BHARATHIDASAN UNIVERSITY TIRUCHIRAPPALLI - 620 024.

B.Sc. ZOOLOGY

CHOICE BASED CREDIT SYSTEM –

LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK (CBCS - LOCF)

(Applicable to the candidates admitted from the academic year 2022-23 onwards)

(NAAN MUDHALVAN SCHEME was implemented from 2nd to 6th Semester)

Sem.	Part	Course	Title of the Course	Ins. Hrs	Credit	Exam Hours	Marks Int.	Marks Ext.	Total
I	I	Language Course – I Tamil $ / Other Languages + #		6	3	3	25	75	100
	II	English Course - I		6	3	3	25	75	100
	III	Core Course – I (CC)	Invertebrata	5	5	3	25	75	100
		Core Practical – I (CP)	Invertebrata	4	4	3	40	60	100
		First Allied Course – I (AC)		4	4	3	25	75	100
		First Allied Practical (AP)		3	-	-	-	-	-
	IV	Value Education		2	2	3	25	75	100
	TOTAL			**30**	**21**	**-**	**-**	**-**	**600**
II	I	Language Course - II Tamil $ / Other Languages + #		6	3	3	25	75	100
	II	English Course - II		4	3	3	25	75	100
	III	Core Course – II (CC)	Chordata	5	5	3	25	75	100
		Core Practical – II (CP)	Chordata	4	4	3	40	60	100
		First Allied Practical (AP)		3	2	3	40	60	100
		First Allied Course – II (AC)		4	4	3	25	75	100
		Add on Course – I ##	Professional English – I	6*	4	3	25	75	100
	IV	Environmental Studies		2	2	3	25	75	100
	VI	Naan Mudhalvan Scheme (NMS) @@	Language Proficiency for Employability - Effective English	2	2	3	25	75	100
	TOTAL			**30**	**29**	**-**	**-**	**-**	**900**

III	I	Language Course – III Tamil $ / Other Languages + #		6	3	3	25	75	100
	II	English Course - III		6	3	3	25	75	100
	III	Core Course – III (CC)	Cell and Molecular Biology	5	5	3	25	75	100
		Core Practical - III (CP)	Cell and Molecular Biology	4	4	3	40	60	100
		Second Allied Course – I (AC)		4	4	3	25	75	100
		Second Allied Practical (AP)		3	-	-	-	-	-
		Add on Course – II ##	Professional English - II	6*	4	3	25	75	100
	IV	Non-Major Elective I @ - Those who choose Tamil in Part I can choose a non-major elective course offered by other departments. Those who do not choose Tamil in Part I must choose either a) Basic Tamil if Tamil language was not studied in school level **or** b) Special Tamil if Tamil language was studied upto 10^{th} & 12^{th} std.	Public Health and Hygiene	2	2	3	25	75	100
	VI	Naan Mudhalvan Scheme (NMS) @@	Digital Skills for Employability – Microsoft Digital Skills	-	2	3	25	75	100
	TOTAL			**30**	**27**	**-**	**-**	**-**	**800**
IV	I	Language Course –IV Tamil $ / Other Languages + #		6	3	3	25	75	100
	II	English Course – IV		6	3	3	25	75	100
	III	Core Course - IV (CC)	Microbiology	5	5	3	25	75	100
		Core Practical - IV (CP)	Microbiology	4	4	3	40	60	100
		Second Allied Practical (AP)		3	2	3	40	60	100
		Second Allied Course – II (AC)		4	4	3	25	75	100
	IV	Non-Major Elective II @ - Those who choose Tamil in Part I can choose a non-major elective course offered by other departments. Those who do not choose Tamil in Part I must choose either a) Basic Tamil if Tamil language was not studied in school level **or** b) Special Tamil if Tamil language was studied upto 10^{th} & 12^{th} std.	Economic Zoology	2	2	3	25	75	100
	VI	Naan Mudhalvan Scheme (NMS) @@	Employability Skills - Employability Skills	-	2	3	25	75	100
	TOTAL			**30**	**25**	**-**	**-**	**-**	**800**

V	III	Core Course -V (CC)	Developmental Biology	5	5	3	25	75	100
		Core Course – VI (CC)	Genetics and Evolution	5	5	3	25	75	100
		Core Course – VII (CC)	Immunology	5	5	3	25	75	100
		Core Practical -V (CP)	Developmental Biology, Genetics and Evolution & Immunology	4	4	3	40	60	100
		Major Based Elective – I (Any one)	1. Aquatic Biology 2. Biodiversity and Conservation	5	4	3	25	75	100
	IV	Skill Based Elective I	Aquarium fish keeping	4	2	3	25	75	100
		Soft Skills Development		2	2	3	25	75	100
	VI	Naan Mudhalvan Scheme (NMS) @@	Advanced Technology for Employability in Life science – Medical Coding	-	2	3	25	75	100
	TOTAL			**30**	**29**	**-**	**-**	**-**	**800**
VI	III	Core Course - VIII (CC)	Animal Physiology	6	5	3	25	75	100
		Core Course - IX (CC)	Biotechnology	6	5	3	25	75	100
		Core Practical – VI (CP)	Animal Physiology and Biotechnology	4	4	3	40	60	100
		Major Based Elective – II (Any one)	1. Environmental Biology 2. Applied Entomology	5	4	3	25	75	100
		Project*		4	3	-	20	80	100
	IV	Skill Based Elective II	Medical Diagnostics	4	2	3	25	75	100
	V	Gender Studies		1	1	3	25	75	100
		Extension Activities **		-	1	-	-	-	-
	VI	Naan Mudhalvan Scheme (NMS) @@	Advanced Medical Coding	-	2	3	25	75	100
	TOTAL			**30**	**27**	**-**	**-**	**-**	**800**
GRAND TOTAL				**180**	**158**	**-**	**-**	**-**	**4700**

List of Allied Courses

First Allied Course	**Second Allied Course**
Botany	Chemistry

$ For those who studied Tamil upto 10th +2 (Regular Stream).

+ Syllabus for other Languages should be on par with Tamil at degree level.

Those who studied Tamil upto 10th +2 but opt for other languages in degree level under Part- I should study special Tamil in Part – IV.

The Professional English – Four Streams Course is offered in the 2nd and 3rd Semester (only for 2022-2023 Batch) in all UG Courses. It will be taught apart from the Existing hours of teaching / additional hours of teaching (1 hour /day) as a 4 credit paper as an add on course on par with Major Paper and completion of the paper is must to continue his / her studies further. (As per G.O. No. 76, Higher Education (K2) Department dated: 18.07.2020).

* The Extra 6 hrs / cycle as per the G.O. 76/2020 will be utilized for the Add on Professional English Course.

@ NCC Course is one of the Choices in Non-Major Elective Course. Only the NCC cadets are eligible to choose this course. However, NCC Course is not a Compulsory Course for the NCC Cadets.

** Extension Activities shall be outside instruction hours.

@@ Naan Mudhalvan Scheme.

SUMMARY OF CURRICULUM STRUCTURE OF UG PROGRAMMES

Sl. No.	Part	Types of the Courses	No. of Courses	No. of Credits	Marks
1.	I	Language Courses	4	12	400
2.	II	English Courses	4	12	400
3.	III	Core Courses	9	45	900
4.		Core Practical	6	24	600
5.		Allied Courses I & II	4	16	400
6.		Allied Practical	2	4	200
7.		Major Based Elective Courses	2	8	200
8.		Add on Courses	2	8	200
9.		Project	1	3	100
10.	IV	Non-Major Elective Courses (Practical)	2	4	200
11.		Skill Based Elective Courses	2	4	200
12.		Soft Skills Development	1	2	100
13.		Value Education	1	2	100
14.		Environmental Studies	1	2	100
15.	V	Gender Studies	1	1	100
16.		Extension Activities	1	1	--
17.	VI	Naan Mudhalvan Scheme	5	10	500
	Total		**48**	**158**	**4700**

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First Year **CORE COURSE I INVERTEBRATA (Theory)** **Semester I**

Code: **Credit: 5**

COURSE OBJECTIVES:

- To perceive the taxonomic relationship and evolution of species.
- To identify each phylum of invertebrates and discuss their key characters.
- To appraise the diversity of invertebrate species in a phylogenetic context.
- To understand how body organization solves biological problems related to physiological and environmental challenges.
- To develop an appreciation for the role of invertebrates in biological and ecological interactions and its conservation strategies.

UNIT – I PHYLUM – PROTOZOA AND PORIFERA:

Introduction to principles of taxonomy and outline classification of Kingdom Animalia.

General characters and classification of Phylum- Protozoa and Porifera (upto class) with examples.

Detailed study – Protozoa – Amoeba (*Amoeba proteus*) Porifera – Ascon Sponge (Leucosolenia)

General Topic:
1. Parasites of Protozoa
2. Canal system in Sponges
3. Economic and ecological importance of Protozoa and Porifera

UNIT – II PHYLUM - COELENTERATA AND PLATYHELMINTHES:

General characters and classification of Phylum Coelenterata and Platyhelminthes (upto class) with examples.

Detailed study – Coelenterata - Aurelia (*Aurelia aurita*), Platyhelminthes – Tapeworm (*Taenia solium*),

General Topic:
1. Polymorphism in Coelenterates
2. Corals and corals reefs and their importance
3. Parasitic adaptations of helminth parasites
4. Invertebrate model organism – *Caenorhabditis elegans*

UNIT – III PHYLUM - ASCHELMINTHES AND ANNELIDA:

General characters and classification of Phylum Aschelminthes and Annelida (upto class) with examples.

Detailed study – Ascaris (*Ascaris lumbricoides*), *Nereis* (*Neanthes virens*) Earthworm (*Pheretima posthuma*)

General Topic: 1. Economic importance of Aschelminthes
2. Vermiculture technology and its economic importance
3. Adaptive radiation in Annelids

UNIT – IV PHYLUM - ARTHROPODA AND MOLLUSCA:

General characters and classifications of Phylum Arthropoda and Mollusca (upto class) with examples.

Detailed study – Cockroach (*Periplanata americana*), *Prawn* (*Penaeus monodon*) Apple snail (*Pila globosa*)

General Topic: 1. Mouth parts of insects
2. Economic importance of Mollusca
3. Economic and ecological importance of Mollusca

UNIT – V PHYLUM - ECHINODERMATA AND MINOR PHYLA:

General characters and classification of Phylum Echinodermata (upto class) with examples and minor phyla (Mesozoa, Ctenophora, Nemertinea, Acanthocephala, Entoprocta, Rotifera, Gastrotricha and Kinorhyncha)

Detailed study – Starfish (*Asterias rubens*), Crinoids Brief about Branchionus

General Topic: 1. Larval forms of Echinodermata
2. Water vascular system in Echinodermata
3. Economic and ecological importance of Echinodermata

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Recent research/discoveries in Zoology - Identification of new species – evolutionary significance between species - mitogenomics study – invertebrate model organisms - *Drosophila melanogaster* as an animal model in biomedical research - automatic invertebrate detection and identification methods - acoustic and vibration sensing - extinct species – protective measures - applications of biotechnology in conservation of invertebrate species.

REFERENCES:

1. Ayyar. E.M. (1966). A Manual of Zoology Part I, Invertebrata, S. Viswanathan Pvt. Ltd., Chennai.
2. Giribet, G. and Edgecombe, G. D. (2020). The Invertebrate Tree of Life. Princeton University Press.
3. Calow, P. (2012). Invertebrate Biology: A Functional Approach. Springer Science & Business Media.
4. Inver Schierwater, B. and DeSalle, R. (2021). Invertebrate Zoology: A Tree of Life Approach. United States: CRC Press.
5. Sandhu, G.S. (2005). Textbook of Invertebrate Zoology. India: Campus Books International.
6. Ruppert, E.E., Fox, R.S. and Barnes, R.D. (2004). Invertebrate Zoology: A Functional Evolutionary Approach. United Kingdom: Thomson-Brooks/Cole.

7. Barnes, R.D., Ruppert, E.E. and Fox, R.S. (2009). Invertebrate Zoology. India: Cengage Learning.
8. Pechenik, J.A. (2014). Biology of the Invertebrates. India: McGraw-Hill Education, VII edition.
9. Shuster, S.M., Moore, W. and Brusca, R.C. (2016). Invertebrates. United States: Sinauer.
10. Brusca, G.J. and Brusca, R.C. (2003). Invertebrates. Sinauer Associates, Inc., Publishers
11. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/porifera
12. https://www.differencebetween.com/difference-between-coelenterates-and-vs-platyhelminthes/
13. https://www.researchgate.net/profile/Anuradha-Sharma-11/publication/311971514_Vermiculture_Technology_A_Novel_Approach_in_Organic_Farming/links/59fae02d458515d20c7d9706/Vermiculture-Technology-A-Novel-Approach-in-Organic-Farming.pdf?origin=publication_detail
14. https://www.biologydiscussion.com/invertebrate-zoology/phylum-mollusca/economic-importance-of-phylum-molluscs/33025
15. https://www.researchgate.net/profile/Huajian-Liu-3/publication/307529800_A_review_of_recent_sensing_technologies_to_detect_invertebrates_on_crops/links/5c0faab1299bf139c7509a61/A-review-of-recent-sensing-technologies-to-detect-invertebrates-on-crops.pdf
16. https://academic.oup.com/ilarjournal/article-pdf/52/2/126/6763915/ilar-52-126.pdf

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Understand the principles of taxonomy and classification of invertebrates.
- Acquire knowledge on the characteristic features of invertebrates.
- Identify the any species at basic level of morphology.
- Aware of the multiparasitism of helminthes and their dynamics in a changing world.
- Understand the economic and ecological importance of Porifera, Coelenterata and Mollusca.
- Realize the significance of larval forms of Echinoderms in understanding as model organisms.

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First Year **CORE PRACTICAL I** **Semester I**

INVERTEBRATA

Code: **(Practical)** **Credit: 4**

COURSE OBJECTIVES:

- To introduce the structure, functions and behavior of specified invertebrate organisms by the observation of both living and preserved specimens.
- To reinforce the student's basic laboratory skills including microscopy, virtual dissection and careful observation.
- To enrich knowledge about the lower invertebrates - used as the model organisms in the scientific research.
- To find the ability to recognize the major species and subspecies of invertebrates.
- To emphasize the investigating methods of evolution of species as well the current state of scientific knowledge.

