Centurion UNIVERSITY

Shaping Lives...
Empowering Communities...

M.Sc. Zoology Syllabus

(Two Years Programme)

School of Applied Sciences

Centurion University of Technology & Management

2024-25

DEPARTMENT OF ZOOLOGY

M.Sc. Zoology
Two Year Programme
Course Structure 2024-25

Basket I - Core Courses				
Sl. No.	**Code**	**Subject Name**	**T-P-P**	**Credits**
1	CUTM2379	Advanced Sustainable Aquaculture	3-1-0	4
2	CUTM1452	Animal Biotechnology	3-1-0	4
3	CUTM1453	Animal Breeding	3-1-0	4
4	CUTM1443	Water and Soil Quality Management in Aquaculture	3-1-0	4
5	CUTM1446	Anatomy and Biology shellfish	3-1-0	4
6	CUTM1448	Fish Processing and Value Addition	3-1-0	4
7	CUTM1444	Fish and Shell fish Nutrition	3-1-0	4
8	CUTM1450	Animal Physiology and Biochemistry	3-1-0	4
9	CUTM1451	Immunology and Cancer Biology	3-1-0	4
10	CUTM1438	Bioanalytical Techniques	3-1-0	4
11	CUTM1445	Fish and Shellfish Health Management	3-1-0	4
12	CUTM1437	Cell and Molecular Biology	3-1-0	4
13	CUTM1449	Ornamental Aquaculture	3-1-0	4
14	CUTM1454	Genetics and Epigenetics	3-1-0	4
15	CUTM1436	Microbiology	3-1-0	4
16	CUTM 2378	Research Methodology and IPR	2-0-2	4
			Basket II (Domain Courses)	**32**
			Total	**96**

Course Outline for MSc courses
Advanced Sustainable Aquaculture

Subject Name	Code	Type of course	T-P-P	Prerequisite
Advanced Sustainable aquaculture	CUTM2379	Theory-Practice	3-1-0	-

Objectives

1 The goal of the Aquaculture Biology specialization is to give a theoretical basis and practical experience for understanding the biological principles in aquatic food production.
2 The specialization is intended to give a solid background for students who wish to work in aquaculture or related industries, or to pursue further research.
3 Students will understand the basis of technologies of fisheries and aquaculture.

Course Outcome

At the end of the course, students will be able:

COs	Course Outcomes
CO1	**Students will understand the basis of technologies of fisheries and aquaculture.**
CO2	**Students will develop a better understanding of the history of aquaculture and different production systems employed for better production.**
CO3	**Students will understand the basis of technologies of fisheries and aquaculture.**
CO4	**Study different aquatic organism as a source of**
CO5	**Students will understand the basis of technologies of fisheries and aquaculture**

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		1	3		2				3		3	3	2	2
CO2	3	2		2	1	2	1			3	1	1	2	1	3
CO3	3		1	2						3		2	1	3	3
CO4		2	2		2		3			3		3	3	2	3
CO5		1	2	1		1	1			3			2	2	2

(High-3, Medium-2, Low-1)

Course outline

Module- I

1. Basics of aquaculture, 2. definition and scope of aquaculture, 3. History of aquaculture, 4. Present global and national scenario. 5. Systems of aquaculture - Pond culture , 6. Pen culture, Cage culture and Running water culture, 7. Zero water exchange system.

Practice 1 (2 h) : Aquaculture production and resource statistics- World and India

Practice 2 (2 h) : Primary productivity calculation, Estimation by Light and Dark Bottle method.

Module- II

1. Extensive, semi-intensive, 2. Intensive and super intensive aquaculture in different types of water bodies - Fresh water , 3. Brackish water, 4. Inland saline and Marine water, 5. Principles of organic aquaculture, 6. Pond Management - Pre stocking and Post stocking, 7. Carrying capacity of pond with shrimps and crabs (Stocking Density), 8. Principle of crab and shrimp culture (Pond design management of crab and shrimp farm). 9. Factors influencing carrying capacity.

Practice 3 (2 h) : Components of Aquaculture farms

Module- III

1. Criteria for selection of animal species for aquaculture, 2. Major animal species for aquaculture: freshwater, 3. brackish water, marine water. 4. Culture System - Monoculture and Polyculture System, 5. Integrated culture systems**,** 6**.**Principles involved in seed production of lobsters crabs and mussels, 7. Fattening process of crab and shrimps.

Practice 4 (2 h) : Collection and identification of commercially important seed of fish and shellfishes

Module- IV

1. Culture of mullet, 2. Culture of Cobia, 3.Culture of Pompano, 4. Lobster culture, 5. Mussel and Pearl /Oyster culture, 6. Sea weed culture,

Practice 5 (2 h) : Study on waste accumulation in aquaculture system (NH_3, Organic matter, CO_2)

Module- V

1. Feed technology**:** Micro encapsulated feeds; 2. micro coated feeds; 3. micro particulate feeds and bio-encapsulated feeds; 4. Mycotoxins and their effects on feeds, 5. Sea ranching.

Practice 6 (2 h): Analysis of manure

Module- VI

1. Algal biotechnology**:** Biotechnological approaches for production of important microalgae; 2. single cell protein from *Spirulina;* vitamins, minerals and omega3 fatty acids from microalgae; 3. enrichment of micro algae with micronutrients.

Module- VII

1. Methods of Shellfish Culture rafts, 2. Racks, 3. Cages, 4.Poles and Ropes, 5.Sea Ranching, 6.Resources for shore-based aquaculture and sea farming in India, 7.Regulation for Mariculture

Practice 7 (2 h): Estimation of seed survival
Project : Use of probiotics in aquaculture farms.

Reference & Textbooks

1 Aquaculture principles and practices ----TVR Pillay and MN Kutty
2 Encyclopedia of aquaculture
3 Hand book fisheries and aquaculture----ICAR New Delhi 2006

4 Sustainable aquaculture byNagabhushanam R, Diwan AD, Zahurnec BJ &Sarojini R. 2004. *Biotechnology of AquaticAnimals.* Science Publ.

Animal Biotechnology

Subject Name	Code	Type of course	T-P-P	Prerequisite
Animal Biotechnology	CUTM1452	Theory andPractice	3-1-0	-

Objectives

1 To make the student understand the tools and techniques required for the animal cell culture, assisted reproductive technology, development of transgenic animals, and development of animal models.
2 The methods of culturing animal cells
3 To utilize animal production technologies for sustainable agriculture and food security

Course Outcome

At the end of the course, students will be able:

COs	Course Outcomes
CO1	**The methods of culturing animal cells**
CO2	**Various techniques involve in making of transgenic animals**
CO3	**To integrate assisted reproductive biotechnology techniques in livestock improvement.**
CO4	**To utilize animal production technologies for sustainable agriculture and food security**
CO5	**To integrate assisted reproductive biotechnology techniques in livestock improvement.**

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**1**		**1**	**3**	**1**	**2**	**2**			**1**		**3**	**3**	**3**	**2**
CO2	**2**	**2**		**2**	**1**		**1**			**2**	**1**	**1**	**2**	**1**	**3**
CO3	**3**		**1**	**1**		**2**				**1**		**2**	**1**	**2**	**2**
CO4	**3**		**2**		**2**		**1**				**2**	**3**	**2**	**2**	**3**
CO5		**1**		**1**		**1**	**1**			**2**		**1**	**2**	**3**	**1**

(High-3, Medium-2, Low-1)

Course outline

Module-I (Animal Cell and tissue culture technology-I): 8 H

1. Overview of animal cell and tissue culture technology; 2. Cell culture laboratory design and basic laboratory equipments; 3.Media preparation, 4.Role of important components of culture media; 5.Common laboratory hazards and safety issues to consider in cell culture laboratory

Practice 1(2h): Sterilization techniques used in animal cell culture
Practice 2(2h) : Preparation of media for animal cell culture

Module-II (Animal Cell and tissue culture technology-II): 8 H

1. Types of animal cell culture; 2. Characterization and preservation of animal cells; 3.Advances in cell culture technology; 4. Opportunities and challenges in animal cell and tissue culture technology

Practice 3 (2h): Study of primary cell culture technique using chick embryo
Practice 4(2h) : Animal cell batch culture technique

Module-III (Transgenesis for livestock improvement-I): 4 H

1. Overview of transgenic technology; 2. Biopharming through animal transgenesis; 3.Methods of producing transgenic farm animals; 4.Identification and transfer of gene influencing better production and disease resistance.

Module-IV (Transgenesis for livestock improvement-II): 5 H

1. Gene transfer methods in animals: Microinjection, 2. Retrovirus mediated gene delivery, 3. Embryonic stem cell mediated gene transfer; 4. Knockout model systems & their utility; 5. Animal as bioreactor.

