University of Mumbai

No. AAMS_UGS/ICC/2024-25/ 108

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments is invited to this office circular No. AAMS_UGS/ICC/2023-24/23 dated 08th September, 2023 relating to the NEP UG & PG Syllabus.

They are hereby informed that the recommendations made by the **Ad-hoc Board of Studies in Life Science** at its meeting held on 01st July, 2024 and subsequently passed by the Board of Deans at its meeting held on 10th July, 2024 **vide** item No.6.10 (N) have been accepted by the Academic Council at its meeting held on 12th July, 2024 **vide** item No.6.10 (N) and that in accordance therewith **syllabus** for the **M.Sc (Life Sciences- Aquaculture Technology) (Sem. III & IV)** is introduced as per appendix (NEP 2020) with effect from the academic year 2024-25.

(The circular is available on the University's website www.mu.ac.in).

Baliram

(Prof.(Dr) Baliram Gaikwad)
I/c Registrar

MUMBAI – 400 032
22nd August, 2024

To

The Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Department.

A.C/6.10 (N)/12/07/2024

Copy forwarded with Compliments for information to:-

1) The Chairman, Board of Deans,
2) The Dean, Faculty of Science & Technology,
3) The Chairman, **Ad-hoc Board of Studies in Life Science**,
4) The Director, Board of Examinations and Evaluation,
5) The Director, Board of Students Development,
6) The Director, Department of Information & Communication Technology,
7) The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari.
8) The Deputy Registrar, Admissions, Enrolment, Eligibility & Migration Department (AEM),

Copy forwarded for information and necessary action to :-	
1	The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Dept)(AEM), dr@eligi.mu.ac.in
2	The Deputy Registrar, Result unit, Vidyanagari drresults@exam.mu.ac.in
3	The Deputy Registrar, Marks and Certificate Unit,. Vidyanagari dr.verification@mu.ac.in
4	The Deputy Registrar, Appointment Unit, Vidyanagari dr.appointment@exam.mu.ac.in
5	The Deputy Registrar, CAP Unit, Vidyanagari cap.exam@mu.ac.in
6	The Deputy Registrar, College Affiliations & Development Department (CAD), deputyregistrar.uni@gmail.com
7	The Deputy Registrar, PRO, Fort, (Publication Section), Pro@mu.ac.in
8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
9	The Deputy Registrar, Research Administration & Promotion Cell (RAPC), rapc@mu.ac.in
10	The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA) dy.registrar.tau.fort.mu.ac.in ar.tau@fort.mu.ac.in
11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
12	The Deputy Registrars, Finance & Accounts Section, fort draccounts@fort.mu.ac.in
13	The Deputy Registrar, Election Section, Fort drelection@election.mu.ac.in
14	The Assistant Registrar, Administrative Sub-Campus Thane, thanesubcampus@mu.ac.in
15	The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan, ar.seask@mu.ac.in
16	The Assistant Registrar, Ratnagiri Sub-centre, Ratnagiri, ratnagirisubcentre@gmail.com

Copy for information :-	
1	P.A to Hon'ble Vice-Chancellor, vice-chancellor@mu.ac.in
2	P.A to Pro-Vice-Chancellor pvc@fort.mu.ac.in
3	P.A to Registrar, registrar@fort.mu.ac.in
4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

1	The Chairman, Board of Deans
2	The Dean, Faculty of Humanities,
3	Chairman, Board of Studies,
4	The Director, Board of Examinations and Evaluation, dboee@exam.mu.ac.in
5	The Director, Board of Students Development, dsd@mu.ac.in@gmail.com DSW direcotr@dsw.mu.ac.in
6	The Director, Department of Information & Communication Technology,
7	The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari, director@idol.mu.ac.in

AC – 12/07/2024
Item No. – 6.10 (N)

As Per NEP 2020

University of Mumbai

Title of the program

M. Sc. (Life Sciences – Aquaculture Technology)

Syllabus for

Semester – Sem.- III & IV
Ref: GR dated 16th May, 2023 for Credit Structure of PG

(With effect from the academic year 2024-25)

University of Mumbai

(As per NEP 2020)

Sr. No.	Heading	Particulars
1	**Title of program** **O:_____ B**	**M.Sc. (Life Science-Aquaculture Technology)**
2	**Scheme of Examination** **R: _____**	**NEP** **50% Internal** **50% External,** **Semester End Examination** **Individual Passing in Internal and External Examination**
3	**Standards of Passing** **R: _____**	**40%**
4	**Credit Structure** **R: SP- 40A** **R: SP- 40B**	**Attached herewith**
5	**Semesters**	**Sem. III**
6	**Program Academic Level**	**6.5**
7	**Pattern**	**Semester**
8	**Status**	**New**
9	**To be implemented from Academic Year**	**2024-25**

Indu Anna George
9/7/2024

Sign of BOS Chairperson
Prof. Indu Anna George
Department of Life Sciences
Ad-hoc BOS in Life Sciences

Sign of Offg. Assoc. Dean
Dr. Madhav Rajvade
Offg. Assoc. Dean
Science and Technology
University of Mumbai

Sign of Offg. Dean
Prof. Shivram Garje
Dean Science and Technology
University of Mumbai

PREAMBLE

1. Introduction:

The Department of Life Sciences at the University is delighted to introduce the Master of Science (MSc) Programme, a comprehensive and dynamic two-year full-time course that aims to provide students with a deep understanding of the diverse aspects of life and its related disciplines. Life Sciences encompass a wide range of fields, offering fundamental knowledge about animals, plants, microorganisms, and the abiotic factors that influence their existence.

This specialized program delves into the intricacies of the biotic world, exploring the structures and functions of living organisms from physical, physiological, metabolic, biochemical, ecological, and socio-economic perspectives. Through this curriculum, students will embark on an exciting journey into the world of various techniques and technologies employed in the study of life, enabling them to appreciate the economic and ecological importance of the living and non-living things.

The MSc Programme in Life Sciences comprises interdisciplinary courses that encompass animal and plant sciences, microbiology, biochemistry and biophysics, molecular biology, and applied genetics. These comprehensive modules empower students to strengthen their knowledge in their respective areas of interest and gain insights into the wide-ranging opportunities available in this field. Additionally, the curriculum is designed to cultivate a deep appreciation for nature and natural resources, fostering skills for data observation and analysis inpreparation for future research endeavours.

The Programme structure entails core papers of three theory and two practical in each semester, allowing students to gain theoretical knowledge as well as hands-on experience. With the implementation of the Choice Based Grading System, the evaluation process incorporates continuous assessment throughout the year, including both Internal Assessment and Term End Assessment. This comprehensive evaluation methodology ensures a holistic approach to students' progress and encourages active engagement throughout the academic year.

To further enhance the students' readiness for the industry, the curriculum incorporates a mandatory On Job Training (OJT) component in Semester II. This intensive training, equivalent to a full course, provides invaluable exposure to real-world scenarios within Life Sciences or Life Sciences-related organizations. By applying their theoretical knowledge in practical settings, students gain firsthand experience and develop the necessary skills to thrive in the professional world.

In addition to technical skills, this programme also focuses on cultivating research ethics and promoting a research-oriented mindset among learners. The inclusion of a Research Methodology Course helps students develop a strong research attitude, enabling them to contribute meaningfully to the advancement of Life Sciences.

Acknowledging the evolving trends in education and the need for flexible learning modes, the syllabus has been augmented to include an online component. Embracing the advantages offeredby online learning, this component is designed to be optional, allowing both teaching faculties and students to collaboratively determine the topics to be covered in the online format. The authorities will oversee the final implementation of this innovative concept, recognizing its potential to revolutionize education by overcoming barriers of time, space, and infrastructure.

In conclusion, the MSc Programme in Life Sciences equips students with a comprehensive understanding of the multidimensional aspects of life and its associated disciplines. With a

curriculum that combines theoretical knowledge, practical skills, on-the-job training, and the integration of online learning, students are prepared for diverse career opportunities and future research endeavours. We invite students to embark on this transformative academic journey, here they will unravel the mysteries of life, contribute to the advancement of scientific knowledge, and make valuable contributions to society.

2. Aims and Objectives

The aims and objectives of the M. Sc. Life Sciences programme collectively aim to develop well-rounded Life Sciences professionals who are not only technically competent but also capable of contributing to research, innovation, and the overall advancement of the field.

Objectives:

The M. Sc Life Sciences programme is designed to help students to:

a) Acquire a comprehensive knowledge base in various disciplines of Life Sciences, providing a strong foundation for further studies and research. Students will develop a deep understanding of key concepts, theories, and methodologies in genetics, cellular biology, ecology, physiology, molecular biology, and other relevant areas.

b) Foster a deep interest in the diverse branches of Life Sciences, encouraging curiosity and exploration. Students will be inspired to delve into specialized areas of interest and engage in independent learning.

c) Understand the rich diversity of organisms and appreciate their ecological, genetic, and evolutionary significance. Students will gain insights into the interconnections between different species and ecosystems, recognizing the importance of biodiversity conservation.

d) Develop essential skills in observation, biological techniques, experimental skills, and scientific investigation, enabling them to contribute to the field through rigorous and reliable research. Students will be trained to design and execute experiments, analyze data, and draw scientifically sound conclusions.

e) Cultivate an understanding of the interconnectedness and harmony of different life systems, while recognizing the importance of maintaining good health through appropriate measures. Students will grasp the intricate relationships between organisms and their environment, emphasizing the significance of sustainable practices for both human and ecological well- being.

f) Gain knowledge and skills in applied branches of Life Sciences that can contribute to self-employment and entrepreneurial opportunities. Students will be equipped with practical knowledge and expertise in areas with direct applications, enabling them to explore entrepreneurial ventures or pursue specialized career paths.

g) Promote awareness and concern for the conservation of the biosphere, emphasizing the importance of environmental sustainability and responsible stewardship. Students will develop a deep appreciation for the biosphere and its conservation, becoming advocates for sustainable practices and environmental protection.

h) Enhance students' Social Intelligence Quotient (SIQ) and Emotional Quotient (EQ), fostering their development as well-rounded individuals and responsible citizens who can positively impact humanity through their acquired and developed knowledge. Students will develop strong interpersonal skills, empathy, and cultural sensitivity to effectively collaborate with diverse stakeholders and address societal challenges.

i) Equip students with the necessary skills and mindset to be self-sustainable and encourage them to become future entrepreneurs, fostering innovation and economic growth. Students will cultivate an entrepreneurial mindset, including critical thinking, problem-solving, creativity, and adaptability, preparing them to identify opportunities and contribute to the growth of the life sciences industry.

j) Provide students with a comprehensive understanding of key concepts, theories, and methodologies in Life Sciences. It covers a range of topics including genetics, cellular biology, ecology, physiology, and molecular biology, enabling students to develop a deep knowledge

base in these areas.

k) Equip students with practical skills through hands-on experience with laboratory techniques, data analysis, and scientific methodologies. Students will gain proficiency in conducting experiments, analyzing data, and interpreting results, enhancing their ability to apply theoretical knowledge to practical situations.
l) Enhance students' critical thinking and problem-solving abilities by challenging them to analyze complex biological systems, evaluate scientific literature, and propose innovative solutions to biological problems.
m) Foster collaboration and an interdisciplinary approach to problem-solving by providing opportunities for teamwork, group projects, and interactions with professionals from different scientific disciplines. Students will develop effective communication and teamwork skills, preparing them for collaborative work environments.
n) Stay updated with the latest trends and advancements in Life Sciences to ensure graduates are well-prepared for the demands of the industry. Through industry collaborations, guest lectures, and exposure to emerging technologies, students will acquire knowledge and skills that are relevant and applicable to real-world scenarios.
o) Develop students' professional skills, including scientific writing, presentation skills, project management, and leadership. Students will have opportunities to participate in conferences, workshops, and seminars to enhance their professional development and networking abilities.
p) Cultivate research skills among students by providing training in research methodologies, data analysis techniques, and critical evaluation of scientific literature. Students will have opportunities to engage in independent or collaborative research projects, enabling them to contribute to the advancement of Life Sciences through original research findings.

