UNIVERSITY OF MUMBAI
No. UG/146 of 2015-16

CIRCULAR:-

A reference is invited to the Syllabi relating to the M.Sc.degree programme, **vide** this office Circular No. UG/22 of 2013-14, dated 9th May, 2013 and the Principals of affiliated Colleges in Science and the Head of the recognized Science Institutions concerned are hereby informed that the recommendation made by the Faculty of Science at its meeting held on 11th August, 2015 has been accepted by the Academic Council at its meeting held on 31st August, 2015 **vide** item No. 4.34 and that in accordance therewith, the revised syllabus as per Credit Based Semester and Grading System in the course of M.Sc. (Marine Microbiology) Sem. III & IV for Paper VII & VIII (Sindhu Swadhyay Sanstha), which is available on the University's web site (www.mu.ac.in) and that the same has been brought into force with effect from the academic year 2015-16.Accordingly the syllabus for Paper I to VI is same as per M.Sc. Life Science.

3/3/16

MUMBAI – 400 032
31st March, 2015

REGISTRAR

To,

The Principals of affiliated Colleges in Science and the Head of the recognized Science Institutions concerned.

A.C/4.34/31/08/2015

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No. UG/146-A of 2016 MUMBAI-400 032 31st March, 2016

Copy forwarded with compliments for information to :-

1) The Dean, Faculty of Science.
2) The Chairperson, Board of Studies in Microbiology.
3) The Director, Board of Colleges and University Development,
4) The Professor-cum-Director, Institute of Distance and Open Learning(IDOL),
5) The Controller of Examinations,
6) The Co- Ordinator, University Computerization Centre.

21/3/16.

REGISTRAR

..PTO

AC 31/08/2015

Item No. 4.34

UNIVERSITY OF MUMBAI

Syllabus for the M.Sc. Part - II
Program: M.Sc.
Course :MarineMicrobiology(PSMMB)
[Semester - III & IV]

(Credit Based Semester and Grading System with effect from the academic year 2015–2016)

PREAMBLE

Seventy percent of the earth is occupied by the ocean. Ocean has been considered as the mother of all forms of life ranging from viruses & bacteria to higher forms of life. Forty percent of the world inhabitants are living along the coastline of the oceans. Marine ecosystems provide more potential biodiversity for novel products and services than any other ecosystem in the world.

Marine microbiology is an interesting field of biology that began in the late 19^{th} century. Ocean expeditions such as the Challenger Expedition held between 1855 and 1890 laid a foundation for subsequent microbiological studies of the ocean. In 1950s, the Galathea Expedition explored microbial aspects of the deep sea and marine psychrophilic bacteria.In 1960s, marine microbes were described for their distribution. Between 1975 to 1980,the role of marine microbes in ecology, productivity, food chain and biofilm production were discovered. During 1990-2005, marine microbes were studied for biotechnological aspects such as genomic identification and microbial drugs.

The marine microbes (often found living in association with other forms of life) occur in extreme conditions at a temperature of 350^{o}C, salinity of 320 gm/L, pressure of >600 atmospheres, pH of <2.0 and at low temperature of – 8^{o}C.These are conditions in which no other life can exist. These extreme living conditions force the microbes to produce a vast number of enzymes with unique activities and pharmaceutically active compounds of new structures. Hence, there is a great scope for bio-prospecting of marine microbes for their utility as thermo stable and cold active enzymes in food preservation, leather processing & cleaning industries, bio-polymers & bio-surfactants in waste management and in nanotechnology for a broad range of applications.

The recent technological developments like Bathymetry, GPS, Shipboard Laboratories and ship manoeuvring have made sampling of marine microbes living in the ocean habitats possible and to investigate more about ocean microorganisms.

With the current scenario MARINE MICROBIOLOGY can be an effective career option for the students of University Of Mumbai and rest of Maharashtra.Mumbai lies on the west coast of India and has a deep natural harbour with 149 Km.long coastline. Mumbai has numerous creeks (encompassing 71 sq.km.of area) and mangroves along it's coastline.Thus,Board of Studies in Microbiology has designed the curriculum for M.Sc. Microbiology with specialization in marine microbiology at M.Sc. Part-II level for Semester-III & Semester-IV. The M.Sc. Part-I (Semester-I & II) syllabus is common to both i.e. General microbiology and Marine microbiology students.