Module-V (Assisted reproduction biotechnology for livestock improvement): 4 H

1. Reproduction biotechnologies and their use in livestock; 2. Somatic cell nuclear transfer cloning; 3.In Vitro Fertilization, 4.Embryo production, 5.Preservation and transfer; 6.Sperm and embryo sexing; 7.Intracytoplasmic sperm injection (ICSI); 8.Cryopreservation and gamete banking.

Module-VI (Animal Production technology for sustainable agriculture and food security):7H

1. Polyculture of fish for high yield; 2. Edible oyster production; 3.Pearl oyster production; 4.Vermi-culture and vermicomposting for alternative and sustainable agriculture; 5.Fish culture in flow through system and recirculation technology.

Practice 5 (2h) :Vermicompost preparation from plant debris, cattle dung and paper waste

Module-VII (Animal Biotechnology & human health): 6 H

1. Recombinant therapeutics and production of pharmaceuticals; 2. Production of tissues and organs for humans and xenotransplantation; 3.Process of gene therapy, 4.*Pros* and *cons* in gene therapy; 5. Retrovirus and adenovirus mediated gene therapy.

Practice 6(2h) : Preparation of competent cell (Calcium chloride treatment method)

Text Books:

1 Freshney RI (1992) Animal cell culture: a practical approach, Oxford University Press
2 Singh B, Gautam SK (2013) Text Book of Animal Biotechnology, TERI

Reference Books:

1 SinghB, Mal G, Gautam SK, Mukesh M (2019) Advances in Animal Biotechnology, Springer
2 Butler M (2003) Animal Cell Culture and Technology, Taylor & Francis

Animal Breeding

Subject Name	Code	Type of course	T-P-P	Prerequisite
Animal Breeding	CUTM1453	Theory and Practice	3-1-0	-

Objectives

1 To educate about the concept of conservation of Animal Genetic Resources and their sustainable utilization.
2 To educate about the small farm animal breeding concepts.
3 To study genetic structure of animal population and importance of genetic variation and covariation among traits.

Course Outcome

COs	Course Outcomes
CO1	**To educate about molecular techniques to identify molecular markers as an aid to selection.**
CO2	**To study genetic structure of animal population and importance of genetic variation and covariation among traits.**
CO3	**To explain the methodology of selection and breeding systems for genetic improvement of livestock and poultry.**
CO4	**To educate about the various biometrical techniques for data analysis and their applications in animal breeding research.**
CO5	**To explain the methodology of selection and breeding systems for genetic improvement of livestock and poultry.**

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1		1	1	3	1	2	2			1		3	3	3	2
CO2		2		2		1	1			2	1	1	2	1	3

CO3	3					2				1	1	2	1	1	2
CO4	2		2		2					2	2		2	3	2
CO5	2	1		1		1	1			2		1	2	2	2

(High-3, Medium-2, Low-1)

Course outline

MODULE -1

1.Domestication, 2. Early Developments in Animal Breeding,Overview of Animal Breeding, Economic Traits, 3. Statistical Measures and Methods in Animal Breeding.

PRACTICE -1 (2h) :- Problems relating to gene and genotypic frequencies under different conditions.

MODULE-2

1. Selection and Response to Selection, 2. Improving Response to Selection, 3.Computation of Selection Differential, 4.Computation of Generation, 5.Interval bases of selection.

PRACTICE-2(2h) :- Estimation of inbreeding in regular and irregular systems.

Estimation of effective population size.

MODULE-3

1. In-breeding & line breeding, 2. Outbreeding&heterosis, 3.Estimation of heterosis& Systems of cross-breeding.

PRACTICE-3(2h) :- a) Computation of quantitative genetic effects.

b) Estimation of variance components

MODULE-4

1. Development of NewBreeds, 2. Breed and Breeding Industry Structure, 3.BreedComparison: Genotype-Environment Interaction, 4. Animal Genetic Resources &Designing of Breeding Program.

PRACTICE-4 (2h) :- Computation of heritability, repeatability, genetic, environmental and phenotypic correlations and their standard errors.

MODULE-5

1. Breeds–Economic traits–Prolificacy-Breeding records and standardization, 2. Genetic parameters – Selection of males and females – Breeding systems, 3.Development of new breeds& Breeding policy – Breeding research – Conservation of breeds.

PRACTICE -5 (2h) :- Estimation of breeding values from different sources of information.

Prediction of direct and correlated response to different bases of selection.

MODULE-6

1. Biometrical models and their analytical techniques on simulated and actual animal breeding data using computer application and use of programme in the field of animal breeding, 2. Advanced techniques in genetic manipulation for multiplication and improvement of livestock species.

PRACTICE-6 (2h) :- a) Computation of realized heritability and genetic correlation.

b) Selection index: Computation, Accuracy and response in component trait

c) Estimation of hetrerosis for different types of crosses.

d) Estimation of GCA and SCA

MODULE-7

1. History of dairy cattle and buffalo breeding, 2. Breeds of cattle and buffalo and their Characterization, 3. Inheritance of important economic traits, 4. Recording and handling of breeding data, 5. Standardization of records, 6. Computation of correction factors for the adjustment of the data andEstimation of the breeding values of cows and bulls.

Text books & References

1 Animal breeding – by Groenkennisnat
2 Animal breeding – by Gurvinder Singh Brar
3 Animal Genetics and Breeding – by Sukhbir Singh Tomar
4 Textbook of Veterinary Physiology – byBhattacharya. B
5 Textbook of Animal husbandry – G.C Banerjee

Water and Soil Quality Management in Aquaculture

Subject Name	Code	Type of course	T-P-P	Prerequisite
Water and soil quality management in aquaculture	CUTM1443	Theory -Practice	3-1-0	-

Objectives

1 To learn effective soil and water quality management practices which is important for any aquaculture endeavours .
2 To acquire knowledge on soil health, its assessment and maintenance for sustaining soil productivity.
3 To understand of soil health and soil quality with reference to manage and maintain aquaculture.

Course Outcome

COs	Course Outcomes
CO1	**To insight into the important water and soil quality management and their amalgamation for successful aquaculture operation**
CO2	**To impart knowledge on soil health, its assessment and maintenance for sustaining soil productivity.**
CO3	**To clear understand of soil health and soil quality**

CO4	**To examine the important water and soil quality management and their amalgamation for successful aquaculture operation**
CO5	**To evaluate different parameters of water and soil sample to enhance the sustainability of soil product.**

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	3	1	2	2			3		3	3	3	2
CO2					1	1				2	1	1	2	1	3
CO3		1		1		2	2			3		2	1	3	2
CO4	3	2	2		2					3	2	3	2	2	2
CO5	2	1		1	1	1	1			2		1	2	2	1

(High-3, Medium-2, Low-1)

Course outline

Module-I

1. Soil and water interaction: Physical and chemical properties of soil and water, 2. Productivity vs nutrient quality and quantity of soil and water; aquatic microorganisms and their role in carbon, 3. Nitrogen, 4. Phosphorus and Sulphur cycles and impact on aquatic habitats and species; Fertilizers and manures: Different kinds of fertilizers and manures; fertilizer grade, 5. source, rate and frequency of application; Use of treated sewage for pond fertilization and biofertilizers, 6. Ecological changes taking place after fertilizing.

PracticeI(2h): 1.Water analysis: measurement of temperature, 2. Turbidity, 3. Determination of pH and EC. Determination of inorganic nitrogen and phosphorus.

Module-II

1. Primary production and its estimation; 2. degradation of molecules in aquatic environment; 3. Utilization of bioactive compounds by microorganisms; 4.Cat clay/pyrite soil and its management; 5.Seepage and its control.

Practice 2(2h): Estimation of primary productivity and chlorophyll

Module-III

1. Water treatment, 2. Water filtration devices, 3.Aeration, 4. Chlorination, 5. Ozonization and UV radiation; eutrophication; Algal bloom control; Aquatic weed management.

Practice 3(2h): Determination of salinity, Chlorinity, Total solids,Redox potential, DO, Free CO2.

Practice 4(2h): Determination of total alkalinity, hardness.

Module-IV

1. Waste water treatment practices; 2. Waste discharge standards; 3.Water quality management in carp culture; 4. Water quality management in brackishwater shrimp culture; 5.Water quality management in hatcheries.

Practice 5(2h) : Calculation of dose of fertilizers and pond liming

Module-V

1. Ecology of Pond system; 2. Role of microorganisms in fish production; 3.Microbial load and algal blooms; 4.fluxes between mud and water, 5. Methane and hydrogen sulphide formation

Module-VI

1. Alkali soils and its management; 2. Saline soils and its management; 3. acidsulphate soils, iron pyrites, 4. Soil reclamation; 5. Soil and water amendments: lime, 6. Manures,fertilizers, 7. Micronutrients, 8. Zeolites, 9. Alum, gypsum.

Module-VII

1. Effluent Treatment plant; 2. Areation, 3.Chlorination, 4.Ozonisation and UV radiation; 5.Waste and water Treatment Practices; 6. Machine Leaning for water quality analysis.