By incorporating these objectives, the M. Sc. Life Sciences program aims to produce graduates who possess a strong foundation in Life Sciences, are adept at problem-solving and collaboration, have industry-relevant skills, and are well-prepared for both research and professional roles in the field. The program strives to foster a deep understanding of Life Sciences, promote scientific inquiry, nurture innovation, and empower students to make meaningful contributions to society.

3. Learning Outcomes

The proposed M. Sc. Programme in Life Sciences aims to provide students with a comprehensive and holistic understanding of the field, equipping them with the skills and knowledge necessary to excel in the ever-evolving biological sciences domain. Learning outcome of the Programme are:

a) Apply advanced scientific principles and cutting-edge technology to solve complex real- world problems in diverse fields such as healthcare, agriculture, and environmental conservation.
b) Critically analyze and evaluate current research literature and effectively communicate scientific concepts and findings to both scientific and non-scientific audiences.
c) Develop innovative and sustainable research projects that adhere to international standards and consider practical limitations and ethical considerations.
d) Demonstrate an in-depth understanding of the structural organization and functional interactions between organisms and their environments, with an emphasis on the integration of interdisciplinary knowledge.
e) Evaluate and synthesize advanced concepts in plant, microbial, and animal physiology and biotechnology, and apply this knowledge to address contemporary challenges in the field.
f) Conduct quantitative and comparative studies, employing advanced statistical methods, to investigate and elucidate various aspects of biological sciences, including ecological interactions, genetic diversity, and population dynamics.
g) Utilize bioinformatics tools and techniques to generate, analyze, and interpret large-scale biological data, including the construction of databases, sequence alignments, and predictive modeling.
h) Apply state-of-the-art technologies and methodologies to explore and comprehend the intricate mechanisms underlying genome and protein biology, including gene expression regulation and

protein-protein interactions.

i) Discuss and critically evaluate the legal and ethical aspects of intellectual property rights (IPR) and the responsible conduct of research, with an understanding of the social and economic implications of biology-related innovations.
j) Foster cross-cultural competence by actively collaborating in diverse teams, valuing and respecting diverse perspectives, and effectively contributing to scientific projects with individuals from different cultural backgrounds.

Second Year PG:

R. SP-40 B									
Year (2Yr PG)	**Level**	**Sem.** (2Yr)	**Major**		**RM**	**OJT / FP**	**RP**	**Cum.Cr**	**Degree**
			Mandatory	**Electives**					
II	**6.5**	**Sem III**	Course1: LScAQT601: Aquaculture Principle, Production & Practices Credits 4 Course 1: LScAQT602: Aquaculture Principle, Production & Practices Practicals Credits 2 Course 3: LScAQT603: Mariculture Biotechnology Credits 4 Course 4: LScAQT604:Mariculture BiotechnologyPracticals Credits 2 Course 5: LScAQT605:Physiology of Finfish & Shellfish Credits 2	**Credits 4** Course LScAQT606a: Blue Revolution 2 TH + 2 PR **OR** Course LScAQT606b: Ornamental Fishes and Aquarium Management 2 TH + 2 PR **OR** Course LScAQT606c: Fish Nutrition and feed Technology 2 TH + 2 PR **OR** Course LScAQT606d: Commercially Important Sea Food 2 TH + 2 PR **OR** Course LScAQT606e: Aquatic Waste Product and its Use 2 TH + 2 PR			LScAQT607 (4)	22	**PGDegree After3-YrUG**

		Sem IV	Course 1: LScAQT608: Fish Products and Quality Assurance Credits 4 Course 2: LScAQT609: Fish Products and Quality Assurance Practicals Credits 2 Course 3: LScAQT610: Aquaculture Drugs and Pharmacological Studies Credits 4 Course 4: LScAQT611: Aquaculture Drugs and Pharmacological Studies Practicals Credits 2	**Credits 4** Course LScAQT612a: Commercial Pearl Production Process 2 TH + 2 PR **OR** Course LScAQT612b: Aquaponics and Aquatic Engineering 2 TH + 2 PR **OR** Course LScAQT612c: Fish Processing and Preservation Technology 2 TH + 2 PR **OR** Course LScAQT612d: Fish Breeding and Hatchery Management 2 TH + 2 PR **OR** Course LScAQT612e: Seaweed Culture & its Economic Importance 2 TH + 2 PR			LScAQT613 (6)	22	
Cum. Cr. for 1 YrPGDegree			**26**	**8**			**10**	**44**	
Cum. Cr. for 2 YrPGDegree			**54**	**16**	**4**	**4**	**10**	**88**	

1. **Credit Structure of the Program (Sem I, II, III & IV) (Table as per Parishisht 1 with sign of HOD and Dean)**

R_____

Post Graduate Programs in University Parishishta - 1

Exit option: PG Diploma (44 Credits) after Three Year UG Degree									
II	**6.5**	**Sem III**	Course 1 Credits 4 Course 2 Credits 4 Course 3 Credits 4 Course 4 Credits 2	**Credits 4** Course 1 OR Course 2 OR			4	22	**PG Degree After 3-Yr UG**
		Sem IV	Course 1 Credits 4 Course 2 Credits 4 Course 3 Credits 4	**Credits 4** Course 1 OR Course 2 OR			6	22	
Cum. Cr. for 1 Yr PG Degree			**26**	**8**			**10**	**44**	
Cum. Cr. for 2 Yr PG Degree			**54**	**16**	**4**	**4**	**10**	**88**	

Detailed Syllabus
M.Sc. (Life Sciences -Aquaculture Technology)

PaperCode	Unit	Description	Credits	Hrs
Course 1: LScAQT601		**Aquaculture Principle, Production & Practices**	**4**	**60**
Module1	I	Scope and Farming Practices of Aquaculture	1	
	II	Fish Production & Management of Cultivable Fishes	1	
Module2	III	Defense Mechanism in Fish, Shellfish & Disease Diagnostics Tools	1	
	IV	Impact of Aquaculture on Environment	1	
Course 2: LScAQT602		**Aquaculture Principle, Production & Practices Practicals**	**2**	**60**
Module1				
Course 3: LScAQT603		**Mariculture Biotechnology**	**4**	**60**
Module1	I	Mariculture	1	
	II	Important Cultivable Finfishes and Shellfishes	1	
Module2	III	Nutrition and Environmental Management in Mariculture	1	
	IV	Biotechnology in Aquaculture	1	
Course 4: LScAQT604		**Mariculture Biotechnology Practicals**	**2**	**60**
Module1				
Course 5: LScAQT605		**Physiology of Finfish & Shellfish**	**2**	**30**
Module1	I	Physiology of Finfish	1	
	II	Physiology of Shellfish	1	
ELECTIVES				
Course: LScAQT606a		**Blue Revolution**	**4**	**90**
Module1	I	Blue Revolution in India	1	15
	II	Blue Revolution Scheme	1	15
Module2		Blue Revolution Practicals	2	60
Course: LScAQT606b		**Ornamental FishandAquarium Management**	**4**	**90**
Module1	I	Ornamental Fish Farming	1	15
	II	Aquarium Management	1	15
Module2		Ornamental Fish and Aquarium Management Practicals	2	60
Course: LScAQT606c		**Enzyme Technology**	4	90
Module I	I	Enzyme Kineticsand Applications	1	15
	II	Enzyme Technology	1	15
Module II		Enzyme Technology Practicals	2	60
Course: LScAQT606d		**Commercially Important Seafood**	**4**	**90**

Module1	I	Seafood & Microalgae	1	15
	II	Fish as Health Food	1	15
		Commercially Important Seafood Practicals	2	60
Course: LScAQT606e		**Aquatic Waste Product and Its Use**	**4**	**90**
Module1	I	Fish Waste	1	15
	II	Aquatic Waste and By-products Processing	1	15
Module2		Aquatic Waste Product and Its Use Practicals	2	60
Course: LScAQT607		**Research Project 1**	**4**	**120**

SEMESTER- IV

Paper Code	**Unit**	**Description**	**Credits**	**Hrs**
Course 1: LScAQT608		**Fish Products and Quality Assurance**	**4**	**60**
Module1	I	Fish Processing Technology	1	
	II	Value Addition & Fish Products Development	1	
Module2	III	Traditional Fishery Products	1	
	IV	Quality Assurance & Management	1	
Course 2: LScAQT609		**Fish Products and Quality Assurance Practicals**	**2**	**60**
Module1				
Course 3: LScAQT610		**Aquaculture Drugs and Pharmacological Studies**	**4**	**60**
Module1	I	Drug Discovery in Aquaculture	1	
	II	Marine Drugs, their Development & Delivery	1	
Module2	III	Marine Pharmacognosy	1	
	IV	Marine Derived Nutraceuticals	1	
Course 4: LScAQT611		**Aquaculture Drugs and Pharmacological Studies Practicals**	**2**	**60**
Module1				
ELECTIVES				
Course LScAQT612a		**Commercial Pearl Production Process**	**4**	**90**
Module1	I	Pearl Producing Species	1	15
	II	Pearl Culture	1	15
Module2		Commercial Pearl Production Process Practicals	2	60
Course LScAQT612b		**Aquaponics and Aquatic Engineering**	**4**	**90**
Module1	I	Aquaponics and Aquafarm Machinery	1	15
	II	Aquaculture Engineering	1	15
Module2		Aquaponics and Aquatic Engineering Practicals	2	60
Course LScAQT612c		**Fish Nutrition and Feed Technology**	**4**	**90**
Module1	I	Fish Nutrition	1	15
	II	Food and Feeding Technique	1	15

Module2		Fish Nutrition and Feed TechnologyPracticals	2	60
Course LScAQT612d		**Fish Breeding and Hatchery Management**	**4**	**90**
Module1	I	Reproductive biology and Induced breeding of Finfishes& Shellfishes	1	15
	II	Present Status of Seed Production and Hatchery Management	1	15
Module2		Fish Breeding and Hatchery Management Practicals	2	60
Course LScAQT612e		**Seaweed Culture & Its Economic Importance**	**4**	**90**
Module1	I	Practice of Cultivating and Harvesting of Seaweed	1	15
	II	Economic Importance of Seaweed Culture	1	15
Module2		Seaweed Culture & Its Economic Importance Practicals	2	60
Course LScAQT613		**Research Project II**	**6**	**180**

Sem. - III

M.Sc. (Life Sciences – Aquaculture Technology)
(Semester - III)

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester III **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Aquaculture Principle, Production & Practices **Total Marks:** 100 **University assessment:** 50 marks

Course Outcomes:

The learner would be able to:

1. Know the utilization of aquaculture management & processing methods.
2. Understand the culture practice of different kinds of fishes.
3. Know that Integrated Farming Systems represent a paradigm shift towards a more holistic, regenerative approach to agriculture.
4. Understandthe effect ofaquaculture on the environment.
5. Enhance the knowledge on the Wastewater-Fed Aquaculture.