As MARINE MICROBIOLOGISTS students shall have career options and job opportunities in the fields of genetics, fossil microbiology, biochemistry, physiology, ecology, taxonomy and applied areas of marine life. Other avenues such as (i) Faculty in academic institutions, colleges & universities,(ii) Research areas of Environmental control & monitoring agencies and NGOs to investigate and manage marine pollution & oil spills,(iii) In petroleum industries to study underground oil reservoirs, marine microbial flora & crude oil recovery, (iv) In industries concerned in the production & certification of marine food,marine products and pharmaceuticals,(v) Entrepreneurial ventures will also provide opportunities for self employment & create more jobs.

M.Sc. Part - II Marine Microbiology Syllabus
[Semester-III & IV]
Designed for Credit Based and Grading System
To be implemented from the Academic year 2015-2016

SEMESTER-III

Theory:

Course Code & Title	Unit	Topic Headings	Credits	Lectures/ Week
PSMMB301 Microbial Ecology of Marine Environment	I	Introduction to Marine Microbes	4	01
	II	Role of Microorganisms in Sea Water - Marine Habitats ,Global Warming		01
	III	Marine Microbial Diversity. Its role in Ecosystem & Environmental Change		01
	IV	Potentials Of Marine Microbiology		01
PSMMB302 Fishery Microbiology	I	Marine Eukaryotic Organisms	4	01
	II	Types of Fishes and other Sea Animals		01
	III	Commensals and Pathogens of Sea Animals i)Vertebrates ii)Invertebrates		01
	IV	Human Pathogens and Toxins in Sea Foods.		01
PSMMB303 Sea Food Processing and Quality Assurance	I	Preservation Methods, Processing and Packaging & Transportation Hurdle Technology. TQM	4	01
	II	HACCP System in Sea Food Industry. Food Safety Issues related to Domestic and International Market		01
	III	Detection & Enumeration Methods of Microorganisms		01
	IV	Sampling, Analysis and Certification for Exports; Export & Import of Sea Foods ;Eco labelling		01

PSMMB304 Research Methodology & Biostatistics	I	Research Methodology: Terminology, Defining a Research Problem, Data Collection,	4	01
	II	Research Methodology :Sampling & Sample Distributions ,Sample Size		01
	III	Research Methodology:Comparative Data,Data Analysis and Report Writing		01
	IV	Biostatistics		01

Practicals:

PSMMB3P1	Microbial Ecology of Marine Environment	2	04
PSMMB3P2	Fishery Microbiology	2	04
PSMMB3P3	Seafood Processing and Quality Assurance Report Writing on Eco-Labelling	2	04
PSMMB3P4	Research Project Proposal Writing and Power Point Presentation.	2	04

SEMESTER-IV

Theory:

Course Code & Title	Unit	Topic Headings	Credits	Lectures/ Week
PSMMB401 Marine Pollution and Microbial Remediation	I	Coastal and Marine Hazards	4	01
	II	Types of Pollution and its Impact		01
	III	Detection Methods for Pollutants and Analysis		01
	IV	Biomonitoring and Bioremediation		01
PSMMB402 Marine Microbial Genomics & Proteomics	I	Microbial Biodiversity Studies	4	01
	II	Bioinformatics		01
	III	Sequencing Of Genomes		01
	IV	Toxicogenomics		01
PSMMB403 Applied Marine Biotechnology	I	Bioprospecting,Drug Discovery and Industrial Enzymes	4	01
	II	Bioactive Compounds from Marine Sources		01
	III	Collection, Identification of Marine Organisms and Novel Screening Methods		01
	IV	Development of Marine Products		01
PSMMB404 Remote Sensing; Laws and Regulations; Enterpreneurship	I	GIS, Remote Sensing	4	01
	II	Entrepreneurial Ventures- Aqua Culture and Fisheries		01
	III	Legislations and Regulations, Agreements with Foreign Countries		01
	IV	IPR and Patent Laws		01

Practicals:

PSMMB4P1	1. Summer Internship Report 2. Case Study of a Patented GMO 3. Case Study of an Invention- Value Chain Approach	2	04
PSMMB4P2	1. Bioinformatics Practicals (Online/Offline) 2. Genomics & Proteomics Practicals 3. Poster Presentation of Research Projects & Viva Voce	2	04
PSMMB4P3	1. Collection and Identification of Marine Organisms	2	04
PSMMB4P4	1. Research Work & it's Write up	2	04

M.Sc.Part-II

Marine Microbiology (Semester-III & IV) Detail Syllabus
Designed for Credit Based and Grading System
To be implemented from the Academic year 2015-2016

SEMESTER-III

Theory:

Course Code & Title	Unit	Topic Headings	Credits	Lec/Week
PSMMB301 Microbial Ecology Of Marine Environment (60 Lec/Sem)	UNIT I (15 L)	Introduction to marine microbes 1.1 Microscopic bacteria and viruses in Marine microbiology 1.2 Marine microbes in three domains of cellular life 1.3 Microbial processes shape the living world 1.4 Size variation in marine microbes	04	01
	UNIT II (15 L)	Role of microorganisms in sea water habitats 3.1 Ocean acidification 3.2 Marine microbes as a major component of the Plankton 3.3 Microbes play a key role in the formation of sediments 3.4 Marine microbes in formation of biofilms		01
	UNIT III (15 L)	Marine microbial diversity and its role in ecosystem and environmental change 3.1 Marine microbial diversity 3.2 Technologies and research toolkits		01
	UNIT IV (15 L)	Potentials of marine microbiology 4.1 Bioactive Marine Natural Products 4.2 Exploring potential of Marine Microorganisms 4.3 Natural Bioactive compounds & potential of Marine microorganisms		01
Course Code & Title	**Unit**	**Topic Headings**	**Credits**	**Lec/Week**

PSMMB302 Fishery Microbiology (60Lec/Sem)	UNIT I (15 L)	Marine eukaryotic organisms 1.1 Evolution of eukaryotes: Biodiversity in marine environment. 1.2 Archae, photosynthetic eukaryotes 1.3 Fungi and other unicellular non-photosynthetic eukaryotes	04	01
	UNIT II (15 L)	Types of fishes and other sea animals 2.1 Classification of fishes according to characteristics 2.2 Important species of fish i.e. fish of economic importance and other sea animals		01
	UNIT III (15 L)	Commensals and pathogens of sea animals 3.1 Parasitic infections of vertebrates 3.2 Non-parasitic infections of vertebrates 3.3 Man made hazards 3.4 Infections in invertebrates		01
	UNIT IV (15 L)	Human pathogens and toxins in sea foods 4.1 Human Pathogens a.Bacterial pathogens b.Viral pathogens c.Parasites 4.2 Toxins affecting fishes and marine life 4.3 Occurrence, source and detection of bio toxin		01
Course Code & Title	**Unit**	**Topic Headings**	**Credits**	**Lec/Week**
PSMMB303 Seafood Processing And Quality Assurence (60Lec/Sem)	UNIT I (15 L)	Preservation methods, processing and packaging & transportation hurdle technology. TQM 1.1 Preservation Methods of seafood – 1.2 Processing of sea food- General techniques in processing of seafood 1.3 Packaging and Transportation of seafood 1.4 Hurdle technology-various hurdles in food preservation 1.5 TQM in seafood	04	01
	UNIT II (15 L)	HACCP system in sea food industry. Food safety issues related to domestic and international market 2.1 HACCP system in sea food industry 2.2 Food safety		01
	UNIT III (15 L)	Enumeration methods. conventional and DNA based methods of detection 3.1 Conventional Detection & Enumeration Methods of microorganisms		01

		3.2 Molecular(DNA based) Enumeration Methods		
	UNIT IV (15 L)	Sampling, analysis and certification for exports. 4.1 Sampling , analysis and certification for Export and import 4.2 Eco Labelling- an introduction		01
Course Code & Title	**Unit**	**Topic Headings**	**Credits**	**Lec/Week**
PSMMB304 **Research Methodology & Biostatistics** **(60Lec/Sem)**	UNIT I (15 L)	Research Methodology: 1.1 Research fundamentals & terminology, 1.2 Defining a research problem, 1.3 Data collection,	04	01
	UNIT II (15 L)	Sampling 2.1Sampling and Sampling distributions, 2.2 Sample size		01
	UNIT III (15 L)	Data analysis 3.1Comparative Data and Data analysis, 3.2 Report writing and review writing		01
	UNIT IV (15 L)	Biostatistics 4.1Central tendency, 4.2 Standard deviation, 4.3 Co-efficient of Correlation, 4.4 Regression analysis, chi square, hypothesis testing, Z-test, t test, Anova		01

PRACTICALS: (SEMESTER-III)