Practice 6(2h) : Jar Test

Reference & Textbooks

1 Bottom soil, sediment and pond aquaculture --- Claude E.Body
2 Fundamentals of Soil --- V.N.Sahai
3 Water quality in ponds for aquaculture --Claude E.Body
4 Fresh water fish culture--- V.R.P.Sinha and V.Ramachandran

Ornamental Aquaculture

SubjectName	Code	Type of course	T-P-P	Prerequisite
Ornamental Aquaculture	CUTM1449	Theory and Practice	3-1-0	

Objectives

1 To impart knowledge on ornamental fish production, bait fish culture and aquatic ornamental plant propagation.
2 To produce ornamental fish for aesthetic appeal and financial enhancement.
3 To fabricate aquarium and mass culture of different live food organisms and aquatic plants.

Course Outcome

At the end of the course, students will be able:

COs	Course Outcomes
CO1	To fabricate aquarium and to have practical experience in aquarium decoration.
CO2	To understand mass culture of different live food organisms and aquatic plants.
CO3	To acquire basic knowledge on ornamental aquaculture will promote the students for research activities and encourage them for entrepreneurship.
CO4	To produce on ornamental fishes in mass scale.
CO5	To practize various techniques of ornamental fish breeding, rearing and marketing to meet them self sustainable.

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1			3		1	1	1			3		3	3	3	2
CO2		2		2						3	1	1	3	1	1
CO3	2				1	1	1			3	2	2	2	3	3
CO4	2		1			2				3	1	2	2	1	3
CO5	3	2	2	3		2				3	3	2	3	3	3

(High-3, Medium-2, Low-1)

Course outline

Module 1: Concept of Aquaculture (5 h)

1. Criteria of selection of suitable fish species, 2. External morphology of important marine aquarium fishes, 3. External morphology of important fresh water aquarium fishes (egg layers and live bearers), 4.Other ornamental organisms (Sea anemone, lobsters, and star fish)

Practice 1 (2h): Identification of common ornamental fishes and plants

Module 2: Aquarium setup and management(5 h)

1. Construction and setting of aquarium - Types of aquarium tanks, 2. Construction of home aquarium, 3.Setting up of home aquarium 1, 4.Maintenance of aquarium (cleaning and water quality management), 5.Feeding of aquarium fishes

Practice 2 (2h) : Fabrication of all-glass aquarium

Module 3: Aquarium Accessories (3 h)

1. Aquarium plants and their propagation methods, 2. Aquarium accessories and decorative, 3.Lighting and aeration, 4.Aquarium fish feeds. Dry, 5.wet and live feeds

Practice 3(2h) : Setting up and maintenance of Aquarium accessories and equipment

Module 4: Breeding techniques of Ornamental fish (4 h)

1. Ornamental fish breeding - Brood stock maintenance, 2. Breeding techniques of ornamental fishes, 3.Nursery rearing of ornamental fishes, 4.Transportation of ornamental fishes, 5.Application of genetics and biotechnology for producing quality strains

Practice 4 (2h): Conditioning and packing of ornamental fishes. Preparation of feed

Module 5: Ornamental fish culture and management (4 h)

1. Ornamental Fish Farm Management Construction of commercial ornamental fish farm, 2. Feeding and maintenance of stock, 3.Common ornamental fish diseases and their management

(4.3.i - Argulus, 4.3.ii - White spot, 4.3.iii- Fin rot 4.3.iv-Mouth fungus)

Practice 5 (2h) : Conditioning and packing of ornamental fishes. Preparation of feed

Module 6: Ornamental fish culture technique (5 h)

1. Management practices of backyard culture of ornamental fish, 2. Conditioning, packing, 3.Transport and quarantine methods, 4.Trade regulations and wild life act in relation to ornamental fishes.(*Value addition;ColourEnhancement,Gene Editing and production of new stains,hybrids)*

Practice 6 (2h): Setting up of breeding tank for live bearers, barbs, goldfish, tetras, chiclids, gouramis, fighters and catfishes

Module 7: Ornamental fishes and Entrepreneurship -(4 h)

1. World trade of ornamental fish and export potential, 2. Starting an aquarium shop – a business opportunity, 3.Small scale ornamental fish farming business

Practice 7(2h): Identification of ornamental fish diseases and prophylactic measures.

Reference & Textbooks

1. Aquarium fish keeping and management----CLS Srivastava and Amita Saxena
   Aquarium fishes ---Jena Burton
2. Hand book of fresh water ornamental fishes----S.Mathur, LL Sharma and AK Mathur
3. Profitable fish keeping ----Guy N Smith
4. Ornamental fish farming ---- Brian Andrews
5. Marine Ornamental species aquaculture--- Wiley online Books.

Fish Processing and Value addition

Subject Name	Code	Type of course	T-P-P	Prerequisite
Fish processing and value addition	CUTM1448	Theory -Practice	3-1-0	-

Objectives

1. To impart skill-based training to the students on different aspects of fish processing technology.
2. To understand the using different technology related to fish production with value added quality and their preservation
3. To learn the methods of preservation and processing of fishery products and their value additions

Course Outcome

COs	Course Outcomes
CO1	To learn how to preserve and process of fishery products and their value additions.
CO2	To impart skill based training to the members of cooperatives on various aspects of fish processing technologies ..
CO3	To understand about different techniques for preservation and processing of fish product.
CO4	To explain the integrated approach to learn various method for fish processing and its value addition.
CO5	To evaluate the various techniques to enhance the skill for the fish processing and preservation. .

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2		2			2				3			3	2	3
CO2				2	1	1				2	1	1	3	1	3
CO3		1		1		1	1			3		3	3	3	3
CO4		1			1					2		1	2	3	2
CO5	2	1		1						2		3	1	1	2

(High-3, Medium-2, Low-1)

Course outline

Module-1: Challenges to the Fish-Processing Industry
1. Introduction ,2. Sustainability tool the capture fishery, 3. Contribution of aquaculture ,4. Implications for the processing industry.
Practice 1(2h): How to make your own fish food

Module-2: Canning Fish and Fish Products
1. Principles of Canning, 2. Packaging Materials ,3. Processing operations ,4. Canning of specific species

Practice-2(2h) : Dry fish preparation

Module-3: Preservation by Curing
1. Drying, 2. Salting ,3. Smoking ,4. Post-harvest losses in fish smoking
Practice-3(2h) : Fresh fish packing

Module-4: **Freezing and Chilling of Fish and Fish Products**
1. Introduction **,**2. Freezing systems ,3. Environmental impact of freezing operations

Practice-4(2h) : preparation of fish pickle

Module-5: Sustainability Impacts of Fish-Processing Operations

1. Introduction ,2. Sustainability issues, 3. Life cycle assessment
Practice-5 (2h): Field study report

Module-6: On-board Fish Processing
1. Introduction, 2. On-board processing, 3.Advantages of on-board processing
Practice-6(2h) :Field processing

Module-7: Fishmeal Production and Sustainability
1. Introduction, 2. The fishmeal process, 3. Sustainability issues ,4. Alternatives to fishmeal
Practice-7(2h) : Related to theory

References

1. Fish Processing – Sustainabilityand New Opportunities2011Edited byGeorge M. Hall. John Wiley & Sons Ltd, UK

ANATOMY AND BIOLOGY OF FISH AND SHELLFISH

Subject Name	Code	Type of course	T-P-P	Prerequisite
Anatomy and Biology and Shellfish	CUTM1446	Theory -Practice	3-1-0	-

Objectives

1 To acquire knowledge about fish and shellfish biology and their ecology and behavior.
2 To gain the knowledge about fish interaction with their environment and biological adaptations.
3 To understand about different biological parameters for the sustainability fish and shellfish.

Course Outcome

COs	Course Outcomes
CO1	**To introduce an integrated approach to fish biology, including anatomy, morphology, physiology, ecology and behavior.**
CO2	**To study how fishes interact with their environment and the wide range of biological adaptations they have evolved to live in a remarkably diverse range of habitats.**
CO3	**To understand about Role of physical, chemical, soil and water parameters for sustainability fish.**
CO4	**To explain the integrated approach to fish biology, including anatomy,**

	morphology, physiology, ecology and behavior.
CO5	**To evaluate the understand about Role of physical, chemical, soil and water parameters for sustainability of fish and shellfish .**

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1		1	2	2			1	2		2	3	1
CO2	2			2	1	2	1				1	3	2	1	2
CO3	2	2	1	1		2						2	1	1	2
CO4							1					1	3	3	3
CO5		1		1		1	1			2		1	3	2	2

(High-3, Medium-2, Low-1)

Course outline

Module-I - Diversity of Fishes

1. Introduction to diversity of fishes, 2. Classification, 3.Basic Structural Features, 4.Body shape, 5.Scales and fins, 6.Internal features

Practice-1(2h): Museum Specimen

Module-2:**Habitat**
1. Introduction to Habitat, 2. Biogeography, 3.Marine Habitats, 4.Freshwater Fishes
Practice -2(2h) :Slide preparation of scales

Module-3: Anatomy
1. Integumentary, 2. Digestive system, 3. Skeleton system, 4. Respiratory System ,5. Circulatory system

Practice -3(2h): Food habit study

Module-4: Anatomy

1. Nervous System ,2. Excretion and osmoregulation ,3. Reproductive system ,4. Endocrine System, 5.Sense and specialized organ.