Course Code	Course Title	Total Credits
LScAQT601	**Aquaculture Principle, Production Practices**	**04**
MODULE I **Unit I: Scope and Farming Practices of Aquaculture (15 L)** **Introduction of Aquaculture**: Concept, definition and scope of aquaculture; Present status, Problems and scope of fish farming in global Indian aquaculture; Aquaculture research & development in India. **Types of aquaculture practices:** Extensive, intensive, semi-intensive and composite culture of fish, polyculture, pen and cage culture. **Economic importance of aquaculture:** Aquaculture productivity, role of science and technology in aquaculture. **Unit II: Fish Production & Management of Cultivable Fishes (15 L)** **Fish Farming:** Cultivable fishes- major & minor Carps, Magur and Tilapia. **Nursery management:** Pond preparation and stocking, feeding of fish and water quality management, seed production. Recent trends in fish culture, Growth & survival of productive fish culture. Marketing of aquaculture products as opportunities for industry, export of fish & fishery products, international quality.		02
MODULE II **Unit III: Defense Mechanism in Fish, Shellfish & Disease Diagnostics Tools (15 L)** **Defense Mechanism in Fish and Shellfish:** Specific and non-specific defense mechanism, Immunogenicity, Immune cells, Immune suppressant, Ontogeny of immune system; Cellular Adaptation, Pathogen specificity. **Disease Diagnostics Tools:** Histopathological methods, Tools used in different types of PCR,		02

Immunoassay, Biochemical assay, Monoclonal and polyclonal based antibody assay, Electron microscopy, Serological techniques. **Unit IV: Impact of Aquaculture on Environment (15 L)** **Impact of different aquaculture systems on the environment:** Algal blooms: (*Pfiesteria spp), Cercopagispengoi* **Factors affecting the environment:** Feed & organic waste, use of chemicals, dissolved oxygen levels in the different water bodies (water and sediments), impact on wild stock population, threat from invasive species, **Habitat destruction:** Terrestrial, riverine, estuarine, brackish - mangrove forests and marine habitats, conflict between native and non-native aquatic species.	

Reference Books:

1. Tripathi, S.D. Lakra W.S. & Chadha, N.K., 2018. Aquaculture in India, Narendra Publishing House.
2. Ujwala Jadhav, 2010. Aquaculture Technology and Environment. Publ. PHI Publication
3. Ayyappan, S. 2011. Handbook of Fisheries and Aquaculture. ICAR.
4. Pillay T.V.R., 1990. Aquaculture: Principles and Practices. Fishing News Books, Cambrige University Press, Cambridge.
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6. Venugopal S., 2005. Aquaculture. Pointer Publ.
7. Agarwal S.C., 2008. A Handbook of Fish Farming. 2nd Ed. Narendra Publication.House.
8. Beveridge M.C.M. & Mc. Andrew B. J. 2000. Tilapias: Biology and Exploitations. Kluwer.
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10. Inglis V., Roberts R.J. & Bromage N.R. 1993. Bacterial Diseases of Fish. Blackwell. Iwama G & Nakanishi T. (Eds.). 1996. The Fish Immune System -Organism, Pathogen and Environment. Academic Press.
11. Shankar KM & Mohan CV. 2002. Fish and Shellfish Health Management. UNESCO Publ.
12. Kimbell E., 1988. Fundamental of Immunology.
13. Iwama G.& Nakanishi T. (Eds.). 1996. The Fish Immune System -Organism, Pathogen and Environment. Academic Press. Roberts
14. W.B. Saunders. Shankar K.M.& Mohan C.V., 2002. Fish and Shellfish Health Management.UNESCO Publ.
15. Felix S., Riji John K., Prince Jeyaseelan M.J.&Sundararaj V., 2001. FishDisease Diagnosis and Health Management. Fisheries College andResearch, Institute, T. N. Veterinary and Animal SciencesUniversity. Thoothukkudi.

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester III	**Course Name:** Aquaculture Principle, Production & Practices Practicals
Total Credits: 02	**Total Marks:** 50
Department assessment: 25 marks	**University assessment:** 25 marks

Course Outcome:

The learner would be able to:

1. Distinguish between various commercially important cultivable fishes.
2. Evaluate the nutritional value and design a fish feed.
3. Analyze water quality suitable for aquaculture farm.
4. Summarize and design various aquaculture farming designs.

Course Code	Course Title	Total Credits
LScAQT602	**Aquaculture Principle, Production & Practices Practicals**	**02**
MODULE I 1. Identification of commercially important marine & freshwater cultivable fishes. 2. Analysis of water quality: DO, BOD, COD, Alkalinity, Hardness, Chlorides. 3. Soil Analysis: pH, soil texture, moisture Visit to Integrated fish farm. 4. Practical on nutrient value of different manures. 5. Design of various integrated farming models. 6. Visit and Survey of marketable aquaculture products. 7. Microbial analysis of diseased fish skin mucus.		02

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester III **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Marine Biotechnology **Total Marks:** 100 **University assessment:** 50 marks

Course Outcomes:

The learner would be able to:

1. Apply the concept of mariculture.
2. Identify the commercially important Finfishes and Shellfishes of India.
3. Demonstrate the principle and components of fish nutrition.
4. Create robust aquaculture animals using molecular biology techniques.

Course Code	Course Title	Total Credits
LScAQT603	**Mariculture Biotechnology**	**04**
MODULE I **Unit I: Mariculture (15 L)** **Production and status:** introduction, an overview of status of mariculture, global production, top countries, present status in India, mariculture production by species. an overview of marine progress in India. **Commercially important mariculture species:** Status of farming of selected species marine finfish, crustaceans, molluscs, sea cucumbers, sponges, corals, seaweeds, global status, present trend and scope in India. **Marine metagenomics:** Flora, fauna, bacteria, algae, fungi and archea. **Unit II: Applications of Biotechnological Tools in Aquaculture (15 L)** **Fish genetics:** Scope of applied fish genetics: inheritance of qualitative and quantitative traits in fish; chromosomal polymorphism. Non-chromosomal inheritance: mitochondrial inheritance. chromosome manipulation: gynogenesis and androgenesis; production of super-males. **Genetic markers:** biochemical and molecular genetic markers. **Cytogenetics:** Fish cytogenetic techniques, karyological aspects, evolution in chromosome morphology and karyotypes, sex chromosomes in fishes, application of cytogenetics in aquaculture and fisheries management. **Stem cell culture:** Types of stem cell: totipotent, pluripotent, multipotent and unipotent, stem cell line, applications of stem cell culture, DNA markers and MAS.		02
MODULE II **Unit III: Bioactive Compounds from Marine Environment (15 L)** **Diversity of marine derived compounds:** Alkaloid, terpenoids and steroids, nucleoside, amino acids, peptides, depsipeptide, polyketide, macrolide. **Polymers from marine sources:** Polysaccharides (agar-agar, alginate, xanthan, carrageenan), chitin, marine collagens. **Marine toxins:** Paralytic shellfish poisoning (PSP), Neurotoxic shellfish poisoning (NSP), Diarrhetic shellfish poisoning (DSP), Ciguatera poisoning, Amnesic shellfish poisoning (ASP), azaspiracid shellfish poisoning, tetrodotoxin, other miscellaneous toxins. **Marine derived drugs in preclinical and clinical trials:** FDA and EMEA approved marine derived drugs, their use and mode of action. Screening of drugs High-throughput Screening		02

Assays (HTS) Bioassays- Enzyme assays, cytotoxicity assay; antimicrobial assay; DNA laddering assay; Apoptosis assays. **Unit IV: Marine Biomimetics and Bioprospecting (15 L)** Concept of marine biomimetics and marine technology. examples of marine biomimetics: propulsion mechanisms (manta ray), locomotion (humpback whale flipper), underwater robotics, biomaterial for tissue regeneration, design-based tissue engineering inspired by jellyfish, advances in marine biomimetics, applications of biomimetics. Fish scale type nanotechnology for reduction of resistance in water. Marine biominerals; Biomineralized structures; Biocomposites; Biopolymers. Marine organisms for biofuels and bioenergy, bioremediation, biofouling, biosurfactants. marine natural products as cosmetics-cosmeceuticals, algotherapy; thalassotherapy; enzymes; food, supplement, nutrition and energy drinks, marine algae as fish feed, manure and fertilizers.	

Reference Books:

1. Ujwala Jadhav, 2010. Aquaculture Technology and Environment. Publ. PHI Publication.
2. Tripathi, S.D., Lakra, S.D. & Chadha, N.K., 2018. Aquaculture in India, Narendra Publishing House.
3. Ayyappan, S., 2011. Handbook of Fisheries and Aquaculture. ICAR.
4. Lakra, W.S., 2000. Fish Genetics & Biotechnology.
5 Lakra, W.S. & Gopalakrishnan, A. 2013. Genetics, genetic engineering and biotechnology in fisheries, Indian Council of Agricultural Research.
6. Mukunda Goswami & W.S. Lakra, 2012. Fish Cell & Tissue Culture, Narendra Publishing House.

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester III **Total Credits:** 02 **Department assessment:** 25 marks	**Course Name:** Mariculture Biotechnology Practicals **Total Marks:** 50 **University assessment:** 25 marks

Course Outcome:

The learner would be able to:

1. Apply various molecular techniques used in aquaculture.
2. Appreciate the use of Bioinformatics tools in Aquaculture.
3. Summarize the identification and harvesting techniques of commercially important bivalves.

Course Code	Course Title	Total Credits
LScAQT604	**Mariculture Biotechnology Practicals**	**04**
MODULE I 1. Demonstration for harvesting of Mussels and Oysters. 2. Identification of commercially important Freshwater Bivalve and Sea water Oyster. 3. Isolation of Shrimp/Bivalve DNA. 4. Data mining of DNA sequences of marine organisms (Bivalves, Finfish, Shellfish, Jellyfish, Bacteria, Algae). 5. BLAST Analysis of the mined DNA sequences. 6. Study of different equipment used in fish cell culture laboratory. 7. Production of chitin/ chitosan from shrimp shells or other suitable sources.		02

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester III **Total Credits:** 02 **Department assessment: 25**	**Course Name:** Physiology of Finfish & Shellfish **Total Marks: 5**0 **University assessment: 25**

Course Outcomes:

The learner would be able to:

1. Acquire knowledge on reproductive biology and induced breeding.
2. To understand the metabolism in finfish & shellfish.
3. Knowledge on the process of osmoregulation.