Major Dissections (Virtual dissection)

Earthworm – Digestive and Nervous system
Cockroach – Digestive and Nervous system
Prawn – Digestive and Nervous system

Minor Dissection

Earthworm – Mounting of body setae and penial setae
Cockroach – Mounting of mouth parts
Honeybee – Mounting of mouth parts
Pila – Mounting of radula
Prawn – Mounting of Appendages

Invertebrata - List of spotters

Protozoa: Amoeba, *Entamoeba histolytica, Plasmodium vivax* or any one Plasmodium sp., Euglena – binary fission and conjugation of Paramecium.

Porifera: Sycon sponge, Sponge gemmules, spicules, Hyalonema, Chalina.

Coelenterata: Obelia - entire, Physalia, Hydra, Porpita, Vellela, Aurelia, Ephyra larva, Sea anemone and Corals and Gorgonia (Sea fan).

Platyhelminthes: Planaria - entire, T.S. of Planaria, T.S. of Liver fluke. Miracidium larva, Redia larva, Cercaria larva, Tapeworm - entire, T.S. of scolex of Tape worm.

Aschelminthes: Ascaris – (entire) male and female, T.S. of male and female Ascaris, Filarial worm, Trichuris and Pinworm.

Annelida: Nereis - entire, Nereis - Parapodium, Heteronereis, Earthworm - entire, Leech - entire, T.S. of leech, Trochophore larva and Aphrodite.

Arthropoda: Honeybee: Queen bee, Worker bee, Drone bee, Housefly, Wasp, Rhinosaur beetle, Mosquito – entire - male and female, Peripatus, Limulus, Scorpion, Spider, Daphnia, Cyclops, Nauplius, Zoea, Mysis, Sacculina, *Penaeus monodon and Macrobrachium rosenbergii*, Lac insect and Silkworm.

Mollusca: Chank (*Turbinella pyrum*), Murex, Patella (Gastropoda), Pearl Oyster, Chiton, Dentalium, Sepia, Nautilus, Pila, Lamellidens, Octopus and Glochidium larva.

Echinodermata: Starfish, Sea urchin, Sea cucumber, Bipinnaria larva and Auricularia larva, Doliolaria larva.

Minor phyla: Rotifera

REFERENCES:

1. Wallis, C. J. (2013). Practical Biology: For Advanced Level, Medical and Intermediate Students. Netherlands: Elsevier Science.
2. Ayyar. E.M. (1966). A Manual of Zoology Part I, Invertebrata, S. Viswanathan Pvt. Ltd., Chennai.
3. Lal, S. S. (2015). Practical Zoology. India: Rastogi Publications.
4. King, T., Reiss, M. and Roberts, M. (2001). Practical Advanced Biology. United Kingdom: Nelson Thornes.
5. Barnes, R. D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition.
6. De Iuliis, G. and Pulera, D. (2006). The Dissection of Vertebrates: A Laboratory Manual. Netherlands: Elsevier Science.
7. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science.
8. Jain. S (2018), Advanced Practical Invertebrate Zoology. Arjun Publishing House.
9. Verma. P.S (2010). A Manual of Practical Zoology: Invertebrates. S Chand Publishers.
10. Osborn. H.L (2015), Invertebrate Dissections. Sagwan press.
11. Sandhu G. S, (2000), Advanced Practical Invertebrate Zoology. Campus Books International Publisher.
12. Cockroach dissection- www.ento.vt.edu
13. Anatomy of earthworm: The dissection works (CD); Source –
14. www.scienclass.com; www.neosci.com

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Gain first-hand knowledge to identify and group non-chordate (species of fresh and preserved) along with larval forms.
- Analyze the relationship between organisms and their environment.
- Recognize the diversity from Protozoa to Echinodermata using their morphological structures.
- Virtually visualize and understand the anatomy and functional features of invertebrates.
- Fortify the ecological and economic importance of invertebrate diversity in their habitat.

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First Year **CORE COURSE II** **Semester II**

CHORDATA

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To enlighten the students about the diverse forms of vertebrate organisms under five major classes.
- To help the students to distinguish various vertebrate species with key characters.
- To understand the classification of chordate animals up to order with suitable examples.
- To acquire the knowledge on adaptations of vertebrates and their evolution.
- To study the detailed knowledge of protochordates like Amphioxus and Chordates like Shark, Frog, Calotes, Pigeon and Rabbit.

UNIT – I Chordata:

General characters of Chordata and its outline classification (upto order)- Origin of chordates.

Prochordata: General characters of Prochordata and its classification (upto order) - affinities with invertebrates and chordates.

Detailed Study on CephalochordataAmphioxus (*Branchiostoma lanceolatum*).

General Topic: Retrogressive metamorphosis in Ascidian.

UNIT – II Vertebrata:

General characters of vertebrata and its classification (upto) class with examples.

Class Pisces: General characters and classification (upto order) with examples.

Detailed study *Scoliodon sorrakowah* (Shark).

General Topics 1. Migration of fishes
2. Parental care in fishes.

Class Amphibia General characters and classification (upto order) with examples.

Detailed study *Rana hexatactyla* [Frog].

General Topic Parental care in Amphibia.

UNIT – III Class Reptilia:

General characters and classification (upto order) with examples.

Detailed study *Calotes versicolor* [Garden lizard].

General Topics 1. Identification and general characters of poisonous and non-poisonous snakes of South India.
2. Rhynchocephalia – [*Sphenodon punctatus*] - living fossil.

UNIT – IV Class Aves:

General characters and classification (upto order) with examples.

Detailed Study *Columba livia* [Pigeon].

General Topics 1. Birds are glorified reptiles.
2. Flightless birds - distribution and adaptations.
3. Migration of birds.

UNIT – V Class Mammalia:

General characters and classification (upto order) with examples.

Detailed Study *Oryctolagus cuniculus* [Rabbit].

General Topics 1. Prototheria, Metatheria and Eutheria (Salient features with examples).
2. Dentition in Mammals.
3. Adaptations of aquatic mammals.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Zoological survey of India - Role of ZSI - Species conservation status and management - first aid advancement for the venomous snake bite - development of snake venom as antivenoms to treat snakebite envenomation and yielding new drugs. Metabolic fossils from the origin of life.

REFERENCES:

1. Ayyar. E.M. and Anantha Krishnan T.N. (1995). Manual of Zoology Vol.II, Part I & II. (Chordata), S. Viswanathan Pvt. Ltd., Chennai.
2. Satoh, N. (2016). Chordate Origins and Evolution: The Molecular Evolutionary Road to Vertebrates. Netherlands: Elsevier Science.
3. Diogo, R., Siomava, N., Ziermann, J. M., Abdala, V. and Molnar, J. (2018). Muscles of Chordates: Development, Homologies, and Evolution. United States: CRC Press.
4. Wise, J., Roush, R. and Fowler, S. (2018). Concepts of Biology. Hong Kong: Samurai Media Limited.
5. Salazar, A. (2018). Advanced Chordate Zoology. United Kingdom: EDTECH.
6. Beer, G. R. D. (2017). Vertebrate Zoology: An Introduction to the Comparative Anatomy, Embryology, and Evolution of Chordate Animals. United States: FB&C Limited.
7. De Beer, G. (2018). Vertebrate Zoology - An Introduction to the Comparative Anatomy, Embryology and Evolution of Chordate Animals: Creative Media Partners, LLC.

8. Kingsley, J. S. (2015). Text Book of Vertebrate Zoology. United States: FB&C Limited.
9. Lydekker, R. (2016). Reptiles, Amphibia, Fishes and Lower Chordata. United States: FB&C Limited.
10. Kardong, K. V. (2019). Vertebrates: Comparative Anatomy, Function, Evolution. United States: McGraw-Hill Education.
11. Heiser, J. B., Janis, C. M. and Pough, F. H. (2013). Vertebrate Life: Pearson Education.
12. Pough, F. H. and Janis, C. M. (2019). Vertebrate Life. United Kingdom: Oxford University Press.
13. https://a-z-animals.com/blog/venomous-vs-non-venomous-snake/
14. https://ecoevocommunity.nature.com/posts/54859-the-evolution-of-parental-care-diversity-in-amphibians
15. https://www.notesonzoology.com/essay/flightless-birds/essay-on-flightless-birds-vertebrates-chordata-zoology/8284
16. http://faunaofindia.nic.in/PDFVolumes/hpg/022/index.pdf
17. https://www.cdc.gov/niosh/topics/snakes/symptoms.html
18. https://www.sciencedaily.com/releases/2020/03/200312101054.htm

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Understand about the vertebrates up to order level with suitable examples.
- Gain knowledge about the adaptation and migration of important tetrapods.
- Understand about the vertebrates in the food web and its diversity.
- Relate about the adaptations of flightless birds and migration of birds.
- Perceive information on the evolutionary relationships of tetrapods.

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First Year	CORE PRACTICAL II CHORDATA	Semester II
Code:	(Practical)	Credit: 4

COURSE OBJECTIVES:

- To impart training on the identification the vertebrate species by observing key characters.
- To make them understand the various systems of vertebrate animals.
- To demonstrate the technique of *in silico* dissection of vertebrate animals.
- To highlight on studying the importance of chordate animals as spotters.
- To emphasize the role and evolution of exo- and endo-skeleton in vertebrates.

VIRTUAL DISSECTIONS:

Fish / Frog / Rat – Digestive, arterial, venous, cranial nerves and reproductive systems.

Mountings: Placoid / Cycloid / Ctenoid scales of fishes Brain of fish and Rat.

Spotters:

1. **Protochordata:**	Amphioxus, Balanoglossus and Ascidia.
2. **Pisces:**	Shark, Ray, Echeneis, Hippocampus, Exocoetus, Catla, Rohu, Mrigal and Tilapia, Dugong, Dolphin.
3. **Amphibia:**	Frog, Tadpole larva, Axolotl larva, Hyla, Salamander, Ichthyophis.
4. **Reptilia:**	Calotes, Sandbow, Hydrophis, Naja, Viper, Draco, hamaeleon, Phrynosoma, Sphenodon.
5. **Aves:**	Pigeon, Parrot, Kingfisher, Owl, Quill and all types of feathers, Eagle, Vulture.
6. **Mammalia:**	Bat, Loris, Rabbit, Rat, Echidna, Duck-billed Platypus, Kangaroo.
7. **Dentition:**	Rabbit, Dog and Man.
8. **Osteology:**	Pigeon – Synsacrum, Rabbit – Pectoral and Pelvic girdles, Forelimb and Hind limb bones

REFERENCES:

1. Ayyar. E.M. and Anantha Krishnan T.N. (1995). Manual of Zoology Vol.II, Part I & II. (Chordata), S. Viswanathan Pvt. Ltd., Chennai.
2. Morgan, J. G. and Carter, M. E. B. (2008). Investigating Biology: Laboratory Manual. United Kingdom: Pearson Benjamin Cummings.
3. Hall B. K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jones and Bartlett Publishers Inc.
4. Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford university press
5. Lal. S. S. (2010), Practical Zoology Vertebrate, Rastogi publications, Meerut, India.

6. Kent, G. C. and Carr R. K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.
1. Hyman, L. H. (2018). A Laboratory Manual for Comparative Vertebrate Anatomy. United States: Creative Media Partners, LLC.
2. Das. S.K, Poddar. T.K, Mukhopadhyay.S (2015), An Advanced Laboratory Manual of Zoology. Trinity Press.
3. Arumugam. N, Thangamani. A, Prasanna kumar. S, Narayanan.L.M, Jayasurya, (2013), Practical Zoology Volume 2 Chordata. Saras publications.
10. Anatomy of Frog: Pro Dissector (CD)- www.prodissector.com
11. Physiology of Frog: Physio Ex 4.0 (CD)- www.physioex.com
12. Anatomy of shark: Shark dissection and anatomy (video)- www.neosci.com
13. Mammalian Physiology– www.biopac.com

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Understand the classification of vertebrates.
- Identify and recognize the organisms by key characters.
- Integrate the ecological adaptation of the studied species.
- Relate the adaptive behaviour of vertebrates.
- Virtually clarify the functional structure in tetrapods.

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Second Year **CORE COURSE III** **Semester III**

CELL AND MOLECULAR BIOLOGY

Code **(Theory)** **Credit 5**

COURSE OBJECTIVES:

- To provide the fundamental knowledge on cell types and characters.
- To make them understand the cell structure with their significance.
- To enhance knowledge on cell organelles and their role in metabolic activities.
- To understand the cell division, its genetic makeup and its regulation.
- It facilitates to signify the structure and function at molecular level in Prokaryotes and Eukaryotes.

UNIT – I Microscopy and Cytological Techniques:

Microscopy - Principles and applications of light - phase contrast - electron microscopy – SEM, -TEM. Cytological techniques – sample preparation - tissue fixation - sectioning and staining. Ultrastructure and organization of virus - bacteria - plant and animal cell.

UNIT – II Cell Organelles I:

Plasma membrane - ultra structure - various models proposed - chemical composition and functions of plasma membrane. Cytoplasm - structure and composition - physical and biological properties. Cytoskeleton - components - structure and functions. Endoplasmic reticulum - ultrastructure - types and functions.

UNIT – III Cell Organelles II:

Golgi complex – morphological - structure - role in secretions and other functions. Lysosome and centrosome – origin - morphology - chemistry and functions. Peroxisomes and their functions. Mitochondria – Ultrastructure and functions. Ribosomes – Ultrastructure, types and functions.

UNIT – IV Cell Organelles-III and Cell Division:

Nucleus - ultrastructure of interphase nucleus. Nucleolus and chromosome – structure and functions. Special types of chromosomes - Giant chromosomes - polytene and lampbrush chromosomes. Molecular structure of DNA - RNA – types and functions. Cell division - mitosis and meiosis Cell cycle - its regulation and significance -

UNIT – V Molecular Events and Cancer Biology:

Molecular events - DNA – replication in Prokaryotes and Eukaryotes - DNA-damage and repair mechanisms. Protein synthesis – genetic code - transcription - translation and post-translational modifications. Aging - factors causing aging. Cancer biology - apoptosis - mechanism of programmed cell death and stem cells.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Microarray analysis - DNA Chip technology - PCR in forensic science - neuronal signals transform from mother to offspring in *C. elegans*. Model organisms in cancer research.