Practice -4(2h): Hematological study

Module-5: Food and feeding habits

1. Introduction ,2. Techniques for Studying Food Habits and Feeding, 3.Optimal Foraging Theor, 4. Food Choices, 5.Size and Development ,6. Food Capture.

Practice -5(2h): Biochemical study

Module-6: Reproduction, and Life Histories

1. Types of Life History, 2.Intersexes and Unisexual Species, 3.Fertilization to Hatching (Incubation) Parental Care, 4.Growth

Practice-6(2h): Writing Review literature

Module-7: Behavior and Cognition

1. Introduction tobehavior as a Discipline, 2. Schooling, 3.Orientation and Migration, 4.Symbiosis

Practice-7(2h): PowerPoint Presentation

References

1. R.L. Kothpal- VertibratesRastogi Publications
2. Handbook of Fish Biology and FisheriesEdited by Paul J.B. Hart and John D. Reynolds 2002 Volume 1 Fisheries
3. Handbook of Fish Biology and Fisheries Edited by Paul J.B. Hart and John D. Reynolds 2002 Volume 2 Fisheries
4. Quentin Bone & Richard H. Moore 2008. Biology of Fishes. Taylor & Francis Group

Fish and Shellfish Health Management

SubjectName	Code	Type of course	T-P-P	Prerequisite
Fish and Shellfish Health Management	CUTM1445	Theory and Practice	3-1-0	

Objectives

1. To provide holistic knowledge on fish and shellfish pathogens and their control measures.
2. To gain knowledge about different types of fish pathogen and their treatments.
3. To understand the various systems of fishes and shrimps with specific reference to their pathological significance.

Course Outcome

At the end of the course, students will be able:

COs	Course Outcomes
CO1	To gain knowledge about different types of fish pathogen and their treatments.
CO2	To understand the various systems of fishes and shrimps with specific reference to their pathological significance.
CO3	To describe the control of disease through environmental management, sanitary and phytosanitary agreement.
CO4	To analyze diseases caused by factors: hereditary factors, tumors of hereditary origin.
CO5	To evaluate histopathology of organs of diseased fish and autopsy of the diseased fish

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1			3			2	1			1		2	3	2	3
CO2		2		2	1					2	1	1	3	1	1
CO3	2	2	1	1	1	1	2			1			2	3	2
CO4	2		1								1	3	2	2	2
CO5	2	1		1	2	1	1			1		2	2	3	3

(High-3, Medium-2, Low-1)

Course outline

Module I

1. Significance of fin Fish and Shellfish diseases in aquaculture, 2. Stress in aquaculture and its role in disease development, 3. Pathological processes: cellular response to injury, 4. Inflammatory response to diseases, 5. Pathogencity mechanism of parasite and bacterial, 6. Pathogencity mechanism of virus and fungus.

Module II

1. OIE listed diseases, 2. Disease surveillance and reporting, 3. Quarantine and health certification in aquaculture, 4. Health management strategies in aquaculture, 5. Good and best management practices.

Module III

1. Disease control through environmental management, 2. Sanitary and phytosanitary agreement, 3. Vaccines used in aquaculture, 4. Immuno-stimulants used in aquaculture.

Module IV

1. Bioremediation, 2. Viral diseases of fish, 3. Viral diseases of shellfish, 4. Bacterial diseases of fish, 5. Bacterial diseases in shellfish.

Module V

1. Fungal diseases of fish, 2. Fungal diseases of shell fish, 3. Protozoan diseases in fish,4. Protozoan diseases in shellfish.

Module VI

1. Metazoan parasites of fish, 2. Metazoan parasites in shell fish, 4. Crustacean parasites of fish, 5. Environmental induced diseases of fish, 6. Nnutrition deficiency diseases.

Module VII

1. Diseases caused by other factors: hereditary factors, 2. Tumours of hereditary origin, 3. Hydrocoel, 4. Tumours, 5. Benign and malignant, 6. SPF and its importance, 7. SPR and its importance, 8. Quarantine methods and its importance.

Practicals (Duration for each practice is 2hours)

1. Examination of normal and diseased fish - thorough examination of external surface.
2. Autopsy of the diseased fish.
3. Histopathology of organs of diseased fish (sectioning – staining and mounting).
4. Slide preparation of fish parasites (Protozoan – Helminth and Copepod).
5. Collection of ectoparasites and its preservation.
6. Extraction of DNA from fish fins.

Reference &Textbooks

1. Fish Pathology. Author: Ronald J. Roberts.
2. Prevention and control of fish and prawn diseases. Author: KP Biswas.

Fish and Shellfish Nutrition

SubjectName	Code	Type of course	T-P-P	Prerequisite
Fish and Shellfish nutrition	CUTM1444	Theory and Practice	3-1-0	

Objectives

1. To learn basic concepts of feed formulation
2. To learn about different feed processing techniques
3. To prepare feed based on the nutritional requirements of fish/shell fish.

Course Outcome

COs	Course Outcomes
CO1	To know the knowledge about feed based on the nutritional requirements of fish/shell fish.
CO2	To enhance the skill for preparation of feed using different feed formulations
CO3	To understand about different techniques for fish and shellfish nutrition .
CO4	To explain the integrated approach to learn physiological process of nutrition related to various fish and shellfish.
CO5	To analyze the process of nutrition and its value addition.

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		1			2				1		2	2	2	3
CO2	3			1	1	1				2	1	1	3	1	3
CO3		1		1			1			1		3	2	3	3
CO4			1			2					1	2	1	3	2
CO5	3				1		1			2		1	3	2	3

(High-3, Medium-2, Low-1)

Course Outline

Module- I

1. Food and feeding habits of commercially important fish and shell fish, 2. Principal Nutrients essential for feed formulation, 3.Role of different nutrients on fish and shellfish growth, 4.Nutritional requirement of cultivable fish and shellfish, 5.Importance of Principle of Protein: Energy Ratio for aquaculture.

Module- II

1. General principles for feed formulation, 2. Different steps of feed formulation, 3. Methods of Feed formulation, 4.Classification of feed ingredients, 5.Energy and protein sources

Module- III

1. Evaluation of ingredient quality, 2. Types of feed Dry (pellets, flakes, powdered, Moist Feed), 3.Micro-encapsulated, 4.Micro-bound and micro-coated diets, 5.Feed manufacturing units and processes

Module- IV

1. Pulveriser, 2. Grinder and Mixer (Types and importance), 3.Pelletizer, Crumbler and Drier, 4.Extruder and Fat sprayer, 5.Hydro-stability of feed and their storage, 6.Prevention of spoilage from rancidity, 7.fungus and associated toxins

Module- V

1. Feed Additive, 2. Anti-nutritional factors in feed ingredients and methods of their, 3.Principles of Nutritional energetic, 4.Energy partitioning

Module-VI

1. Concept of GE, ME, FE, UE etc. and their relation, 2. Methods of digestibility study, 3. Factors affecting digestibility, 4.Role of feed digestibility study in feed quality evaluation, 5. Feed Management in Aquaculture Farms

Module-VII

1. Traditional Feeding methods in Aquaculture, 2. Different Feeding Practices used by Indian Farmers, 3. Demand Feeders

Fish and Shellfish Nutrition Lab (Practice).