Course Code	Course Title	Total Credits
LScAQT605	**Physiology of Finfish & Shellfish**	**02**
MODULE I **Unit I: Physiology of Finfish (15 L)** Reproduction Reproductive cycles, Reproductive mechanisms, sexual maturity; Environmental and endocrine control of reproduction, spawning and fecundity, physiology. **Induced breeding:** Brood stock availability, methods of natural and artificial fertilization, Evaluation of milt and egg, Egg staging, Stripping and fertilization. **Respiration:** Respiratory organs, respiratory mechanism, respiratory pigments, mechanism of gaseous exchange, accessory respiratory organs. **Excretion and osmoregulation:** Mechanism of excretion, structure of kidney and its functions, osmoregulation in freshwater and marine water finfishes and salt balance. **Digestive system:** Organs, digestive enzymes, process of digestion, absorption and assimilation. **Unit II: Physiology of Shell Fish (15 L)** Reproduction Reproductive cycles, Reproductive mechanisms, sexual maturity; Environmental and endocrine control of reproduction, spawning and fecundity, physiology and techniques of eyestalk ablation. **Induced breeding:** Brood stock availability, Methods of natural and artificial fertilization, Evaluation of milt and egg, Egg staging, Stripping and fertilization. **Respiration:** Respiratory organs, respiratory mechanism, respiratory pigments, mechanism of gaseous exchange, accessory respiratory organs. **Excretion and osmoregulation:** Mechanism of excretion, structure of kidney and its functions, osmoregulation in freshwater and marine water finfishes and salt balance. **Digestive system:** Organs, digestive enzymes, process of digestion, absorption and assimilation.		02

Reference Books:

1. Ujwala Jadhav, 2010. Aquaculture Technology and Environment. Publ. PHI Publication.
2. AyyappanS., 2011. Hand Book of Fisheries and Aquaculture. ICAR.
3. World Aquaculture Society.
4. Ghosh R. 2007. Fish Genetics and Endocrinology. Swastik Publ. & Distr.
5. Hoar W.S., Randall D.J. & Donaldson E.M.M., 1983. Fish Physiology. Vol. IX. Academic Press. 5. Maria RJ, 6. Augustine A & Kapoor BG. 2008. Fish Reproduction. Science Publ.
7. Hour W. S. and D. J. Randal 1976. Fish Physiology. VOL. I to IX Academic Press, New York.

Semester III ELECTIVES

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester III **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Blue Revolution **Total Marks:** 100 **University assessment:** 50 marks

Course Outcomes:

The learner would be able to:

1. Gain insight to blue revolution in India.
2. Relate to the multifaceted approach of blue revolution.
3. Acquire the knowledge onvarious blue revolution schemesin India.
4. Able to apply these schemes to enhance the production and productivity of aquaculture and fisheries.

Course Code	Course Title	Total Credits
LScAQT606a	**Blue Revolution**	**04**
MODULE I Course LScAQT606a T (Credits 2) **Unit I: Blue Revolution in India (15L)** **Status and future perspectives:** Introduction, Father of Blue revolution, Fisheries resources, Capture fisheries. **Aquaculture:** Freshwater aquaculture, Brackish water aquaculture, Mariculture and cage farming, Ornamental fisheries, Harvest, post-harvest processing and seafood trade, Climate change and its impact on fisheries. **Policies and Regulations:** (National Policy on Marine Fisheries 2017 (NPMF 2017),: National Mariculture Policy 2019 (NMP 2019), National Inland Fisheries and Aquaculture Policy 2019 (NIFAP 2019), National Fisheries Policy 2020 (NFP 2020). **Aspects of Blue Revolution:** Capacity building and training of stakeholders, Challenges in the growth of fisheries and aquaculture, Future perspectives and recommendations. The Benefits of a Blue Revolution. **Unit II: Blue Revolution Scheme (15L)** **The Department of Fisheries (DoF), Ministry of Fisheries, Animal Husbandry and Dairying (MFAH&D) Scheme:** Components- National Fisheries Development Board (NFDB) and its activities; Development of inland fisheries and aquaculture; Development of marine fisheries, infrastructure and post-harvest operations ; Strengthening of Database and Geographical Information System of the fisheries sector; Institutional arrangement for fisheries sector; Monitoring, Control and Surveillance (MCS) and other need-based Interventions ; National Scheme of Welfare of Fishermen) **Pradhan Mantri Matsya Sampada Yojna (PMMSY):** objectives: Harnessing of fisheries potential in a sustainable, responsible, inclusive and equitable manner; Enhancing fish		02

production and productivity through expansion, intensification, diversification and productive utilization of land and water; Modernising and strengthening of value chain, post-harvest management and quality improvement; Doubling fishers' and fish farmers' income and generation of employment; Enhancing contribution to Agriculture GVA (Gross Value Added) and exports; Social, physical and economic security for fishers and fish farmers; Robust fisheries management and regulatory framework. Features of the Blue Revolution Scheme.	
Module II Course LScAQT606a P (Credits 2) **Practical:** Assignments and Case studies of the above topics.	02

Reference Books:

1. Latha Shenoy, Shridhar Rajpathak (2021). Sustainable Blue Revolution in India: Way Forward Hardcover.
2. Lakra W. S. and Gopalakrishnan A., 2021. Blue revolution in India: Status and future perspectives Indian J. Fish., 68(1): 137-150.
3. Hassan, M.A., Mishal Puthiyottil, Gunjan Karnatak and Sharma, A.P., (2017). Toward the Blue Revolution in India: Prospects for Inland Open Waters, World Aquaculture 48(1):25-28.
4. FAO (Food and Agriculture Organization of the United Nations) 2014. The State of World Fisheries and Aquaculture 2014. Rome, Italy.
5. Sugunan, V.V., A.P. Sharma and B.C. Jha. 2013. Recent advances in culture based fisheries in India. Pillai Aquaculture Foundation.
6. Nicholas Sullivan The Blue Revolution: Hunting, Harvesting, and Farming Seafood in the Information Age Ebook365 page.

ELECTIVE

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester III **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Ornamental Fish and Aquarium Management **Total Marks:** 100 **University assessment:** 50 marks

Course Outcomes:

The learner would be able to:

1. Gainin-depth knowledge on the breeding and larval rearing of freshwater ornamental fishes.
2. Gain knowledge onaquariums plant management.
3. Develop Technical skillsfor ornamental fish production.
4. Build, design and maintainhome and public aquaria.

Course Code	Course Title	Total Credits
LScAQT606b	**Ornamental Fish and Aquarium Management**	**04**
MODULE I Course LScAQT606b T (Credits 2) **Unit 1: Ornamental Fish Farming (15 L)** Global status of ornamental fish trade, present status and prospects of ornamental fish farming and trade in India, Indian ornamental fish diversity and its status. Marketing strategies, anesthetics, packing and transportation. **Breeding Techniques:** Reproductive biology, Breeding and rearing of Egg-laying and Live-bearing ornamental fishes, Fecundity of ornamental fishes. **Unit II: Aquarium Management (15 L)** **Aquarium fish trade:** Present status, Potential, Major exporting and importing countries. **Aquarium keeping:** Design and construction of tanks, heating, lighting, aeration and filtration arrangements, decoration used, common aquarium plants and their propagation, health and water quality management, prophylaxis, quarantine. **Aquarium species:** Freshwater, marine water and brackish water fish, marketing strategy. **Ornamental plants:** Aquarium plants, general types and description of aquarium/ ornamental plants, primary producers, heterophylly: temperature, hormones, water status. advantage of growing aquatic plants in fish tanks and aquaria. propagation of aquarium plants. **Legislation regarding import of plants:** Relevant topics fromThe Environment Protection Act (1986), The Foreign Trade (Development & Regulation) Act, 1992 No.22 of 1992 Notification No.2 (RE-2006)/2004-2006, The Destructive Insects and Pests Act, 1914 and expot and import procedure in brief.		02
MODULE II Course LScAQT606b P (Credits 2) 1. Identifications of marine & freshwater Ornamental fishes. 2. Identification of common aquarium plants. 3. Aquarium fabrication, setting and maintenance.		02

4. Propagation of selected aquarium plants. 5. Pigment (chlorophyll, carotenes, anthocyanins etc.) evaluation of aquarium plants. 6. Visit to different commercial aquaria.	

Reference Books:

1. Saroj K. Swain, Sarangi N. and Ayyappan S. 2010. Ornamental Fish Farming ICAR.
2. Ayyappan, S., 2011. Handbook of Fisheries and Aquaculture. ICAR.
3. Mary Baily and Gina (2000).Choosing Fish for Your Aquarium: A complete guide to tropical freshwater brackish and marinefishes. Sandford, Anness Publishing Ltd.
4. Axelrod H.R. & Sweenen M.E., 1992. The Fascination of Breeding Aquarium Fishes. TFH.
5. Mills, D., 1981. Aquarium Fishes. Kingfisher Books.
6.Website of government of india ministry of agriculture & farmers welfare department of agriculture & farmers welfare directorate of plant protection, quarantine & storage; https://ppqs.gov.in/divisions/plant-quarantine

ELECTIVE

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester III **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Enzyme Technology **Total Marks:** 100 **University assessment:** 50 marks

Course Outcome:

The learner would be able to:

1. Understand thekinetics of enzyme catalysed reactions.
2. Explain the concept and application of immobilization of enzymes.
3. Learn the purification, characterization and estimation of enzymes.
4. Understand the applications of protein engineering for novel enzyme design.

Course Code	Course Title	Total Credits
LScAQT606c	**Enzyme Technology**	**04**
MODULE I Course LScAQT606c T (Credits 2) **Unit I: Enzyme Kineticsand Applications (15L)** Enzyme Kinetics: Enzyme catalysis and factors contributing to high catalytic rates; Molecular aspectsof catalysis for specific enzyme substrate complexes (Lysozyme, carbonic anhydrase, carboxypeptidaseand chymotrypsin); Multisite binding of ligands to proteins; Bohr's effect; Models of Allostery – MWCand KNF models, Hill's equation coefficient; Kinetics of multi substrate enzyme-catalysed reactions; Ping-pong bi-bi, random order and compulsory order mechanism.Immobilised enzymes: Methods and applications. Enzyme therapy, enzyme inhibitors and drug design; enzymes as biosensors, enzyme reactors; Applications of enzymes in medicine, textile, leather, detergent, paper, bakery, dairy industry, beverage and fruit processing, food processing and preservation, clinical applications of enzyme estimation. **Unit II: Enzyme Technology (15L)** Strategies used for enzyme production, isolation and purification at laboratory and industrial scale from plant, animal and microbial sources, purification fold; estimation of enzyme activity; characterization of an enzyme, criteria of enzyme purity, determination of the molecular weight (MW) and the number of sub-units of an enzyme; Protein Engineering Design and construction of novel proteins and enzymes using site-directedmutagenesis and Random/directed evolution strategies; Conformation of proteins in general andenzymes in particular; Effect of amino acids on structure of proteins; Energy status of a proteinmolecule, Structure- function relations of enzymes.Basic concepts for design of a new protein/enzyme molecule; Specific	02

examples of enzymeengineering – Dihydrofolate reductase and Subtilisin.	
MODULE II Course LScAQT606c P (Credits 2) **Practicals:** 1. Enzyme inhibition a. Inhibition of enzyme activity b. Determination of Ki values 2. Immobilization studies a. Preparation of urease entrapped in alginate beads and determination of percententrapment b. Study of the kinetics of the rate of urea hydrolysis by urease entrapped alginate beads c. Study of reusability and storage stability of urease entrapped alginate beads d. Immobilization of urease by covalent attachment to solid support 3. Protein purification methods: a. Isolation of casein from milk b. Purification of an enzyme by ion exchange chromatography/affinity chromatography c. Use of ammonium sulphate precipitation and dialysis d. Use of gel filtration e. SDS-PAGE 4. Polyacrylamide gel electrophoresis under non-denaturing conditions a. Silver staining b. Activity staining of enzymes c. Determination of effect of acrylamide concentration on the mobility of proteins	02