REFERENCES:

1. Verma, P.S. and Agarwal, V.K. (2003). Cell Biology (Cytology, Biomolecules and Molecular Biology). S. Chand Company Ltd, New Delhi.
2. Powar, C.B. (2019). Cell Biology. Himalaya Publishing House, Bombay.
3. Lodish, H., Berk, A., Kaiser, C.A. and Krieger, M. (2021). Molecular Cell Biology. IX Edition, W. H. Freeman Publisher
4. Jeon, K. (2015). International Review of Cell and Molecular Biology. Elsevier Publication.
5. Karp, G., Iwasa, J. and Marshall, W. (2019). Karp's Cell and Molecular Biology. IX Edition, Wiley Publication.
6. Kumar, H.D. (2003). Molecular Biology. Vikas Publishing House Pvt. Ltd., New Delhi.
7. Rastogi, S.C. (2008). Cell and Molecular Biology. II Edition, New Age International (P) Ltd., New Delhi.
8. Glick, B.R. and Pasternak, J.J. (2009). Molecular Biotechnology - Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA.
9. Dubey, R.C. (2008). A Text Book of Biotechnology. S. Chand & Co, New Delhi.
10. Cooper, G.M. and Hausman, R.E. (2009). The Cell – A Molecular Approach. V Edition, ASM PRESS, Washington, DC.
11. https://www.caister.com/highveld/pcr/pcr-forensic-science.html
12. https://www.the-scientist.com/infographics/infographic-how-c-elegans-transmit-stress-signals-to-offspring-69408
13. https://thorax.bmj.com/content/55/4/329
14. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4700099/
15. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2117903/
16. https://pediaa.com/what-is-the-difference-between-polytene-and-lampbrush-chromosome/

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Understand the principles of microscopes and cytological techniques.
- Describe the structure and functions cell and cell organelles.
- Recognize the properties of cytoplasm and ultra-structure of nucleus and the metabolic machinery of the cell.
- Explain cell cycle and types of cell division.
- Relate on molecular events of cell and in cancer biology.

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Second Year **CORE PRACTICAL III** **Semester III**

CELL AND MOLECULAR BIOLOGY

Code **(Practical)** **Credit 4**

COURSE OBJECTIVES:

- To provide practice on handling of microscope.
- To differentiate the types of dyes and stains used in histology.
- To clarify the process of cell division and its phases.
- To relate the principle and role of polytene chromosomes.
- To highlight the role of Barr body.

Major Experiments:

1. Onion root tip – squash preparation and study of mitosis.
2. Grasshopper testes - squash preparation and study of meiosis.
3. Chironomous larva - squash preparation and study of giant chromosomes.
4. Enumeration of red blood cells (RBC) in human blood by using haemocytometer.
5. Enumeration of white blood cells (WBC) in human blood by using haemocytometer.
6. Preparation of buccal smear – observation of squamous epithelial cells (Barr body) in human.
7. Measurement of the size and volume of cells using ocular and stage micrometer.
8. Isolation of DNA from animal tissue by SSC method (Demo).
9. Isolation of plasmid DNA from bacteria (Demo).

Spotters:

Permanent slides - Sections of columnar, ciliated, squamous epithelium, cardiac, striated, non-striated muscle cells, nerve cell, blood cells of human and frog. Compound microscope, centrifuge, micrometer, camera lucida. Models of DNA, DNA replication and types of RNA.

REFERENCES:

1. Rajan, S. and Selvi Christy, R. (2015). Experimental Procedures in Life Sciences. CBS Publications and Distributors.
2. Sisodia, R. and Majumdar, R. (2018). Laboratory Manual of Cell Biology, Prestige Publishers.
3. Poonja, S.H. and Shetty, B. (2017). Histology Practical Manual. III Edition, Jaypee Brothers Medical Publishers.
4. Safadi-Chamberlain, F. (2018). Cell Biology Laboratory Manual. Revised III Edition, Kendall / Hunt Publishing Co, U.S.
5. Sati, B.K. and Gupta, A. (2019). Practical Laboratory Manual - Cell Biology, Lambert Academic Publishing.

6. Trigunayat, M.M, and Trigunayat, K. (2019). A Manual of Practical Zoology: Biodiversity, Cell Biology, Genetics & developmental Biology. Scientific Publishers.
7. Gupta. R, Makhija. S, and Toteja, R. (2018). Cell Biology: Practical Manual, Prestige Publishers.
8. Gakhar. S.K, Miglani. M, and Ashwani Kumar, A, (2019). Molecular Biology: A Laboratory Manual, Dreamtech Press.
9. Karp, G. (2013). Cell and Molecular Biology, Cell Biology Lab Manual, VII Edition, United States: Wiley.
10. Carson, S., Miller, H.B., Witherow, D.S., Carson, S. (2012). Molecular Biology Techniques: A Classroom Laboratory Manual. Netherlands: Elsevier Science.
11. Gerstein, A.S. (2004). Molecular Biology Problem Solver: A Laboratory Guide. Germany: Wiley.

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Familiarize on the handling of microscopes and its applications.
- Differentiate the cell cycle stages in plant / animal cells.
- Infer the importance of giant chromosomes during the development of larval stages.
- Handle and perform the histological procedures and observation of stages.
- Relate the fundamental composition of blood components.

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Second Year **NON MAJOR ELECTIVE I** **Semester III**

PUBLIC HEALTH AND HYGIENE

Code **(Theory)** **Credit 2**

COURSE OBJECTIVES:

- To enrich general knowledge on public health and hygiene.
- To provide information on environmental pollution related hazards and their impacts.
- To impart knowledge about communicable and non-communicable diseases and its treatment strategies.
- To create awareness of various acts for the betterment of health and hygiene.
- To clarify the importance of preventive measures against various diseases.

UNIT – I Introduction to Public Hygiene:

Introduction - definition **-** scope of public health and hygiene – nutrition and health – classification of foods – balanced diet - protein – energy - nutritional deficiency diseases –- malnutrition- Kwashiorkor, Marasmus - vitamin deficiency diseases.

UNIT – II Environment and Health Hazards:

Environmental degradation – pollution – sources - impacts of air - water - soil and noise pollution - occupation associated health hazards and treatments. Major environmental issues - global warming - ozone depletion - acid rain and climate change. Environmental and health impact assessment - significance.

UNIT – III Communicable Diseases:

Overview - types – mode of transmission- etiological agents - preventive and control measures of measles - malaria - hepatitis - cholera - filariasis - HIV / AIDS.

UNIT – IV Non-Communicable Diseases:

Definition - types - etiological agents – control and preventive measures. Genetic diseases - cancer - cardio vascular diseases - chronic respiratory disease - diabetes - epilepsy - coronary heart diseases - hypertension.
Social health - related problems - smoking - alcoholism and drug addiction - counselling - rehabilitation - de-addiction centres.

UNIT – V Health Education:

Health care legislation in India - Medical Termination of Pregnancy Act, 1971 - Maternity Benefit Act, 1961 - Transplantation of Human Organs Act (THOA), 1994 - Child Labour (Prohibition and Regulation) Act, 1986 - Environment (Protection) Act, 1986 - Bio-medical Waste Management Rules, 2016 - Employees' State Insurance Act (ESI), 1948. WHO Programmes – Government and voluntary organizations and their health services – precautions - first aid and awareness on epidemic/sporadic diseases.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

WHO-Integration of preventive and medical care services - ICMR-Community awareness programs - health camp and awareness campaign on drugs - antibiotic usage - dengue and malaria in schools and colleges by Health and Family Welfare Department, Govt. of Tamil Nadu-Covid-19 Protocols.

REFERENCES:

1. Modi, R.B.J.P. (2015). Elements of Hygiene and Public Health: For the Use of Medical Students and Practitioners. India: Elsevier Science.
2. Dunn, C.L. and Pandya, D.D. (2013). Indian Hygiene and Public Health. India: Elsevier Science.
3. David, V.M. (2013). Global Handbook on Non-communicable Diseases and Health Promotion. Germany: Springer New York.
4. Berridge, V. (2017). Public Health: A Very Short Introduction. United Kingdom: OUP Oxford.
5. Landon, M. (2006). Environment, Health and Sustainable Development McGraw-Hill International.
6. Richa, M.D., Gyan Prakash Singh and Mishra, C.P. (2012). Burden of Non Communicable Diseases, Lap Lambert Academic Publishing.
7. Goel, S.L. (2009). Education of Communicable and Non-Communicable Diseases. Deep Publications Pvt. Ltd.
8. Theodore, L. and Dupont, R.R. (2017). Environmental Health and Hazard Risk Assessment: Principles and Calculations. United States: CRC Press.
9. Deana, L., Katie, F, and Jan Wright. (2020). Social Theory and Health Education: Forging New Insights in Research. United Kingdom: Taylor & Francis.
10. Sudhar, R.W., Vinod, B.K, and Jiwan, P.S. (2015). Public Health and Hygiene. Success Publications.
11. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6454996/
12. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6950494/
13. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6618210/
14. https://www.aiims.edu/en/departments-and-centers/central-facilities/265-biomedical/7346-bio-medical-waste-management.html
15. https://www.unodc.org/docs/treatment/Guide_E.pdf
16. https://www.unodc.org/documents/india/ddch9.pdf
17. https://www.intechopen.com/books/6682

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Understand the concept of nutrition, balanced diet and related deficiencies.
- Comprehend environmental health related risks and their impacts.
- Identify the source of origin of any disease and its related symptoms.
- Perceive the precautionary strategies to avoid any type of disease.
- Create awareness on various health education policies, Amendments and Acts and social health programmes.

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Second Year	**CORE COURSE IV MICROBIOLOGY**	**Semester IV**
Code	**(Theory)**	**Credit 5**

COURSE OBJECTIVES:

- To understand and relate the general characteristic nature of microbes.
- To describe about bacterial growth and techniques involved.
- To explain by differentiating on the beneficial and harmful microbes around us.
- To signify the principle role of microbes in food spoilage and how to preserve from spoilage.
- To explicit the methods to recognize/diagnose common infectious diseases through symptoms and treatment strategies.

UNIT – I Characteristics of Microbes:

History and scope of microbiology - contribution of Anton Von Leeuwenhoek - Edward Jenner - Robert Hooke. Classification of microbes - five kingdom and three kingdom concepts. General characteristics of bacteria - virus - fungi - Protozoan – classification - structure - reproduction and economic importance. General characteristics of virus - classification of virus - physical and chemical structures (capsid of complex symmetry) - enveloped (Herpes virus) - helical (TMV) - icosahedral (Polyomavirus) - complex (Bacteriophage) and virion.

UNIT – II Bacterial Growth:

Concept of sterilization - physical and chemical methods of sterilization. Stains and staining techniques. Bacterial nutrition and growth - nutrition types. Growth factors - types of culture media – synthetic - complex - selective - enrichment - differential media. Isolation of pure culture – colony morphology - growth- growth curve - different phases and growth kinetics.

UNIT – III Environmental Microbiology:

Microbes in aquatic environments - microbiological analysis of water - fresh water and marine water. Overview of soil microbes - interactions with the ecosystem. Microbial interaction – mutualism - synergism - commensalism - competition - amensalism - parasitism - predation. Microorganisms in extreme environments - thermophiles - methanogens - halophiles. Photosynthetic bacteria - Cyanobacteria and some Archaea in extreme cold and space. Principles and degradation of common pesticides - organic (hydrocarbons, oil spills) and inorganic (metals) matter and biosurfactants. Microbes in wastewater treatment.

UNIT – IV Food Microbiology:

Growth of microorganisms in food - intrinsic and extrinsic factors. Food borne infections and intoxications – microbial growth and food spoilage - *Clostridium botulinum* - Salmonella - *Staphylococcus aureus* – microtoxins in food with reference to Aspergillus species. Principles and methods of food preservation - temperature - irradiation - processing and packaging. Food safety and quality

control - microbiological standards - government regulatory practices and policies – Food and Drug Administration (FDA) and Environmental Protection Agency (EPA).

UNIT – V Medical Microbiology:

Microbial morphology – characteristics - pathogenesis - laboratory diagnosis - treatment. Respiratory diseases - rheumatic fever – pneumonia. Gastrointestinal diseases – cholecystitis - typhoid. Viral diseases - Polio - herpes - hepatitis - rabies - dengue - AIDS. Fungal diseases - cutaneous mycoses - Tineapedis (Athlete's foot) - systemic mycoses – histoplasmosis - opportunistic mycoses - candidiasis and Protozoan diseases – malaria - prophylaxis.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Metagenomics analysis - identification of genomic populations - microbiome research - identification of antibiotic resistance genomes by next generation sequencing - microarrays for expression analysis - genome annotation.

REFERENCES:

1. Willey, J.M., Sherwood, L. and Woolverton, C.J. (2014). Prescott's Microbiology. Mc-Graw Hill, New York.
2. Dubey, R.C. and Maheshwari, D.U. (2005). A Text book of Microbiology. S. Chand and Company Ltd, New Delhi.
3. Rao, A.S. (2001). Introduction to Microbiology. Prentice Hall of India Private Limited, New Delhi.
4. Pelczar, M.J., Chan, E.S. and Kreig, N.R. (1993). Microbiology. IV Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi.
5. Purohit, S.S. (2005). Microbiology Fundamentals and Applications. VI Edition (Student Edition), Agrobios (India), Jodhpur.
6. Raman Rao, P.V. (2005). Essentials of Microbiology. CBS Publishers and Distributors, New Delhi.
7. Malacinski, M.G. (2006). Essentials of Microbiology. Narosa Publishing House, New Delhi.
8. Narayanan, L.M., Selvaraj, A.M. and Arumugam, N. (1999). Microbiology. Saras Publication, Nagercoil.
9. Ananthanarayanan, R. and Jayaraman Paniker, C.K. (1990). Text Book of Microbiology. Orient Longman Ltd.,
10. Murray, P.R., Rosenthal, K.S, and Pfaller, M.A. (2016). Medical Microbiology E-Book, VIII Edition, Elsevier
11. https://www.ncbi.nlm.nih.gov/books/NBK7795/#A250
12. http://ecoursesonline.iasri.res.in/mod/resource/view.php?id=5036
13. https://www.ncbi.nlm.nih.gov/books/NBK8142/
14. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7152272/
15. https://www.mlsu.ac.in/econtents/1817_NPTEL%20growth%20kinetics.pdf
16. https://www.frontiersin.org/articles/10.3389/fmicb.2018.01156/full
17. https://microbenotes.com/microbial-interaction-and-its-types-with-examples/
18. https://www.mlsu.ac.in/econtents/1111_Microbial%20genomes.pdf

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Apply knowledge to understand classification of microbes and its basic characteristics.
- Acquire information on methods of sterilization of microbial cultures and requirements for the media preparation.
- Attain knowledge about the interactions of microbes with their ecosystem.
- Perceive the role / action mechanism microbes on food spoilage and the principles of food preservation.
- Comprehend various diseases caused by the microbes and its treatments.