Experiments:(2h each experiment)

1. Identification of Common feed ingredients
2. Preparation of artificial feeds using locally available feed ingredients
3. Proximate analysis of feed ingredients and feeds: Moisture, Crude protein
4. Proximate analysis of feed ingredients and feeds: Crude lipid, Ash
5. Preparation of feeds with various binders in order to determine their hydro-stability
6. Effect of Storage on Feed Quality and Determination of sinking rate feeds

References:

1. Fish in Nutrition ---- Halver
2. Fish Nutrition in Aquaculture ---- De Silva, Trevor & Anderson

E-sources-
https://www.researchgate.net/publication/308653321_Microencapsulated_diets_for_fish_larvae_-_current_'state_of_art

Animal Physiology and Biochemistry

SubjectName	Code	Type of course	T-P-P	Prerequisite
Animal Physiology and Biochemistry	CUTM1450	Theory and Practice	3-1-0	

Objectives

1. To know the functioning of various organs and their inter relationship.
2. To understand about the various metabolic processes
3. To facilitate students about applications in medicine, drugs and research

Course Outcome

COs	Course Outcomes

CO1	*To compare the different anatomical aspect of various organisms.*
CO2	**To acquire the knowledge of functioning of different body parts.**
CO3	**The apply the acquired knowledge for higher study.**
CO4	**To know and compare the different anatomical aspect of various organisms.**
CO5	**To analyze the functioning of different body parts.**

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1			2				2		3	3	3	3
CO2	2			2	1						1	1	2	1	3
CO3	1	1		1		2	1			1			2	3	2
CO4			1									2	1	3	3
CO5		1			1							1	3	2	3

(High-3, Medium-2, Low-1)

Course Outline

Module- I

1**.** Physiology of Digestion and Respiration:Absorptions of essential molecules (carbohydrates, proteins, lipids, vitamins and minerals), 2. Hormonal control and enzymatic roles in Gastrointestinal tract, 3. Pulmonary ventilation, 4.Respiratory volumes and capacities, 5.Role of respiratory pigments and factors influencing respiration, 6.Control and regulation of respiration

Module- II

1. Physiology of Circulation and Excretion: Coronary circulation, 2. Conducting system(Origin and conduction of cardiac impulses), 3. Frank-Starling Law, 4. Cardiac Cycle and cardiac output, 5.Neural and chemical regulation of heart, 6.Mechanism of Urine formation , 7. Counter-current theory, 8.Regulation of water and acid-base balance.

Module- III

1. Physiology of Nervous, 2. Reproduction and Endocrine system:Control and coordinating system, 3. Mechanism of neural action(Action potential and propagation in myelinated and non-myelinated nerve), 4. Sympathetic, 5.Parasympathetic and reflex action, 6.Muscle contraction, 7. Physiology of male and female reproduction, 8.Mechanism and regulation of hormonal action

Module- IV

1. Metabolic of Carbohydrate: Sequential Reactions and regulation of : Glycolysis, 2. Citric acid cycle and Gluconeogenesis, 3. Phosphate pentose pathway, 4. Glycogenolysis and Glycogenesis, 5. Compartmentalization, 6. Shuttle systems and membrane transporters, 7. Oxidative phosphorylation(Redox system and coupler reaction), 8. Inhibitors and un-couplers of ETC

Module- V

1. Biochemistry of Lipid:β-oxidation and omega-oxidation of saturated fatty acids(with even and odd number of carbon atoms), 2. Biosynthesis Palmitic acid;,3. Ketogenesis, 4.Metabolism of unsaturated fatty acids

Module-VII

1. Biochemistry of Protein:Transamination and Deamination**, 2.** Mechanism of Urea cycle**, 3.** Protein-protein interactions, 4. Fate of C-skeleton (Glucogenic and Ketogenic amino acids)

Module-VII

1. Enzymes:Mechanism of enzyme action, 2. Enzyme Kinetics,3. Inhibition and Regulation

Animal Physiology and Biochemistry Lab (Practice)

Experiments: (2h each experiment)

1. Study of T.S/L.S/V.S of digestive organs (Stomach,Liver,Kidney,intestine etc.)
2. Study of TLC/DLC from prepared blood smear/Determination of ABO Blood group
3. Estimation of haemoglobin using Sahli'shaemoglobinometer /Enumeration of
4. RBC & WBC using haemocytometer
5. Estimation of presence of lipid/carbohydrate from supplied sample by using spectrophotometer
6. Estimation of total protein content by spectrophotometer/Lowrey's Method
7. To demonstrate the effect of temperature/pH/concentration on salivary enzyme activity

References:

Online Source:

https://www.udemy.com/course/human-physiology/

https://www.coursera.org/specializations/anatomy

https://www.edx.org/course/anatomy-cardiovascular-urinary-and-respiratory-sys

Text Books:

1. Guyton's Physiology

Reference Books:

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. W.B. Saunders Company.
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons,
3. Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.
4. Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills

Immunology and Cancer Biology

Code	Course Title	Course Type	Credits	L-Pr-P (hrs)
CUTM1451	Immunology and Cancer biology	Theory + Practice	4	3-1-0

Objectives

1 The primary objective of this course is to help students develop knowledge and skills related to health and disease and role of immune system.

2 students are taught immunology so as to develop understanding of the subject, such as functioning the immune system, the molecular and cellular components and pathways that protect an organism from infectious agents.

3 The common cellular and molecular mechanisms that are deregulated in cancerous cells and their contribution to the development of cancer.Role of gene mutation and environmental factors in the development of cancer.

Course Outcome

COs	Course Outcomes
CO1	**To understand the immunomodulatory strategies essential for generating or suppressing immune responses as required in hypersensitivity reactions, transplantation, autoimmune diseases and cancer.**
CO2	**To know about biological aspects of cancer, carcinogenesis and cancer therapy.**
CO3	**Students will know the principle and application of various immune techniques and they can Will be able to make a strategy for immunological research and execute it.**
CO4	**To understand the immunomodulatory strategies essential for generating or suppressing immune responses as required in hypersensitivity reactions, transplantation, autoimmune diseases and cancer.**
CO5	**To apply various immune techniques and they can will be able to make a strategy for immunological research and execute it.**

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		1			2		3				3	2	1	1
CO2	2			2	1	2		2			1	1	2	1	3
CO3	2	1		1		1	1	2					1	2	3
CO4		1			2			3				3	2	2	1
CO5		1		1			2	2				2	3	1	1

(High-3, Medium-2, Low-1)

Course Outline

1. Module-1 Cells and Organs of the Immune System- Hematopoiesis, 2. Cells and Organs of the Immune System, 3.Structure and function of antibodies, 4.Inflammation

Practice 1(2h): Demonstration of lymphoid organs

Module-II

1. Development and Signaling of Immune system- Innate Immunity, 2. TLRs and their role in innate, 3. Immune response Adaptive Immunity, 4. Cytokines, 5. Development of B-lymphocyte and T-lymphocyte

Practice 2(2h): To isolate the lymphocyte from whole blood by density gradient centrifugation method

Module III

1. Structure and function of MHC complex -antigen processing cells, 2. Antigen processing and presentation to T lymphocytes, 3.MHC restriction. TCR structure and function

Practice 3(2h): Screening antisera or hybridoma supernatants for specific antibodies

Module-IV

1. Effector mechanisms and regulation of immune responses: Complement system, 2. hypersensitivity, 3. autoimmunity and tolerance, 4. Transplantation

Module V

1. Techniques related to immunology Monoclonal Antibodies, 2. Vaccines , 3. Radio 4. Immunoassay,5. ELISA, 6.Diffusion.

Practice 4(2h) : To detect the presence of an antigen in a sample

Practice 5 (2h): To learn coupling of antibody to enzyme Horse Radish Peroxidase (HRP)

Practice 6(2h): Study of basic Ouchterlony's double immuno-diffusion method.

Module-VI

1. Biology of cancer cells, 2. Genetics of Cancer, 3.Genetic Variation and Mutation, 4.Two-Hit Hypothesis, 5.Epigenetics of cancer

Practice 7(2h): Tumor cell growth in different media

Module VII

1. Oncogene and tumour suppressor gene: progression of cancer, 2. Metastasis, 3. Apoptosis in cancer, 4. DNA repair in cancer

Recommended books:

1 **Text Books**:
Owen, J. A., Punt, J., &Stranford, S. A. (2013). Kubyimmunology.seventh Edition, New York: WH Freeman.
2 Robert A. Weinberg, "The Biology of Cancer," Garland Science; 1 Cdr Edition, 2010

Reference Books:

1. Owen, J. A., Punt, J., &Stranford, S. A. (2013). Kubyimmunology. New York: WH Freeman
2. Abbas, K. Abul and Lechtman H. Andrew (2003.) Cellular and Molecular Immunology, V Edition, Saunders Publication.
3. Janeway'sImmunobiology(2016) 9th Edition, by Kenneth Murphy, Casey Weaver, Garland Science
4. David Male, Jonathan Brostoff, David Roth and Ivan Roitt(2012) Immunology,8th Edition, Elsevier Publication
5. Lauren Pecorino, "Molecular Biology of cancer: Mechanisms, Targets, and Terapeutics," Oxford University.

Bioanalytical Techniques

Code	Course Title	Course Type	Credits	L-Pr-P (hrs)
CUTM1438	Bioanalytical Techniques	Theory + Practice	4	3-1-0

Objectives

1 To bridge the gap between academics, research and industry. This course begins with a review of basic bio analytical technique and an introduction to general terminologies.
2 To apply bioanayltical techniques to solve biological questions.
3 To analyze various biological techniques and their applications in identification, isolation of different biological molecules

Course Outcome

At the end of the course, students will be able:

COs	Course Outcomes
CO1	**To know the principle and application of various instruments and molecular techniques for the improvement in any trait or its well being.**
CO2	**To learn the techniques such as flow cytometry, western blot and immunofluorescence**
CO3	**To describe different chromatographic and spectroscopic techniques**
CO4	**To analyse and implement different techniques to solve biological questions.**
CO5	**To impart knowledge for designing a project for research and execute it.**

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1			2				1		2	2	3	2
CO2	2			2	1	2					1	3	2	1	1
CO3	2	1		1		1	1			1			2	3	3
CO4		2									1	1	3	1	2
CO5			2		1						2	3	1	2	3

(High-3, Medium-2, Low-1)

Course Outline

Module-1: Microscopic techniques

1. Visualization of cells and sub-cellular components by light microscopy and fluorescent 2. microscope, 3. Resolving powers of different microscopes, 4.Electron microscope, 5.Scanning and transmission microscopes, 6.fixation and staining techniques for EM, 7. Scanning probe microscopes: AFM and STM.

