eggs (2 hrs)

Classification of eggs with examples based on: Amount of yolk (micro, meso & macrolecithal); Distribution of yolk (iso, centro and telolecithal); Presence or absence of shell (cleidoic & non cleidoic); Types of development (determinate and indeterminate).

Egg membranes: primary, secondary and tertiary; functions of egg envelopes.

[Short answers/Paragraphs/Essays]

MODULE 5. Cleavage and cell lineage (3 hrs)

Types of cleavage with examples based on: Plane of cleavage (Meridional, Vertical, Equatorial and Latitudinal); Amount of yolk (Holoblastic and Meroblastic); Types of development (Determinate and Indeterminate); Pattern of arrangement of blastomeres (Radial and Spiral).

Germ layers and derivatives. Cell lineage studies in Planocera (brief account only). Different types of blastula.

[Short answers/Paragraphs]

MODULE 6. Development of Amphioxus, frog, chick and man (22 hrs)

Early development of Amphioxus (3 hrs)

Brief account of fertilization. Cleavage, Blastulation, Gastrulation and Neurulation.

Development of Frog **(8 hrs)**

Fertilization, Cleavage, Blastulation and fate map, Gastrulation (Morphogenetic movements) and formation of germ layers, neurulation and notochord formation, mesoderm and coelom formation; organogeny of brain and eye. Hormonal control of amphibian metamorphosis.

Development of Chick **(7 hrs)**

Structure of egg; fertilization, cleavage, blastulation, gastrulation and formation of germ layers. Salient features of chick embryo at primitive streak stage, 24, 33 and 48 hours stages. Development and functions of extra embryonic membranes.

Development of Man **(4 hrs)**

Cleavage and formation of morula, development of blastocyst, implantation, gastrulation up to the formation of germ layers. Human placenta; functions of placenta.

[Short answers/Paragraph/Essays]

MODULE 7. Cell Differentiation and Gene action during development (3 hrs)

Cell differentiation, totipotency, pluripotency, dedifferentiaton and redifferentiation. Controlled gene expression during development; Homeotic genes, Mention Hox-genes. Stem cells – embryonic and adult stem cells; their significance and applications.

[Short answers/Paragraphs]

MODULE *8.* Parthenogenesis (2 hrs)

Definition and types. Natural parthenogenesis: Arrhenotoky, Thelytoky, Obligatory and Facultative. Artificial parthenogenesis. Significance of parthenogenesis.

[Short answers/Paragraphs]

MODULE *9.* Experimental Embryology & Teratology (7 Hrs)

Experimental Embryology **(5 hrs)**

Construction of fate map, vital staining, marking with carbon particles and radioactive tracing. Spemann's constriction experiments on amphibian embryos,

potency of nuclei and importance of Grey crescent. Organizers in amphibian development (primary, secondary & tertiary organizers). Embryonic induction. Gradient experiments in sea urchin eggs. Cloning experiments in sheep.

Teratology **(2 hrs)**

Environmental disruption in animal development: Teratogenic agents and their effects (alcohol, drugs, nicotine and other chemicals), infections (Herpes virus, Cytomegalovirus and Rubella virus), metabolic imbalance (malnutrition and autoimmunization) (brief account).

[Short answer/Paragraphs]

Topics for assignments/seminars

(Topics allotted for assignments/ seminars should be considered for internal assessments only, and can be subdivided among students)

1. Development of foetal membranes in man.
2. Types of placenta (brief account).
3. Regeneration in animals.
4. Factors affecting regeneration.
5. Factors inducing parthenogenesis.
6. Structure of different types of eggs (Amphioxus, frog, insect)

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SIXTH SEMESTER B.Sc. ZOOLOGY PROGRAMME

ZOOLOGY CORE COURSE –XI [Theory]

ENVIRONMENTAL AND CONSERVATION BIOLOGY

Code: ZOL6B12T

[54 hrs] [3 hours per week] [3 credits]