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Second Year	**CORE PRACTICAL IV MICROBIOLOGY**	**Semester IV**
Code	**(Practical)**	**Credit 4**

COURSE OBJECTIVES:

- To gain knowledge about the operating procedure.
- To enrich knowledge on culture media preparation and sterilization.
- To understand reproduction and growth of the bacteria.
- To learn the staining techniques to identify the bacteria.
- To attain knowledge about the diversity of microbes.

Experiments

1. Standard Operating Procedures (SOP) and Good Laboratory Practices (GLP).
2. Sterilization of culture media, techniques and equipments - Demonstration.
3. Isolation of microbes from soil sample by serial dilution technique.
4. Collection of microbes from water samples.
5. Collection of microbes from air samples.
6. Determination of germ counts.
7. Cultivation of microbes by spread plate and pour plate methods.
8. Preparation of different culture media for microbes.
9. Identification of bacteria using Gram's staining method.
10. Demonstration of morphological identification of various bacterial cells using microscope.
11. Motility of bacteria – Lactobacillus sp.

Spotters

Laminar air flow, autoclave, petri dish, inoculation loop, L-rod, sprit lamp, incubator, cavity slides, stains (crystal violet, safranin and iodine), disinfectants (spirit and ethanol), BOD incubator, light microscope and pH meter.

REFERENCES:

1. Brown, A. and Smith, H. (2015). Benson's Microbiological Applications, Laboratory Manual in General Microbiology, Short Version. XIII Edition, McGraw-Hill Education.
2. Harry W, Seelay. and Paul J. VanDemark. (1962). Microbes in action. A laboratory manual of microbiology. San Francisco, Freeman.
3. Taniwaki, H., Christina, V., Junqueira, A., Neliane Ferraz de Arruda Silveira, Okazaki, M.M. and Renato Abeilar Romeiro Gomes (2018). Microbiological Examination Methods of Food and Water: A Laboratory Manual. CRC Press.
4. Leboffe, Michael J. and Pierce, B. E. (2019). Microbiology: Laboratory Theory and Application Essentials. Morton Publishing Company.
5. Sastry. A.S. and Bhat. S.K. (2018), Essentials of Practical Microbiology. Jaypee Brothers Medical Publishers.
6. Cappuccino, J.G. and Welsh, C.T. (2017). Microbiology: A Laboratory Manual, Global Edition, United Kingdom: Pearson Education.

7. Smith, H. and Brown, A.E. (2014). Benson's Microbiological Applications, Laboratory Manual in General Microbiology, Short Version. United Kingdom: McGraw-Hill Education.
8. Harrigan, W.F. and Mc Cance, M.E. (2014). Laboratory Methods in Microbiology. United Kingdom: Elsevier Science.
9. Harley, J. (2010). Microbiology Lab Manual. United Kingdom: McGraw-Hill Education.
10. Dash, H.R. and Das, S. (2014). Microbial Biotechnology - A Laboratory Manual for Bacterial Systems. India: Springer India.
11. Selman, A.W. and Broun Fred, E. (2020). Laboratory Manual of General Microbiology, with Special Reference to the Microorganisms of the Soil. India: Alpha Editions.
12. Jain, A., Venkatesh, V. and Agarwal, J. (2018). Microbiology Practical Manual, I Edition, India: Elsevier Health Sciences.

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Enrich the knowledge on handling microbes in laboratory conditions.
- Comprehend the diversity of microbes in various environments.
- Understand the methods of the culture of bacterial strains in laboratory conditions.
- Perceive information on the morphological identification of various microbes.
- Acquire knowledge of pathogenic and non-pathogenic microbes.

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Second Year **NON MAJOR ELECTIVE II** **Semester IV**

ECONOMIC ZOOLOGY

Code **(Theory)** **Credit 2**

COURSE OBJECTIVES:

- To encourage young learners to take up knowledge for the benefit of mankind.
- To motivate them to acquire self-employment opportunities.
- To disseminate information on social and economic aspects of development.
- To inculcate the impact to develop skills among rural population.
- To satisfy the learners with advancement of modern techniques in integrated culture / farming.

UNIT – I Vermiculture:

Vermiculture and composting – introduction - scope - species of earthworm – rearing technology – management – economic importance – potential use in vermicomposting.

UNIT – II Apiculture:

Apiculture – introduction - scope - species of honey bee – types of bee hives – care and management – appliances used in apiculture - honey extraction – production and marketing of quality honey - nutritive - economic and medicinal value of honey.

UNIT – III Sericulture:

Sericulture – introduction - scope - feeding habits of larvae – rearing of silkworm – life cycle of silkworm (*Bombyx mori*) – economic importance of silkworm and silk.

UNIT – IV Aquaculture:

Aquaculture – introduction - scope – design, construction and management of a pond – freshwater cultivable fishes – fish feed – induced breeding – prawn culture – fish diseases – preventive measures.

UNIT – V Poultry Farming:

Poultry farming – introduction - scope - types of poultry – brooding and rearing of chicks and management – poultry nutrition – diseases and their prevention – economic importance of poultry.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Recent scenario on scope of animals and human society - animal breeding techniques - genetic engineering applications in vermi / animal breeding - breeds and variation - latest research in aquaculture - pisciculture - poultry farming - sericulture and apiculture.

REFERENCES:

1. Shanmugam, K. (1990). Fishery Biology and Aquaculture. Leo Publications, Madras, India.
2. Kameshwar Pandey and Sukla J.P. (2019). Fish and fisheries. Rastogi Publications. IV Edition.
3. Babu, K.M. (2018). Silk: Processing, Properties and Applications. United Kingdom: Elsevier Science.
4. Rosser, D. (2021). Worm Farming: An Essential Guide to Vermiculture, Vermicomposting, and Making Worm Bins. Amazon Digital Services LLC - Kdp.
5. Shukla, G.S. and Upadhyay, V.B. (2016-2017). Economic Zoology. Rastogi Publications. IV Reprint, V Edition.
6. Ashok Kumar Rathoure, D.K. (2015). Applied and Economic Zoology. India: Daya Publishing House.
7. Abrol, D.P. (2013). Beekeeping: A Compressive Guide to Bees and Beekeeping. India: Scientific Publishers (India).
8. Oladottir, A.D. and Einarsson, A. (2020). Fisheries and Aquaculture - The Food Security of the Future. United Kingdom: Elsevier Science.
9. Ganga, G. and Sulochana Chetty, J. (2019). Introduction to Sericulture. Oxford & Ibh Publishing Co Pvt Ltd.
10. Ullal, S.R. and Narasimhanna, M.N. (1987). Handbook of Practical Sericulture. Bangalore: Central Silk Board, Bombay.
11. Ghosh, N. (2020). Livestock Production Management. India: Prentice Hall India Pvt., Limited.
12. Manju, Y. (2003). Economic Zoology. New Delhi: Discovery Publishing House.
13. https://www.sciencedirect.com/book/9780128052471/animals-and-human-society
14. https://pubmed.ncbi.nlm.nih.gov/2213713/
15. https://link.springer.com/article/10.1186/2251-7715-1-8
16. https://www.nature.com/articles/s41586-021-03308-6
17. https://krishijagran.com/animal-husbandry/a-guide-to-poultry-farming-business-in-india/
18. https://egov.uok.edu.in/elearning/tutorials/1011020512BR15103CR15Apiculture%20Lac%20culture%20and%20%20sericultureapiculture%20lac%20culture%20and%20%20sericulture%20upload.pdf

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Understand the significance and economic value of commercial Zoology.
- Relate the economic impact of aquaculture and their global importance.
- Knowledge on the farm management practices of various economically important species.
- Management of techniques in various agro-based cultures and to make up value added products from animal husbandry.
- Enrich knowledge on various basic and advanced disease prevention methods adopted in rearing practices.

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Third Year **CORE COURSE V** **Semester V**

DEVELOPMENTAL BIOLOGY

Code **(Theory)** **Credit 5**

COURSE OBJECTIVES:

- To provide basic idea on the processes of an embryo development.
- To signify the mechanisms of development of various animals.
- To review current developments in the field of embryology.
- To emphasize the molecular regulation of development.
- To differentiate the mechanism of vertebrate and invertebrate development.

UNIT – I Basic Concepts in Embryology and Gametogenesis:

Scope of embryology - theories on development - Baer's law - Epigenesis theory-germ plasm theory – Lyon's hypothesis - gradient theory and Spemann and Mangold theory of organizers. Gametogenesis - spermatogenesis -structure and types of sperms. Oogenesis - vitellogenesis and types of Vertebrate eggs.

UNIT – II Fertilization and Cleavage:

Fertilization - types of fertilization - physico-chemical changes during fertilization - theories of fertilization - parthenogenesis in lower animals. Cleavage – patterns of cleavage - factors affecting cleavage – chemo-differentiation.

UNIT – III Blastulation and Gastrulation:

Blastulation – types of blastula – Amphioxus - Frog - Chick. Gastrulation - morphogenetic movements - Amphioxus - Frog - Chick - fate maps.

UNIT – IV Organogenesis and Regeneration:

Organogenesis - development of heart - eye - brain of Frog – extra-embryonic membranes in Chick. Placenta in Mammals - types and physiology. Metamorphosis in Amphibians. Regeneration - types and morphological events in regeneration.

UNIT – V Infertility Management:

Artificial Reproductive technology (ART) - definitions - precautions and health care during human pregnancy and gestation - infertility. Artificial insemination – concept of test-tube baby - methods of birth control. Factors involved in teratogenesis - nuclear transplantation - cryopreservation.

UNIT- VI CURRENT CONTOURS (For continuous internal assessment only):

Latest research in developmental biology from embryology to model organisms. Molecular regulation in differentiation, growth, homeostasis and regeneration in animals. Congenital malformations due to teratogens.

REFERENCES:

1. Berrill, N.J. (1974). Developmental Biology. New Delhi: Tata Mc Graw-Hill Publishing Company Ltd.
2. Berry, A.K. (2007). An Introduction to Embryology. New Delhi. Emkay Publications.
3. Gilbert, S.F. and Barresi, M.J.F. (2020). Developmental Biology. United States: Oxford University Press.
4. Balinsky, B.I. (1981). An Introduction to Embryology. Philadelphia: W.B. Saunders Company.
5. Subramanian, M.A. (2022). Developmental Biology. India: MJP Publishers.
6. Agarwal, V.K. and Verma, P.S. (2006). Chordate Embryology. India: S. Chand & Company.
7. Carlson, B.M. (2019). Human Embryology and Developmental Biology. Netherlands: Elsevier.
8. Dale, L. and Slack, J.M.W. (2021). Essential Developmental Biology. United Kingdom: Wiley.
9. Wolpert, L. (2011). Developmental Biology: A Very Short Introduction. United Kingdom: OUP Oxford.
10. Hodge, R. (2009). Developmental Biology: From a Cell to an Organism (Genetics and Evolution). United States: Facts on File publications.
11. Subramoniam, T. (2011). Molecular Developmental Biology. United Kingdom: Alpha Science International Ltd.
12. Slack, J.M.W. and Dale, L. (2021). Essential Developmental Biology. United Kingdom: Wiley.
13. https://www.ncbi.nlm.nih.gov/books/NBK225682/
14. https://pubmed.ncbi.nlm.nih.gov/29966360/
15. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7937350/
16. https://www.ncbi.nlm.nih.gov/books/NBK576409/
17. https://jamanetwork.com/journals/jama/article-abstract/456288

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Understand the basic theories of development of embryo and its stages.
- Compare the formation of gametogenesis in the various Invertebrate and Vertebrates.
- Relate the process of fertilization with the onset of cleavage and gastrulation process.
- Know the basics of development of organs, functions of extra embryonic membranes and physiology of placenta.
- Logically view the concept infertility, birth control and applications of cryopreservation techniques.

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Third Year **CORE COURSE VI** **Semester V**

GENETICS AND EVOLUTION

Code **(Theory)** **Credit 5**

COURSE OBJECTIVES:

- To highlight Mendelian inheritance and its principles.
- To explain and relate to understand the theories related to genetics.
- To impart knowledge on the similarities and differences of genetic information transfer in Prokaryotes and Eukaryotes.
- To emphasize about the chromosomal aberrations related to mutations.
- To make them understand the concepts of the species evolution and related experiments.
- To describe the theory of natural selection and its associated theories.

GENETICS

UNIT – I Mendelism:

Mendelism – Mendelian laws of inheritance - monohybrid and dihybrid experiments - linkage – types of linkage – coupling and repulsion - chromosomal theory of linkage. Crossing over – crossing over in Drosophila - significance of crossing over - mechanism of crossing over. Chromosome map. Chromosomal theory of sex determination - sex determination in man - Drosophila - fowl - grasshopper.

UNIT – II Sex-linked Inheritance:

Sex linked inheritance – colour blindness – haemophilia - eye colour in Drosophila - types of sex-linked inheritance. Non-disjunction – Klinefelter's syndrome - Turner's syndrome - Down's syndrome - primary and secondary non-disjunction in Drosophila. Inborn errors of metabolism – phenylketonuria - alkaptonuria - albinism. Pedigree analysis.

UNIT – III Mutation:

Mutation – chromosomal mutations - changes in the structure and number of chromosomes. Gene mutation - Types of gene mutations - base substitution - frame shift mutation - insertion - deletion - missense - nonsense mutation - chromosomal aberrations. Gene and gene-concept - DNA as the genetic material. Nucleic acids – DNA - properties and functions of DNA - nucleotides – nucleosides- replication of DNA - and DNA repair. DNA transcription –RNA-protein synthesis

EVOLUTION

UNIT – IV Origin of Life:

Theories of origin of life - biochemical origin of life Oparin's concept - Urey Miller's experiment. Evidences of evolution – morphological - embryological - paleontological - biochemical evidences. Lamarckism and neo - Lamarckism. Darwinism and neo-Darwinism.