Reference Books:

1. Bailey JE, Ollis, DF: Biochemical Engineering Fundamentals
2. Blanch HW and Clark DS: Biochemical Engineering Marcel Decker
3. Schugerl K., Bellgart KH (Eds): Biorection Engineering, modeling and control: Springer-Verlag, Berlin.
4. Nicholas C. Price, Lewis Stevens, and Lewis Stevens, Fundamentals of Enzymology: The cell and molecular Biology of Catalytic Proteins by (2000) Publisher: Oxford University Press, USA
5. Alejandro G. Marangoni, Enzyme Kinetics: A modern Approach Book: Enzyme Kinetics: A Modern.
6. Approach, (2003) Publisher: Wiley-Interscience Enzyme Kinetics and Mechanisms by Taylor Publisher: Springer.
7. Christian Müller (Editor), Protein Engineering Protocols (Methods in Molecular Biology) K, Publisher: Humana Press; Softcover reprint of hardcover 1st ed. 2007
8. Anders Liljas, Structural Aspects of Protein Synthesis Publisher: World Scientific Pub Co Inc; 1 edition (November 2004)
9. Wiseman, A: Handbook of Enzyme Biotechnlogy, 3rd Edition, Ellis Horwood Publication.

ELECTIVE

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester III **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Commercially Important Seafood **Total Marks:** 100 **University assessment:** 50 marks

Course Outcomes:

The learner would be able to:

1. Assessthe domesticand internationalSeafood sector.
2. Determine the potential of microalgae for biofuel, food and high value bio-compounds.
3. Evaluate the nutritional value of Seafood.

Course Code	Course Title	Total Credits
LScAQT606d	**Commercially Important Sea Food**	**04**
	MODULE I Course LScAQT606d T (Credits 2) **Unit 1: Seafood (15 L)** Introduction, definition, structure and composition of seafood. **Types of seafood:** Global status, types and commercially important Sea food species (lobsters, crabs, prawn, shrimps, scallops, oysters, squid, octopus, salmon, tuna, etc). Nutrient profile of different types of fish and shellfish (freshwater, marine, brackish), macronutrients, fatty acids, importance of omega-3 fatty acids in diet, fish oils and PUFAs for human health, micronutrients (vitamins, minerals), formulation of fish based diet. **Seafood spoilage:** Spoilage due to autolytic enzyme activity, microbial spoilage, oxidation and hydrolysis. **Unit II: Source to Market (15 L)** **Harvesting Methods:** Gillnetting, longline, purse seiners trolling. **Seafood Preservation Methods:** Use of natural preservatives, high hydrostatic pressure, ozonation of seafood, irradiaton of seafood pulsed electric field processing, retort pouch processing (RPP). **Packaging methods:** Modified atmosphere packaging, selection of packaging materials for map or active packaging. Assessment of food quality and marketing strategy.	02

	MODULE II Course LScAQT606d P (Credits 2) 1. Preparation of fishmeal /fish body oil/ fish liver oil. 2. Preparation of chitin/chitosan. 3. Nutritional content of fresh and preserved Seafood (Carbohydrates/ proteins/ fats). 4. Microbial load of fresh and preserved sea food.	02

Reference Books:

1.Wheaton F.W.& Lawson T.B., 1985. Processing Aquatic Food Products. John Wiley & Sons.
2. Fereidoon Shahidi 2007, Maximizing the value of marine by products, CRC Press Inc. (Florida)
3. Ayyappan, S., 2011. Handbook of Fisheries and Aquaculture. ICAR.
4. Faizal Bux and Yusuf Chisti (2016). Algae Biotechnology: Products and Processes, Springer.
5.Stengel and Connan (2015). Natural Products from Marine Algae: Methods and Protocols. Humana Press.

ELECTIVE

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester III **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Aquatic Waste Product and Its Use **Total Marks:** 100 **University assessment:** 50 marks

Course Outcomes:

The learner would be able to:

1. Acquire knowledge on fish and shellfish processing.
2. Create products from aquatic waste.
3. Develop renewable fuel from aquatic waste.

Course Code	**Course Title**	**Total Credits**
LScAQT606e	**Aquatic Waste Product and Its Use**	**04**
MODULE I Course LScAQT606e T (Credits 2) **Unit 1: Fish Waste (15 L)** **Introduction**: Generation of Fish waste, Types and Applications. **Recovery of products from fish waste & use:** Collagen, Gelatin, Glucosamine, Cartilage of Shark, Astaxanthin, Carotenoids, Chitin, Chitosan and Fish meal in products from waste. **Unit II: Aquatic Waste and By-Products Processing (15 L)** **Fish protein concentrate:** Fish hydrolysate, partially hydrolyzed and deodorized fish meat, functional fish protein concentrate and their incorporation to various products. **Fish silage**: acid silage fermented silage application. **Utilization of seaweeds:** Agar agar, algin, carrageenan. **Fishery By-Products:** Fish maws, shark leather, fish glue, isinglass, pearl essence, shark fin rays, beach-de-mer.		02
MODULE II Course LScAQT606e P (Credits 2) 1. Preparation of fish protein concentrate and fish hydrolysate. 2. Preparation of fish Pearl essence. 3. Preparation of fish Fish glue from fish waste. 4. Preparation of fish Fish Silage from fish waste. 5. Extraction and estimation of Carotenoids from fish waste. 6. Extraction and estimation of crude glucosamine.		02

Reference Books:

1. Ranendra K. Majumdar & Amjad K. Balange, 2022. Advances in Fish Processing Technologies, CRC Press.
2. Gopakumar K. (Ed.). 2002. Text book of Fish Processing Technology. ICAR. 198.
3. Elvevoll EO, Fish waste and functional foods, Norwegian College of Fishery Science, Department of Marine Biotechnology, Norway.

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester III **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name: Research Project I** **Total Marks:** 100 **University assessment:** 50 marks

Course Outcome:

The learner would be able to correlate the theoretical and practical aspects of research. The learner would be able to:

1. Collate, organize and analyse the existing literature in any given field of study.
2. Formulate a hypothesis following literature review.
3. Design a study to prove/ disprove the hypothesis using the tenets of Research Methodology.
4. Design data/ sample collection.
5. Prepare a presentation and appropriately record the studies done in this course.

Course Code	Course Title	Total Credits
LScAQT607	**Research Project I**	**04**

Introduction: This course is designed to extend the concepts capturedin the theory lectures into practical applications and discovery. The learner would be able to identify and organize the existing literature on a given topic and plan experiments to prove a hypothesis. The research project is aimed to enhance research temper in the learner. The learner would be able to formulate a hypothesis and design a research project using the concepts of research methodology. The learner would be able to effectively document and present the parameters of the research project. What is required: There are four credits assigned to the course. As this is of a practical and hands-on nature, every two hours spent on the project in a week would earn a credit. The course spans over 15 weeks and hence the time that needs to be devoted would be 120 hours. This could be planned and completed over a span of 15 weeks or continuously 4 - 5 weeks. Where can these projects be done: The projects could be conducted in-house or could be in industry or research institutes or recognized institutes that carry out research. The host institution would be from any field of Life Sciences. The project would be carried out with the consent and understanding between the thetheUDLSc and the relevant Academic/ research Institute or the Industry Documentation for the Research Project I: The proforma for internal evaluation by the mentor (at the place of work) is given at the end of the syllabus. This evaluation along with a thesis submission would be proportionately added for the calculation of the internal marks. The scheme for the same is given at the end of the syllabus. A draft paper of the project and its presentation would be evaluated by external examiners as the external evaluation. The relevant weightages are given at the end of the document. The reports will be governed by the plagiarism rules as dictated in the document No. Th./ICD/2018 – 19/ 448	04

Sem. - IV

M.Sc. (Life Sciences – Aquaculture Technology)
(Semester - IV)

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester IV **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Fish Products and Quality Assurance **Total Marks:** 100 **University assessment:** 50 marks

Course Outcomes:

The learner would be able to:

1. Gain Knowledge on fish processing technology.
2. Demonstratethe process of value addition and quality fishery products.
3. Perceive the nutritional value of fishery products.
4. Comprehendthequality indicators in fishes.

Course Code	Course Title	Total Credits
LScAQT608	**Fish Products and Quality Assurance**	**04**
MODULE I **Unit 1: Fish Processing Technology (15 L)** **Introduction:** Causes of fish spoilage; principles of fish preservation, importance of processing; handling of fish and transportation. traditional methods of fish processing (icing, drying, salting, smoking, pickling, fermentation). post-mortem changes in fish. structural and chemical features of fish and shellfish as raw material for processing. factors affecting quality of fresh fish- intrinsic and extrinsic factors. On board handling of fish, landing centers and farm sites-different types of chilling methods, depuration of bivalves. **Unit II: Value Addition & Fish Products Development (15 L)** **Value addition:** Definition, shelf life, scope of value addition, present market trends, surimi, protein deficiency and need for fortification of food. digestibility and nutritive value of fish meat. **Value Added Fishery Products:** Types: 1. Battered and breaded products 2. minced based products, equipment for mince preparation, effect of mincing on physical and chemical properties 3. Fermented products. 4. Ready-to-eat and ready-to-cook products- Extruded fish products: Mechanism of extrusion, types of extruders: single screw, twin screw, mechanical and chemical changes during extrusion, parameters affecting quality of extruded product, cook-chill process. **Colour Enhancement in Fish:** Colour enhancers- Carotenoids, Different colour obtained by different pigments.		02
MODULE II **Unit III: Traditional Fishery Products (15 L)** **Principles of drying and dehydration:** Kinetics of drying, psychometrics, drying calculation, constant rate and falling rate, drying time in air, moisture transport mechanism, natural drying,		02

solar drying and mechanical drying, different types of dryers, tunnel drier, vacuum drier, drum drier, solar drier, etc. Dehydration of fish products: dehydration ratio, precautions to be taken in fish drying; Denaturation of fish protein, Spoilage of dried/cured fish, physical, chemical and microbiological changes, methods to prevent/control spoilage, extension of shelf life. Free and bound water in foods, water activity and sorption behaviour of foods, storage characteristics, microbial spoilage, effects of water activity on chemical deterioration, enzymatic reaction, non-enzymatic browning, lipid oxidation, reaction between lipids and proteins, dry fish, control of micro-organisms. **Unit IV: Quality Assurance & Management (15 L)** **Fish Inspection & Quality Assurance:** Fish inspection in India, process water quality in fishery industry, product quality, water analysis, treatments, chlorination, ionization, UV radiation, reverse osmosis, techniques to remove pesticides and heavy metals. physical, chemical, organoleptic and microbiological quality standards. Sensory evaluation of fish and fish products: basic aspects, different methods of evaluation, taste panel selection & constitution, statistical analysis, poisoning by chemicals: heavy metals, pesticides, non-metals, occurrence in food and toxic effects; Biological toxins occurring in seafoods: scombroid poisoning, histamine problem, shellfish poisoning, ciguatera poisoning, puffer fish poison. Food laws in India, integrated food law (FSSAI), Hazard Analysis and Critical Control Point (HACCP).	

