



Andhra Pradesh State Council of Higher Education

B.Sc., Honours in AQUACULTURE: MAJOR

w.e.f AY 2023-24 onwards

COURSE STRUCTURE

SEMESTER	Code	Title of the paper	Hr /week	Credits	
I	1	Introduction to Classical Biology	5	4	
	2	Introduction to Applied Biology	5	4	
II	3	Taxonomy and Functional Anatomy of Fin Fish and Shellfish - (T)	3	3	
		Taxonomy and Functional Anatomy of Fin Fish and Shellfish - (P)	2	1	
	4	Biology of fin fish & shell fish - (T)	3	3	
		Biology of fin fish & shell fish- (P)	2	1	
III	5	Basic Principles of Aquaculture- (T)	3	3	
		Basic Principles of Aquaculture - (P)	2	1	
	6	Capture Fisheries- (T)	3	3	
		Capture Fisheries- (P)	2	1	
	7	Fresh water Aquaculture- (T)	3	3	
		Fresh water Aquaculture- (P)	2	1	
	8	Brackish water Aquaculture- (T)	3	3	
		Brackish water Aquaculture- (P)	2	1	
IV	9	Fish Health management- (T)	3	3	
		Fish Health management- (P)	2	1	
	10	Shrimp Health Management- (T)	3	3	
		Shrimp Health Management- (P)	2	1	
	11	Fish nutrition & Feed technology - (T)	3	3	
		Fish nutrition & Feed technology - (P)	2	1	
V	12	Extension, Economics & Marketing- (T)	3	3	
		Extension, Economics & Marketing- (P)	2	1	
	13	Ornamental Fishery- (T)	3	3	
		Ornamental Fishery - (P)	2	1	
	14	Fishery Engineering- (T)	3	3	
		Fishery Engineering - (P)	2	1	
	15	Fish Processing Technology- (T)	3	3	
		Fish Processing Technology- (P)	2	1	
VI		Internship			
VII	16	Post Harvest Technology & Transportation- (T)	3	3	
		Post Harvest Technology & Transportation - (P)	2	1	
	17	Fishery Microbiology- (T)	3	3	
		Fishery Microbiology - (P)	2	1	
	18	Quality Control in Processing Plants. - (T)	3	3	
		Quality Control in Processing Plants. - (P)	2	1	
VIII	19	Crustacean culture- (T)	3	3	
		Crustacean culture - (P)	2	1	
	20 A	Molluscan and Seaweed culture- (T)	3	3	
		Molluscan and Sea weed culture - (P)	2	1	
			OR		
	20 B	Genetics in Aquaculture- (T)	3	3	
		Genetics in Aquaculture - (P)	2	1	

	21 A	Marine Fin Fish culture- (T)	3	3
	21 A	Marine Fin Fish culture - (P)	2	1
		OR		
	21 B	Fish Immunology- (T)	3	3
	21 B	Fish Immunology - (P)	2	1

Skill Enhanced Courses Syllabus will be available in due course of time.

I - SEMESTER

Course: 1: INTRODUCTION TO CLASSICAL BIOLOGY

Hours/Week: 5

Credits: 4

Learning objectives

The student will be able to learn the diversity and classification of living organisms and understand their chemical, cytological, evolutionary and genetic principles.

Learning Outcomes

1. Learn the principles of classification and preservation of biodiversity
2. Understand the plant anatomical, physiological and reproductive processes.
3. Knowledge on animal classification, physiology, embryonic development and their economic importance.
4. Outline the cell components, cell processes like cell division, heredity and molecular processes.
5. Comprehend the chemical principles in shaping and driving the macromolecules and life processes.

Unit 1: Introduction to systematics, taxonomy and ecology.

- 1.1. Systematics – Definition and concept, Taxonomy – Definition and hierarchy.
- 1.2. Nomenclature – ICBN and ICZN, Binomial and trinomial nomenclature.
- 1.3. Ecology – Concept of ecosystem, Biodiversity and conservation.
- 1.4. Pollution and climate change.

Unit 2: Essentials of Botany.

- 2.1. The classification of plant kingdom.
- 2.2. Plant physiological processes (Photosynthesis, Respiration, Transpiration, phytohormones).
- 2.3. Structure of flower – Micro and macro sporogenesis, pollination, fertilization and structure of mono and dicot embryos.
- 2.4 Mushroom cultivation, floriculture and landscaping.

Unit 3: Essentials of Zoology

- 3.1. The classification of Kingdom Animalia and Chordata.
- 3.2 Animal Physiology – Basics of Organ Systems & their functions, Hormones and Disorders
- 3.3 Developmental Biology – Basic process of development (Gametogenesis, Fertilization, Cleavage and Organogenesis)
- 3.4 Economic Zoology – Sericulture, Apiculture, Aquaculture

Unit 4: Cell biology, Genetics and Evolution

- 4.1. Cell theory, Ultrastructure of prokaryotic and eukaryotic cell, cell cycle.

4.2. Chromosomes and heredity – Structure of chromosomes, concept of gene.

4.3. Central Dogma of Molecular Biology.

4.4. Origin of life

Unit 5: Essentials of chemistry

5.1. Definition and scope of chemistry, applications of chemistry in daily life.

5.2. Branches of chemistry

5.3. Chemical bonds – ionic, covalent, noncovalent – Vander Waals, hydrophobic, hydrogen bonds.

5.4. Green chemistry

References

1. Sharma O.P., 1993. Plant taxonomy. 2nd Edition. McGraw Hill publishers.

2. Pandey B.P., 2001. The textbook of botany Angiosperms. 4th edition. S. Chand publishers, New Delhi, India.

3. Jordan E.L., Verma P.S., 2018. Chordate Zoology. S. Chand publishers, New Delhi, India.

4. Rastogi, S.C., 2019. Essentials of animal physiology. 4th Edition. New Age International Publishers.

5. Verma P.S., Agarwal V.K., 2006. Cell biology, genetics, Molecular Biology, Evolution and Ecology. S. Chand publishers, New Delhi, India.

6. Sathyanarayana U., Chakrapani, U., 2013. Biochemistry. 4th Edition. Elsevier publishers.

7. Jain J.L., Sunjay Jain, Nitin Jain, 2000. Fundamentals of Biochemistry. S. Chand publishers, New Delhi, India.

8. Karen Timberlake, William Timberlake, 2019. Basic chemistry. 5th Edition. Pearson publishers.

9. Subrata Sen Gupta, 2014. Organic chemistry. 1st Edition. Oxford publishers.

ACTIVITIES:

1. Make a display chart of life cycle of nonflowering plants.

2. Make a display chart of life cycle of flowering plants.

3. Study of stomata

4. Activity to prove that chlorophyll is essential for photosynthesis

5. Study of pollen grains.

6. Observation of pollen germination.

7. Ikebana.

8. Differentiate between edible and poisonous mushrooms.

9. Visit a nearby mushroom cultivation unit and know the economics of mushroom cultivation.

10. Draw the Ultrastructure of Prokaryotic and Eukaryotic Cell

11. Visit to Zoology Lab and observe different types of preservation of specimens

12. Hands-on experience of various equipment – Microscopes, Centrifuge, pH Meter, Electronic Weighing Balance, Laminar Air Flow
13. Visit to Zoo / Sericulture / Apiculture / Aquaculture unit
14. List out different hormonal, genetic and physiological disorders from the society

I - SEMESTER

Course: 2: INTRODUCTION TO APPLIED BIOLOGY

Hours/Week: 5

Credits: 4

Learning objectives

The student will be able to learn the foundations and principles of microbiology, immunology, biochemistry, biotechnology, analytical tools, quantitative methods, and bioinformatics.

Learning Outcomes

1. Learn the history, ultrastructure, diversity and importance of microorganisms.
2. Understand the structure and functions of macromolecules.
3. Knowledge on biotechnology principles and its applications in food and medicine.
4. Outline the techniques, tools and their uses in diagnosis and therapy.
5. Demonstrate the bioinformatics and statistical tools in comprehending the complex biological data.

Unit 1: Essentials of Microbiology and Immunology

- 1.1. History and Major Milestones of Microbiology; Contributions of Edward Jenner, Louis Pasteur, Robert Koch and Joseph Lister.
- 1.2. Groups of Microorganisms – Structure and characteristics of Bacteria, Fungi, Archaea and Virus.
- 1.3. Applications of microorganisms in – Food, Agriculture, Environment, and Industry.
- 1.4. Immune system – Immunity, types of immunity, cells and organs of immune system.

Unit 2: Essentials of Biochemistry

- 2.1. Biomolecules I – Carbohydrates, Lipids.
- 2.2. Biomolecules II – Amino acids & Proteins.
- 2.3. Biomolecules III – Nucleic acids -DNA and RNA.
- 2.4. Basics of Metabolism – Anabolism and catabolism.

Unit 3: Essentials of Biotechnology

- 3.1. History, scope, and significance of biotechnology. Applications of biotechnology in Plant, Animal, Industrial and Pharmaceutical sciences.
- 3.2. Environmental Biotechnology – Bioremediation and Biofuels, Biofertilizers and Biopesticides.
- 3.3. Genetic engineering – Gene manipulation using restriction enzymes and cloning vectors; Physical, chemical, and biological methods of gene transfer.
- 3.4. Transgenic plants – Stress tolerant plants (biotic stress – BT cotton, abiotic stress – salt tolerance). Transgenic animals – Animal and disease models.