Practice1(2h): To study and gain expertise on differential and cytological staining techniques.

Module-II: Spectroscopic techniques

1. Laws of absorption of light, 2. Beer-Lambert's Law, 3.Absorption spectra, 4.Measurement of absorption of light, 5.Factors affecting the absorption properties of chromophores, 6.Ultraviolet-visible absorption spectroscopy: Principle, 7. Instrumentation and application, Fluorescence spectrophotometry: Principle, 8. Instrumentation and application, 9. Mass spectroscopy: Principle, 10. Instrumentation and application.

Practice 2 (2h): Demonstration of UV-vis Spectrophotometer.

Module-III: Radiolabeling Techniques

1. Isotopes and Nature of radioactivity, 2. Radioactive decay, 3.Radioisotopes used in Biology, 4. Detection and measurement of radioactivity, 5.Carbon dating, 6.Geiger-Muller counting and liquid scintillation Counting, 7.Safety guidelines related to Radiolabeling techniques.

Module-IV : Centrifugation techniques

1. Basic principles of sedimentation, 2. Types of centrifuges, 3.Types of rotors, 4.Preparative centrifugation (Differential & density gradient), 5.Analytical ultracentrifugation. FISH and GISH

Practice3(2h): To separate proteins on the basis of their size and charge

Module-V:Chromatographic techniques

1. Principles of chromatography (Adsorption and Partition chromatography), 2. Planar chromatography (Paper and Thin-layer chromatography), 3.Column chromatography,Gas chromatography, 4.Gel permeation chromatography, 5. Ion exchange chromatography, 6.Affinity chromatography, 7.HPLC

Practice4(2h): To separate the amino acids in a mixture by thin layer chromatography.

Practice5(2h): Purification of immunoglobulins by affinity chromatography

Module-VI: Electrophoretic techniques

1. General principles, 2. Electrophoresis of nucleic acids (Agarose gel, pulse-field), 3.Electrophoresis of proteins (SDS-PAGE, native gels)isoelectric focusing and two dimensional gels, 4.Blotting techniques-Southern, 5.northern, 6. Western blotting.

Practice 6 (2h): To study the separation of DNA by agarose gel electrophoresis

Module-VII

Electrophysiological &Biostatistical methods

1. Electrocardiogram (ECG), 2. Positron emission tomography (PET), 3.Magnetic resonance imaging (MRI), 4.Flow cytometry, 5. Nuclear magnetic resonance, 6.Gene expression analysis.Sampling distribution; Regression and Correlation; t-test; Analysis of variance; Chi-square test.

Text Books:

Keith Wilson and John Walker (2009)Principles and techniques of biochemistry and molecular biology.7th Edition,Cambridge University Press, Cambridge, UK.

Reference Books:

1 Wilson K and Walker J (2009)Principles and techniques of biochemistry and molecular biology.7th Edition,Cambridge University Press, Cambridge, UK.

2 Voet D and Voet J Biochemistry, 4th Edition. (2010). John Wiley and Sons. New Jersey, USA

3 Rodney F Boyer(2012) Biochemistry laboratory: modern theory and techniques.2nd Edition, Pearson Prentice Hall, Boston,USA.

R. Katoch(2011) Analytical techniques in biochemistry and molecular biology,Springer, New York.

Cell and Molecular Biology

Subject Name	Code	Type of course	T-P-P	Prerequisite
Cell and Molecular Biology	CUTM1437	Theory and Practice	3-1-0	

Objectives

1 To understand cell biology of all major groups of organisms, including microorganisms, plants and animals
2 To analyze genome organisation differs in the major groups of organisms
3 To evaluate the complex interactions between nucleus and cytoplasm that determine how cells function

Course Outcome

At the end of the course, students will be able:

COs	Course Outcomes
CO1	**To understand major ideas and current experimental approaches in cell biology and molecular biology.**
CO2	**To describe the biological processes such as DNA replication, transcription and translation.**
CO3	**To analyze basic concepts specialization of cells into different types in complex organisms.**
CO4	**To apply the concepts of molecular biology in realizing the biological issues occurring in the cell.**
CO5	**To evaluate the role of cytoskeleton in cell trafficking.**

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		3		1	1	1	1				3	3	3	2
CO2	2	2		2			2				1	1	3	1	1
CO3	2					1	2						2	2	3
CO4			1								1	2	2	2	3
CO5		1		1	2		1					3	2	3	2

(High-3, Medium-2, Low-1)

Course outline

Module I: Biological Membranes And Transport Of Biomolecules

1. Structure of biological membranes: Cell wall (Prokaryotic versus eukaryotic), 2. The plasma membrane, 3. Membrane proteins, 4. Mobility of membrane proteins, 5. Membrane biogenesis: Cell wall and cell membrane biogenesis, 6. Cell-Cell and cell-matrix interactions: Extracellular matrix and cell-matrix interactions (Matrix structural proteins, Matrix Polysaccharides; Matrix adhesion proteins), 7. Cell-Cell interactions (Adhesion Junctions, 8. Tight Junctions, 9. Gap junctions, Plasmodesmata), 10. Membrane Trafficking (Pumps, channels, transporters): Ions channels, 11. Active transport driven by ATP hydrolysis, 12 Active transport driven by Ion gradients, 13. Passive transport, 14. Facilitated transport, 15. Endocytosis (Phagocytosis, receptor-mediated endocytosis).

Module II: Cytoskeleton, Cell motility and Cell division

1. Structure and Organization of Actin Filaments: assembly and disassembly of actin filaments, 2. Organization of actin filaments, 3. Association of actin filaments with the plasma membrane, 4. Intermediate filaments: assembly of intermediate filaments, 5. Intracellular organization of intermediate filaments, 6. The microtubule: structure and dynamic organization of microtubules, 7. Eukaryotic cell division: Mitosis and Meiosis, 8. Cell death and cell renewal: Programmed cell death, 9. Stem cells and maintenance of adult tissues. Cell cycle and its regulation. Chek point.

Module III: Intercellular communication and the Nucleus

1. Signaling molecules and their receptors, 2. Modes of cell signaling, 3. Cell surface receptors, G Protein-coupled receptors. Receptor protein tyrosine kinases, 4. Cytokine receptors, 5. Pathways of Intracellular signal transduction, 6. Second messengers, 7. The cAMP Pathway, 8. CGMP, 9. Nuclear organization, 10. Traffic between the nucleus and the cytoplasm, 11. Chromosomes, 12. Chromatin organization (DNA packaging), 13. Lampbrush chromosome, 14. Polytene chromosome, 15. Telocentric chromosome, 16. Inter-phase chromatin, 17. Euchromatin and Heterochromatin, 18. karyotype and its significance, 19. The Nucleolus.

Module IV: Replication, Protein-Nucleic Acid Interactions and Transcription

1. Prokaryotic and eukaryotic DNA replication: DNA polymerases, 2. Replisome, 3. Primase, telomerase, 4. Inhibitors of replication. DNA synthesis by reverse transcription, 5.Prokaryotic transcription mechanisms, 6.Prokaryotic transcriptional regulation (Operon concept), 7.Eukaryotic transcription –core promoter and general transcription factors (GTFs), 8. Eukaryotic transcription–activating transcription factors and enhancers, 9.Post-Transcriptional Control of Gene Expression.

Module V: RNA Processing, Translation and Protein sorting.

1. RNA-processing, 2. mRNA export. Post transcriptional modification and: RNA splicing, 3. Spliceosome, 4. RNA editing, 5. Genetic code. Translation: Protein synthesis,6. Post-translational modifications: Glycosylation, 7. Phosphorylation, 8. Ubiquitination, 9. Inhibitors of transcription and translation.Protein sorting and Targeting: Co translational targeting and post translational targeting. Protein targeting to Mitochondria, 10 Chloroplast, 11.Endoplasmic reticulum, 12.Peroxisome and Plasmamembrane. Regulation of gene expression in prokaryotes and eukaryotes: role of chromatin in regulating gene expression

and gene silencing.