Reference Books:

1. Ranendra K. Majumdar & Amjad K. Balange 2022. Advances in Fish ProcessingTechnologies, CRC Press.
2. Venugopal V., 2006. Seafood Processing. Taylor & Francis.
3. Balachandran K. K., 2001. Post-harvest Technology of Fish and Fish Products. Daya Publication House.
4. Gopakumar K. (Ed.). 2002. Text Book of Fish Processing Technology. ICAR. 198 3.
5. Sen D. P., 2005. Advances in Fish Processing Technology. Allied Publ.
6. Wheaton F. W.& Lawson T.B. 1985. Processing Aquatic Food Products. John Wiley & Sons.
7. Hall G.M., 1992. Fish Processing Technology. Blackie.
8. Oefjen G, Wilhelm H.& Peter., 2004. Freeze Drying. Wiley-VCH GmbH & Co.
9. Assessment and Management of Seafood Safety and Quality. (2003) Free amino acids Technical Paper No. 444
10. Food borne Disease Handbook. IInd Edn. (2001) Vol.4: Seafood and Environmental Toxins, Marcel Dekker Inc New York
11. Handbook of Natural toxins - Vol 3. Marine Toxins and Venom. 1988. Marcel Dekker Inc. New York.

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester IV **Total Credits:** 02 **Department assessment:** 25 marks	**Course Name:** Fish Products and Quality Assurance Practicals **Total Marks:** 50 **University assessment:** 25 marks

Course Outcome :

The learner would be able to:

1. Gain insight into preparation of fish products.
2. Evaluate the quality of the fish products.
3. Summarize the nutritional value of the fish products.

Course Code	Course Title	Total Credits
LScAQT609	**Fish Products and Quality Assurance Practicals**	**02**
MODULE I 1. Proximate composition of different fish and fishery products. 2. Estimation of TMA in fresh and dried fish. 3. Estimation of TVBN in fresh and dried fish. 4. Estimation of salt content in dried fish. 5. Preparation of value-added products from low-cost fishes. 6. Physico-chemical analysis of fish and fishery product. 7. Estimation of protein in cured products. 8. Estimation of moisture in dried/cured products.		02

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester IV **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Aquaculture Drugs and Pharmacological Studies **Total Marks:** 100 **University assessment:** 50 marks

Course Outcomes:

The learner would be able to:

1. Comprehend the drug development process and potential of marine environment as source of next generation drugs.
2. Discuss the importance of aquaculture drugs in the human health.
3. Utilize marine therapeutic drugs in the prevention and cure of fish and shellfish diseases.

Course Code	Course Title	Total Credits
LScAQT610	**Aquaculture Drugs and Pharmacological Studies**	**04**
MODULE I **Unit I: Drug Discovery in Aquaculture (15 L)** Introduction, approaches in drug discovery, classical approaches - target based drug discovery, mechanism based drug discovery, physiology based and functional based; new approaches in drug discovery; high throughput screening, ultra-high –throughput screening and high content screening; drugs with target specific; reduction in the non-targeted activity. aquaculture and veterinary drugs, market authorization and control. **Unit II: Marine Drugs, Their Development & Delivery (15 L)** **Marine pharmaceuticals:** Drugs approved by FDA; drugs approved by EMEA; mechanisms of action; adverse reaction; targeted delivery of drugs; polymer based nano-particle for marine derived drugs; chitosan PHB, surface modification of nanoparticles. Developmental cycle of drugs discovery, development of new drugs. in vitro screening systems; *in vivo* pharmacokinetics; pharmacodynamics; animal models of disease states; adverse drug reactions; basics of clinical trials, drug approval process, post marketing safety surveillance (PMS) & safety alerts.		02
MODULE II **Unit III: Marine Pharmacognosy (15 L)** Source of drugs; medicinal and aromatic plants; pharmacological potential of marine plants and animal; microorganisms, actinomycetes; endosymbiotic microorganisms, sponges, tunicates, mollusks, cyanobacteria, algae, seaweeds. drugs against multiple antibiotic resistance bacteria, antiviral drugs; drugs targeting cancer cells; drugs against diabetics, neurodegenerative diseases. **Pharmaceutical legislation and regulation:** Basic scenario introduction to the leading international instruments concerning intellectual elements of national pharmaceutical legislation, medicine registration, licensing, and marketing authorization, drug control authority. **Unit IV: Marine derived Nutraceuticals (15 L)** **Marine-Derived Nutraceuticals:**Introduction, nutritional value of seaweeds, algae; omega-3 polyunsaturated fatty acids, glucosamine; chitin and chitosan, marine polysaccharides, fucoidans, marine pigments, astaxanthine, functional and bioactive peptides; carrageenans; cosmetics.		02

Reference Books:

1. Benjamin Blass. Basic Principles of Drug Discovery and Development; ISBN: 978- 0-12-411508-8; Academic Press.
2. Dean Martin (Ed) Marine Pharmacognosy: Action of Marine Biotoxins at the cellular level
3. Marine Nutraceuticals and Functional Foods. Colin Barrow, Fereidoon Shahidi, ISBN 9781574444872 –CRC press.
4. Charles G. Smith, James T. O'Donnell Ed, The Process of New Drug Discovery and Development, Second Edition, CRC Press ISBN 9780849327797.
5. John P. Griffin John Posner Geoffrey R. Barker, The Textbook of Pharmaceutical Medicine, 7th Edition, ISBN: 978-0-470-65987-8, BMJ Books.

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester IV **Total Credits:** 02 **Department assessment:** 25 marks	**Course Name:** Aquaculture Drugs and Pharmacological Studies Practicals **Total Marks:** 50 **University assessment:** 25 marks

Course Outcome:

The learner would be able to:

1. Evaluate various medicinal properties of aquaculture drugs.
2. Determine the toxicity of a drug at molecular level.
3. Gain insight into the clinical trial procedure.

Course Code	Course Title	Total Credits
LScAQT611	**Aquaculture Drugs and Pharmacological Studies Practicals**	**02**
MODULE I 1. Detemination of Antioxidant activityof marine derived compounds. 2. Detemination of Anti-diabetic activityof marine derived compounds. 3. Estimation ofAnti -inflammatory activityof marine derived compounds. 4. Detemination of Antiglycatingactivityof marine derived compounds. 5. Determine the toxicity of marine derived compounds using DNA aberrationassay. 6. Case study of clinical trial on a popular marine drug in the market.		02

SEMESTER IV ELECTIVES

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester IV **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Commercial Pearl Production Process **Total Marks**: 100 **University assessment:** 50 marks

Course Outcomes:

The learner would be able to:

1. Create awareness on pearl culture.
2. Evaluate pearl quality.
3. Identify pearl producing species in India.

Course Code	Course Title	Total Credits
LScAQT612a	**Commercial Pearl Production Process**	**04**
MODULE I Course LScAQT612a T (Credits 2) **Unit I: Pearl Producing Species (15 L)** Introduction, **Pearl producing marine oysters:***Pinctada fucata, P. margaritifera, P. chemnitzii, P. sugillata, P. anomioides, P. atropurpurea* **Important freshwater pearl producing mussels in India:***Lamellidens marginalis, L. corrianus, Parreysia corrugata.* Life cycle of pearl oyster and freshwater pearl mussel, economy of freshwater pearl culture. **Unit II: Pearl Culture (15 L)** Introduction, importance of pearls, mechanism of pearl formation, scientific background & historical belief. **Pearl Types:** Natural and artificial pearls. **Pearl Culture Technology:** Freshwater pearl culture (collection of mussels and transportation, selection of mussel, process of implantation, preparation of graft for implantation), pearl oyster culture/marine pearl culture, pearl grading.		02
MODULE II Course LScAQT612a P (Credits 2) 1. DNA isolation from mantle tissue and its quantification. 2. Genetic variation of bivalves using RAPD/RFLP. 3. Phylogenetic analysis of pearl producing bivalves. 4. Identification of commercially important freshwater pearl producing Bivalve. 5. Identification of commercially important Sea water Oyster. 6. Dissection of commercial bivalve. 7. Pearl Grading (Demonstration).		02

Reference Books:

1. Ujwala Jadhav, 2010. Aquaculture Technology and Environment. Publ. PHI Publication.
2. Ayyappan, S., 2011. Handbook of Fisheries and Aquaculture. ICAR.

ELECTIVE

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester IV **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Aquaponics and Aquatic Engineering **Total Marks:** 100 **University assessment:** 50 marks

Course Outcomes:

The learner would be able to:

1. AcquireSufficient knowledge of the different systems of aquaculture including recent techniques like aquaponics.
2. Easily substantiate on recent trends in aquaculture engineering.
3. Engage in a successful design andconstructionof aquaculture farm.
4. Easily focus on the various equipments required for anaquafarm.

Course Code	Course Title	Total Credits
LScAQT612b	**Aquaponics and Aquatic Engineering**	**04**
MODULE I Course LScAQT612b T (Credits 2) **Unit I: Aquaponics and Aquafarm Machinery (15 L)** **Aquaponics:** Introduction, design, principle, components, fish, plant & water quality, maintenance. **Aquafarm Machinery: Pumps:** Types, working, maintenance, application in aqua farms, operation and maintenance aspects - selection of pumps for the aquafarms. **Aeration system:** Principle, classification, aeration process in aqua farm and maintenance, types of aerators and their application in aqua farms, operation and maintenance. **Filter system:** Introduction, principle of filtration, types, rate of filtration, construction and their maintenance. advantages & disadvantages. **Boat:** Introduction of different types of boat & motors. **Feeders:** Types & maintenance. **Unit II: Aquaculture Engineering (15 L)** Introduction, classification of aquaculture (Extensive, intensive and semi-intensive). **The farm: Technical Components in a System** 1. Land-based hatchery and juvenile production farm: water inlet and transfer, water treatment facilities, production units, feeding equipment, internal transport and size grading, transport		02

of fish, Equipment for waste handling and wastewater treatment, instrumentation and monitoring, 2. On-growing sea cage farm: necessary components (production units, feeding equipment, working boat, equipment for size grading, base station). **Future Trends:** increased importance of aquaculture engineering.	
MODULE II Course LScAQT612b P (Credits 2) 1. Study of aquarium Aeration system (demonstration). 2. Study of aquarium Filtration system (demonstration). 3. Identification of fishing materials. 4. Study components and design of aquaponics. 5. Estimation of ammonia/ nitrate/ phosphate content in fish tank water.	02

Reference Books:

1. Sylvia Bernstein, 2011. Aquaponic Gardening- A step by step guide to raising.
2. Raju, V.T., Shankerrao, oxford & ibh, 2017. Economics of farm production & management, paperback.
3. Bimal Chandra Mal, 2021. Aquacultural facilities & equipment, Elsevier.
4. Ayyappan, S., 2011. Handbook of Fisheries and Aquaculture. ICAR.
5. Tripathi, S.D., Lakra, W.S. & Chadha, N.K., 2018. Aquaculture in India, Narendra Publishing House.
6. Odd-Ivar Lekang (2013). Aquaculture Engineering, Second Edition A John Wiley & Sons, Ltd., Publication.
7. Lekang, O. I. & Fjæra, S.O. (1997) Teknologi for Akvakultur. Landbruksforlaget, Oslo (in Norwegian).
8. Lekang, O. I. & Fjæra, S.O. (2002) Teknisk Utstyr til Fiskeoppdrett. Gan forlag, Oslo (in Norwegian).