COURSE OUTCOMES [COs]

COs	Course outcome statements
CO1	Explain the structure of ecosystem and its functioning through energy flow and nutrient cycling (6 hrs).
CO2	Enumerate biogeochemical cycles and understand the concept of limiting factors (5 hrs).
CO3	Describe the ecology of population, community and habitat as a self regulating system (14 hrs)
CO4	Understand various types of population interactions and appraise the co-evolution (3 hrs).
CO5	Comprehend the diverse environmental and sustainability challenges ranging from local to global and the establishment of perfect harmony between economic development, social issues and environmental conservation (4 hrs).
CO6	Enumerate the several tools and techniques employed for studies on populations, communities and ecosystems. (4 hrs)
CO7	Understand the threats to biodiversity, and strategies adapted for the conservation of diversity of organisms (10 hrs)
CO8	Describe the various international strategies for conserving biodiversity (4 hrs)
CO9	Describe the toxic chemicals, their toxicity levels and the health hazards caused by them (4 hrs).

Question paper pattern for external examination

[Module 1-6: Short answer 9x2=18 marks, Paragraph 5x5=25 marks, Essay 1x10= 10 marks
Module 7-9: Short answer 3x2= 6 marks, Paragraph 2x5=10 marks, Essay 1x10=10 marks]

Section A: ENVIRONMENTAL BIOLOGY (36 hrs)

MODULE 1. Introduction, Ecosystem and Energetics (6 hrs)

Introduction to Environmental biology: Definition, divisions of ecology, modern branches and scope.

Ecosystem-Structure and functions: Concept of ecosystem, characteristics; Structure (components) of ecosystem (pond as an example); Mention kinds of ecosystems.

Ecosystem Energetics: Photosynthetic production and energy fixation; Energy flow in the ecosystem, Energy flow and laws of thermodynamics, Energy transfer and energy transformations [Trophic dynamics or community dynamics (Lindeman's model of energy flow)]; Ecological efficiency.

Productivity of ecosystem: Concept of productivity- standing crops, material removed and production rate; Kinds of productivity: a) Primary productivity (GPP, NPP, NCP) b) Secondary productivity).

[Short answer/Paragraph/Essays]

MODULE 2. Biogeochemical Cycles and Limiting factors (5 hrs)

Biogeochemical Cycles: Basic types of biogeochemical cycles: Gaseous cycles (Carbon and nitrogen cycles) Sedimentary cycle (Phosphorous cycle).

Limiting factors: Basic concepts. Leibig's law of minimum; Shelford's law of tolerance and combined concept of limiting factors. Ecological indicators.

[Short answer/Paragraph/Essays]

MODULE 3. Population, Community and Habitat Ecology (14 hrs)

Population Ecology

Properties of population: density, natality, mortality, age distribution, biotic potential, environmental resistance, migration, emigration, immigration and carrying capacity. Population growth forms, J and S shaped curves.

Community Ecology

Biotic community: Definition and kinds of communities.

Characteristics: Species diversity, abundance, dominance, stratification, succession, growth forms, trophic structure, co-existence, interdependence and key stone species; Concept of ecotype, ecotone and edge effect.

Habitat ecology

a) Marine ecology: Biotic divisions of the marine habitat, their characteristics. Pelagic realm- planktonic and nektonic adaptations. Benthic realm – littoral and abyssal adaptations. Adaptations of animals of rocky, sandy and muddy sea shores.

b) Fresh water ecology: Lentic and lotic habitats, their characteristics, faunal characteristics and adaptations.

c) Terrestrial ecology: Tropical wet evergreen forests and Tropical dry deciduous forests, their characteristics, adaptations of animals of forests.

[Short answer/Paragraph/Essays]

MODULE 4. Population Interactions (3 hrs)

a) Intraspecific interactions b) Inter specific interactions: Positive interactions- Mutualism, Commensalism and Proto-cooperation (with examples). Negative interactions- Competition, Predation and Parasitism (with examples).