Unit 4: Analytical Tools and techniques in biology – Applications

- 4.1. Applications in forensics – PCR and DNA fingerprinting
- 4.2. Immunological techniques – Immunoblotting and ELISA.
- 4.3. Monoclonal antibodies – Applications in diagnosis and therapy.
- 4.4. Eugenics and Gene therapy

Unit 5: Biostatistics and Bioinformatics

- 5.1. Data collection and sampling. Measures of central tendency – Mean, Median, Mode.
- 5.2. Measures of dispersion – range, standard deviation and variance. Probability and tests of significance.
- 5.3. Introduction, Genomics, Proteomics, types of Biological data, biological databases- NCBI, EBI, Gen Bank; Protein 3D structures, Sequence alignment
- 5.4. Accessing Nucleic Acid and Protein databases, NCBI Genome Workbench

REFERENCES

1. Gerard J., Tortora, Berdell R. Funke, Christine L. Case., 2016. Microbiology: An Introduction. 11th Edition. Pearson publications, London, England.
2. Micale, J. Pelczar Jr., E.C.S. Chan., Noel R. Kraig., 2002. Pelczar Microbiology. 5th Edition. McGraw Education, New York, USA.
3. Sathyanarayana U., Chakrapani, U., 2013. Biochemistry. 4th Edition. Elsevier publishers.
4. Jain J.L., Sunjay Jain, Nitin Jain, 2000. Fundamentals of Biochemistry. S. Chand publishers, New Delhi, India.
5. R.C. Dubey, 2014. Advanced Biotechnology. S. Chand Publishers, New Delhi, India.
6. Colin Ratledge, Bjorn, Kristiansen, 2008. Basic Biotechnology. 3rd Edition. Cambridge Publishers.
7. U. Sathyanarayana, 2005. Biotechnology. 1st Edition. Books and Allied Publishers pvt. Ltd., Kolkata.
8. Upadhyay, Upadhyay and Nath. 2016. Biophysical Chemistry, Principles and Techniques. Himalaya Publishing House.
9. Arthur M. Lesk. Introduction to Bioinformatics. 5th Edition. Oxford publishers.
10. AP Kulkarni, 2020. Basics of Biostatistics. 2nd Edition. CBS publishers.

ACTIVITIES

1. Identification of given organism as harmful or beneficial.
2. Observation of microorganisms from house dust under microscope.
3. Finding Microorganism from pond water.

4. Visit to a microbiology industry or biotech company.
5. Visit to a waste water treatment plant.
6. Retrieving a DNA or protein sequence of a gene'
7. Performing a BLAST analysis for DNA and protein.
8. Problems on biostatistics.
9. Field trip and awareness programs on environmental pollution by different types of wastes and hazardous materials.
10. Demonstration on basic biotechnology lab equipment.
11. Preparation of 3D models of genetic engineering techniques.
12. Preparation of 3D models of transgenic plants and animals.

[NOTE: In the colleges where there is availability of faculty for microbiology and biotechnology, those chapters need to be handled by microbiology and biotechnology faculty. In other colleges, the above topics shall be dealt by Botany and Zoology faculty]

II SEMESTER
Course No.: 3 Taxonomy and Functional Anatomy of Fin Fish and Shellfish
credits :3

Course Outcomes

1. Acquire knowledge on the Classification of major groups of Finfish and Shell fish
2. Students will be familiar with the general characters of Finfish and Shell fish
3. Gain knowledge on the structure and functions of Digestive system
4. Understand the difference between the brain of fish and prawn
5. Acquire knowledge on the functional anatomy of fish and prawn

Unit I: General characters & Classification of Cultivable fin fish and shell fish

- 1.1 General Characters of Crustacea
- 1.2 Classification of Crustacean: Major groups up to orders and their important characters.
- 1.3 General Characters of fishes
- 1.4 Classification of Fishes: Major groups up to subclass and their important characters.

Unit 2: Digestive and Respiratory systems of Fish and shell fish

- 2.1: Digestive system of fish
- 2.2 Respiratory system of fish
- 2.3 Digestive system of Prawn
- 2.4 Respiratory system of prawn

Unit 3: Circulatory systems of Fish and shell fish

- 3.1 Cardiovascular system: Structure of heart in fishes
- 3.2 Blood vascular system in prawn

Unit 4: Nervous system of Fish and shell fish

- 4.1 Nervous system in fish: Structure and functions of Brain
- 4.2 Central Nervous system in prawn.

Unit 5 Reproductive system of Fish and shell fish

- 5.1 Urino-genital system in fishes
- 5.2 Reproductive system in prawn

II SEMESTER
Course No.: 3 Taxonomy and Functional Anatomy of Fin Fish and Shellfish
Credits :1

1. Study of mouth parts in herbivorous and carnivorous fishes
2. Comparative study of digestive system of herbivorous and carnivorous fishes
3. Demonstration of brain of fish
4. Demonstration of cranial nerves of fish
5. Demonstration of Nervous system of prawn
6. Exposure of gills of prawn
7. Exposure of gills of fish

REFERENCE BOOKS

1. Bond E. Carl. 1979. *Biology of Fishes*, Saunders.
2. Halver JE. 1972. *Fish Nutrition*. Academic Press.
3. Hoar WS and Randall DJ. 1970. *Fish Physiology*, Vol. I-IX, Academic Press, New York.
4. Lagler KF, Bardach, JE, Miller, RR, Passino DRM. 1977. *Ichthyology*, 2nd Ed. John Wiley & Sons, New York.
5. Lovell J. 1989. *Nutrition and Feeding of Fish*. Van Nostrand Reinhold, New York.
6. Moyle PB and Joseph J. Cech Jr. 2004. *Fishes: An Introduction to Ichthyology*. 5th Ed. Prentice Hall.
7. Nikolsky GV. 1963. *Ecology of Fishes*, Academic Press.
8. Norman JR and Greenwood PH. 1975. *A History of Fishes*, Halsted Press.
9. Potts GW and Wootten RJ. 1984. *Fish Reproduction: Strategies and Tactics*, Academic Press.

II SEMESTER
Course No.: 4 -Biology of Fin Fish & Shellfish
credits :3

Course outcomes:

1. Gain Knowledge of feeding habits, gut content analysis and growth factors in fishes.
2. Understand the commercial importance of crustaceans and Fish
3. Understand and learn breeding in fishes, breeding habits, method of induced breeding in fishes.
4. To create awareness on parental care of Fishes and embryonic and larval development and environmental factors affecting development of major aquaculture organisms.
5. Acquire knowledge about Endocrine system in fishes.

SYLLABUS

UNIT- I: Specialised organs in fish

- 1.1 Sense organs of fishes and crustaceans .
- 1.2 Specialized organs in fishes – electric organ, venom and toxins
- 1.3 Buoyancy in fishes- swim bladder and mechanism of gas secretion
- 1.4 Fish and Crustaceans of commercial importance

UNIT- II: Food, Feeding and Growth

- 2.1 Natural fish food, feeding habits, feeding intensity, stimuli for feeding, utilization of food, gut content analysis, forage ratio
- 2.2 Principles of Age and growth determination; growth regulation, Growth rate measurement – scale method, otolith method, skeletal parts as age indicators
- 2.3 Length-frequency method, age composition, age-length keys, absolute and specific growth, back calculation of length and growth, annual survival rate,
- 2.4 Length-weight relationship.

UNIT- III: Reproductive Biology

- 3.1 Breeding in fishes, breeding places, breeding habits & places, breeding in natural environment and in artificial ponds, courtship and reproductive cycles
- 3.2. Induced breeding in fishes
- 3-3 Breeding in shrimp, oysters, mussels, clams, pearl oyster, pila, and cephalopods.

UNIT- IV: Development

- 4.1. Parental care in fishes, ovo-viviparity, oviparity, viviparity, nest building and brooding
- 4.2 Embryonic and larval development of fishes
- 4.3 Embryonic and larval development of shrimp, crabs and molluscs of commercial importance
- 4.4 Environmental factors affecting reproduction and development of cultivable aquatic fin & shell fish

UNIT- V: Hormones & Growth.

- 1.1 Endocrine system in fishes.
- 1.2 Neuro-secretory cells, androgenic gland, ovary, chromatophores,
- 1.3 Molting, molting stages, metamorphosis in crustacean shell fish

II SEMESTER
Course No.: 4 -Biology of Fin Fish & Shell Fish
credits :1

1. Length-weight relationship of fishes
2. Gut content analysis in fishes and shrimp
3. Mouth parts and appendages of cultivable prawns, shrimps and other crustaceans
4. Study of eggs of fishes, shrimps, prawns and other crustaceans
5. Study of oyster eggs
6. Embryonic and larval development of fish
7. Study of gonadial maturity and fecundity in fishes and shellfish
8. Observation of crustacean larvae
9. Study of nest building and brooding of fishes

PRESCRIBED BOOK(S)

1. Bone Q et al., 1995. Biology of fishes, Blackie academic & professional, LONDON.
2. Saxena AB 1996. Life of Crustaceans. Anmol Publications Pvt.Ltd., New Delh

REFERENCES:

1. Tandon KK & Johal MS 1996. Age and Growth in Indian Fresh Water Fishes. Narendra Publishing House, New Delhi.
2. Raymond T et al., 1990. Crustacean Sexual Biology, Columbia University Press, New York
3. Guiland J.A (ed) 1984. Penaeid shrimps- Their Biology and Management. 1.18Barrington FJW 1971. Invertebrates: Structure and Function.ELBS
4. 1.19Parker F & Haswell 1992. The text book of Zoology, Voll. Invertebrates (eds. Marshal AJ & Williams). ELBS & Mc Millan & Co.