UNIT – V Speciation:

Speciation and isolation - mimicry and colouration – principle and application of Hardy Weinberg law. Gene pool - gene-frequency. Evolution of horse and man. Geological time scale - Indian fossils - living fossils – Culture and evolution of man.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Research highlights on therapies for genetic disorders and role of model organisms in genetics - recent studies on evolutionary and population genetics - origin and maintenance of genetic variation in populations and molecular mechanisms of adaptation.

REFERENCES:

1. Ridley, M. (2009). Evolution. United Kingdom: Wiley.
2. Zeigler, D. (2014). Evolution: Components and Mechanisms. Netherlands: Elsevier Science.
3. Stebbins, G.L. (1979). Processes of Organic Evolution. India: Prentice-Hall of India Private Limited.
4. Prakash, M. (2008). Molecular Biology of Evolution. India: Discovery Publishing House Pvt. Limited.
5. Strickberger, M.W. (2000). Strickberger's Evolution. United Kingdom: Jones and Bartlett.
6. Kirkpatrick, M. and Futuyma, D.J. (2018). Evolution. United Kingdom: Oxford University Press.
7. Darwin, C. (2008). On The Origin of Species. United States: Chartwell Books.
8. Schluter, D. and Schluter, P.Z.D.D. (2000). The Ecology of Adaptive Radiation. Equatorial Guinea: OUP Oxford.
9. Kirkpatrick, M. and Futuyma, D.J. (2018). Evolution. United Kingdom: Oxford University Press.
10. Brock, J.P. (2000). The Evolution of Adaptive Systems: The General Theory of Evolution. United Kingdom: Elsevier Science.
11. Krajewski, C., Feldhamer, G.A., Stewart, K.M., Merritt, J.F. and Rachlow, J.L. (2020). Mammalogy: Adaptation, Diversity, Ecology. United States: Johns Hopkins University Press.
12. Roberts, D.A. (2018). Evolution: The Human Story. United Kingdom: Dorling Kindersley Limited
13. Brundle, J. (2017). Genetics. United Kingdom: Book Life Publishing Limited.
14. Sturtevant, A.H. (2001). A History of Genetics. United States: Cold Spring Harbor Laboratory Press.
15. Miglani, G.S. (2007). Advanced Genetics. United Kingdom: Alpha Science International Limited.
16. Agarwal, V.K. (2009). Genetics. India: S. Chand Limited.
17. Hickey, G.I., Fletcher, H.L. and Winter, P.C. (2007). Genetics. United Kingdom: Taylor & Francis Group.
18. Dawes Hoang, R., Heston, K., Meneely, P.M. and Okeke, I.N. (2017). Genetics: Genes, Genomes, and Evolution. United Kingdom: Oxford University Press.

19. Chaudhari, K. (2013). Microbial Genetics. India: Energy and Resources Institute.
20. Snyder, L.A. (2020). Bacterial Genetics and Genomics. United Kingdom: CRC Press.
21. Trempy, J. and Trun, N. (2009). Fundamental Bacterial Genetics. Germany: Wiley.
22. https://www.nature.com/scitable/topic/evolutionary-genetics-13/
23. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3352415/
24. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1456383/
25. https://www.nature.com/scitable/topicpage/the-use-of-animal-models-in-studying-855/
26. https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/model-organisms-in-genetics
27. https://www.nature.com/subjects/population-genetics

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Comprehend and understand the chemical basis of evolution.
- Understand about one role of genetics in evolution.
- Evolve conclusion that are based on genetics data.
- Relate the origin of species on earth by observed theories and experiments.
- Describe evolutionary history of Vertebrates.

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Third Year	**CORE COURSE VII**	**Semester V**
	IMMUNOLOGY	
Code	**(Theory)**	**Credit 5**

COURSE OBJECTIVES:

- To emphasise the function of immune organs and system.
- To study the structure of antigen, antibody and its interactions.
- To perceive the knowledge about the complex interactions between donor and recipient adaptive immunity.
- To understand the action mechanism of the various immune system diseases.
- To relate various applications/techniques detecting antigen, antibody or its complex.

UNIT – I Immune System:

History and scope of Immunology - types of immunity (Innate and Adaptive) - natural and acquired immunity. Hematopoiesis- Organs of the immune system - primary and secondary lymphatic system. Cells of the immune system - B lymphocytes -T-lymphocytes and subsets-Th1/Th2 shift – Antigen presenting cells (APC) - NK cells, dentritic cells and macrophages and their roles.

UNIT – II Antigen-antibody Interactions:

Antigens structure - properties - functions - types. Immunoglobulins - types - structure - properties – functions - Theories of antibody formation and properties. Antigen-antibody interactions - Vaccines - types and vaccination schedule. Complement system - classical and MBL pathways and its biological consequences.

UNIT – III Transplantation Immunology:

Major Histocompatibility Complex (MHC) and its significance. Genomic organization of HLA complex – Endogenous - Exogenous pathways - HLA typing. Transplantation - types of grafts - examples for grafting- mechanism of graft rejection.

UNIT – IV Immune System Disorders:

Hypersensitivity reaction - types. Infectious diseases – viral (SARS-CoV) – bacterial (Tuberculosis) – fungal (Oral candidiaisis) - parasitic (Dengue) infections -Primary and secondary Immuno deficiency diseases. Autoimmune diseases (systemic lupus erythematosus). Immune response to tumour cells.

UNIT – V Immuno-techniques and its Applications:

Agglutination – ABO Blood grouping and Rh typing. Immuno precipitation - Immuno electrophoresis –types. Hybridoma technology - Monoclonal and polyclonal antibodies production - Enzyme linked immunosorbent assay (ELISA) - types - Radio immuno assay (RIA) - Western blot. Flow cytometry and immune fluorescence microscopy - Fluorescence *in situ* hybridization (FISH) and Genomic *in situ* hybridization (GISH).

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Recent research on experimental techniques - methods used to investigate fundamental questions in immunology research - Cellular and molecular immune cell markers for diagnosing disease state, accelerating and delayed disease progression. Vaccine research and developments - reverse vaccinology.

REFERENCES:

1. Rao, C.V. (2017). Immunology. III Edition, Narosa Publishing House, New Delhi.
2. Flajnik, M., Singh, N.J. and Holland. S.M. (2022). Paul's Fundamental Immunology. Wolters Kluwer Health.
3. Kannan, I. (2019). Immunology. MJP Publishers, Chennai.
4. Gupta S.K. (2017) Essentials of Immunology. II Edition, Arya Publications, New Delhi.
5. Delves, P.J., Martin, S.J., Burton, D.R. and Roitt. I.M. (2016). Roitt's Essential Immunology. XIII Edition, Wiley Blackwell Scientific Publication.
6. Male, D., Peebles, S. and Male, V. (2020). Immunology. IX Edition, Elsevier.
7. Punt, J., Stranford, S., Jones, P. and Owen, J.A. (2018). Kuby Immunology. VIII Edition, WH Freeman Co.
8. Shetty, N. (2021). Immunology. New Age International (P) Limited, Publishers. New Delhi.
9. Shastri, N.V. (2005). Principles of Immunology. Himalaya Publishing House, Delhi.
10. Annadurai, B. (2009). A Textbook of Immunology and Immunotechnology. S. Chand & Company Ltd., New Delhi.
11. https://www.sciencedirect.com/topics/nursing-and-health-professions/immunological-technique
12. https://www.nature.com/subjects/vaccines
13. https://www.frontiersin.org/journals/immunology/sections/vaccines-and-molecular-therapeutics
14. https://pubmed.ncbi.nlm.nih.gov/19828300/
15. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6940521/
16. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3320742/#:~:text=In%20conclusion%2C%20reverse%20vaccinology%20uses,that%20may%20improve%20existing%20vaccines.

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Understand the difference types of natural and acquired immunity.
- Comprehend the Classification of immunoglobulins and their roles during antigenic response.
- Relate various mechanisms that regulate immune responses.
- Realize the adverse effects of immune system causing autoimmune disorders and therapeutic advancements.
- Perceive the applications antigen-antibody interactions by immunological techniques.

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Third Year **CORE PRACTICAL V** **Semester V**

DEVELOPMENTAL BIOLOGY, GENETICS AND EVOLUTION, IMMUNOLOGY

Code **(Practical)** **Credit 4**

COURSE OBJECTIVES:

- To observe the developmental stages and organ formation of Vertebrate species.
- To learn methods of Mendelian genetics – testing.
- To understand pedigree construction, analysis and risk calculation.
- To understand genetic importance and evolutionary significance.
- To familiarize the various immunological assays and staining techniques.

DEVELOPMENTAL BIOLOGY

Experiments

1. Observation of sperm motility of bull.
2. Blastoderm mounting in Chick (*Gallus gallus domesticus*) embryo (demonstration only).
3. Observation of early developmental stages of frog (Metamorphosis).
4. Temporary mounting of invertebrate larvae (from plankton collection).
5. Collection and identification of types of Invertebrate and Vertebrate eggs.

Spotters

1. **Permanent slide –** T.S. of Mammalian testis and ovary, Ovum and Sperm.
2. **Frog -** Egg, Cleavage, Blastula and C.S. of blastula, Gastrula and C.S. of gastrula, Yolk plug and tadpole stages.
3. **Chick -** Egg - entire, developmental stages - 24 hrs, 48hrs, 72 hrs and 96 hrs.
4. **Placenta types –** Zonary, diffuse, cotyledonary and discoid.

GENETICS

Experiments

1. Recording of Mendelian traits in human - tasters and non-tasters, tongue rollers, non-rollers.
2. Blood grouping in human.
3. Pedigree analysis.
4. Identification of mutants in Drosophila.
5. Identification of sex in Drosophila.
6. Finger printing (genetic variation).

Models

1. Monohybrid and dihybrid cross.
2. Human Karyotypes of normal male and female, Klinefelter syndrome, Turner's syndrome and Down's syndrome.

3. Drosophila: Male and female identification, models for DNA, RNA structure and DNA replication.

EVOLUTION

Experiment

1. Comments on animals of evolutionary significance.

Spotters

1. **Protective colouration –** Leaf insect, Stick insect, Chamaeleon, Hippocampus, Pepper moth.
2. **Mimicry –** Monarch and Viceroy butterfly, Bat and Pteropus.

IMMUNOLOGY

Experiments

1. Immunodiffusion assay.
2. Precipitin test.
3. Differential staining and identification of leucocytes.
4. ELISA technique (Demonstration).
5. Western blotting (Demonstration).

Spotters

1. **Lymphoid organs -** Thymus, Spleen, Bone marrow, Lymph node.

REFERENCES:

1. Verma, P.S. (2013). A Manual of Practical Zoology of Invertebrates. New Delhi: S. Chand & Company Ltd.
2. Sam-Yellowe, T.Y. (2021). Immunology: Overview and Laboratory Manual. Switzerland: Springer International Publishing.
3. Nelson, P.N., Hay, F.C., Westwood, O.M.R. and Hudson, L. (2002). Practical Immunology. United Kingdom: Wiley Publications.
4. Mahon, C.R. and Tice, D.G. (2006). Clinical Laboratory Immunology. United Kingdom: Pearson Prentice Hall.
5. Hay, F.C. and Westwood, O.M.R. (2008). Practical Immunology. Germany: Wiley.
6. Gibbs, M.A. (2003). A Practical Guide to Developmental Biology. United Kingdom: Oxford University Press.
7. Evans, J.H., Keller, L.R. and Keller, T.C.S. (1999). Experimental Developmental Biology: A Laboratory Manual. United Kingdom: Academic Press.
8. Billett, F.S. and Wild, A.E. (2012). Practical Studies of Animal Development. Netherlands: Springer Netherlands.
9. Pendarvis, M.P. and Crawley, J.L. (2019). Exploring Biology in the Laboratory: Core Concepts. United States: Morton Publishing.
10. Koliantz, G. and Szymanski, D.B. (2009). Genetics: A Laboratory Manual. United States: Madison, WI: American Society of Agronomy: Crop Science society of America.

11. Scott, R.J. (2001). Contemporary Genetics Laboratory Manual. United States: Morton Publishing Company.
12. Gopinath, A., Perlin, M. and Beckerson, W. (2017). Cell, Genetics, and Molecular Biology: A Lab Manual. I Edition, United States: Cognella, Inc.,
13. Sullivan, W. (2004). Drosophila Protocols. China: Science Press.
14. Golic, K.G., Hawley, R.S. and Ashburner, M. (2005). Drosophila: A Laboratory Handbook. United Kingdom: Cold Spring Harbor Laboratory Press.
15. Cruz, Y.P. (2012). Laboratory Exercises in Developmental Biology. United Kingdom: Elsevier Science.

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Gain knowledge on the importance of heredity of all living organisms.
- Acquire idea about the blood types and its grouping.
- Understand the concept of Mendelian traits and pedigree concept.
- Realize the paleontological evidences of evolution of organisms.
- Be aware on the concept of mimicry and colouration.
- Signify heredity importance and its dysfunctions.

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Third Year **MAJOR BASED ELECTIVE I** **Semester V**

1. AQUATIC BIOLOGY

Code **(Theory)** **Credit 4**

COURSE OBJECTIVES:

- To emphasize an insight about diversity of aquatic biomes.
- To give an idea on the freshwater biology and its interactions.
- To provide knowledge on marine biology and its interactions.
- To make them view on the importance of the wetland biology.
- To describe the importance of various management strategies of aquaculture resources.

UNIT – I Aquatic Biomes:

Brief introduction on aquatic biomes - freshwater ecosystem (lakes, wetlands, streams and rivers) - estuaries - intertidal zones – oceanic, pelagic zone and marine benthic zone. Coral reefs.

UNIT – II Freshwater Biology:

Lakes - origin and classification - lake as an ecosystem - lake morphometry. Physico–chemical characteristics - light - temperature - thermal stratification - dissolved solids - carbonate - bicarbonates - phosphates - nitrates and turbidity. Dissolved gases - oxygen and carbon dioxide. Nutrient cycles in lakes – nitrogen - sulphur - phosphorous. Streams - different stages of stream development - physico-chemical environment and adaptation of hill-stream fishes. – Pond - types – ecosystem - river ecosystem – types.