[Short answer/Paragraph/Essays]

MODULE 5. Social issues and Environment (4 hrs)

Sustainable development; Joint Forest Management; Goals of United Nations; Environmental ethics: Issues and possible solutions, Habitat destruction and its consequences- socio-ecological concern: wetland, paddy fields, mangrove, river encroachment, sand and clay mining; Ecological impacts of tourism.

Disaster management: Natural & Artificial - floods, drought, earthquake, cyclone and landslides.

[Short answer/Paragraphs]

MODULE 6. Ecological tools and Techniques (4 hrs)

Commonly used techniques for study of animal populations: a) Sampling of animal populations b) Trapping and collecting various groups of organisms [insects, aquatic organisms, soil organisms, birds and mammals] c) Marking of animals d) Determination of age in animal groups d) Determination of home range and territory e) Estimation of number of animals in a population f) Indirect method of estimating wild animal populations g) Recent trends- Camera trapping, Radio collaring and Remote sensing

[Short answer/Paragraphs]

Section B: CONSERVATION BIOLOGY (14 hrs)

MODULE 7. Biodiversity (10 hrs)

Introduction, Components of biodiversity: Genetic diversity, species diversity (mention Shannon diversity index and Simpson's dominance index), community diversity and ecosystem diversity, landscape diversity; Levels of diversity in community and ecosystem diversity: Alpha, beta and gamma diversities.

Hot spots of biodiversity. Mention hotspots in Indian region (Western Ghats and Sri Lanka, Himalayas, Indo Burma and Sundaland).

Threats to biodiversity; Loss of biodiversity and its causes.

Threatened species, Extinction of species, Red data book and IUCN Red list categories.

Conservation of biodiversity and wildlife: conservation measures; Wild life (protection Act) 1972, Conservation projects: Project Tiger, Elephant, Lion, Crocodile, Gangetic Dolphins, Kashmir Red Deer and Brow-antlered Deer (Sangai).

Biodiversity conservation strategies: Protection of endangered species- *Ex situ conservation* (conservation in Seed banks, Gene banks, Germ plasm banks, Zoo, Botanical gardens etc.).

In situ conservation: Wildlife Sanctuaries -Thattekkad bird sanctuary, ParambikulamWLS, PeriyarWLS, Malabar WLS); National Parks- Eravikulam NP & Silent Valley NP; Biosphere Reserves - Nilgiri BR & Agasthyamalai BR; Community reserve- Kadalundy.

[Short answer/Paragraph/Essays]

MODULE 8. Global strategy for conservation (4 hrs)

Brief notes on i) Stockholm conference/Declaration (1972), ii) IUCN, iii) WWF, iv) UNEP, v) CITES, vi) Rio Declaration vii) Rio convention on Biodiversity, 1992 (Rio Earth Summit, 1992), Rio (2012). viii) Kyoto Agreement (1997), Paris Agreement (2016) and Conference of the Parties (COP) on climate change (2018), ix) Ramsar convention (2018).

[Short answer/Paragraphs]

Section C: TOXICOLOGY (4 hrs)

MODULE 9. Toxicants and public health hazards (4 hrs)

a. Toxic chemicals (biocides, automobile emissions, heavy metals, fertilizers, food additives, xenobiotics, radioactive wastes).

b. Classification of poisons; Physico-chemical characteristics and mode of action of poisons; Accidental, suicidal and homicidal poisonings; Signs and symptoms of common poisoning and their antidotes.

c. Levels of toxicity: Acute, sub acute, chronic, Dose-response relationship. Measures of toxicity: LD_{50} and LC_{50}.