III SEMESTER
Course No.: 5 - Basic Principles of Aquaculture
credits :3

COURSE OUTCOMES

Co1 Understand the concept of blue revolution, analyse the history and compare the present status of aquaculture at global, national and state levels and its significance over agriculture .

Co2: Acquire knowledge in the different types of aquaculture, culture systems and culture methods in practice worldwide.

CO3: Gain knowledge in the different types of culture ponds.

Co4: Understand the arrangement of different types of ponds in a fish farm and design an ideal fish farm

CO5: Comprehend the best management practices to be adopted in aquaculture for good yield and acquire the skill in the analysis of water and soil parameters of a culture pond.

SYLLABUS

UNIT-I (Introduction)

1. Definition and History of Aquaculture
2. Concept of Blue Revolution and Pradhan Mantri Matsya Sampada Yojana (PMMSY)
3. Present status of Aquaculture at global level, India and Andhra Pradesh
4. Aquaculture versus Agriculture; Present day needs with special reference to Andhra Pradesh

UNIT-II (Types of Fish Ponds)

1. Lotic and lentic systems, streams and springs
Classification of ponds based on water resources – spring, rain water, flood water, well water and water course ponds
2. Functional classification of ponds – head pond, hatchery, nursery, rearing, production and stocking
3. ponds; quarantine ponds, isolation ponds and wintering ponds

UNIT- III (Design and Construction of Aqua Farms)

1. Important factors in the construction of an ideal fish pond – site selection, topography, nature of the soil, water resources
2. Lay out and arrangement of ponds in a fish farm
3. construction of an ideal fish pond – space allocation, structure and components of barrage Pond

UNIT-IV (Aquaculture Systems and Practices)

1. Types of aquaculture Fresh water aquaculture - Brackish water aquaculture - Mari culture
2. Aquaculture Systems – Pond, Raceways, Cage, Pen, Rafts, Running water, Water Recirculating Systems, Biofloc Technology and 3-C System
3. Pond culture practices- Traditional, Extensive, Modified Extensive, Semi-Intensive, Intensive & Super-intensive systems of fish and shrimp and their significance.
4. Fin fish culture methods - Monoculture, Poly culture and Monosex culture and Integrated fish farming.

UNIT-V (Management Factors of Culture Ponds, Pre-stocking Management

1. Dewatering, drying, ploughing/desilting
2. Predators, weeds and weed fish in culture ponds - Advantages and disadvantages of weed plants; Toxins used for weed control and control of predators. Liming and fertilization;
3. Algal blooms and their control
4. Stocking Management – Stocking density and stocking
5. Post-stocking Management Feeding: Role of nutrients
6. Water quality: Physico-chemical conditions of soil and water optimum for culture – temperature, depth, turbidity, light, water and shore currents, PH, DOD, CO₂, NH₃, NO₂

III SEMESTER

Course No.: 5 - Basic Principles of Aquaculture

credits :1

1. Estimation of Carbonates, Bicarbonates in watersamples
2. Estimation of DissolvedOxygen
3. Estimation of Ammonia in water.
4. Estimation of Total Hardness of water sample.
5. Study of beneficial and harmful algal species
6. Collection, identification and isolation of zooplankton and phytoplankton
- 7 Collection and study of aquaticweeds, aquatic insects, weed fish and larvivorous fish
8. Field visit to hatchery, nursery, rearing and stocking ponds of aqua farms.

PRESCRIBED BOOKS:

1. Jhingran VG 1998. Fish and Fisheries of India. Hindusthan Publishing Corporation, New Delhi
2. Pillay TVR, 1996. Aquaculture Principles and Practices, Fishing News Books Ltd., London

REFERENCES:

1. Pillay TVR &M.A.Dill, 1979. Advances in Aquaculture. Fishing News BooksLtd., London
2. Stickney RR 1979. Principles of Warm Water Aquaculture. John Wiley & SonsInc. 1981

3. Boyd CE 1982. *Water Quality Management for Pond Fish Culture*. Elsevier Scientific Publishing
4. Bose AN et.al, 1991. *Costal Aquaculture Engineering*. Oxford & IBH Publishing Company.

REFERENCES

1. Boyd CE. 1979. *Water Quality in Warm Water Fish Ponds*. Auburn University
2. Boyd, CE. 1982. *Water Quality Management for Pond Fish Culture*. Elsevier Sci. Publ. Co.
3. FAO. 2007. *Manual on Freshwater Prawn Farming*.

III SEMESTER

Course No.: 6 - Capture Fisheries

credits :3

Course Outcomes

- CO1:** Understand the EEZ concept & its implementation in fisheries
CO2: Knowledge on Fish Distribution
CO3: Acquire Knowledge on the Riverine systems of India
CO4: Gain Knowledge on Reservoir Fishery

Unit I : Fish Catch Statistics :-

- 1.1 Fish production of the world both inland and marine, contribution of different countries, position of India in the Fish Catches.
- 1.2 The EEZ concept & its implementation in fisheries. The Indian EEZ, Fishery survey in India

Unit II : Fish Distribution .

- 2.1 General account of the distribution
- 2.2 Biology and fishery of important fishes and other aquatic animals of India,
- 2.3. Economically Important Fresh Water Fishes of Andhra Pradesh.

Unit-III Riverine Fishery I :-

- 3.1 Important characters of Streams.
- 3.2 Different riverine systems in India, and their fishery: The Ganga River System, the Brahmaputra river system,

Unit-IV Riverine Fishery II :-

- 4.1 The East Coast River System.
- 4.2 The West Coast River System, River Jhelum of the Indus River System, Fisheries of trout and Mahseer, Problems and management.

Unit-V Reservoir Fishery (Lacustrine Fishery) :-

- 5.1 Definition of a Lake, Origin and classification of lakes.
- 5.2 Kolleru Lake and its fishery.
- 5.3 Different reservoirs of River systems in India with special reference to Nagarjuna Sagar,

III SEMESTER
Course No.: 6 - Capture Fisheries
credits :1

PRACTICALS SEMESTER – II

1. Identification of Freshwater fishes based on colour, Pigmentation, morphometric and meristic characters and other characters relevant to the group.
2. Identification of fry and fingerlings of Indian Major Carps.
3. Examination of Commercially Important Freshwater fishes and prawns, from the point of view of ecology and fishery.
4. Knowledge of common types of Freshwater craft and gear on models provided in the department.

Field Work : Visit to fish landing centers of rivers, lakes and reservoirs.

Reference Books :-

1. Jhingram, V.G. Fish and Fisheries of India. Second edition 1983, Hindustan Pub.Co. Picker,
2. W.E. Methods for assessment of Fish Production in Fresh Waters. Blackwell Scient. Publ. 1970
3. Bal, D.V. and Veerabhadra Rao, K. Marine Fisheries, Tata MC Grawhill Publications, New Delhi.
4. Srivastava, U.K. et.al. Freshwater aquaculture in India, Oxford and IBH Publ. Co. New Delhi 1980
5. C.B.L. Srivastava – A text book of Fishery Science and Indian Fisheries. Kitab Mahal Agencies, Patna.

III SEMESTER
Course No.: 7 - Fresh water Aquaculture
credits :3

Course outcomes:

1. Learn the Status, Scope and Prospects of fresh water aquaculture in the world, India and AP.
2. Learn about Major Cultivable Indian Carps and Exotic fish Species introduced in India
3. Know about recent developments in the culture of clarius, anabas and murrels and special systems of aquaculture.
4. Gain knowledge of commercially valuable Fresh water prawns of India and their culturing methods.

UNIT-1: Introduction to Freshwater Aquaculture

- 1.1 Status, scope and prospects of fresh water aquaculture in the world, India and AP
- 1.2 Different fresh water aquaculture systems

UNIT-II: Carp Culture

- 2-1 Major cultivable Indian carps – Labeo, Catla and Cirrhinus & Minor carps
- 2-2 Exotic fish species introduced to India – Tilapia, Pangassius and Clarius sp.

Unit-III

- 3.1 Composite fish culture system of Indian and exotic carps
- 3.2 Impact of exotic fish, Compatibility of Indian and exotic carps and competition among them

UNIT-IV: Culture of air-breathing and cold water fish

- 4-1 Recent developments in the culture of clarius, anabas, murrels,
- 4-2 Advantages and constraints in the culture of air-breathing and cold water fishes- seed resources,
feeding, management and production
- 4-3 Special systems of Aquaculture- brief study of culture in running water, re-circulatory systems, cages and pens, sewage-fed fish culture

UNIT-V: Culture of Prawn

- 5-1 Fresh water prawns of India - commercial value
- 5-2 *Macrobrachium rosenbergii* and *M. Malcomsonii*– biology, seed production, pond preparation,
stocking, management of nursery and grow-out ponds, feeding, morphotypes and harvestin

III SEMESTER
Course No.: 7 - Fresh water Aquaculture.
credits :1

1. Identification of important cultivable carps.
2. Identification of important cultivable air-breathing fishes .
3. Identification of important cultivable freshwater prawns.
- 4 Identification of different life history stages of fish.
- 5 Identification of different life history stages of fresh water prawn.
- 6 Identification of commercially viable crabs – *Scylla cerrata*, *Portunus pelagicus*,
P.sanguinolentus,
Neptunus pelagicus, *N. Sanguinolentus* .
7. Identification of lobsters – *Panulirus polyphagus*, *P.ornatus*, *P.homarus*, *P.sewelli*,
P.penicillatus.
8. Identification of oysters of nutritional significance – *Crossostrea madrasensis*,
C.gryphoides,
C. cucullata, *C.rivularis* , *Picnodanta* .
9. Identification of mussels and clams.
10. Identification of developmental stages of oysters.