UNIT – III Marine Biology:

Introduction to marine biology - oceanography. Water and water cycle. Physico-chemical properties of water and seawater. Zonation of marine environment - neritic - oceanic - continental shelves - oceanic trenches - hydrothermal vents and continental shelf. Adaptations of deep-sea organisms. Sea weeds.

UNIT – IV Wetland Biology:

Estuarine habitats in India - Backwaters - mangroves and its significance. Impacts of dams. Detailed study of Pitchavaram and Muthupet mangroves, Kuttanad ecosystem and Sundarbans. Productivity - primary and secondary. Migration of fishes.

UNIT – V Management of Aquatic Resources:

Causes of aquatic pollution - agricultural - industrial - sewage - thermal - oil spills and its treatment - eutrophication. Management and conservation (legislations). Sewage treatment. Water quality assessment - BOD and COD.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Recent studies on restoration of mangroves and coral reefs - recent research on different aquatic biomes and its impact on species diversity.

REFERENCES:

1. Goldman, C.R. and Horne, A.J. (1994). Limnology, II Edition, McGraw-Hill Education.
2. Odum, E.P. and Barret, G.W. (2004). Fundamentals of Ecology, V Edition, Brooks/Cole.
3. Pawlowski, L. (1980). Physicochemical Methods for Water and Wastewater Treatment, I Edition, Elsevier.
4. Wetzel R.G. (2001). Limnology Lake and Reservoir Ecosystems. III Edition, Elsevier, Academic Press, San Diego.
5. Trivedi, R.K. and Goel, P.K. (1986). Chemical and Biological Methods for Water Pollution Studies. Environmental publication, (Karad, India).
6. Barnes, R.S.K. (1991). Fundamentals of Aquatic Ecosystems. II Edition, Willey-Blackwell, London.
7. Mackie, G. (2005). Applied Aquatic Ecosystem Concepts. II Edition, Kendall/Hunt Publishing, Dubuque, Lowa.
8. Qasim, S. Z. (2004). Handbook of Tropical Estuarine Biology. Narendra Publishing House, Delhi.
9. Shalini Verma. (2015). Basic Limnology and Fish Biodiversity. Random Publishers, New Delhi.
10. Hosetti, B.B. and Arvind Kumar. (2016). A Textbook of Applied Aquatic Biology. Daya Publishing House.
11. Barnes R.S.K. and Hughes, R.N. (1988). An Introduction to Marine Ecology. II Edition, Boston: Blackwell Scientific Publications.
12. https://libguides.jcu.edu.au/marine_biology/key-resources/websites
13. https://www.nature.com/subjects/marine-biology
14. https://www.tandfonline.com/doi/full/10.1080/09670262.2017.1365175
15. https://www.qub.ac.uk/research-centres/QueensUniversityMarineLaboratory/research/seaweed-research/
16. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/seaweed
17. https://www.nature.com/scitable/knowledge/library/ecology-of-wetland-ecosystems-water-substrate-and-17059765/

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Understand and apply relevant scientific principles in the area of aquatic biology.
- Employ scientific methodologies and data analysis in the area of aquatic biology.
- Understand the adaptations of the aquatic species.
- Explore the causes of aquatic pollution and its impact on ecosystem.
- Develop employable skills in physico-chemical parameters.

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Third Year **MAJOR BASED ELECTIVE I** **Semester V**

2. BIODIVERSITY AND CONSERVATION

Code **(Theory)** **Credit 4**

COURSE OBJECTIVES:

- To imply the heritage of biodiversity of India.
- To make students aware on the threats to biodiversity.
- To give an insight knowledge on developments in conservation biology.
- To make them improve in understanding the significance of biodiversity conservation and management.
- To analyze and represent various conservation measures adopted/practiced in India.

UNIT – I Introduction to Biodiversity:

Biodiversity – definition - concepts - scope and significance. Levels of biodiversity - Introduction to genetic - species - ecological system biodiversity. Values of biodiversity - mega diversity zones - biodiversity hot spots with special reference to India.

UNIT – II Threats to Biodiversity:

Red data book - Biodiversity laws - past and present - habitat loss by natural and human induced fragmentation. Over exploitation - invasive alien species - threats and vulnerability of species to extinctions. Mass extinction - zero extinction - extinction vortex. Problems of genetic diversity loss over time – bottleneck effect - genetic drift - inbreeding depression.

UNIT – III Conservation Methods:

Conservation strategies - *in situ* - *ex situ* conservation. Protected area concept – sanctuary - national park - biosphere reserve - tiger reserves (with examples) – zoos – botanical gardens. Core zone and buffer zone. Germ plasm conservation - DNA libraries - tissue culture and cloning. Corridor concept - conservation reserves and sacred grooves. Role of NGOs and people participation in conservation of biodiversity.

UNIT – IV Biodiversity Conservation and Management:

Concept of wildlife - wildlife heritage of India - causes for wildlife depletion in Indian context - concept of threatened fauna. Introduction to International efforts - Convention on Biological Diversity (CBD), International Union for Conservation of Nature (IUCN), UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC). National Biodiversity Action Plan, 2002 - Introduction to Indian Wildlife (Protection) Act, 1972 - Convention for International Trade of Endangered species.

UNIT – V Faunal Conservation:

Distribution and conservation of sea turtles - old world monkeys - Indian ungulates - project tiger and its implications - project elephant and status. Conservation of Indian rhino - breeding biology and feeding ecology of elephants. Human animal

conflicts and mitigation in Indian landscape – understanding national biodiversity portal. Restoration of damaged ecosystem and endangered population.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Data on recent loss of biodiversity in India and reviews on current status of biodiversity in India - emerging technologies to conserve biodiversity.

REFERENCES:

1. Krishnamurthy, K.V. (2003). Textbook of Biodiversity. Science Publication.
2. Groom, M.J., Meffe, G.R. and Carroll, C.R. (2005). Principles of Conservation Biology. III Edition, Sinauer Associates, Inc., Sunderland, Massachusetts.
3. Rangarajan, M. (2001). India's Wildlife History. Permanent Black, New Delhi, India.
4. Arumugam, N. (2014). Animal Diversity. Vol - II – Chordata. Saras Publication, Nagercoil, Tamil Nadu.
5. Kartik Shanker and Choudhury, B.C. (2006). Marine Turtles of the Indian Subcontinent. Natraj Publications, Delhi.
6. Kotpal, R.L. (2015), Modern Text Book of Zoology Vertebrates. V Edition, Rastogi Publications, Meerut.
7. Thangamani, A., Prasannakumar, S., Narayanan, L.M. and Arumugam, N. (2018). A Text Book of Chordates. Saras Publication, Nagercoil, Tamil Nadu.
8. Jordan, E.L. and Verma, P.S. (2013). Chordate Zoology. XIV Edition, S Chand Publishers, New Delhi.
9. Anderson, J. and Slater, D.L. (1981). Catalogue of Mammals Vols. I and II. Cosmo Publications, New Delhi.
10. Underkoffler, S.C. and Adams, H.R. (2021). Wildlife Biodiversity Conservation: Multidisciplinary and Forensic Approaches. I Edition, Springer.
11. https://www.eolss.net/ebooklib/bookinfo/biodiversity-conservation-habitat-management.aspx
12. https://www.eolss.net/ebooklib/bookinfo/natural-human-induced-hazards-environmental-waste-management.aspx
13. https://www.cambridge.org/core/series/ecology-biodiversity-and-conservation/F501DCEE23BD5B5FB20C94F52D63A73B
14. https://ncert.nic.in/ncerts/l/lebo115.pdf
15. https://www.wwf.org.uk/project/conservationtechnology

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Understand the value and responsibility to conserve biodiversity.
- Relate the current threats to biodiversity and its impacts of ecosystem.
- Recall the basic concepts / steps involving in conservation practices.
- Be aware of the relevant legislation and recent initiatives of biodiversity conservation.
- Update knowledge on the national biodiversity portal.

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Third Year **SKILL BASED ELECTIVE I** **Semester V**

AQUARIUM FISH KEEPING

Code **(Theory)** **Credit 2**

COURSE OBJECTIVES:

- To understand the benefits and characteristics of an aquarium setup.
- To gain knowledge on the benefit on culture of live feeds.
- To comprehend the breeding techniques of ornamental fishes.
- To understand the role and significance of aquascaping.
- To study the current status of ornamental fish trade in India.

UNIT – I Fabrication and Establishment of an Aquarium:

Introduction – scope - benefits of aquarium. Types of ornamental fishes - indigenous fish - exotic fish - fresh water fish - marine water fish. World trade ornamental fishes - export potential. Different types of fish tanks - fish bowl - acrylic glass tanks - construction of glass tanks. Setting up of aquarium - aquarium accessories - equipment for setting up beginner - setup for large scale. Aeration and filtration – types and advantages of filters.

UNIT – II Feed and Water Quality Management:

Introduction - types of feed - feed for fry - live feed - artificial feed - formulated feed. Culture of live feed - Artemia - Infosuria - blood worms. Maintenance of water quality parameters - temperature - pH - chlorine - water hardness - dissolved oxygen.

UNIT – III Breeding and Disease Management:

Breeding – introduction - breeders - live bearers - sex determination - fish fry. Egg layering fish - Angel fish - Zebra fish - Neon tetras - egg scatterers - egg depositors - egg buriers - mouth brooders - nest builders (Betta fish). Hatchery management system - nursery management - induced spawning - water conditioning - food - rearing - rising the young ones / fish fry. Disease management - types - bacterial - viral - protozoan and parasitic disease. Physical observation - diagnostic techniques - prevention - control and treatment.

UNIT – IV Aquascaping and Aquatic Plants and Animals:

Introduction – scope - aquascaping - woods and decorations in aquascaping. Aquatic plants - types - floating plants - substrate plants. Aquarium soil - propagation and lighting. Aquatic animals – benefits and types - snail - types of snail and shrimp - types of shrimp, crayfish.

UNIT - V: Aquarium Business:

Scope of aquarium fish industry - cottage industry. Budget for setting up and maintenance of aquarium /ornamental fish farm. Live fish transport - conditioning - packing - transport and quarantine methods. Factors and principles associated with live fish transport.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Current ideology on aquascaping and its trade in India - benefits of aquarium on health and mood and aquascape in ornamental industry. Present status - challenges and scope of indigenous ornamental fish trade.

REFERENCES:

1. Ahilan, B., Felix, N. and Santhanam, R. (2008). Text book of Aquariculture. Daya Publishing House, New Delhi.
2. Alderton, D. (2019). Encyclopedia of Aquarium and Pond Fish. United Kingdom, Dorling Kindersley Limited.
3. James, C. Cato, and Christopher, L. Brown. (2008). Marine Ornamental Species: Collection, Culture and Conservation. John Wiley & Sons.
4. Emmens, C.W. (2013). Keeping and Breeding Aquarium Fishes. Netherlands: Elsevier Science.
5. Ruff, K.J. (2009). Freshwater Aquarium Chemistry: A Comprehensive Guide for Tropical Fish Hobbyists. AquaChem Publishing.
6. Heleine, M.F. (2019). Freshwater Aquariums for Dummies. United Kingdom: Wiley.
7. Goemans, B. (2019). Freshwater and Marine Aquarium Filtration - The Path Toward Camelot. United States: Page Publishing, Inc.
8. Thierry Maitre-Alain and Chrisitan Piednoir. (2009). Aquariums: The Complete Guide to Freshwater and Saltwater Aquariums. Firefly Books Ltd.
9. Smith, D.J. (2016). Aquarium Keeping: The Aquarium Keeping Basics. David Justin Smith publications.
10. Mundy, O.J. (2019). Aquarium Making: Fish-keeping and Maintenance. JimArts. II Edition.
11. https://www.academia.edu/20345828/Ornamental_fish_Keeping
12. https://www.oftri.org/
13. https://worldwidescience.org/topicpages/o/ornamental+fish+culture.html
14. https://www.mdpi.com/journal/fishes/special_issues/nutrition_feeding_fish
15. https://www.researchgate.net/publication/354461677_Food_and_Feeding_of_Ornamental_Fishes
16. https://www.researchgate.net/publication/352372859_Art_and_science_of_aquascaping
17. http://ecoursesonline.iasri.res.in/course/view.php?id=579

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Understand the key skills needed to set up an aquarium through institutional visits.
- Maintain suitable water quality in aquarium tank and culture live feeds.
- Learn and imply the fish breeding techniques and culture setup.
- Rear idea on creating models for aquascaping,
- Understand the basic ideology on import and export for commercialization.

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Third Year **CORE COURSE VIII** **Semester VI**

ANIMAL PHYSIOLOGY

Code **(Theory)** **Credit 5**

COURSE OBJECTIVES:

- To familiarize students with the principles and basics of animal physiology.
- To integrate the body functions, its adaptations with respect to its external and internal environment.
- To understand about nervous integration, sensation, metabolism and reproduction.
- To provide knowledge about the nutrition and balanced diet.
- To compare and signify the structure and functions of various organ systems.
- To understand the interrelationship among the physiological systems.

UNIT – I Food and Nutrition:

Nutrition – composition of food- food requirements - calorific values – carbohydrates - proteins - fats - minerals and vitamins. Digestive system - enzymes and their role in digestion - absorption - assimilation. Metabolism of proteins - carbohydrates and lipids. Balanced diet - malnutrition- Basal Metabolic Rate (BMR) and Body Mass Index (BMI).

UNIT – II Respiration and Circulation:

Respiration - types of respiration - structure of lungs and gaseous exchange - transport of O_2 – transport of CO_2 – structure and functions of haemoglobin. Circulation – structure and functions of mammalian heart - working mechanism – heart beat - cardiac rhythm - cardiac cycle. Myogenic and neurogenic heart. Properties and functions of blood - ECG - blood pressure- myocardial infarction - factors contributing to heart attacks and cardiac arrest.

UNIT – III Excretion and Muscular Organization:

Excretion - structure and function of kidney - nephron - mechanism of urine formation. Osmotic and ionic balance regulation in freshwater and marine animals. Muscles – structure - composition and types of muscles – Structure of skeletal muscle - mechanism of muscle contraction.