[Short answer/Paragraps]

Topics for Assignments/Seminars

(Topics allotted for assignments/ seminars should be considered for internal assessments only, and can be subdivided among students)

1. Environmental factors (Temperature, water, light, soil) and their influence on organisms.

2. Concept of habitat and niche.
3. Food chains and food web.
4. Major biomes of the world.
5. Ecological pyramids.
6. Ecological succession, basic types and processes in succession.
7. Environmental pollution-Land, water, air, sound and radiation.
8. Global warming and Ozone depletion.
9. Individual responsibilities – Role of Governmental and Non-Governmental Organizations in biodiversity conservation – Chipko, Green peace WWF
10. Food additives.

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SIXTH SEMESTER B.Sc. ZOOLOGY PROGRAMME

ZOOLOGY CORE COURSE –XII [Theory]

ETHOLOGY, EVOLUTION AND ZOOGEOGRAPHY

Code: ZOL6B13T

[54 hrs] [3 hours per week] [3 credits]

COURSE OUTCOMES [COs]

COs	Course Outcome Statements
CO1	Describe the patterns and mechanisms of animal behaviour (5 hrs)
CO2	Illustrate biological rhythms and the chemical basis of communication (7 hrs)
CO3	Identify major evolutionary transitions over time, and explain the tools and evidences that support current hypotheses of the history of life on earth (8 hrs)
CO4	Describe the evidences for evolution and its required corollaries (5 hrs)
CO5	Explain the various theories of evolution (6 hrs)
CO6	Describe the mechanisms by which evolution occurs (5 hrs)
CO7	Recognize the significance of reproductive isolation in reducing gene flow between populations, biological and morphological species concepts and distinguish between prezygotic and postzygotic barriers to reproduction (7 hrs)
CO8	Review the events in human evolution (3 hrs)
CO9	Explain ecological and historical foundations for understanding the distribution and abundance of species, and their changes over time and comprehend the basic principles of biogeography as a discipline (8 hrs)

Question paper pattern for external examination

[Module 1-2: Short answer 4x2=8 marks, Paragraph 2x5=10 marks;
Module 3-8: Short answer 5x2=10 marks, Paragraph 4x5=20 marks, Essay 2x10=20 marks;
Module 9: Short answer 3x2=6 marks, Paragraph 1x5=5 marks]

Section A: ETHOLOGY (12 hrs)

MODULE 1. Patterns and Mechanisms in Animal Behaviour (5 hrs)

Introduction and Patterns of behavior **(4 hrs)**

History (brief), scope of ethology. (a) Innate behaviour: Orientation-taxes/kinesis, simple reflexes, instincts, motivation. (b) Learned behaviour: Habituation, conditioned reflex, trial and error learning; latent learning, imprinting, insight learning, memory and learning.

Neural mechanism in behavior **(1 hr)**

Role of hypothalamus in thirst and feeding; role of cerebral cortex in emotional behavior; mammalian limbic system and control of behavior (brief account).

[Short answers/Paragraphs]

MODULE 2. Biological rhythm and Sociobiology (7 hrs)

Biological clocks/rhythms **(4 hrs)**

Photoperiodism, circadian rhythm; migration, orientation, navigation and homing; diapause, hibernation and aestivation (brief account)

Sociobiology **(3 hrs)**

Social groups in termites and elephants; Chemical communication: classification and significance of pheromones (mention human pheromones also).

[Short answers/paragraphs]

Section B: EVOLUTION (34 hrs)

MODULE 3. Course of Evolution (8 hrs)

History of Evolutionary thought (1 hr)

History of evolutionary thought: Ideas of evolution during Pre-Darwinian, Darwinian and Post- Darwinian periods (brief account).

Origin of life (6 hrs)

Biochemical origin of life (Modern hypothesis–Oparin-Haldane Theory). Major steps in the biochemical evolution of life (brief account): Origin of Earth and the primordial atmosphere, formation of simple organic molecules, formation of macromolecules or polymers, and formation of coacervates, microspheres, protocells and full-fledged living cells; origin of mitochondria and chloroplast. Experimental evidence for biochemical origin of life: Urey-Miller experiment; Other experiments; Modern ideas on the origin of life. Mention origin of prokaryotes and eukaryotes.