PRESCRIBED BOOK(S):

1 Jhingran VG 1998. Fish and Fisheries of India. Hindusthan Publishing Corporation, New Delhi

REFERENCES:

1. Santharam R, N Sukumaran and P Natarajan 1987. A manual of aquaculture, Oxford-IBH, New Delhi
2. Srivatsava 1993. Fresh water aquaculture in India, Oxford-IBH, New Delhi Marcel H 1972. Text book of fish culture.Oxford fishing news books.

III SEMESTER
Course No.: 8 - Brackish water Aquaculture
credits :3

Course Outcomes:

CO1: Knowledge on development and present status of brackish water farming in India.

CO2: Learn about the types of culture systems

CO3: Gain knowledge on commercial value of prawns in India

CO4: Know about the biology of important shrimps

CO5: Know about the species of crabs and edible oysters cultured

Unit – I Introduction

1.1 Introduction, History, Development and present status of brackish water farming in India.

1.2 Brackish water as a medium for aquaculture, ecological factors – Abiotic and biotic factors.

1.3 Types of culture systems – Traditional, extensive, semi-intensive and intensive culture systems of shrimp, their management and economics.

Unit – II Culture of brackish water prawns

2.1 Culture practices of *Penaeus monodon*/ *P.vannamei*

2.2 Brackish water prawns of India – Commercial value.

2. Morphotypes and harvesting

Unit – III Biology of Shrimp

3.1 Biology of *Penaeus monodon*,

3.2 Biology of *P.indicus*

3.3 Biology of *P.vannamei*.

Unit – IV Management practices

4.1 Nutritional requirements of cultivable prawns.

4.2 Natural food and artificial feeds and their importance in shrimp culture

4.3. Pond preparation, stocking, of Hatchery, Nursery, grow out ponds. and harvesting of shrimp.

Unit – V Culture of Brackish water species

5.1 Species of crabs cultured, biology and culture technique, prospects in India.

5.2 Species of edible oysters, culture techniques used for farming edible oysters.

5.3 Important species of pearl oysters and method of artificial pearl production.

III SEMESTER
Course No.: 8 - Brackish water Aquaculture
credits :1

Identification of cultivable fresh water and marine water prawns (any 3 each)

Identification of marine crabs and oysters of commercial importance (any 2 each).

3. Identification of Phytoplankton and Zooplankton (any 5 each).

4. Identification of different live feed organisms for shrimp larvae (any 4)

5. Identification of larval stages of prawn. 6. Demonstration of eye stalk ablation in penaeus monodon.

References :

1. Pillay, TVR. Aquaculture principles and practices, Fishery News (Books) Ltd., London 1990.

2. Prawn and prawn fisheries by Kurain and Sebestain.

3. Shankar KM & Mohan CV 2002. Fish and Shell Fish Health Management UNESCO. Publ. Sundermann CJ 1990.

4. Johnson SK 1995. Hand book of shrimp diseases Texas A & M university, Texas.

5. Guland J.A. (ed) 1984. Penaeid Shrimps – Their Biology and Management.

6. Raymond T et al., 1990. Crustacean Sexual Biology, Columbia University Press, New York.

7. Identification and mounting of appendages of prawn / shrimp.

8. Field visit to prawn / shrimp hatchery

. 9. Field visit to prawn / shrimp culture ponds.

IV SEMESTER
Course No.: 9 - Fish Health Management
credits :3

Course outcomes:

1. Provide students with knowledge about fish diseases and pathological aspects of diseases.
2. Learn about Fungal, Viral and Bacterial diseases of finfish.
3. Gain knowledge of Nutritional deficiency related diseases and antibiotic and chemotherapeutics.
4. Understand and learn the importance of diagnostic tools in identification of diseases and application and development of vaccines.

UNIT I: Pathology and parasitology

1-1 Introduction to fish diseases –Definition and categories of diseases – Disease and environment

1-2 Disturbance in cell structure – changes in cell metabolism, progressive and retrogressive tissue changes, types of degeneration, infiltration, necrosis, cell death and causes

1-3 Atrophy, hypertrophy, neoplasms, inflammation, healing and repair

UNIT II: Fungal and viral Diseases of fin fish.

2-1 Fungal diseases (both of shell and finfish) – Saprolegniosis, brachiomycosis, ichthyophorus

diseases – Lagenidium diseases – Fusarium disease, prevention and therapy

2-2 Viral diseases – Emerging viral diseases in fish, haemorrhagic septicemia, spring viremia of carps, infectious hematopoietic necrosis in trout, infectious pancreatic necrosis in

salmonids, swim-bladder inflammation in cyprinids, channel cat fish viral disease, prevention and therapy

UNIT III: bacterial Diseases of fin fish.

2-3 Bacterial diseases – Emerging bacterial diseases, aeromonas, pseudomonas and vibrio infections, columnaris, furunculosis, epizootic ulcerative syndrome, infectious abdominal dropsy, bacterial gill disease, enteric red mouth, bacterial kidney disease, proliferative kidney

disease, prevention and therapy

UNIT IV: Protozoan Diseases of fin fish.

Protozoan diseases: Ichthyophthiriasis(White spot Disease), Costiasis, Whirling disease

UNIT V: Nutritional diseases

4-1 Nutritional pathology – lipid liver degeneration, Vitamin and mineral deficiency diseases. Aflatoxin and dinoflagellates.

4-2 Antibiotic and chemotherapeutics. Nutritional cataract. Genetically and environmentally induced diseases.

IV SEMESTER
Course No.: 9 - Fish Health Management
credits :1

1. Enumeration of Bacteria by TPC Method
2. Enumeration of total Coli forms
3. Observation of gross pathology and external lesions of fish with reference to the common diseases in aquaculture
4. Examination of pathological changes in gills and gut lumen, lymphoid organ, muscles and nerves of fish
5. Collection, processing and analysis of data for epidemiological investigations of viral diseases
6. Bacterial pathogens – isolation, culture and characterization
7. Identification of parasites in fishes: Protozoan, Helminths, Crustaceans
8. Estimation of dose, calculation of concentration, methods of administration of various chemotherapeutics to fish and shell fish
9. Estimation of antibiotics used in aquaculture practices

PRESCRIBED BOOK(S):

1. Shaperclaus W. 1991 Fish Diseases- Vol.I & II. Oxonian Press Pvt.ltd
2. Roberts RJ 1989. Fish pathology. Bailliere Tindall, New York
3. Lydia Brown 1993. Aquaculture for veterinarians- fish husbandry and medicine. Pergamon Press. Oxford

REFERENCES:

1. Shankar KM & Mohan CV. 2002. Fish and Shellfish Health Management. UNESCO Publ. Sindermann CJ. 1990
2. Walker P & Subasinghe RP. (Eds.). 2005 Principal Diseases of Marine Fish and Shellfish. Vols. I, II. 2nd Ed. Academic Press
3. DNA Based Molecular Diagnostic Techniques: Research Needs for Standardization and Validation of the Detection of Aquatic Animal Pathogens and Diseases. FAO Publ. Wedmeyer G, Meyer FP & Smith L. 1999.
4. Bullock G et.al., 1972 Bacterial diseases of fishes. TFH publications, New Jersey
5. Post G 1987. Text book of Fish Health. TFH publications, New Jersey
6. Johnson SK 1995. Handbook of shrimp diseases. Texas A & M University, Texas

IV SEMESTER

Course No.:10 - Shrimp Health Management

credits :1

Course outcomes:

1. Provide students with knowledge about shrimp diseases and pathological aspects of diseases.
2. Learn about Fungal, Viral and Bacterial diseases of shellfish.
3. Gain knowledge of Nutritional deficiency related diseases and antibiotic and chemotherapeutics.
4. Understand and learn the importance of diagnostic tools in identification of diseases and application and development of vaccines.
5. To know about production of disease free seeds and good feed management.

Syllabus

UNIT I: Viral Diseases of shell fish (Symptoms, Treatment and Prophylaxis)

- 1-1 Major shrimp viral diseases – Baculovirus penaeii, Monodon Baculovirus,
- 1-2 Baculoviral midgut necrosis, Infectious hypodermal and haematopoietic necrosis virus, Hepatopancreatic parvo like virus,
- 1-3 Yellow head baculovirus, white spot baculovirus.

UNIT II: Bacterial Diseases of shell fish (Symptoms, Treatment and Prophylaxis)

- 2.1 Bacterial diseases of shell fish – aeromonas, pseudomonas and vibrio infections,
- 2.2 Luminous bacterial disease, filamentous bacterial disease. Prevention and therapy

UNIT III: Protozoan Diseases of shell fish (Symptoms, Treatment and Prophylaxis)

- 3-1 Protozoan diseases- Ichthyophthiriasis, Costiasis,
- 3-2 Whirling diseases, trypanosomiasis

UNIT IV: Health management

- 4-1 Diagnostic tools – immune detection- DNA/RNA techniques, General preventive methods and prophylaxis. Application and development of vaccines.

- 4-2 Quarantine – Significance, methods and regulations for transplants.