Module VI: Protein Structure, Function and Evolution

1. Unique principles of protein structure and molecular machines (primary, secondary, 2. Tertiary, 3. quaternary structures), 4. Study of protein structures (circulsardichorism, X-ray crystallography and cryo electron microscopy), 5. How proteins have evolved and how analysis of protein structure can help us to understand the evolutionary relationships between different proteins and their function

Module VII: Enzyme Catalysis and Protein Engineering

1. How the peptide and protein structures discussed in the preceding module can assume functions, 2. Enzyme catalysis, 3. Mechanism and kinetics, 4. Co-operative (allosteric) molecular basis of metabolic regulation, Principles of protein folding and stability, 5. Protein engineering and mechanistic enzymology–how to create novel, 6. functional proteins by rational design, 7. Semi-rational approaches and by directed evolution.

Practicals(Duration of each practice is of 2hours)

1. Visualization of DNA by performing agarose gel electrophoresis and extraction of DNA from the agarose gel.
2. Extraction of DNA from the fish fins.
3. Plasmid isolation (miniprep).
4. Polymerase Chain Reaction (PCR)
5. Glucose uptake assay
6. *In silico*membrane-receptor and ligand interaction studies using DISCOVERY STUDIO (BIOVIA).

Reference

E-content:

Youtube animations and videos, virtual lab, Slide share.

Text Books:

1. Geoffrey M. Cooper, Robert E. Hausman (Boston University). The Cell: A Molecular Approach. ASM Press, Washington D.C. Fourth edition.
2. Cell and molecular biology Robertis, De and Robertis Lea and Febiger. Eighth Edition.

Reference Books:

1. Molecular Biology of the Cell Alberts, B., et al. 6th Rev ed. Taylor & Francis; 2014 ISBN 978-0-8153-4432-2 (hard), 978-0-8153-4524-4
2. Essential Cell Biology Alberts, B., et al. 4th Rev ed. Garland; 2013 ISBN 9780815344544
3. Lewin's Genes XII Krebs, J.E. et al. Jones & Bartlett; 2018 ISBN 9781284104493
4. Molecular Cell Biology Lodish H. et al. 8th ed. W.H. Freeman and Company; 2016 ISBN 9781464183393

Genetics and Epigenetics

SubjectName	Code	Type of course	T-P-P	Prerequisite
Genetics and Epigenetics	CUTM1454	Theory and Practice	3-1-0	

Objectives

1. To explain and provide examples of how continuous traits are "quantitative traits" and that phenotypic variation may be due to genetic variation within a population and/or environmental variation experienced by individuals within a population.
2. To explain the polygenic theory of genetic variance and the nature of additive alleles, and the assumptions that accompany these ideas and also able to provide competing hypotheses that explain a distribution data set of phenotypes.
3. To discuss epigenetics and its role in cancer, imprinting and X chromosome inactivation.

Course Outcome

At the end of the course, students will be able:

COs	Course Outcomes
CO1	**Students will have an understanding of the role of genetic mechanism in evolution.**
CO2	**Be able to predict the phenotypic classes and their ratios from a monohybrid cross involving dominant and recessive alleles.**
CO3	**Be able to predict the phenotypic classes and their ratios from a cross involving co-dominant or incompletely dominant alleles .**
CO4	**Be able to predict the ratio of a specific genotype and/or phenotype from a cross involving multiple independently assorting genes (with each gene exhibiting only dominant and recessive alleles) .**
CO5	**To analyze the modifications/mechanisms of DNA marks that result in epigenetic changes and also to discuss the role of epigenetics in environmental exposures.**

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1			2		1		1		1	3	3	2
CO2	2			2	1	2	2				1	1	2	1	3
CO3	3	3	2		2							2	2	3	2
CO4			2			1					2	2	2	3	3
CO5		1		2	2	1	1			1		3	1	2	3

(High-3, Medium-2, Low-1)

Course outline

Module - 1: Principles of Inheritance (5 h)

1. Laws of heredity, Co-and incomplete dominance, Gene Linkage and crossing over, 2. Varieties of Gene interractions - lethal genes, 3. Multiple alleles, 4. Pleiotropic genes, 5.Gene epistasis, 6.Structural and numerical alterations of chromosomes and meiotic consequence, Cytoplasmic Inheritance ,7. Sex-chromosome systems; Different mechanisms of sex determination in animals(Drosophila, Man, Bees and Bonellia)

Module - 2: Linkage and Crossing over in diploid organisms (5 h)

1. Sex linkage: Sex linked genes in man, 2. Sex chromosome disorders in man, 3. Detection of linkage & Linkage maps: Test cross, 4. Test for linkage on the basis of F2 generation, 5. LOD score, 6. Gene mapping, 7. Three point test cross in Drosophila, 8. Construction of linkage maps, Identification of particular linkage groups with specific chromosome, 9. Physical distance and map distance, 10. Interference and coincidence

Module - 3: Mitotic recombination and Chromosomal abnormalities (4 h)

1. Mitotic Recombination, 2. Recombination within gene, 3.Spontaneous and induced mutations, 4.Physical and chemical mutagens, 5. Chromosomal aberrations, 6. meiotic behaviour of deletion, 7. Duplication, 8. Inversion and translocation, 9.Euploids and aneuploids-classification, 10.Origin, 11.Induction, 11.Role of polyploidy in evolution.

Practice 1 (2h) : Preparation of Mitotic chromosomes from the given sample

Module - 4: Human genetics and Genomics (5 h)

1. Human genetics - Chromosomal disorder, 2. Some common human syndromes, 3.Twin study, 4.Superfoetation, 5.Polyembryony, 6.Free Martin, 7. Multiple birth, 8.Amniocentesis and Genetic Counselling, 9.Nature and function of genetic material, 10.Chemical compounds causing genetic damage, 11. Gene mapping and genome analysis.

Practice 2 (2h): To study the karyotyping of chromosomes from the given animal samples.

Module - 5: Epigenetics and Chromatin structures (4 h)

1. Epigenetics vs Genetics, 2. Epigenetics from phenomena to field : overview and concepts, 3. Basic organization of eukaryotic genome, 4. Histone proteins.

Practice 3 (2h): To study the chromatin modelling and Chromatin-immunoprecipitation (ChIP)

Practice 4(2h):Isolation of total histones, and resolution on SDS-PAGE.

Module - 6: Epigenetic marks and chromatin modifications (5 h)

1. Histone modifications and the histone code, 2. Chromatin remodelling complex and histone variants, 3.DNA Methylation, 4.Acetylation and Deacetylation, 5.Phosphorylation, Ubiquitylation, 6.Deubiquitylation and Phosphorylation.

Practice 5 (2h): Isolation of DNA from animal cell (Isolation of nuclei (as a source for studies on structure of chromatin) from rat/mouse liver by discontinuous sucrose-density gradient centrifugation.

Module - 7: Dosage compensation and Genomic imprinting (4 h)

1. Dosage compensation in mammals, 2. Genomic imprinting in mammals, 3.Germline and pleuripotent stem cells, 4. Epigenetics and human disease.

Practice 6(2h): Identification of inactivated X chromosomes as barr body from the given sample

Practice 7 (2h) : Preparation and study of metaphase chromosomes from mouse bone marrow

Reference & Textbooks

1 Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). Principles of Genetics. VIII Edition. Wiley India.

2 Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.

3 Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics X Edition. Benjamin Cummings.

4 Russell, P. (2009). Genetics- A Molecular Approach. III Edition. Benjamin Cummings.

5 Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B.

6 Introduction to Genetic Analysis. IX Edition. W. H. Freeman and Co.

7 Ridley, M. (2004). Evolution. III Edition. Blackwell Publishing

8 Barton, N. H., Briggs, D. E. G., Eisen, J. A.Goldstein, D. B. and Patel, N. H. (2007). Cold Spring, Harbour Laboratory Press.

9 Hall, B. andHallgrimsson, B. (2008). Evolution. IV Edition. Jones and BartlettPublishers

10 Campbell, N. and Reece J. B. (2011). Biology. IX Edition, Pearson, Benjamin,Cummings.

11 Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.

12 Epigenetics, C. David Allis and Thomas Jenuwein, (2007)Cold Spring Harbor Laboratory Press, New York, USA .

13 Molecular Biology of Gene, Watson et al., (5th Ed. 2004), Pearson Education, Delhi, INDIA, Genetics by P.K Gupta.

Microbiology

SubjectName	Code	Type of course	T-P-P	Prerequisite
Microbiology	CUTM1436	Theory and Practice	3-1-0	

Objectives

1. To know various culture media and their applications and also understand various physical and chemical means of sterilization.
2. To master aseptic techniques and be able to perform routine culture handling tasks safely and effectively.
3. To know the various physical and chemical growth requirements of microbes and get equipped with various methods of microbes culture techniques and their role in various industry.