ELECTIVE

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester IV **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Fish Nutrition and Feed Technology **Total Marks:** 100 **University assessment:** 50 marks

Course Outcomes:

The learner would be able to:

1. Acquire knowledge on the importance of nutrition.
2. Understand the food and feeding habits
3. Acquire knowledge on feed composition.
4. Know the importance of supplementary feeds.

Course Code	Course Title	Total Credits
LScAQT612c	**Fish Nutrition and Feed Technology**	**04**
MODULE I Course LScAQT612c T (Credits 2) **Unit I: Fish Nutrition (15 L)** **Fish nutrition:** Principles of fish nutrition and terminologies, role of nutrients: amino acids, fatty acids, proteins, lipids, carbohydrates, vitamins and minerals. nutritional requirements of cultivable finfish and shellfish. **Larval fish nutrition:** Nutritional requirements of fish and shellfish larvae, quality requirements of larval feeds (particle size, digestibility), natural food and its importance in aquaculture, nutritional quality of commonly used fish food organisms (bacterioplankton, phytoplankton and zooplankton) and their roles in larval nutrition. antinutritional factor, nutrient deficiency and symptoms. **Unit II: Food and Feeding Technique (15 L)** **Types of feeds:** Feed ingredients used and proximate composition, feed formulation, pelleted diet preparation, live-food, feeding of larvae, storage of prepared feed, overfeeding and underfeeding. **Feed formulation:** Conventional and non-conventional feedstuffs, feed formulation technology, growth promoting agents in aqua feed.		02
MODULE II Course LScAQT612c P (Credits 2) 1. Determination of Moisture content of feeds. 2. Determination of Ash content of Feeds. 3. Estimation of Vitamin C from feed ingredients. 4. Formulation of fish feed. 5. Proximate composition (lipid/ protein/ carbohydrate/ crude fibre) analysis of feed ingredients and feeds.		02

Reference Books:

1.Baton Roughe, De Silva S.S. & Anderson T.A. 1995. Fish Nutrition in Aquaculture. Chapman & Hall Aquaculture Series.
2. Halver J. & Hardy R.W. 2002. Fish Nutrition. Academic Press.
3. Halver J.E. & Tiews K.T. 1979. Finfish Nutrition and Fish feed Technology. Vols. I, II Heenemann, Berlin.
4. Ujwala Jadhav (2010). Aquaculture Technology and Environment. Publ. PHI Publication
5. Ayyappan, S. (2011). Handbook of Fisheries and Aquaculture. ICAR
6. Saroj K. Swain, Sarangi N. and Ayyappan S. 2010. Ornamental Fish Farming ICAR.
7. Ojha J.S., 2005. Aquaculture Nutrition and Biochemistry. Daya Publication.

ELECTIVE

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester IV **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Fish Breeding and Hatchery Management **Total Marks:** 100 **University assessment:** 50 marks

Course Outcomes:

The learner would be able to:

1. Acquire in -depth knowledge on the reproductive biology, induced breeding.
2. Demonstrate the larval rearing offinfishes and shellfishes.
3. Developtechnical skills to managecommercial unitsand hatcheries.
4. Demonstrable skills on the design of fish hatcheries.

Course Code	Course Title	Total Credits
LScAQT612d	**Fish Breeding and Hatchery Management**	**04**
MODULE I Course LScAQT612d T (Credits 2) **Unit I: Reproductive biology and Induced breeding of Finfishes & Shellfishes (15 L)** **Finfishes Gamete maturation and development:** spermatogenesis and oogenesis, environmental and endocrine control of reproduction: reproductive cycles, induced breeding: brood stock availability, methods of natural and artificial fertilization, evaluation of milt and egg, cryopreservation technique, use of different synthetic hormones and analogues for induced breeding, eggstaging, stripping and fertilization. **Shellfishes (Prawns):** Reproductive biology and reproductive mechanisms in prawns. Age at first maturity; factors affecting maturation and spawning. **Broodstock:** Availability; improvement; nutritional requirements; transport; captive rearing and maturation; induced spawning; physical and chemical inducing agents; physiology and techniques of eyestalk ablation. **Unit II: Present Status of Seed Production and Hatchery Management (15 L)** **Present status of seed production:** Introduction, history, constraints and current status of natural seed collection and hatchery seed production of finfishes and shellfishes. **Hatchery Design and Management:** Introduction, criteria for site selection of hatchery and nursery, design and function of incubators, Jar hatchery, Chinese hatchery and other hatchery systems- design and operation, hatchery protocols, larval rearing stages, rearing technology, packaging and transport of seed.		02
MODULE II Course LScAQT612d P (Credits 2) 1. Eyestalk ablation technique of shrimp/prawn. 2. To study histological changes in the liver/gonads of fish. 3. Cryopreservation of fish and shellfish gametes (Demonstration). 4. Collection and identification of cultivable brackishwater finfish.		02

5. Packing and transportation of cultivable finfish seed. 6. Visit to different finfish hatcheries.	

Reference Books:

1. FAO. 1992. Manual of Seed Production of Carps. FAO Publ.
2. Ayyappan, S.,2011. Handbook of Fisheries and Aquaculture. ICAR.
3. Jhingran V.G.& Pullin R.S.V., 1985. Hatchery Manual for the Common, Chinese and Indian Major Carps. ICLARM, Philippines.
4. Jhingran V.G. 1991. Fish and Fisheries of India. Hindustan Publ.
5. Landau M., 1992. Introduction to Aquaculture. John Wiley & Sons.
6. Mcvey J.P., 1983. Handbook of Mariculture. CRC Press.
7. Pillay T.V.R.& Kutty M.N., 2005. Aquaculture- Principles and Practices. Blackwell.
8. Rath R.K., 2000. Freshwater Aquaculture. Scientific Publ.
9. Thomas P.C., Rath S.C.& Mohapatra K.D., 2003. Breeding and Seed Production of Finfish and Shellfish. Daya Publ. AQC.
10. CMFRI Bulletin. 1987. National Seminar on Shellfish Resources and Farming.
11. FAO. 2007. Manual for Operating a SmallScale Recirculation Freshwater Prawn Hatchery.
12. Ujwala Jadhav (2010): Aquaculture Technology and Environment. Publication, PHI Publication.
13. Bardach E.J., Rhyther J.H.& Mc Larney WO., 1972. Aquaculture. The Farming and Husbandry of Freshwater and Marine Organisms. John Wiley & Sons.
14. Chakraborty C.& Sadhu A.K., 2000. Biology Hatchery and Culture Technology of Tiger Prawn and Giant Freshwater Prawn. Daya Publ. House.
15. Diwan A.D., Joseph S & Ayyappan S., 2008. Physiology of Reproduction, Breeding and Culture of Tiger Shrimp. Narendra Publ. House.
16. Gilbert B., 1990. Aquaculture. Vol. II. Ellis Harwood.

ELECTIVE

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester IV **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name:** Seaweed Culture & Its Economic Importance **Total Marks:** 100 **University assessment:** 50 marks

Course Outcomes:

The learner would be able to:

1. Acquire knowledge on seaweed culture and its economically important species.
2. Create awareness on Seaweed uses in industrial sectors.
3. Appreciate therole of seaweeds in environment sustainability.

Course Code	Course Title	Total Credits
LScAQT612e	**Seaweed Culture & Its Economic Importance**	**04**
MODULE I Course LScBT612e T (Credits 2) **Unit I: Practice of Cultivating and Harvesting of Seaweed (15 L)** **Seaweed Culture:** Introduction, present status of seaweed culture in India. site selection, design of culture ponds and transplanting; determining growth pattern and environmental monitoring, problems and prospects. major seaweed species of commercial importance, methods of culture, seaweed cultivation in coastal area of India for small scale fisheries. constraints in seaweed culture. **Culture Methods:** Line farming, net farming, raft cultivation, culture in ponds, bottom culture on coral stones. **Unit II: Economic Importance of Seaweed Culture (15 L)** **Commercially important products obtained from seaweeds:** agar, alginate, carrageenan, chemical composition of seaweeds; processing and extraction of agar, alginic acid, mannitol and carrageenan. **Important uses of seaweeds:** In medicines, as food additives, as fertilizer, in cosmetic industry, in the wastewater treatment, for human consumption, as soil conditioners.		02
MODULE II Course LScBT612e P (Credits 2) 1. Identification of different seaweeds. 2. Chlorophyll estimation from seaweeds. 3. Effect of seaweed extract on growth rate of a suitable plant material. 4. Estimation of iodine content of seaweed. 5. Phytochemical analysis ofseaweed.		**02**

ReferencesBooks:

1. Bird, K.T. and Benson, P.H., 1987. Seaweed Cultivation for Renewable Resources. Elsevier Science

Publishers, New York. Chapman,
2. A.R.O., 1992. Fourteenth International Seaweed Symposium. Kluwer Academic Press, London
3. Chapman, V. J. and Chapman D. J., 1980. Seaweed and their uses. Methuen & Co., London. CMFRI (Central Marine Fisheries Research Institute), 1987.
4. Seaweed research and utilization in India. CMFRI Bulletin No. 41, CMFRI, Cochin, India. FAO (Food & Agriculture Organization), 1975.
5. Ujwala Jadhav, 2010. Aquaculture Technology and Environment. Publ. PHI Publication.
6. Ayyappan, S.,2011. Handbook of Fisheries and Aquaculture. ICAR.

Programme Name: M. Sc. Life Sciences – Aquaculture Technology Semester IV **Total Credits:** 04 **Department assessment:** 50 marks	**Course Name: RESEARCH PROJECT II** **Total Marks:** 100 **University assessment:** 50 marks

Course Outcome:

The learner would be able to:

1. Analyze and determine the lacunae of the existing literature in any given field of study.
2. Formulate a hypothesis based on a focussed literature review.
3. Use the tenets of research methodology to design an effective research study.
4. Demonstrate the actual execution of the research design
5. Highlight the weaknesses and strengths of the study.
6. Prepare a presentation and appropriately record the studies done in this course.