History of Life on Earth (1 hrs)

Geological time scale (simple chart), mention Cambrian explosion. Fossils, Fossilization and Dating of fossils (brief account). Living fossils: *Peripatus*, *Limulus* and *Sphenodon* as examples.

[Short answers/Paragraphs/Essays]

MODULE 4. Evidences of Organic Evolution (5 hrs)

i) Morphological and anatomical, ii) physiological and biochemical, iii) embryological, iv) palaeontological, v) molecular, vi) taxonomical evidences and vii) biogeographical evidences

[Short answers/Paragraphs/Essays]

MODULE 5. Theories of Evolution (6 hrs)

Lamarck's theory: Explanation of the major postulates of the Lamarck's theory with examples, Criticism against Lamarckism, Neo-Lamarckism, Present status of Lamarckism.

Darwin's theory: Explanation of important postulates of Darwin's theory, Examples for natural selection, Criticism against Darwinism, Neo-Darwinism (Synthetic theory of evolution).

Weismann's germplasm theory; Mutation theory of De Vries. Mention the contributions of Wallace.

[Short answers/Paragraphs/Essays]

MODULE 6. Concepts of Evolutionary Process (5 hrs)

Genetic basis of evolution: i) Mutations (brief account of gene and chromosomal mutations), ii) Variations: somatic (environmental) variations and genetic (hereditary) variations, iii) Hardy-Weinberg Principle: Hardy-Weinberg Equilibrium, Factors that upset Hardy-Weinberg Equilibrium, iv) Genetic drift: effects on population, Evolutionary bottleneck and Founder effect, genetic drift and natural selection, importance of genetic drift in evolution; theory of punctuated equilibrium and its relevance.

[Short answers/Paragraphs/Essays]

MODULE 7: Nature of Evolution (7 hrs)

Species and Speciation: Species concept: phylogenetic and biological species concepts; General characteristics and subdivisions of species: subspecies, semi species, sibling species, cline and deme.

Speciation: Types of speciation i) Phyletic speciation ii) Quantum speciation iii) Gradual speciation; Major methods of natural speciation: Allopatric, parapatric and sympatric speciation.

Isolation and Isolating mechanisms: Types of isolating mechanisms i) Geographic isolation: mention examples, ii) Reproductive isolation (a) Prezygotic isolation (habitat, seasonal, ethological, morphological, physiological and cytological isolation with examples), (b) Postzygotic isolation (hybrid inviability, hybrid sterility and F2 breakdown isolation with examples).

Adaptive Radiation (Divergent Evolution): cause and significance, adaptive radiation in Darwin's finches; Convergent Evolution; Pre-adaptation; Co-evolution (mention examples also).

[Short answers/paragraphs/Essays]

MODULE 8: Evolution of Modern Man (3 hrs)

Evolutionary trends in humans; Fore-runners of anthropoids-*Parapithecus*; Fore-runners of apes-*Dryopithecus*; Fore-runners of modern man-*Ramapithecus* (Kenyapithecus), *Australopithecus* (The ape-man), *Homo habilis* (The handy man), *H.erectus* (Pithecanthropines), *H.sapiens neanderthalensis* (Neanderthal man), *Homo sapiens fossilis* (The Cro-magnon), *Homo sapiens sapiens* (Modern man), mention Denizoans and Malapan man.

[Short answers/paragraphs/Essays]

Section C: ZOOGEOGRAPHY (8 hrs)

MODULE 9: Zoogeographical realms and Biogeography of India (8 hrs)

Geographical Distribution (4 hrs)

(a) Geographical distribution of animals: Cosmopolitan, discontinuous, bipolar and isolated distribution. (b) Barriers in animal distribution: Physical, climatic and biological barriers.

Zoogeographical realms (2 hrs)

Zoogeographical regions with specific fauna (faunal regions): Palaeartic region, Nearctic region, Neotropical region, Ethiopean region, Oriental region and Australian region; brief description on Wallace line, Weber line and Wallacea.