UNIT – IV Nerve Physiology and Sensory Receptors:

Structure of nerve cell - types of neurons - conduction of nerve impulse. Structure of synapse - mechanism of synaptic transmission – neurotransmitters - types. Bioluminescence – biological clock. Sensory Receptors - types - photoreceptor - structure – physiology of vision - phonoreceptors – structure and mechanism of hearing.

UNIT – V Endocrinology:

Endocrine glands – structure of pituitary gland – secretions of pituitary - structure and hormones of hypothalamus - adenohypophysis – neurohypophysis - secretion and functions of pineal gland. Thyroid gland - parathyroid - thymus - adrenal and

pancreas. Testis and ovary – types of hormones - male and female reproductive hormones – hormonal control of menstrual cycle in human - pregnancy - lactation and menopause.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Research topic related to molecular neuro physiology - neuronal regulation in basic physiology - articles on chemical functions in animals including animal reproduction, disease and nutrition.

REFERENCES:

1. Kay, D.I. (2020). Introduction to Animal Physiology. United States: CRC Press.
2. Verma, P.S. and Agarwal, V.K. (2009). Animal Physiology. S. Chand & Company Ltd., New Delhi
3. Goyal, K.A. and Sastry, K.V. (2012). Animal Physiology. Rastogi Publications, Meerut, India.
4. John E. Hall. (2016). Text book of Medical Physiology. Elsevier Health Sciences, (Jordanian Edition).
5. Yancey, P., Sherwood, L. and Klandorf, H. (2013). Animal Physiology: From Genes to Organisms. Cengage Learning, Inc.,
6. Hill, R., Cavanaugh, D. and Anderson, M. (2021). Animal Physiology. United Kingdom: Oxford University Press.
7. Aschoff, J., Daan, S. and Groos, G.A. (2012). Vertebrate Circadian Systems: Structure and physiology. Germany: Springer Berlin Heidelberg.
8. Pocock, G., Richards, C.D. and Richards, D.A. (2018). Human Physiology. United Kingdom: Oxford University Press.
9. Clark, A.J. (2015). Comparative Physiology of the Heart. United Kingdom: Cambridge University Press.
10. Moyer, C.D. and Schulte, P.M. (2007). Principles of Animal Physiology. II Edition, Pearson Benjamin - Cummings Publishing Company.
11. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1959222/
12. https://www.frontiersin.org/research-topics/30898/diving-deeper-with-metabolomics-into-animal-physiology
13. https://canterbury.libguides.com/c.php?g=243216&p=1618605
14. https://pubmed.ncbi.nlm.nih.gov/16645885/
15. https://www.frontiersin.org/research-topics/7257/comparative-endocrine-stress-responses-in-vertebrates
16. https://www.frontiersin.org/research-topics/19463/hormone-regulation-of-insect-development

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Understand and analyze the nutritional requirements and its calorific values.
- Explain and recognize the physiological structure and functions of various organs.
- Gain anatomical knowledge in predicting the physiological changes and its consequences.
- Understand and relate the physiological activity of sensory organs.
- Distinguish the types and functions of endocrine glands.

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Third Year	**CORE COURSE IX BIOTECHNOLOGY**	**Semester VI**
Code	**(Theory)**	**Credit 5**

COURSE OBJECTIVES:

- To enlighten on various aspects of scopes in biotechnology.
- To make aware on various applications in genetic engineering, gene cloning techniques.
- To share knowledge on various molecular markers and its potential applications.
- To enlighten the applications of biotechnology in the field of medicine and therapies for human welfare.
- To encourage students to take biotechnology as their career as it provides ample scope for bright future.

UNIT – I History and Scope:

Biotechnology – definition - history - scope - important landmarks and applications of biotechnology. Genetic engineering and gene cloning methods - tools of genetic engineering - enzymes. Gene cloning vectors - pBR322 plasmid - pUC 18 - Ti plasmid - pSV plasmid - simian virus 40. Selection and preparation of desired DNA - *In vitro* construction of rDNA.

UNIT – II Gene Transfer Mechanisms and Screening:

Gene transfer mechanisms - bacterial conjugation - transformation - transfection - transduction. Methods of gene cloning in prokaryotes - microinjection - electroporation – microprojectile - ultrasonication - liposomal fusion and microlaser. Selection (screening) of recombinants - immunochemical method and colony hybridization – construction of gene library and cDNA library.

UNIT – III Genetic Engineering and its Applications:

Genetic engineering for human welfare - production of recombinant insulin - somatotropin (HGH) - human interferons. Vaccine - types - applications. Transgenic animals - production and their uses. Animal biotechnology - requirements for animal cell culture – maintenance and storage of cell lines - Cryopreservation – methods – advantages - cell bank.

UNIT – IV Molecular Markers:

Molecular markers - applications - Restriction Fragment Length Polymorphism (RFLP) – Random Amplified Polymorphic DNA (RAPD) – Minisatellites or Variable Number of Tandem Repeats (VNTRs) – Microsatellites (SSRs). PCR (Amplification of DNA) – applications of PCR Technology. DNA sequencing methods - Maxam and Gilbert method - Sanger's method and automatic DNA sequencing. DNA finger printing and foot printing – applications of DNA finger printing.

UNIT – V Environmental Biotechnology:

Waste water treatment – anaerobic - aerobic treatment of solid and liquid wastes. Microorganisms in pollution control and abatement – bioremediation - biological bleaching - biomass production - bio-fuels - bio-prospecting.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Artificial intelligence – Alpha Fold programme - Biotechnology tool for mRNA vaccines preparation - Biowaste conversion into batteries applications - Artificial meat production - Genetically modified biocontrols - Developing the CRISPR/CAS9 gene editing tool - CO_2 to Protein technology - Printable organic solar cells

REFERENCES:

1. Gahlawat, S.K. and Duhan, J.S. (2018). Advances in Animal Biotechnology and its Applications. Springer, Nature.
2. Godbey, W.T. (2014). An introduction to Biotechnology: The Science Technology and Medical Applications. Woodhead Publishing.
3. Satyanarayana, U. (2020). Biotechnology. Books and Allied (p) Ltd, Kolkata.
4. Dubey, R.C. (2014). A Text book of Biotechnology. S. Chand and Company Ltd, New Delhi.
5. Gupta, P.K. (2017). Biotechnology and Genomics. I Edition, VII Reprint), Rastogi Publications, Meerut.
6. Purohit, S.S. (2010). Biotechnology. Agrobios publishers (P) Ltd., Jodhpur.
7. Pranav Kumar and Usha Mina. (2015). Biotechnology: A Problem Approach. VI Edition, Pathfinder Publication.
8. Kumerasan, V. (2014). Biotechnology. (Revised Edition), Saras Publications, Kanyakumari.
9. Ignacimuthu, S.J. (2008). Biotechnology – An Introduction. Narosa Publishing House New Delhi.
10. Arora, P.M. 2003. Biotechnology. I Edition, Himalaya Publishing House, Mumbai.
11. Gupta, P.K. 2001. Elements of Biotechnology and Genomics. I Edition, Rastogi Publications, Meerut.
12. Das, H.K. 2005. Text book of Biotechnology. II Edition, Wiley Dreamtech India (P) Ltd., New Delhi.
13. https://www.analyticsinsight.net/deepminds-alphafold2-solves-the-long-stood-protein-folding-problem/
14. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3597572/
15. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7318311/
16. https://deepbranch.com/technology/
17. https://www.agro-chemistry.com/news/deep-branch-to-scale-up-protein-production-from-co2/
18. https://www.nature.com/articles/s41467-018-04252-2
19. https://pubs.acs.org/doi/full/10.1021/acsami.0c12190
20. https://www.sciencefocus.com/science/what-is-lab-grown-meat-a-scientist-explains-the-taste-production-and-safety-of-artificial-foods/

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Know the scope and various applications in biotechnology.
- Realise gene cloning principles in Prokaryotes and basic techniques involved in human genome project.
- Acquire knowledge on techniques and the applications of genetic engineering in diagnosis and prevention of genetic diseases.
- Understand applications of transgenic animals.
- Apply with gained knowledge on recombinant DNA technology in solving environmental issues.

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Third Year	CORE PRACTICAL VI ANIMAL PHYSIOLOGY AND BIOTECHNOLOGY	Semester VI
Code	(Practical)	Credit 5

COURSE OBJECTIVES:

- To emphasize on basic laboratory procedures and protocols.
- To train on handling various equipments and usage of microscopy.
- To impart hands-on practice on the techniques in physiology.
- To train students to identify bacterial cells and its culture techniques.
- To make them familiarize with reagent preparation and its standardization.

ANIMAL PHYSIOLOGY

Experiments

1. Qualitative and quantitative estimation of proteins.
2. Qualitative and quantitative estimation of carbohydrates and lipids.
3. Human salivary amylase activity in relation to temperature and pH.
4. Qualitative estimation of ammonia, urea and uric acid.
5. Enumeration of human RBCs/WBCs using haemocytometer.
6. Estimation of oxygen consumption by fish (an aquatic animal).
7. pH measurement of various samples using pH meter and pH paper.

Spotters

Haemoglobinometer, Kymograph, Sphygmomanometer, pH meter, Thermometer, UV-Spectrophotometer, Models of amino acids, Haemoglobin, ATP, Steroids.

BIOTECHNOLOGY

Experiments

1. Estimation of DNA and protein by colorimetry.
2. Protein separation by PAGE (Poly acrylamide gel electrophoresis)
3. DNA separation by AGE (Agarose gel electrophoresis)
4. Isolation of plasmid DNA (Alkali lysis method)-Demo only.
5. Isolation of Genomic DNA (Saline Sodium Citrate Method) - Demo only.
6. Selection (Screening) of transformants and recombinants- Demo only.

Spotters

DNA double Helix model, Rotary shaker, Incubator, Autoclave, Hot air oven, Micro pipette, Centrifuge (Table top, ultra-centrifuge), Electrophoresis apparatus (AGE, PAGE), Fermentor, Animal cell culture flask.

REFERENCES:

1. Gottam, G.S., Mittal, P.K., Gupta, B., Jindal, S.K. and Bilochi, D.R. (2020). Practical Veterinary Physiology. Satish Serial Publishing House.
2. Harsh Vardhan Bhask. (2009). Manual of Practical Physiology and Endocrinology. Campus Books International.
3. Howard, B., Nevalainen, T. and Perretta, G. (2010). The COST Manual of Laboratory Animal Care and Use: Refinement, Reduction, and Research. Taylor and Francis.
4. Patton, Kevin T. (2018). Anatomy & Physiology Laboratory Manual and E-Labs E-Book. Elsevier Health Sciences.
5. Nagarajan, P., Ramachandra, G. and Ramesh, S. (2021). Essentials of Laboratory Animal Science: Principles and Practices. Springer Singapore.
6. Martin, Terry R., David, Shier., Jackie, Butler. and Ricki, Lewis. (2000). Laboratory Manual to Accompany Hole's Essentials of Human Anatomy and Physiology. McGraw-Hill Science/Engineering/Math. XI Edition.
7. Ashish, S., Das, S. and Singh, A. V. (2014). Laboratory Manual for Biotechnology. S. Chand publications.
8. Supriya, D., Swagat, K,D. and Thatoi, H,N. (2017), Practical Biotechnology: Principles and Protocols, I K International Publishing House.
9. Lisa, A.S., Mary, E.K. and Diana, B. (2010). Laboratory Manual for Biotechnology and Laboratory Science: The Basics. Pearson.
10. Yadav, V.K. and Yadav, N. (2007). Biochemistry and Biotechnology: A Laboratory Manual. Pointer Publishers.

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Perform physiological and biochemical assays.
- Carry out qualitative and quantitative estimations of various biomolecules.
- Expertise in the quantification of RBC and WBC of human blood and identify pH of any sample.
- Gain well versed knowledge on structural aspects of DNA, plasmid, and proteins.
- Get exposure on types of electrophoresis with special reference to the separation of DNA and protein.

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Third Year **MAJOR BASED ELECTIVE II** **Semester VI**

1. ENVIRONMENTAL BIOLOGY

Code **(Theory)** **Credit 4**

COURSE OBJECTIVES:

- To provide in-depth knowledge to understand our biotic and abiotic environment.
- To enrich on fundamental ideas on ecological principles.
- To make them understand by relating community interactions.
- To impart knowledge on complex bio-geochemical cycles.
- To make them aware on the environmental issues, effects and solutions.

UNIT – I Introduction of Ecology:

Definition – concept and scope and types of ecology - branches of ecology. Environment - atmosphere (air) - hydrosphere (water) and lithosphere (soil); Abiotic factors - temperature and light – influence of light and temperature on animals. Biotic factors - animal association - ecological interaction – neutralism – symbiosis - commensalism - mutualism - antagonism - antibiosis - parasitism - predation and competition – intra-specific and interspecific interactions.

UNIT – II Ecosystem:

Natural ecosystem and man-made ecosystems - trophic levels - energy flow - ecological pyramids and productivity - food chain and food web. Principles and concepts of biogeochemical cycles – carbon - oxygen - nitrogen - phosphate and sulphur. Laws of limiting factors. Habitat ecology - fresh water - marine water and terrestrial habitat.

UNIT – III Community and Population Ecology:

Community Ecology – types and characteristics – stratification - community interdependence – ecotone - edge effect - ecological niche – ecological succession - types and mechanism and concept of climax.

Population Ecology - population size and density – natality, mortality - age structure - population growth curve - biotic potential - population dynamics emigration and immigration. Regulation of population size.

UNIT – IV Environmental Pollution:

Introduction - types – air - water - land - noise - thermal and radiation. Environmental Impact Assessment (EIA) - Geographic information system (GIS) - global warming and biomagnifications. Biological indicators and their role in environmental monitoring - environmental conservation and management. Waste water treatment - primary - secondary - tertiary stages. Acid rain. Solid waste management - effects of hazardous waste - bio medical waste - process of waste management.

UNIT – V Energy and Conservation:

Energy – introduction and types - conventional - non-conventional source energy. Conventional sources of energy – coal - oil - natural gas - thermal power - nuclear power. Non-conventional sources of energy – solar - wind - tidal and bio energy. Terrestrial resources - forest and agriculture. Aquatic resources and their conservation. Wildlife conservation - sanctuaries and national parks - conservation and management. Conservation of biodiversity - *in-situ* and *ex-situ* conservation.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Recent innovations to reduce global warming - threats of natural resources depletion - climatic changes and deforestation. Waste management - environmental Acts and Amendments.