Course Outcome

At the end of the course, students will be able:

COs	Course Outcomes
CO1	**To develop extensive knowledge in various areas of Microbiology.**
CO2	**To explain vaccine strategies and mechanisms of antiviral drugs and interferons.**
CO3	**To apply tools to study biological processes, as cloning vectors and for gene transfer.**
CO4	**To develop extensive knowledge in various areas of Microbiology.**
CO5	**To analyze the interactions between viruses, bacteria and the host immune system.**

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	1	1			2		2	2	3	2
CO2	2	2	3	2	2	3	3				1	1	1	1	2
CO3	2	2	3	2	1	1	2			1			3	3	3
CO4		3	2	2	3	2	3					2	3	1	2

CO5		**1**	**2**	**1**	**2**	**1**	**1**			**1**		**1**	**2**	**2**	**2**

(High-3, Medium-2, Low-1)

Course Outline

Module-I

Bacteria and virus

1. Classification, 2. Taxonomy, 3.Cataloguing virus to ICTV and ICNV Structural and genetic diversity of viruses; Transmission and Replication; Prions, 3.Viriods, 4.Anti viral agents and Vaccines; Bacterial Classification (phenetic, genetic and phyllogenetic); Bergeys manual of systematic bacteriology; Classification, 5. Identification and Culturing Technique of cyanobacteria; Industrial Application, 6.Cyanotoxins.

Practice 1(2h): Preparation of bacterial smear and staining – Gram's, Acid-fast, Staining of bacterial spores flagella, capsule, spirochaetes

Practice 2(2h):Isolation, purification, identification and biomass production of cyanobacteria

Module 2

Microbial Physiology and Metabolism

1. Growth Kinetics, 2. Growth cycle, 3.Logistic growth equation, 4.Measurement and growth monitoring in culture, 5.Factor affecting growth.6. Photosynthetic pigments, 7. Paths of carbon and electron in bacterial photosynthesis.8. Fermentation, 9. Respiratory metabolism, 10.Embden-Meyerhoff pathway, 11.Entner-Doudroff pathway, 12.Pasteur Effect.

Practice 3(2h): Methods for measurement of bacterial growth by haemocytometer and spectrophotometer

Module 3

Environmental Microbiology & Wastewater Management:

1. Microbes and quality of environment, 2. Biotransformation, 3.Microbes in waste water management; Microbial degradation of pesticides, toxic chemicals, oil; Bioleaching, 4. Bioremediation.

Module 4

Agricultural and food Microbiology

1.Agriculturally important microorganisms, 2. Mycorrhizae, 3.Microbial mineralization, 4.Microbial toxins, 5.Biological control.6. Microbial toxins produced in food items, 7. Probiotics and preBiotics, 8.Methods of food preservation, 9. Microbiological legal standards of selected food and milk products.

Practice 4(2h): Estimation of phosphate solubilizing capacity of microorganisms

Practice 5(2h): Qualitative analysis of Milk and milk products; Microbiological analysis of food products; Detection of bacteria in milk by Standard plate count

Module 5

Medical Microbiology:

1. Host pathogen interactions, 2. Pathogenicity of bacteria invasiveness and toxigenicity, 3.Constitutive and inducible host defence mechanism, 4. Important diseases caused by bacteria, 5. Protozoa, 6.Virus. Antibiotics: Definition, phenomenon of antibiotics, 7. Chemical and biochemical modification of antibiotic structures, assay and Mode of action, 8. Biochemical mechanisms of resistance development, 9. Multiple-drug resistance.

Practice 6(2h): Antibiotic sensitivity test disc preparation; Antibiotic sensitivity test – Kirby – Bauer, Stoke's; MIC determination by filter paper disc assay

Module 6

Industrial Microbiology

Cyanobacterial Biotechnology:

1. Application as nutraceuticals, 2. Pharmaceuticals, 3.Cosmetic, 4.Biofertilizer; application as biofuel, CO_2 sequestration and pollution control, 5. Mass cultivation, 6.Single cell protein

Microbial enzymes: Sources, 7. Large scale production, 8. Recovery, 9. Microbial enzymes of industrial interest, 10. Novel medicines from microbes, 11.Biotechnological application of Microbial enzyme, 12.Use of Microbes in Biotechnology.

Bioprocess technology and Engineering:

Culture media (types, Different culturing Technique, Media formulation, Preservation of Microbes, Fermenter design and growth processes, Bioreactors, and Membrane Bio reactors, Analysis of different bioreactors, stability of microbial reactors, specialized bioreactors. Isolation, preservation, and Maintenance of Industrial Microorganisms.

Practice 7(2h): Preparation of different microbial culture media

Module 7 :**Microbial genetics**

1. Lytic and Lysogenic cycle, 2. Conjugation, 3.Transduction, 4.Recombination; Genetic regulation: Operon concept (lac,trpara), 5. Genetic mapping: Genome mapping of E. *coli*, QTL Mapping.Molecular markers in genome analysis, 6.RAPD, RFLP,AFLP, FISH and GISH.

Text Books:

1 Prescott, L. M., Harley, J. P. and Klen, D. A. (1999). Microbiology, 7th Ed., McGraw-Hill, New York.
2 Pelczar, Jr., M. J., Chan E.C.S. and Krieg, N. R. (2005). Microbiology, 5th Ed, Tata McGraw-Hill, New Delhi.
3 Alexopoulus, C. J., Mims, C. W. and Blackwel, M. (1996). Introductory Mycology, John Wiley, New York.

4 Kumar, H. D. (1988). Introductory Phycology. East-West Press, New Delhi.
5 Maloy, S. R., Cronan, J. E. Jr. and Freifielder, D. (2008). Microbial Genetics, 2nd Ed. Norosa, New Delhi.

Reference Books

1 Mehrotra, R. S. and Aneja, R. S. (1998). An Introduction to Mycology, New Age International, New Delhi
2 Agrios, G. N. (2005). Plant Pathology,5th Ed, Elsevier Academic press, USA

RESEARCH METHODOLOGY AND IPR

Code	Subject Name	Type of course	T-P-Pr (Credit)
CUTM 2378	**Research Methodology and IPR**	**Theory + Project**	**(2-0-2)**

Course objectives

- To develop an appropriate framework for various research designs and techniques
- To identify various sources of information for literature review and data collection
- To make expertise in academic writing and patenting

Course outcome

At the end of the course the student will be able to:

COs	Course outcomes
CO1	**Know** about the elementary research methodology and significance of research
CO2	**Understand** the scientific writing skills, plagiarism, impact factor, citation index of standard journals and importance of publications
CO3	**Acquire** knowledge on web browsing for gathering scientific data, PowerPoint making, scientific poster preparation and presentation skills including computing skills required for scientific research
CO4	**Utilize** the knowledge on intellectual property, trademarks, copyright, plant variety protection and farmers' rights
CO5	**Decide** about the types of patents and able to **compile** the patent application forms

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		3		3	3	1					2	2	3	1
CO2	3	2		2	3						1	1	1	1	2
CO3	3		1		1	1	2					3	2	3	2
CO4	2		1	1		3						2	3	1	3
CO5	2	1		1	2	1	1					1	3	3	2

(High-3, Medium-2, Low-1)

Module 1

Elementary Research Methodology: Research Concept, Objectives, characteristics, Steps and Significance of Research, Arbitrary and Scientific Research, Research approaches. Types of research: Historical, Descriptive, Analytical, Case Study, Quantitative vs. qualitative, Conceptual, Empirical Action Research, Research Methods Vs Methodology. Research Problems: Selection and definition of the research problems, formulating a research problem, identifying variables and Constructing hypothesis; Choosing a mentor, lab and research question; maintaining a lab notebook; Selection of problems - stages in the execution of research

Module II

Academic Writing and Presentation: Technical writing skills - types of reports; layout of a formal report; standard of Journal (Impact Factor, Citation Index), Scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

Module III

Scientific communication skills: Concept of effective communication- setting clear goals for communication; determining outcomes and results; barriers to effective communication; non-verbal communication- importance of body language, power of effective listening; Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search.

Module IV

Introduction to IPR: Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; plant variety protection and farmer's rights.

Module V

Types of Patents: Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; filing of a patent application; role of a Country Patent Office; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications.

Projects

1. Write a review article and submit to a journal
2. Write a book chapter/ book for publishing
3. Write an original article for a journal

Text Books:

1. Kothari CR (2016) Research Methodology: Methods and Techniques, New Age Pvt Ltd

2. Ganbawale RM, (2017) Bioststistics and Research Methodology, New Central Book Agency
3. Sinha, S.C. and Dhiman, A.K., (2002). Research Methodology, Ess Ess Publications. 2 volumes

Reference Books:

1. Geoffrey Marczyk, David DeMatteo, David Festinger (2005). Essentials of Research Design and Methodology, John Wiley & Sons, Inc.
2. Carol Ellison (2010) McGraw-Hill's ConcisevGuide to WritingvResearch Papers, McGraw-Hill
3. Trochim, W.M.K., (2005). Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
4. Wadehra, B.L. (2000). Law relating to patents, trademarks, copyright designs and geographical indications. Universal Law Publishing.

Neuman, W.L. (2008). Social research methods: Qualitative and quantitative approaches, Pearson Education