Insular fauna (1 hr)

Faunal characteristics of continental (Madagaskar and Sri Lanka) and oceanic islands (Galapagos and New Zealand).

Biogeography of India (1 hr)

Biogeographical zones of India: Himalayan, Desert zone, Semi-arid zone, Western Ghats, Deccan plateau, Gangetic plain, North east Indian zone, Island zone and Coastal zone (brief account).

[Short answer/Paragraphs]

Topics for Assignments / Seminars

(Topics allotted for assignments/ seminars should be considered for internal assessments only, and can be subdivided among students)

1. Old theories on origin of life: i) Theory of abiogenesis ii) Theory of biogenesis iii) Theory of special creation iv) Theory of Panspermia.
2. Evolution of Vertebrate Groups: Evolution of agnathans, fishes, amphibians, reptiles, birds and mammals (brief account).
3. Evolution of horse
4. Polypliody and Evolution
5. Ancestry of human population of India

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Module 1-2 (Ethology)

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Module 3-8 (Evolution)

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Module 9 (Zoogeography)

- Andrews, M.I. & Joy, K.P. *Ecology, Evolution & Zoogeography*. S.M. Book Depot, Changanassery
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SIXTH SEMESTER B. Sc. ZOOLOGY PROGRAMME

ZOOLOGY ELECTIVE CORE COURSE- II (Theory)

AQUACULTURE, ANIMAL HUSBANDRY AND POULTRY SCIENCE

Code: ZOL6B14BE02T

[54 hours] [3 hours per week] [3 Credits]

COURSE OUTCOMES [COs]

COs	Course Outcome Statements
CO1	Explain aquaculture and the process of prawn, mussel and pearl culture (10 hrs).
CO2	Illustrate the methodology of pisciculture and understand common culture fishes and ornamental fishes (13 hrs)
CO3	Identify major fishing crafts and gear and enumerate fish utilization and preservation (13 hrs)
CO4	Enumerate the poultry rearing techniques and understand major breeds of fowl (7 hrs)
CO5	Understand the major breeds of cattle, cattle feeds and diseases of cattle (6 hrs)
CO6	Illustrate the steps in dairy processing and identify the role of dairy development in rural economy (5 hrs).

Question paper pattern for external examination

[Module 1-3: Short answer 6x2=12 marks, Paragraph 4x5=20 marks; Essay 2x10=20 marks
Module 4-6: Short answer 6x2=12 marks, Paragraph 3x5=15 marks]

MODULE 1. Aquaculture (10 hrs)

Types of aquaculture (3 hrs)

Brief account of classification of aquaculture based on:

Environment – Freshwater, brackish water and mariculture.
Temperature – Warm water/cold water culture.
Culture techniques – pond aquaculture, cage culture, pen culture, raft culture, pole culture, rack culture and long line culture.
Number of species – Mono culture and poly culture.
Type of organism – prawn culture, shrimp culture, edible oyster culture, lobster culture etc.

Mariculture (7 hrs)

Prawn culture: Important cultivable species in India, seed collection, spawning and larval rearing, induced breeding, types of culture systems - Pokkali culture, culture in bheries/ponds, culture and harvesting.

Mussel culture: *Perna indica*, *Perna viridis*, Seed collection, artificial seed production, induced spawning, culture techniques and harvesting.

Pearl culture: Method of pearl formation, selection and preparation of host, preparation of nucleus and implantation, post-operation care, post-operation culture and collection of pearls.