Course Code	Course Title	Total Credits
LScAQT613	**RESEARCH PROJECT II**	**06**
Introduction This course is designed to extend the concepts in Research Methodology to address a lacuna in the existing knowledge in a particular area of the discipline of Life Sciences. The learner would be able to identify and organize the existing literature on a given topic, formulate a hypothesis, design a research project and plan experiments to prove a hypothesis. The research project is aimed to enable the researcher to conduct scientifically designed experiments for a meaningful assessment and conclusion of the observations and results. The learner would be able to effectively document and present the parameters and findings of the research project. There are six credits assigned to the course. As this is of a practical and hands-on nature, every two hours spent on the project in a week would earn a credit. The course spans over 15 weeks and hence the time that needs to be devoted would be 180 hours. This could be planned and completed over a span of 15 weeks or continuously 6 - 8 weeks. Where can these projects be done: The projects could be conducted in-house or could be in industry or research institutes or recognized institutes that carry out research. The host institution would be from any field of Life Sciences. The project would be carried out with the consent and understanding between the University Department of Life Sciences and the relevant Academic/ research Institute or the Industry Documentation for the Research Project II: The proforma for internal evaluation by the mentor (at the place of work) is given at the end of the syllabus. The formulation of the project, the application and attendance of the learner would be evaluated on a continuous basis. This would be the backbone of the internal assessment. The scheme for the same is given at the end of the syllabus. The submitted thesis of the project, a draft research paper based on the results obtained in Research Project II and its presentation would be evaluated by external examiners The		06

relevant weightages are given at the end of the document. The reports will be governed by the plagiarism rules as dictated in the document No. Th./ICD/2018 – 19/ 448.	

EVALUATION SCHEME

Evaluation: SEMESTER III

Paper Code	Theory		Practical		Total
	Internal	External	Internal	External	
LSc601	50	50			100
LSc602			25	25	50
LSc603	50	50			100
LSc604			25	25	50
LSc605	25	25			50
LSc606 (Electives: a to e)	25	25	25	25	100
LSc607 (ResearchProject I)	Evaluation scheme at the end of the Document				100

Evaluation: SEMESTER IV

Paper Code	Theory		Practical		Total
	Internal	External	Internal	External	
LSc608	50	50			100
LSc609			25	25	50
LSc6010	50	50			100
LSc611	25	25			50
LSc612 (Electives: a to e)	25	25	25	25	100
LSc613 (ResearchProject II)	Evaluation scheme at the end of the Document				100

A. Evaluation for Mandatory Theory Courses (4 Credit Courses)

I. Internal Evaluation for Mandatory Theory Courses: 50 Marks

The internal evaluation for mandatory theory courses comprises two components, each carrying a specific weightage. Students can choose between the following options to fulfil the evaluation requirements:

Option 1: (i) The course teacher will have the liberty to choose the assessment tools/ methods (class test/assignment/record book/tutorials/seminars/case study/ field work/ project work/ quiz/ etc.) – 50 marks.

Option 2: (i) Completion of SWAYAM (Advanced Course) of minimum 2 credits and certification exam - 50 Marks

Option 3: (i) Completion of NPTEL (Advanced Course) of minimum 2 credits and certification exam - 50 Marks

Option 4: (i) Possession of valid International Certifications from recognized providers such as Prometric, Pearson, Certiport, Coursera, Udemy, or similar platforms - 50 Marks

Note: It's important to note that each certification will be awarded marks for only one course. For example, if a student completes four courses, they will need to obtain four different certifications to fulfil the certification marks requirement for each course.

II. External Examination for Mandatory Theory Courses- 50 Marks

- Duration: **2.0 Hours**
- Theory question paper pattern:

	All questions are compulsory.		
Question	**Based on**	**Options**	**Marks**
Q.1	Unit I	Any 1 out of 2 (1 or 1 a, b)	10
Q.2	Unit II	Any 1 out of 2 (2 or 2 a, b)	10
Q.3	Unit III	Any 1 out of 2 (3 or 3 a, b)	10
Q.4	Unit IV	Any 1 out of 2 (4 or 4 a, b)	10
Q.5	Unit I, II, III& IV	Any 4 out of 8 (short notes)	10

B. Evaluation for Elective Theory Courses (4 Credit Courses)

Evaluation for Elective Theory Courses (2 Credit Courses)

I. Internal Evaluation for Elective Theory Courses: 25 Marks

The internal evaluation for elective theory courses consists of two components, each carrying a specific weightage. These components are as follows:

The course teacher will have the liberty to choose the assessment tools/ methods (class test/assignment/record book/tutorials/seminars/case study/ field work/ project work/ quiz/ etc.) – 50 marks.

II. External Examination for Elective Theory Courses- 25 Marks

- Duration: **1 Hour**
- Theory question paper pattern:

	All questions are compulsory.		
Question	**Based on**	**Options**	**Marks**
Q.1	Unit I	Any 1 out of 2 (1 or 1 a, b)	10
Q.2	Unit II	Any 1 out of 2 (2 or 2 a, b)	10
Q.3	Unit I & II	Any 2 out of 4 (short notes)	5

C. Evaluation for Mandatory & Elective Practical Courses (2 Credit Courses)

The evaluation for both mandatory and elective practical courses is conducted according to the following criteria:

- Each practical course carries a **total of 50 Marks**, distributed as follows:
  - University Assessment: 25 Marks for practical performance (1 question of 15 marks, spot tests for 5 marks and viva for 5 marks)
  - Departmental Assessment: 5 Marks for the journal, 5 marks for attendance, 5 marks for participation and 10 marks for viva – total 25 marks.
  - The duration of each practical course is 6 to 8 hours.
- To be eligible for evaluation, students must complete a minimum of 80% of the practical work assigned in each core subject.
- It is mandatory for students to submit a certified journal at the time of the practical examination. The journal serves as a record of their practical work and is an essential component of the evaluation process.

Evaluation of Research Project Work I (4 Credit Course):

(Proforma for the Evaluation of the learner by the industry mentor /to whom the learner was reporting in the organization)

Internal Evaluation (by the institution/ at place of Internship by Mentor): 50 Marks

No	Particular	Excellent	Very Good	Good	Moderate	Satisfactory
1	Attendance & Punctuality					
2	Ability to work in a team					
3	Written and oral communication skills					
4	Problem solving skills					
5	Ability to grasp new concepts					
6	Technical skill in terms of technology, programming, etc					
7	Ability to complete tasks					
8	Quality of overall work done					
9	Time management*					
10	Critical thinking*					

- **Time Management:** Evaluating the ability to effectively manage time and meet deadlines.
- **Critical Thinking:** Assessing the ability to analyze information, evaluate options, and make reasoned decisions.

- **Patterns of Marks: out of 50 as per marks obtained in each of the 10 categories**

Excellent	Very Good	Good	Moderate	Satisfactory
5	4	3	2	1

Comments:_____

Signature: _____

Name:

Designation:

Contact details:

Email:

(Seal of the organization)

Research Project (I): Total Marks = 100.
Internal Assessment: 50 mks.
Thesis submission and evaluation along with Feedback From the organization: 25 mks
Viva: by an Internal Committee (2 members): 25 mks.

External Assessment: 50 mks.
Draft Paper submission: 25 mks
Presentation: 25 mks.

D. Evaluation of Research Project Work II (6 Credit Course):

(Proforma for the Evaluation of the learner by the industry mentor /to whom the learner was reporting in the organization)

Internal Evaluation (by the institution/ at place of Internship by Mentor): 50 Marks

No	Particular	Excellent	Very Good	Good	Moderate	Satisfactory
1	Attendance & Punctuality					
2	Ability to work in a team					
3	Written and oral communication skills					
4	Problem solving skills					
5	Ability to grasp new concepts					
6	Technical skill in terms of technology, programming, etc					
7	Ability to complete tasks					
8	Quality of overall work done					
9	Time management*					
10	Critical thinking*					

- **Time Management:** Evaluating the ability to effectively manage time and meet deadlines.
- **Critical Thinking:** Assessing the ability to analyze information, evaluate options, and make reasoned decisions.

- **Patterns of Marks: out of 50 as per marks obtained in each of the 10 categories**

Excellent	Very Good	Good	Moderate	Satisfactory
5	4	3	2	1

Comments:_____

Signature: _____

Name:

Designation:

Contact details:

Email:

(Seal of the organization)

Research Project (II): Total Marks = 150.

Internal Assessment: 75 mks

- Research Proposal: 25 mks
- Progress evaluation by internal committee or along with Feedback from the organization: 25
- Attendance: 25

External Assessment: 75 mks.

- Thesis submission and evaluation: 25
- Draft paper/ Presentation: 25
- Viva: 25

Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result
9.00 - 10.00	90.0 - 100	O (Outstanding)
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)
5.00 - < 5.50	50.0 - < 55.0	C (Average)
4.00 - < 5.00	40.0 - < 50.0	P (Pass)
Below 4.00	Below 40.0	F (Fail)
Ab (Absent)	-	Absent

Appendix-I

Maintain the weekly online diary for each week in the following format.

	Day	Date	Name of the Topic/Module Completed	Remarks
1st WEEK	Monday			
	Tuesday			
	Wednesday			
	Thursday			
	Friday			
	Saturday			

Signature of the Faculty mentor: _____

Seal of the University Department

Appendix-II

(Proforma for the certificate for internship in official letter head)

This is to certify that Mr. /Ms. ……..... of University Dept of Life Sciences worked as an intern as part of his/her M.Sc. course in Life Sciences of University of Mumbai. The particulars of internship are given below:

Internship starting date: _____

Internship ending date: _____

Actual number of days worked: _____

Tentative number of hours worked:_____Hours

Broad area of work: _____

A small description of work done by the intern during the period:

Signature: _____

Name:

Designation:

Contact details:

Email:

(Seal of the organization)

Appendix-III

(Proforma for the certificate for Project Work in official letter head)

This is to certify that Mr. /Ms. ……..... of University Dept of Life Sciences worked as an Project Student as part of his/her M.Sc. course in Life Sciences of University of Mumbai. The particulars of internship are given below:

Project Work starting date: _____

Project Work ending date: _____

Actual number of days worked: _____

Tentative number of hours worked:_____Hours

Broad area of work: _____

A small description of work done by the Project Student during the period:

.

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Signature: _____

Name:

Designation:

Contact details:

Email:

(Seal of the organization)

Team for Creation of Syllabus (M. Sc. Life Sciences - Biotechnology)

Name	College Name	Sign
Prof. Indu Anna George	Department of Life Sciences, University of Mumbai	
Dr. Tejashree Shanbag	Principal, K.C. College, HSNC University	
Dr. Prashant Ratnaparkhi	Head, Department of Life Science, St. Xaviers College	
Prof. Priya Sundarrajan	Department of Life Science, St. Xaviers College	
Dr. Nilima Gajbhiye	Department of Life Science, Ramnarain Ruia College	
Dr. Kanchan Chitnis	Department of Life Science, Ramnarain Ruia College	
Dr. Ahmad Ali	Department of Life Sciences, University of Mumbai	
Dr. Suruchi Jamkhedkar	Department of Life Sciences, University of Mumbai	
Dr. Nisha Shah	Department of Life Sciences, University of Mumbai	
Dr. Hina Alim	Department of Life Sciences, University of Mumbai	
Dr. W. S. Lakra	Retd. Vice Chancellor, CIFE	
Dr. A. K. Balange	Head, Division of Animal, Poultry, Fisheries Sciences, IARI, Assam.	

Indu Anna George
9/7/2024

Sign of BOS Chairperson
Prof. Indu Anna George
Department of Life Sciences
Ad-hoc BOS in Life Sciences

Sign of Offg. Assoc. Dean
Dr. Madhav Rajvade
Offg. Assoc. Dean
Science and Technology
University of Mumbai

Sign of Offg. Dean
Prof. Shivram Garje
Dean Science and Technology
University of Mumbai