UNIT V: Production of disease free seeds

- 5-1 Production of disease-free seeds. Evaluation criteria of healthy seeds.
- 5-2 Good Feed management for healthy organisms, Zero water exchange, Probiotics in

IV SEMESTER
Course No.:10 - Shrimp Health Management
credits :1

1. Enumeration of Bacteria by TPC Method
2. Observation of gross pathology and external lesions of fish and prawn with reference to the common diseases in aquaculture
3. Examination of pathological changes in gut lumen, hepatopancreas, lymphoid organ, muscles and nerves of prawn and shrimp
4. Collection, processing and analysis of data for epidemiological investigations of viral diseases
5. Bacterial pathogens – isolation, culture and characterization
6. Antibioassays – preparation and evaluation
7. Molecular and immunological techniques; Biochemical tests; PCR; ELISA; Agglutination test; Challenge tests; Purification of virus for development of vaccines (Demonstration at institutes/labs)
8. Estimation of dose, calculation of concentration, methods of administration of various chemotherapeutics to fish and shell fish
9. Estimation of antibiotics used in aquaculture practices
10. Estimation of probiotics used in aquaculture

IV SEMESTER
Course No.: 11 - Fish nutrition & Feed technology
credits :3

Course outcomes:

1. Understand Nutritional requirements of cultivable fishes and factors affecting energy partitioning and feeding.
2. Know different types of feed and FCR and different types of feeders
3. Gain Knowledge of Feed manufacture and storage methods of feeds
4. Understand the value of Feed additives and Non-Nutrient ingredients.
5. To create awareness of different nutritional deficiency and importance of natural and supplementary feeds and balanced diet.

UNIT-I: Nutritional requirements of cultivable fish

- 1.1 Requirements for energy, proteins, carbohydrates, lipids, fiber, micronutrients for different stages of cultivable fish and prawns
- 1-2 Essential amino acids and fatty acids, protein to energy ratio, nutrient interactions and protein sparing effect
- 1.3 Dietary sources of energy, effect of ration on growth, determination of feeding rate, check tray

UNIT-II: Forms of feeds & Feeding methods

- 2-1 Feed conversion efficiency, feed conversion ratio and protein efficiency ratio
- 2-2 Wet feeds, moist feeds, dry feeds, mashes, pelleted feeds, floating and sinking pellets, advantages of pelletization
- 2-3 Manual feeding, demand feeders, automatic feeders, surface spraying, bag feeding and tray feeding

UNIT-III: Feed manufacture & Storage

- 3-1 Feed ingredients and their selection, nutrient composition and nutrient availability of feed ingredients
- 3-2 Feed formulation – extrusion processing and steam pelleting, grinding, mixing and drying, pelletization, and packing
- 3-3 Water stability of feeds, farm made aqua feeds, micro-coated feeds, micro-encapsulated feeds and micro-bound diets
- 3-4 Microbial, insect and rodent damage of feed, chemical spoilage during storage period and proper storage methods.

UNIT-IV: Feed additives & Non-nutrient ingredients

- 4-1 Binders, anti-oxidants, probiotics
- 4-2 Feed attractants and feed stimulants
- 4-3 Enzymes, hormones, growth promoters and pigments
- 4-4 Anti-metabolites, aflatoxins and fiber.

UNIT-V: Nutritional Deficiency in Cultivable fish

- 5-1 Protein deficiency, vitamin and mineral deficiency symptoms
- 5-2 Nutritional pathology and ant-nutrients
- 5-3 Importance of natural and supplementary feeds, balanced diet.

IV SEMESTER
Course No.:11 - Fish nutrition & Feed technology
credits :1

1. Estimation of protein content in aquaculture feeds
2. Estimation of carbohydrate content in aquaculture feeds
- 3 Estimation of lipid content in aquaculture feeds
4. Estimation of ash in aquaculture feed
5. Study of water stability of pellet feeds
6. Feed formulation and preparation in the lab
7. Study of binders used in aquaculture feeds
8. Study of feed packing materials
9. Study of physical and chemical change during storage
- 10.Study on physical characteristics of floating and sinking feeds
- 11.Visit to a aqua-feed production unit

PRESCRIBED BOOK(S):

- 1.HALVER JE 1989. Fish nutrition. Academic press, San diego

REFERENCES:

- 1.1 Lovell rt 1998. Nutrition and feeding of fishes, Chapman & Hall, New York
- 1.2 Sena de silva, trevor a anderson 1995. Fish nutrition in aquaculture. Chapman & Hall, New York.

V SEMESTER
Course No.:12 - Extension, Economics & Marketing
credits :3

Course outcomes:

1. Gain Knowledge of basic concepts of economics with reference to fisheries and various factors influencing the fishery products price.
2. Know about fisheries marketing, methods of economic analysis of business organizations and preparation of project and project appraisal.
3. To know about application of economic principles to aquaculture operations.
4. Get the broad knowledge of scope and objectives, principles of fisheries extension.
5. Understand the importance of transfer technology of ICAR programmes and training at DAATT Centers and their role in education of aqua farmers through print and electronic media.

SYLLABUS

UNIT – 1 Introduction

- 1-1 Meaning and scope of economics with reference to fisheries
- 1-2 Basic concepts of economics – goods, services, wants and utility, demand and supply, value price, market demand and individual demand, elasticity of demand.
- 1-3 Theory of production, production function in fisheries
- 1-4 Various factors influencing the fishery product's price

UNIT – II Fisheries marketing

- 2-1 Basic marketing functions, consumer behavior and demand, fishery market survey and test marketing a product
- 2-2 Fish marketing – prices and price determination of fishes
- 2-3 Marketing institutions- primary(producer fishermen, fishermen cooperatives, and fisheries corporations) and secondary (merchant/agent/speculative middlemen)
- 2-4 Preparation of project and project appraisal

UNIT-III Fisheries economics

- 3-1 Aquaculture economics- application of economics principles to aquaculture operations
- 3-2 Cost and earnings of aquaculture systems – carp culture, shrimp farming systems, hatcheries, Cost and earnings of fishing units and freezing plants
- 3-3 Socio-economic conditions of fishermen in Andhra Pradesh, Role of Matsyafed and NABARD in uplifting fishermen's conditions, fishermen cooperatives
- 3-4 Contribution of fisheries to the national economy

UNIT-IV Fisheries extension

- 4-1 Fisheries extension – scope and objectives, principles and features of fisheries extension education
- 4.2 Fisheries extension methods and rural development
- 4-3 Adoption and diffusion of innovations

UNIT-V Transfer of technology

- 5-1 ICAR programs – salient features of ORP, NDS, LLP, IRDP, ITDA, KVK, FFDA, FCS, FTI, TRYSEM
- 5-2 Training – meaning, training vs. education and teaching
- 5-3 DAATT centres and their role in tot programs, video conferencing, education of farmers through print and electronic media

V SEMESTER
Course No.: 12 - Extension, Economics & Marketing
credits :1

1. Basic marketing functions
2. Prices and price determination of fishes
3. Fisheries extension
4. Education of Fish farmers
5. Field notes and necessary inputs –should be focused in the practicals

Prescribed Books:

1. Adivi Reddy sv 1997. An introduction to extension education. Oxford & IBH Co.Pvt. Ltd. New Delhi
2. Jayaraman R 1996. Fisheries Economics. Tamilnadu Veterinary and Animal Science University. Tuticorn
3. Subba Rao N 1986. Economics of Fisheries. Daya publishing house, Delhi

References:

1. Dewwett KK and Varma JD 1993. Elementary economic theory. S.chand, New Delhi
2. Korakandy R 1996. Economics of Fisheries Mangement. Daya Publishing House, Delhi
3. Tripathi SD 1992. Aquaculture Economics. Asian Fisheries Society, Mangalore.

V SEMESTER
Course No.: 13 - Ornamental Fishery
credits :3

Course outcomes:

- CO1: Gain Knowledge on Aquarium Fishes
- CO2: Have Knowledge on fresh water and marine water Ornamental Fishes
- CO3: Have Practical knowledge on the setting up of aquarium
- CO4: gain knowledge on water quality management for different types of aquariums
- CO2: Apply the knowledge for self employment

SYLLABUS

UNIT I: Introduction

- 1-1 Aquarium and ornamental fishes – introduction
- 1-2 Present status of Aquarium trade in the world and India
- 1-3 Aquarium accessories – aerators, filters, lighters and heaters
- 1-4 Water quality needs and different kinds of feeds

UNIT II: Fresh water ornamental fishes

- 2-1 Live bearers, gold fish, koi, gourami, barbs and tetras, angel fish and cichlid fish
- 2-2 Brood stock development, breeding, larval rearing and grow out
- 2-3 Larval feeds and feeding

UNIT III: Marine ornamental fishes

- 3-1 Varieties and habitat of marine ornamental fishes
- 3-2 major marine ornamental fish resources of India
- 3-3 Collection and transportation of live fish, use of anaesthetics
- 3-4 Breeding of marine ornamental fish
- 3-5 Other aquarium animals – sea anemones, lobsters, worms, shrimps, octopus and starfish

UNIT IV: Aquarium management

- 4-1 Setting up fresh water, marine and reef aquariums
- 4-2 Water quality management for different types of aquariums
- 4-3 Common diseases of aquarium fish, diagnosis and treatment
- 4-4 Temperature acclimatization and oxygen packing for aquarium fish

UNIT V: Commercial production of aquarium fish and plants

- 5-1 Commercial production units of ornamental fish- requirements and design
- 5-2 Commercial production of goldfish, live bearers, gouramies, barbs, angels and tetras
- 5-3 Mass production of aquarium plants
- 5-4 Retail marketing and export of ornamental fish

V SEMESTER
Course No.: 13 - Ornamental Fishery
credits :1

PRACTICALS:

1. Study of aerators – types and structures
2. Water circulation methods in aquarium and filtration
3. Collection and identification of aquarium plants
4. Identification of common marine aquarium fishes
5. Identification of common fresh water aquarium fishes
6. Breeding of egg layers
7. Breeding of live bearers
8. Evaluation of significance of aquaria for commercial and domestic use.