REFERENCES:

1. Jones, A.M. (2006). Environmental Biology. India: Taylor & Francis.
2. Odum, E.P. (2005). Fundamentals of Ecology. India: Cengage Learning India Private Limited.
3. Van Dyke, F. and Lamb, R.L. (2020). Conservation Biology: Foundations, Concepts, Applications. Switzerland: Springer International Publishing.
4. Khoiyangbam, R.S. (2015). Introduction to Environmental Sciences. India: Teri (The Energy and Resources Institute).
5. Schroer, J. and Ramsay, J. (2020). Environmental Biology. Kendall Hunt Publishing Company.
6. Bailer, A. (2020). Statistics for Environmental Biology and Toxicology. United States: CRC Press.
7. Verma, P.S. and Agarwal, V.K. (2000). Environmental Biology: Principles of Ecology. India: S. Chand Limited.
8. Jones, A.M. (2006). Environmental Biology. India: Taylor & Francis.
9. Strayer, D.L., Weathers, K.C. and Likens, G.E. (2012). Fundamentals of Ecosystem Science. Netherlands: Elsevier Science.
10. Thipse, S.S. (2014). Energy Conservation and Management. United Kingdom: Alpha Science International, Limited.
11. Demirel, Y. (2021). Energy: Production, Conversion, Storage, Conservation, and Coupling. Switzerland: Springer International Publishing.
12. Spellman, F.R. (2021). The Science of Environmental Pollution. United States: CRC Press.
13. https://www.yourarticlelibrary.com/biodiversity/conservations-of-biodiversity-in-situ-conservation-and-ex-situ-conservation/30144
14. https://www.insightsonindia.com/environment/environment-impact-assessment/
15. https://www.biologydiscussion.com/population/population-growth/population-growth-curves-ecology/51854
16. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7122413/
17. http://www.freebookcentre.net/biology-books-download/Fundamentals-of-Ecology-Lecture-Notes.html
18. https://www.bbvaopenmind.com/en/articles/innovation-and-climate change/#:~:text=replace%20high%2Dcarbon%20fossil%20fuels,its%20release%20to%20the%20atmosphere

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Understand the basic components on environment.
- Acquire knowledge on complex food chain/web of different ecosystems.
- Create ideology and promotes to conserve / formation of community / an ecosystem.
- Know about various effects of pollutions and its preventing measures.
- Gain knowledge and awareness about conservation / management of biodiversity.

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Third Year **MAJOR BASED ELECTIVE II** **Semester VI**

2. APPLIED ENTOMOLOGY

Code **(Theory)** **Credit 4**

COURSE OBJECTIVES:

- To get the knowledge about the classification of insect pests.
- To learn about pests of storage products and its impacts.
- To gain the knowledge of economically important insects.
- To understand the household pests and its effects.
- To have an elaborative idea about insect pest management in agriculture.

UNIT – I Introduction and Classification of Entomology:

Entomology – definition - scope - basics of insect classification (upto Order). General characteristics of insects - salient features - insect Orders with South Indian examples - Thysanura, Orthoptera, Isoptera, Hemiptera, Coleoptera, Diptera, Odonata Thysanoptera, Lepidoptera and Hymenoptera - economic importance of the insects.

UNIT – II Insect Morphology and Physiology:

Insect morphology - structure and modifications of head – thorax - sutures of tergum - sternum – pleuron. Wings- structure and modifications - venation. Legs - structure and modifications. Abdomen - segmentation and appendages. System of insects - structure and physiology of integumentary - digestive - circulatory - excretory - respiratory - nervous - reproductive - endocrine system – metamorphosis - moulting.

UNIT – III Agricultural Entomology and Beneficial Insects:

Biology of agriculture pests - crop damage - control methods. Major pest of brinjal - paddy - sugarcane - coconut - groundnut. Pests of stored products - black gram - green gram. Productive insects - Honeybee – biology - production and uses. Silkworm – biology - production and uses. Lac insect – biology - production and uses. Helpful insects - scavengers - pollinators. Forensic entomology - insects of forensic importance - corpse feeders - maggots. Life cycle analysis - role of insects in crime investigation.

UNIT – IV Medical Entomology:

Vectors – medical and biological role - definition - Arthropods of public health importance. Anthroponotic diseases - malaria - filariasis - trypanosomiasis. Zoonotic diseases - leptospirosis - plague. Public health nuisance - cockroach - housefly - wasps - beetles - mosquitoes -ticks - sand flies - fleas - assassin bugs - spiders.

UNIT – V Integrated Pest Management (IPM):

Pest – definition - methods of pest control – cultural - mechanical - physical and legal methods. Role of biotechnology in pest control. Biological control - parasitoids - predators. Chemical control – pesticides - organochlorines - organophosphates - pyrethroids. Insect Growth Regulators (IGR). Applications of pheromones and chemosterilants in pest managements. Biopesticides - Integrated Pest Management (IPM) - classification of insecticides - mode of entry - mode of action. Anti-feedants -insect repellents and attractants.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

New strategies for the control of malarial mosquito (*Anopheles gambiae*) using hormones – Recent development of pollinators. Technological software use of entomology - recent techniques to cultivate pollinators.

REFERENCES:

1. Gillott, C. (2014). Entomology. Netherlands: Springer Netherlands.
2. Jain, P.C. and Bhargava, M.C. (2007). Entomology: Novel Approaches. India: New India Publishing Agency.
3. Krell, R.K., Pedigo, L.P. and Rice, M.E. (2021). Entomology and Pest Management. United States: Waveland Press Inc.,
4. Hagstrum, D. (2016). Fundamentals of Stored-Product Entomology. United States: Elsevier Science.
5. Hill, D.S. (2009). Agricultural Entomology. United States: Timber Press.
6. Matheson, R. (2008). Medical Entomology. Read Books publications.
7. Wiggles Woth, V.B. (2017). The Principles of Insect Physiology. United States: Creative Media Partners, LLC.
8. Simpson, S. (2011). Advances in Insect Physiology. United Kingdom: Elsevier Science.
9. Sanjayan, K.P. (2018). Insect Physiology. India: Scientific Publishers.
10. Snodgrass, R.E. (2019). Textbook of Arthropod Anatomy. United States: Cornell University Press.
11. Schowalter, T.D. (2022). Insect Ecology: An Ecosystem Approach. Netherlands: Elsevier Science.
12. Mullen, G.R. (2009). Medical and Veterinary Entomology. Netherlands: Elsevier Science.
13. Petric, D., Kaiser, A., Dahl, C., Madon, M.B., Boase, C., Becker, N. and Zgomba, M. (2020). Mosquitoes: Identification, Ecology and Control. Cham Springer Nature Switzerland.
14. Vonnie Shields, D.C. (2017). Biological Control of Pest and Vector Insects. Croatia: Intech Open.
15. Chapman, R.F., Simpson, S.J. and Douglas, A.E. (2013). The Insects: Structure and Function. United Kingdom: Cambridge University Press.
16. https://onlinecourses.swayam2.ac.in/cec20_bt02/preview
17. https://www.mooc-list.com/course/bugs-101-insect-
18. https://cms.ctahr.hawaii.edu/epp/Education/Study-Guide-Packets/APC-Core/APC-Unit1
19. https://sites.lafayette.edu/esarchive/files/2013/12/Lafarm-CapstoneFinal_posters.pdf

20. https://thebiologynotes.com/economic-importance-beneficial-and-harmful-of-insects/
21. https://academic.oup.com/bioscience/article/56/4/311/229003
22. https://www.nature.com/articles/s41586-022-04908-6
23. https://slate.com/technology/2022/07/how-useful-are-bird-bug-plant-id-apps.html
24. https://www.fao.org/zhc/detail-events/en/c/428504/

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Acquire knowledge on classification of pests and beneficial insects.
- Have an elaborative idea about pests on stored products.
- Gain Knowledge on commercial insects and usage in the field of agriculture.
- Learn in depth on ideas about role of vectors in medicinal purposes.
- Attain deep knowledge on pest management strategies.

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Third Year **PROJECT** **Semester-VI**

Code: **Credit: 3**

The candidate shall be required to take up a Project Work by group or individual and submit it at the end of the final year. The Head of the Department shall assign the Guide who, in turn, will suggest the Project Work to the students in the beginning of the final year. A copy of the Project Report will be submitted to the University through the Head of the Department on or before the date fixed by the University.

The Project will be evaluated by an internal and an external examiner nominated by the University. The candidate concerned will have to defend his/her Project through a Viva-voce.

ASSESSMENT/EVALUATION/VIVA VOCE:

1. PROJECT REPORT EVALUATION (Both Internal & External)

   I. Plan of the Project - 20 marks

   II. Execution of the Plan/collection of Data / Organisation of Materials / Hypothesis, Testing etc. and presentation of the report. - 45 marks

   III. Individual initiative - 15 marks

2. Viva-Voce / Internal & External - 20 marks

TOTAL **- 100 marks**

PASSING MINIMUM:

	Vivo-Voce 20 Marks	**Dissertation 80 Marks**
Project	40% out of 20 Marks (i.e. 8 Marks)	40% out of 80 marks (i.e. 32 marks)

A candidate who gets less than 40% in the Project must resubmit the Project Report. Such candidates need to defend the resubmitted Project at the Viva-voce within a month. A maximum of 2 chances will be given to the candidate.

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Third Year **SKILL BASED ELECTIVE II** **Semester VI**

MEDICAL DIAGNOSTICS

Code **(Theory)** **Credit 2**

COURSE OBJECTIVES:

- To make them understand the principle, essentials and scope of molecular diagnosis.
- To highlight the importance of Clinical and Laboratory Standards Institute (CLSI) guidelines.
- To provide knowledge on molecular techniques used in diagnostics.
- To enrich the ideas/methods to identifying a disease by diagnosing various samples.
- To attain practical knowledge on the principles, instrumentation and application of rapid diagnostic kits.

UNIT – I Introduction to Medical Diagnostics:

Introduction – history - scope - importance of diagnosis of diseases – infectious - physiological - metabolic errors - genetic basis of diseases - inherited diseases - patient history - physical examination. Diagnostic consideration - diagnostic process – improving diagnosis in health care.

UNIT – II Body Fluids in Diagnosis:

Concepts in body fluids – hematology in diagnostics – RBC - WBC - plasma - separation of serum and plasma – blood counting - staining and grouping - Haemogram (CBC, ESR). Immunological methods in diagnostics - antigen-antibody reactions – agglutination – precipitation - immune electrophoresis – Coombs test – ELISA – RIA – WIDAL test.

UNIT – III Diagnostic Microbiology:

Concepts of microbiology – collection of specimens for microbiological investigations - blood – urine - throat swab - rectal swab - stool - pus (swabs) – normal microbial flora of the human body - antimicrobial susceptibility and antibiotic assays. Analysis of urine - standard loop test. Identification and characterization of common disease causing pathogens.

UNIT – IV Molecular Diagnostics:

Infectious diseases - method of sample collection - transport - processing of samples - interpretation of results. Liver function test – renal profile - rapid diagnostic tests - nucleic acid amplification methods and types of PCR - Automated DNA sequencing – principle - methods and instrumentation. Overview of clinical proteomics.

UNIT – V Medical Imaging and Diagnostics:

Medical imaging and clinical diagnosis – introduction - clinical skills in diagnosis – ECG - EEG - 2D Echo - pap smear/cervical smear. Imaging and radiological methods in diagnosis - X rays - CT scans - nuclear medicine scan – MRI scans – ultrasound.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Recent research on advanced techniques (AI) in medical science and technology and medical microbiology.

REFERENCES:

1. Prescott, L.M. (2002), Microbiology. VI Edition, McGraw-Hill Companies.
2. Forbes, B.A., Sahm, D.F., Weissfeld, A.S. and Bailey, W.R. (2007) Bailey & Scott's Diagnostic Microbiology. XII Edition, Elsevier Mosby, St. Louis.
3. Bruns, D.E., Burtis, C.A. and Ashwood, E.R. (2007). Fundamentals of Molecular Diagnostics. United Kingdom: Saunders Elsevier.
4. Carson, S., Witherow, D.S., Carson, S. and Miller, H.B. (2012). Molecular Biology Techniques: A Classroom Laboratory Manual. Netherlands: Elsevier Science.
5. Buckingham, L. (2012). Molecular Diagnostics: Fundamentals, Methods, and Clinical Applications. United States: F.A. Davis Company.
6. Papadakis, M.A., Rabow, M.W. and McPhee, S.J. (2020). Current Medical Diagnosis and Treatment. United States: McGraw-Hill Education.
7. Merck. (2018). The Merck Manual of Diagnosis and Therapy. Merck Manuals.
8. Stephen, J,M., Lawrence, M,T. and Maxine, A,P. (2006). Current Medical Diagnosis and Treatment. Lange Medical Books/McGraw-Hill.
9. Rajneesh, Prajapat and Manivannan, Kasturi. (2021). A Textbook of Medical Diagnostics: Laboratory Medicine. XI Edition, Notion Press.
10. Haren Ram Chiary, and Singh, H.S. (2020). A Textbook on Medical Diagnostics. IK International Publishing House Pvt. Ltd.
11. https://www.ncbi.nlm.nih.gov/books/NBK338593/
12. https://www.merckmanuals.com/home/special-subjects/common-imaging-tests/overview-of-imaging-tests
13. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8184621/
14. https://link.springer.com/article/10.1007/s11042-021-10707-4
15. https://www.frontiersin.org/articles/10.3389/fneur.2021.734345/full
16. https://www.mdpi.com/journal/mathematics/special_issues/Math_Modeling_Anal_Biol_Med
17. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4482237/
18. https://ibkp.dbtindia.gov.in/DBT_Content_Test/CMS/Guidelines/20181115134719867_Regulations-Guidelines-for-Reocminant-DNA-Research-and-Biocontainment-2017.pdf

COURSE OUTCOMES:

Upon successful completion of this course the students would be able to:

- Describe basics on sample collection and specimen types in medical diagnostics.
- Select appropriate diagnostic tools for specific conditions.
- Know the basics of biometrics that predict and prevent certain infections/diseases.
- Understand the science behind the analyses and diagnosis of common infections.
- Differentiate molecular diagnostics tools, their relation to precision medicine.
- Describe the most common imaging technologies and their applications.

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