[Short answers/Paragraphs/Essays]

MODULE 2. Pisciculture (13 hrs)

i. Egg collection; induced spawning; construction, preparation and maintenance of ponds; manuring; feeding and harvesting. Cryopreservation of fish germplasm, semen bank and preservation media.
ii. Biology and culture of following Indian major carps: *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*.

iii. Biology and culture of Exotic carps: *Cyprinus carpio* (common carp), *Hypophthalmichthys molitrix* (Silver carp).

iv. Inland fishes and Fisheries (Brief account): *Channa, Clarias* and *Etroplus suratensis*

v. General account and fishery aspect of Sardine, Shark and Tuna. Mention GIFT Tilapia and Nutter (*Pygocentrus nutterei*)

vi. Ornamental fisheries: Common aquarium fishes: e.g: *Carassius auratus* (Gold fish), *Pterophyllum* spp. (Angel fish), *Astronotus ocellatus* (Oscar cichlid), *Poecilia reticulata (*Guppy), *Poecilia sphenops* (Black molly), aquarium management.

vii. Plankton and Fishery production: Zoo and Phytoplankton – Vertical migration – Plankton and Productivity.

[Short answers/Paragraphs/Essays]

MODULE 3. Fishing Crafts and Gear, fish preservation and utilization (13 hrs)

i. Fishing crafts – Mention Catamaran, Canoes and dug-out-canoes.

ii. Fishing gears – Gillnet/drift gillnet, purse-seines, harpoon, Chinese dipnets, echo sounders, sonar, remote sensing.

iii. Fish Spoilage and Preservation: Biochemical changes, spoilage, use of ice, freezing, canning, dehydration, salting and smoking.

iv. Fish utilisation: Nutritive value, bye products, liver oil, body oil, fish meal, fish flour, Isinglass, glue, skin, fin soup, lime, chitin and chitosan.

v. Diseases and parasites of Fish: Fungal infection – Epizootic Ulcerative Syndrome (EUS), Saprolegnia, Fin and tail rot disease, Dropsy.

vi. Mud banks of Kerala coast.

[Short answers/Paragraphs/Essays]

MODULE 4. Poultry science (7 hrs)

i. Egg production, cable bird production, nutritive value and bye products.

ii. Breeds of fowl – Exotic –Rhode Island Reds, Plymouth Rock, Naked Neck and Leghorn; Indigenous – Gramapriya, Giriraja and Kalinga Brown.

iii. Poultry rearing: Selection of eggs, hatching, incubation, brooding, sexing and vaccination.

iv. Poultry housing: Free range system, Semi-intensive system (deep litter system and individual cage system).

v. Equipments for feeding: Nutrients for starting, growing, laying hen.

vi. Common poultry feeds, food rations and feed formulation.

vii. Common diseases of poultry (Ranikket, Pullorum and Fowl pox)

[Short answers/Paragraphs]

MODULE 5. Animal husbandry (6 hrs)

Introduction: History, origin, domestication.

Breeds of cattle:

Dairy breeds: Sindhi, Gir

Draught breeds of cattle: Nagori, Kangayam

Dual purpose breeds: Ongole, Hariana

Exotic breeds: Jersey, Holstein – Friesian

Native breeds: Conservation programmes, Vechur cow and Kasargod Dwarf

Feeding: Common cattle feeds, fodder

Common diseases: Anthrax, Foot & Mouth disease.
Parasites of cattle
Meat hygiene: Slaughter and clean meat production – Zoonotic diseases.

[Short answers/Paragraghs]

MODULE 6. Dairy science (5 hrs)

i. Role of dairy development in rural economy, employment opportunities, white revolution.
ii. Dairy processes: Straining, Filtration, Cooling, Chilling, Clarification, Pasteurisation, Freezing, Recombined milk, Soft curd milk, Skimmed and toned milk.
iii. Artificial milk, Milk adulteration.

[Short answers/Paragraphs]

Topics for Assignments/Seminars

(Topics allotted for assignments/ seminars should be considered for internal assessments only, and can be subdivided among students)

1. Role of physical and chemical factors in aquaculture.
2. Sea weed culture: e.g: Grassilaria, Sargassum.
3. Dairy products, manufacture and nutritive value.
4. Milk and milk spoilage.
5. Crab and lobster culture.

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