PRESCRIBED BOOK(S):

1. Dick Mills 1998. Aquarium fishes, Dorling Kindersly Ltd, London
2. Van Ramshort JD 1978. The complete aquarium encyclopedia, Elsevier

REFERENCES:

1. Jameson JD and Santhanan R 1996. Manual of ornamental fishes and farming technologies, Fisheries College and research institute, Tuticorn
2. Stephen Spotte 1993. Marine aquarium keeping. John wiley and sons, USA

V SEMESTER
Course No.:14: Fishery Engineering
credits :3

Course outcomes:

- CO1:** Have knowledge on traditional, motorized and mechanized fishing crafts of India
CO2: Gain Knowledge on Design of fishing gear and fish catching methods
CO3: Learn about the type of anchors and Navigation equipment
Co4: Gain Knowledge on Remote sensing applications in fish finding and catching
CO5: Learn about the Fish Processing Equipment

SYLLABUS

UNIT I: Fishing crafts

- 1-1 Different types of fishing crafts in India- inland and marine– traditional, motorized and mechanized.
1-2 Classification of fishing craft.
1-3 Boat building materials - wood, steel, FRP, ferro-cement, aluminum etc.,
1-4 Mechanization of fishing craft and its impact

UNIT II: Fishing gear

- 2-2 Design of fishing gear and fish catching methods
2-2 Fishing accessories, Netting materials – natural and synthetic fishing gear materials and yarn numbering system
2.3 Active fishing gear - classification and description of modern fishing gears.- Design and operation of –trawls, purse seines, ring seines, beach / shore seine, boat seine, pole and line, squid jigs, trolling.

UNIT III: Anchors, Fish Finding & Navigational Equipment (Introductory)

- 3-1 Types of Anchors – Chains, ropes, blocks, leads and drogues
3-2 Echo sounders, fish finders, sonar and net sonde
3-3 Chronometer, gyro compass, radar, decca, omega etc.

UNIT IV: Exploration of fish and Conservation

- 4-1 Remote sensing applications in fish finding and catching
4-2 Turtle exclusion devices
4-3 By-catch reduction devices
4-4 Destructive and prohibited fishing practices

UNIT V: Fish Processing Equipment

- 5-1 Ice making machinery, Brine tank
5-2 Arrangements for leak detection
5-3 Operation of various freezing machinery
5-4 Special equipment for freeze-drying, irradiation and cryogenics

V SEMESTER
Course No.: 14 - Fishery Engineering
credits :1

PRACTICALS:

1. Site survey: preparation of site map and contour map
2. Ice making and harvesting
3. Testing different netting materials- natural and synthetic
4. Estimation of buoyancy and de-buoyancy of different floating and sinking materials
5. Designing trawl net by conducting survey
6. Solving problems on finding position of gravity, flotation and buoyancy
7. Visit to fishing harbor to study deck machinery
8. Visit to fishing harbor to study hull equipment
9. Visit to boat building yard and dry docking yard
10. Visit to a fish processing unit to study the equipment used in fish processing

PRESCRIBED BOOKS:

1. Fridman Al 1992. Calculations for fishing gear designs. FAO, USA. Fishing news books Ltd, England
2. Gerhard Klust 1982. Netting material for fishing gears. FAO, USA. Fishing news books Ltd, England
3. Jan-Olf- Traung 1992. Fishing boats of the world- Volumes – 1, 2, & 3. FAO, USA. Fishing news books Ltd, England

REFERENCES:

1. Dag Pike 1992. Fishing boats and their equipment. FAO, USA. Fishing news books Ltd, England

V SEMESTER
Course No.: 15 - Fish Processing Technology
credits :3

Course outcomes

CO1: Understand the Principles of fish preservation

CO2: Learn about fundamental principles involved in chilling and freezing of fish and fishery products

CO3: Understand the methods of drying, smoking and freeze drying

CO4: Knowledge about packaging materials and the process of packing

CO5: gain Knowledge about the export of Fishery products from India

SYLLABUS

UNIT 1: Introduction

1.1 Principles of fish preservation.

1.2 Quality of water and ice in fish handling and processing.

1.3 Preparation of ice. Different types of ice used in the seafood industry and their merits.

UNIT 2: Freezing and Canning:

2.1 Fundamental principles involved in chilling and freezing of fish and fishery products.

2.2 Various freezing methods. Freezing of shrimps and fishes.

2.3 Changes during the cold storage of fish and fishery products.

2.4 Principles involved in canning of fish. Different types of containers.

UNIT 3: Drying, Smoking and Freeze-drying:

3.1 Different types of drying, Factors affecting drying.

3.2 Packing and storage of dried products. Spoilage of dried products. Preventive measures

3.3 Smoking of fish, Salting of fish

3.4 Principles of freeze drying. Accelerated freeze drying and packing of freeze dried products. Modern methods of preservation by irradiation and modified atmospheric storage.

UNIT 4: Packing, Cold Storage and Export of Fishery Products:

4.1 Functions of packing. Different types of packing materials and its quality evaluation.

4.2 Packing requirements for frozen and cured products.

4.3 Statutory requirements for packing.

4.4 Labeling requirements. Different types of cold storages, Insulated and refrigerated vehicles.

UNIT 5: Export of fishery products

5.1 Export of Fishery products from India - major countries, important products, export documents and procedures.

5.2 Prospects and constraints in export including tariff and non- tariff barriers, marine insurance, export incentives, registered exporters

V SEMESTER
Course No.: 15 - Fish Processing Technology
credits :1

Experiments:

1. Determination of moisture content in fish and fishery products
2. General description –freezing
3. Processing shrimp
4. Filleting of fish 5. Drying of fish
6. Organoleptic analysis of fish
7. Preparation of fishery by products
8. Preparation of shark fin rays fish maws, chitin, fish wafer
9. Fish pickling
10. Value added fishery products, fish curry, cutlets fish finger.
11. Preparation of surimi

Filed visit:

1. Visit to sea food pre-processing plants
2. Visit to fish processing plants

Text books:

1. K.Gopakumar, Fish Processing Technology, ICAR, New Delhi
2. T.K. Govindan, Fish Processing Technology Oxfor & IBH Publication Co.
3. K.K. Balachandran Fish Canning – Principles & Practices.
4. Borgstrom,G. Fish as Food.
5. K.K. Balachandran, Postharvest Technology in Fish and Fishery Products. 6. Moorjani,M.V. Fish Processing in India.
7. Connell,J.J. Advances in Fishery science and Technology.
8. CIFT. Manual of Quality Control in Fish and Fishery Products. 9. Gopakumar,K. Fish Packaging Technology

Reference Books:

1. A.M.Martin, Fisheries – Processing Chapman & Hall, Madras 2. Ed.G.M.Hall – Fish Processing Technology Chopra & Hall. Madras.

VII SEMESTER
Course No.: 16: - Post Harvest Technology & Transportation
credits :3

Course Out comes:

Syllabus

Unit I: Harvest, Handling and Principles of fish Preservation

- 1-1 Harvest methods, Normal harvest and emergency harvest,
- 1.2 Handling of fresh fish, storage and transport of fresh fish, post-mortem changes (rigor mortis and spoilage), spoilage in marine fish and freshwater fish.
- 1.3 Principles of preservation—cleaning, lowering of temperature, rising of temperature, dehydration, use of salt, use of fish preservatives, exposure to low radiation of gamma rays.

Unit II: Fishery Products

- 2-1 Different types of value added products from fish and shell fish
- 2-2 Fish mince and surimi
- 2-3 Coated fishery products-different types of batter and breading

Unit III: Fishery by-products

- 3.1 Fish meal, fish protein concentrate, isinglass, fish liver oil, fish body oil
- 3.2 Fish hydrolysates, chitosan, glucosamine hydrochloride, pearl essence, ambergris, fish silage, fish maws, fish leather, shark fin rays

Unit IV: Sea weed products

UNIT IV: Seaweed Products

- 4.1: Preparation of agar, algin and carrageen
- .4.2 Use of seaweeds as food for human consumption, in disease treatment and preparation of therapeutic drugs.

UNIT V:TRANSPORTATION

- 5-1 Outlets for aquaculture products,
- 5-2 Transport of seed and brood stocks.
- 5.3 Causes of mortality during transport, techniques of transport, open and closed systems, methods of transportation, use of anaesthetics.

VII SEMESTER
Course No.: 16 - Post Harvest Technology & Transportation
credits :1

PRACTICALS:

1. Determination of moisture content in fish and fishery products
2. Chilling of fish using ice
3. Processing shrimp
4. Filleting of fish
5. Drying of fish
6. Preparation of boiled fish products
7. Preparation of shark fin rays, fish meal, chitin, and fish water
8. Fish pickling
9. Value added fishery products, fish curry, cutlets and fish fingers
10. Estimation of lactic acid content in fermented fish products

PRESCRIBED BOOKS: 1. Govardhan TK, 1985. Fish processing technology. Oxford & IBH Publishing, New Delhi

2. Wheaton FW and Lawson TB 1985. Processing aquatic food products. Wiley inter-science publication, USA

REFERENCES: 1. Balachandran KK 2001. Post-harvest technology of fish and fish products. Daya publishing ouse, Delhi

2. Moorjani MN 1998. Fish processing in India, ICAR, New Delhi

VII SEMESTER
Course No.: 17 - Fishery Microbiology
credits :3

Course Outcomes

- CO1:** Learn about history and development of microbiology
CO2:: Understand the ultra structure of prokaryotic cell
CO3: Gain knowledge about different culture techniques.
CO4: Application of routine tests for identification of bacteria
CO5: Know about intrinsic and extrinsic factors affecting spoilage.

SYLLABUS

UNIT 1: Introduction:

1.1 History and development of microbiology – Different members of the microbial community

1.2 General characteristics of bacteria, fungi, viruses, algae and protozoan's.

Unit II: Microbial structures

2.1 Ultra structure of prokaryotic cell – structure and function of bacterial cell wall, plasma membrane, capsule, flagella and endospore.

2.2 Structure of fungi and yeast cell. Ultra structure of virus – classification of viruses, Life cycle bacteriophages - lytic and lysogenic cycle.

UNIT III: Aquatic Microbiology I

3.1 Microflora of aquatic environment, Different culture techniques.

3.2 Nutrition and growth of bacteria – different types of media for isolation of bacteria and fungi.

UNIT IV: Aquatic Microbiology II

4.1 Isolation, enumeration, preservation and maintenance of cultures.

4.2 Routine tests for identification of bacteria – morphological, cultural biochemical and serological.

4.3 Basics of mycological and virology techniques.

UNIT V: Fish Microbiology

5.1 Perish ability of seafood – Fish as an excellent medium for growth of microorganisms.

5.2 Spoilage microflora of fish and shellfish

5.3. Intrinsic and extrinsic factors affecting spoilage.

VII SEMESTER
Course No.: 17 - Fishery Microbiology
credits :1

Experiments/Activities

1. Sterilization technique- dry heating, autoclaving
2. Media preparation
3. Isolation and maintenance of bacteria from fishes and water.
4. Gram staining of bacteria
5. Enumeration of bacteria by TPC method
6. Enumeration of total coli forms.
7. Evaluation of fish / fishery products for organoleptic, chemical and microbial quality

Collection:

1. Collection of fishery by-products.

Text Books:

1. Pelzar, Reid & Chan – Microbiology
2. Prescott, Harley & Klein – Microbiology
3. Adelogerg, Ingra & Wheates – Introduction to Microbial World
4. Windsor and Barlow. Introduction to Fishery Byproducts.
5. CIFT. Proceedings on Summer Institute on Non-traditional Diversified Fish Products & Byproducts.
6. Anon. Productivity in Aquatic Bodies.
7. Chincheste, C.O. and Graham, H.D. Microbial Safety of Fishery Products.
8. Amerine, M.A. and Pangborn, R.M. Principles of Sensory Evaluation of Foods.
9. Connell, J.J. Control of Fish Quality
10. Bigh, E.G. Seafood Science and Technology
11. Gopakumar, K. Tropical Fishery Products

Reference Books

1. Kreuzer, R. Fishery Products.
2. Borgstrom, G. Fish as Food
3. Suzuki, T. Fish and Krill Protein: Processing Technology

VII SEMESTER
Course No.:18 - Quality Control in Processing Plants
credits :3

Course Outcomes:

CO1: Gain Knowledge on Quality management, total quality concept.

CO2: Know about fish inspection in India

CO3: Understand Statistical analysis Quality problems in fishery products

CO4: Know about certification of export worthiness of fish processing units,

CO5: Application of laboratory techniques for detection and identification of food poisoning bacteria

SYLLABUS

UNIT I:

1.1 Quality management, total quality concept and application in fish trade.

1.2 Quality assessment of fish and fishery products - physical, chemical, organoleptic and microbiological.

1.3 Quality standards, Quality Assurance.

UNIT 2:

2.1 Fish inspection in India, process

2.2 water quality in fishery industry, product quality

2.3 Water analysis, treatments, chlorination, ozonisation, UV radiation, reverse osmosis, techniques to remove pesticides and heavy metals.

UNIT 3:

3.1 Sensory evaluation of fish and fish products, basic aspects, different methods of evaluation, taste panel selection & constitution

3.2 Statistical analysis Quality problems in fishery products

3.3 Good manufacturing practices.

3.4 HACCP and ISO 9000 series of quality assurance system, validation and audit.

National and international standards, EU regulation for fish export trade,

UNIT 4:

4.1 IDP and SAT formations in certification of export worthiness of fish processing units,

4.2 Regulations for fishing vessels pre-processing and processing plants, regulations.

4.3 Factory sanitation and hygiene: National and international requirements, SSOP.

UNIT 5:

5.1 Hazards in sea foods: Sea food toxins, biogenic amines, heavy metals and industrial pollutants.

5.2 Infection and immunity, Microbial food poisoning, bacteria of public health significance in fish /fishery products / environments - Salmonella, Clostridia, Staphylococcus, E. coli, Streptococcus, Vibrio, Aeromonas, Listeria, Yersinia, Bacillus.

5.3 Laboratory techniques for detection and identification of food poisoning bacteria.

Mycotoxins in cured fish, bacterial associated with fish disease.

VII SEMESTER

Course No.: 18 - Quality Control in Processing Plants

credits :1

1. Practical Assessment of quality of fresh fish by sensory, biochemical, and instrumental methods.
2. Chlorination and Hardness estimations
3. Quality analysis of canned, frozen, cured and pickled fish products.
4. Quality tests for tin and corrugated containers.
5. Assessment of plant, equipment sanitation and personnel hygiene.
6. Detection of filth and extraneous matter in traditional processed products.

Reference books

1. Connell, J.J. 1980. Control of Fish Quality. Springer – Verlag, New York.
2. Huss, H.H., et al. 1992. Quality Assurance in the Fish Industry. Elsevier Science 60 Publishers, B.V., Amsterdam, Netherlands.
3. Jeyasekharan, G., Jaya Shakila, R. and Sukumar, D. 2006. Quality and Safety of Seafoods – Text Book, Tamilnadu Veterinary and Animal Sciences University, Chennai.
4. Quality Assurance in Sea Food Processing. 2005. Published by CIFT, Cochin.
5. Burgess, et al. 1982. Fish Inspection and Quality Control. Fishing News Books Ltd England.
6. Bonell, A.O. 1994. Quality Assurance in Seafood Processing: A practical Guide. Chapman and Hall, New York.
7. Huss, H.H. 1994. Assurance of Seafood Quality. FAO Fisheries Technical Paper 334, FAO, Rome, Italy.
8. Guthrie, R.K. 1988. Food Sanitation. Van Nostrand Reinhold, New York.

VIII SEMESTER
Course No.: 19 - Crustacean Culture
credits :3

Course Outcomes:

COI: Understand the Status of Crustacean farming in India

CO2: Gain Knowledge Important cultivable species of shrimps and prawns

CO3: Acquire knowledge on crustaceans culture

CO4: Importance of farming of Prawns and Shrimps

CO5: Gain Knowledge on diseases of Crustaceans

SYLLABUS

UNIT – 1

1.1 Status of Crustacean farming in India

1.2 Food and Export value of Crustaceans; Present status of their resources and culture practices.

UNIT 2 –

2.1 Important cultivable species of shrimps and prawns, their food and feeding habits and their reproductive biology.

2.2 Types of farming: traditional, extensive, semi-intensive and intensive methods; their management techniques.

UNIT 3 –

3.1 Crustaceans culture in cages, re-circulatory systems, rice fields and super intensive and ultra intensive systems.

3.2 Supplementary feeding: dry feeds, wet feeds, role of artificial feeds; feed ingredients and nutritional quality.

UNIT 4 -

4.1 Farming of Prawns and Shrimps – Pond and Large Scale farming; Composite Culture; Farming of Crab and Lobster.

UNIT 5-

5.1 Diseases of Crustaceans – Bacterial, Fungal and Viral diseases encountered during large scale culture of Crustaceans

VIII SEMESTER
Course No.: 19 - Crustacean Culture
credits :1

Practicals:

1. Identification of shrimp upto species level based on morphological characters.
2. Dissect and display the appendages of shrimp and crab.
3. Dissect and display the digestive system of shrimp, crab and lobster
4. Dissect and display the reproductive system of shrimp and squilla.
5. Identification:
 - A. Cultivable crustaceans
 - B. Larval forms
 - C. Shrimp and crab feed.

References:

Shigueno K Shrimp culture of Japan AITP, Tokyo
Milne PH Fish & shellfish farming in coastal waters FNB
McVey JP Crustacean aquaculture CRC handbook CRC press
Korringa P Farming of marine fishes & shrimps Elsevier
Walne PR Culture of bivalve mollusks PNB

VIII SEMESTER
Course No.: 20A - Molluscan and Seaweed Culture
credits :3

Course Outcomes:

UNIT - 1

Present status of molluscan farming: Life cycles of cultivable molluss. Oyster and mussel farming: growth, fattening and greening.

UNIT - 2

Hatchery management and seed production oyster, pearl-oysters, mussels and seaweeds. Feed and nutrition. Harvesting of fry, packaging and transport of fry; Small scale hatcheries. Nursery Management: preparation of nurseries; Effect of physico-chemical factors, feeding and control of predators.

UNIT -3

Culture of pearl oyster and pearl production; Culture of cephalopods. Different types of Culture Methods

UNIT - 4

Water quality management and biofouling. Harvesting, post-harvest technology, management, production and economics.

UNIT- 5

Seaweed farming: present status. Life cycles of cultivable seaweeds. Culture practices of seaweeds in india and abroad: improvement of breed.

VIII SEMESTER
Course No.: 20 A - Molluscan and Seaweed Culture
credits :1

Practicals:

I. Dissections:

1. Digestive system of cephalopods and bivalves
2. Reproductive system of cephalopods and bivalves
3. Gill mounting of molluscans

II. Identification:

- A. Cultivable Molluscans
- B. Sea weeds and their by-products,
- C. Predators
- D. Models of Culture systems

References:

Bardach JE et al aquaculture wiley Interscience Milne fish and shellfish farming fish In coastal waters
Culture of bivalve mollusks Pillay & dill advances in aquaculture FAO
Korringa fish farming of the oyster Elsevier

VIII SEMESTER
Course No.: 20 B :Genetics in Aquaculture
credits :3

Course Outcomes

- CO1:** Know about the basic principles of genetics
- CO2:** Understand the chromosome theory of inheritance
- CO3** Acquire knowledge on the importance of genome size in fishes
- CO4** Discuss the basic role of genetics in Aquaculture
- CO5** Gain knowledge on applications of markers for species identification

SYLLABUS

Unit I

- 1.1 Principles of Genetics: Mendelian principles,
- 1.2 Probability of Mendelian inheritance, modification to Mendelian ratios.

UNIT II

- 2.1 Chromosome theory of inheritance; genetic basis of determination of sex in fish and shellfish.
- 2.2 Chromosome manipulation: Induction of chromosomal ploidy, polyploidy & aneuploidy, gynogenesis, androgenesis, sex reversal, transgenesis and its applications in aquaculture.

UNIT III:

- 3.1 Genome size in fishes, Mechanism of variations in genome size.
- 3.2 Sex control and its role in aquaculture
- 3.3 Cryopreservation of gametes, in-vitro fertilization, artificial insemination.

UNIT IV

- 4.1 Role of genetics in Aquaculture: Genetic selection, inbreeding, cross breeding, hybridization, karyotyping, heterosis, hybrid vigour, introgression.
- 4.2 Genetic tools for aquaculture applications: DNA markers in stock identification- allozymes, RFLP, RAPD, AFLP, Microsatellite, ESTs and SNPs, mt DNA.

UNIT V:

- 5.1 Applications of markers for species identification, hybridization, stock identification,
- 5.2 Genetic diversity and conservation, Parentage, Linkage, QLT mapping and microarray genes.
- 5.3 Karyotyping and chromosome banding- C-banding, G-banding, NOR banding.

VIII SEMESTER
Course No.: 20 B: Genetics in Aquaculture
credits :1

- 1. Exercises on Mendelian laws
- 2. Estimation of gene and genotypic frequencies
- 3. Estimation of effective population size
- 4. Building of pedigree size
- 5. Metaphase plate preparation of fish kidney/spleen
- 6 Numericals on inbreeding, cross breeding, ploidy and genetic selection
- 7. Karyotyping
- 8 Computational tools for RFLP, RAPD, AFLP analysis

References:

1. Pandian TJ, Strussmann CA & Marian MP Fish Genetics & Aquaculture SciencePub
2. Biotechnology
3. Lakra/Singh Fish genetic resources
4. Mirza Akbar Khan Genetic Embryology and fishes
5. References:
6. Carvalho GR & Pitcher TJ. (Eds.). 1995. *Molecular Genetics in Fisheries*. Chapman & Hall.
7. Falconer DS & Mackay. 1996. *Introduction to Quantitative Genetics*. 4th Ed. Longman.
8. Kanakaraj P. 2001. *A Text Book on Animal Genetics*. International Book. Distributing Co.
9. Nair PR. 2008. *Biotechnology and Genetics in Fisheries and Aquaculture*. Dominant Publ.
10. Padhi BK & Mandal RK. 2000. *Applied Fish Genetics*. Fishing Chimes.
11. Pandian TJ, Strüssmann CA & Marian MP. 2005. *Fish Genetics and Aquaculture*
12. *Biotechnology*. Science Publ.
13. Purdom CE. 1993. *Genetics and Fish Breeding*. Chapman & Hall.
14. Reddy PVGK. 2005. *Genetic Resources of Indian Major Carps*. FAO Publ.
15. Reddy PVGK, Ayyappan S, Thampy DM & Krishna G. 2005. *Text book of Fish Genetics and*
16. *Biotechnology*. ICAR.
17. Ryman N & Utter F. (Eds.). 1988. *Population Genetics and Fishery Management*. Washington
18. Sea Grant Programmes, USA.
19. Tave D. 1996. *Genetics for Fish Hatchery Managers*. 2nd Ed. AVI Publ.
20. Thorpe JE, Gall GAE, Lannan JE & Nash CE. (Eds.). 1995. *Conservation*
21. *of Fish and Shellfish Resources, Managing Diversity*.

VIII SEMESTER
Course No.: 21A - Marine Fin Fish culture
credits :3

Course outcomes

- CO1: Understand the life history of milk fish, sea bass, yellow tail.
- CO2: Gain Knowledge on pond preparation and fertilization
- CO3: Acquire skills in Hatchery and Nursery management
- CO4: Learn about production and quality control
- CO5: Know about ranching methods and implements.

SYLLABUS

UNIT 1

- 1.1 Important cultivable finfish species and the life history of milk fish, seabass, yellow tail.

UNIT 2

- 2.1 Criteria for selection of finfish for culture. Classification of culture systems: ponds, pens, cages, raceways.
- 2.2 Pond preparation and fertilization; eradication of weed and Predatory finfishes.

UNIT 3:

- 3.1 Hatchery management and seed production of mullets, milkfish, seabass.
- 3.2 Feed and nutrition.
- 3.3 Harvesting of fry, packaging and transport of fry; Small scale hatcheries.
- 3.4 Nursery Management: preparation of nurseries; effect of physico-chemical factors, feeding and control of predators

UNIT - 4

- 4.1 Culture practices of milkfish, mullets, seabass and yellowtail. Monoculture and polyculture
- 4.2 Principles and practices. Integrated farming, organic farming and their management. Harvesting and post-harvesting technology of cultured finfish.
- 4.3 Production, quality control, marketing and economics.

UNIT – 5

- 5.1 Aquaranching – Principles and Practices,
- 5.2 Large Scale culture in Natural waters, Ranching methods and implements.

VIII SEMESTER
Course No.:21A- Marine Fin Fish culture
credits :1

Practicals:

- 1. Fish identification based on morphometric and meristic data.
- 2. Dissect and display the digestive system of herbivorous and carnivorous fish and reproductive system of fish
- 3. Important calculations in aquaculture: FCR and FCE, Daily ration of feed, Survival rate, Specific growth rate, quantifying the seed for transport.

4. Identification:

- A. Cultivable fishes
- B. Predatory and weed fishes
- C. Fertilizers
- D. Supplementary feeds

VIII SEMESTER
Course No.: 21 B - Fish Immunology
credits :1

Course Outcomes

- CO1:** Knowledge on **types** of immunity
CO2; Understand the concept of lymphatic system
CO3: Gain knowledge on structure, types and functions of antibodies
CO4: Discuss about types of autoimmune diseases.
CO5: Acquire knowledge on importance of vaccines

SYLLABUS

UNIT I:

- 1.1 Immunity and types of immunity.
- 1.2 Fundamental concepts and anatomy of the immune system, components of innate and acquired immunity, Phagocytosis, Complement and inflammatory responses,
- 1.3 Organs and Cells of the immune system-primary and secondary lymphoid organs

UNIT II

- 2.1 Lymphatic system, Lymphocyte circulation, Lymphocyte homing, Mucosal and Cutaneous associated Lymphoid tissue (MALT & CALT); Mucosal immunity.
- 2.2 Antigens: Types and properties. Major Histocompatibility Complex (MHC) - MHC genes,
- 2.3 Immune responsiveness and disease susceptibility and HLA typing.

UNIT III

- 3.1 Immunoglobulins: Structure, types and functions.
- 3.2 Immunogenetics: Genetic basis of antibody diversity. Molecular biology of B and T cells.
- 3.3 Complement proteins and cytokines.

UNIT IV:

- 4.1 Disorders of immune system: autoimmunity- types of autoimmune diseases.
- 4.2 Immunodeficiency- Primary immuno deficiencies, Acquired or secondary immuno deficiencies,
- 4.3 Hypersensitivity.
- 4.4 Hybridoma technology- mono and polyclonal antibodies.

UNIT V

- 5.1 Vaccines- Live, killed, attenuated, sub unit vaccines.
- 5.2 Non-specific immunity of shellfish.
- 5.3 Active and passive immunization; ELISA, RIA and Immuno electrophoresis applications.
- 5.4 Transplantation- Immunological basis of graft rejection. Tumor immunology- Tumor antigens; immune response to tumors and tumors evasion of the immune system, Cancer immunotherapy.

VIII SEMESTER
Course No.: 21 B - Fish Immunology
credits :1

Practicals:

1. Preparation of antigens, Immunization and methods of bleeding, serum separation and storage.
2. Antibody titre by ELISA method.
3. Isolation and purification of Ig G from serum or Ig Y from chicken egg.
4. Blood smear identification of leucocytes by Giemsa stain.
5. Separation of leucocytes by dextran method.
6. Demonstration of phagocytosis.

7. Immuno electrophoresis, Isolation of antibody from serum, Nonspecific immune response

References:

Eli Benjamini Immunology – a short course

I. Riott Essentials of immunology Blackwell

I Riott et al Immunology Molsby

Aruna B Manual of practical immunology Palaniparamount