Course Code	**Experiment/Report/Assignment/Project**	**Credits**	**Practical Periods/Week**
PSMMB3P1	Microbial Ecology of Marine Environment 1. Sampling techniques in marine microbiology 2. Enumeration of total heterotrophic bacteria in sea water 3. Isolation of marine actinobacteria	02	04
PSMMB3P2	Fishery microbiology 1. Identification of fishes and other sea animals on the basis of characteristics. 2. Isolation and identification & characterization of bacterial pathogens in sea foods(Identification)	02	04
PSMMB3P3	Seafood processing and quality assurance 1. Visit to canning industry- Hurdle technology 2. Study of normal flora of any two sea water fishes 3. Isolation ,Identification and Characterization	02	04

	of the pathogen form sea food- *Salmonella spp., S. aureus, Vibrio spp, Coliforms* (For Quality Assurance) 4. Report writing on EcoLabelling		
PSMMB3P4	1. Research Project Proposal:Research proposal writing and power point presentation 2. Problems based on biostatistics	02	04

SEMESTER-IV

THEORY:

Course Code & Title	**Unit**	**Topic Headings**	**Credits**	**Lec/Week**
PSMMB401 **Marine pollution and microbial remediation (60 Lec/Sem)**	UNIT I (15 L)	Coastal and Marine hazards. . 1.1 Land Degradation, Impacts of soil amendments. 1.2 Urbanization. 1.3 Coastal Erosion due to Human activities, Loss of coastal zones and resilience. 1.4 Offshore sewage outfall. 1.5 Algal Blooms, Hazardous Marine life.	04	01
	UNIT II (15 L)	2.1Types of pollution and Impact on Ecosystems, marine animals, Flora and Fauna& Economy 2.2 Pollution by Shipping vessels & Ship breaking Industry.		01
	UNIT III (15 L)	3.1 Detection Methods for pollutants, 3.2 Analysis		01
	UNIT IV (15 L)	4.1 Bio monitoring and Bioremediation. 4.2 Bioenergy		01
Course Code & Title	**Unit**	**Topic Headings**	**Credits**	**Lec/Week**
PSMMB402 Marine microbial genomics & proteomics (60 Lec/Sem)	UNIT I (15 L)	1.1 Microbial Biodiversity, 1.2 Microbial culture collection, 1.3 Polyphasic taxonomic techniques: a.) DNA hybridization studies,b.) rRNA sequence analysis,c.) Whole cell fatty acid analysis,d.) Whole cell protein analysis,e.) DNA-based typing methods,f.) Polyphasic identification	04	01
	UNIT II (15 L)	Bioinformatics: 2.1 Introduction to bioinformatics,scope of bioinformatics,(2 L) 2.2 Information Networks:Bioinformatics & the internet,useful bioinformatics &		01

		sites on the www,(1 L) 2.3 Protein information resourses (3 L) 2.4 Genome information resourses (3 L) 2.5 DNA sequence analysis (3 L) 2.6 SequenceAlignment:Meaning&Types(3 L):- (a) Blast,(b) Pairwise & multiple sequence alignment,global & local alignments,(c) Phylogenetic analysis & importance,(d) sequence logo & consensus sequences		
	UNIT III (15 L)	3.1 Sequencing of genomes,whole genome sequencing,, 3.2 Functionalgenomics,transcriptomics,proteomics and metagenomics.		01
	UNIT IV (15 L)	4.1 Toxicogenomics- (a) Genomic islands,(b) horizontal gene transfer,(c) gene expression,(d) Microarrays.		01
Course Code & Title	**Unit**	**Topic Headings**	**Credits**	**Lec/Week**
PSMMB403 Applied Marine Biotechnology (60 Lec/Sem)	UNIT I (15 L)	1.1Biomedical Potential of Marine Products:(5 L) Marine natural products that act as a. membrane receptors, b. Antitumor compounds,Tumor promoters c. Anti-inflammatory/analgesic compounds d. Antiviral agents, e. Metabolites which affect microfilament mediated processes 1.2 Isolation, structural and mode-of-action studies on bioactive marine natural products:(5 L) a. Crustacean molt-inhibiting regulators b. Shark repellants in the defense secretion of pardachirid soles. c. Tunichromes, the blood pigments of tunicates (sea squirts) 1.3 Pharmacological studies of novel marine metabolites:(5 L) a. Pharmacological models of cellular and molecular processes b. Site and mechanism of action of marine natural products	04	01

	UNIT II (15 L)	2.1 Eicosanoids and related compounds from marine algae:(6 L) a. Eiconasoids and related compounds from marine algae. 2.2 Marine proteins in clinical chemistry:(5L) a. Vitamin B-12 Binding proteins of marine organisms. b. Limulus proteins for the detection of endotoxins.Marine lectins 2.3 Medical and Biotechnological applications of marine microalgal polysaccharides: (4 L) a. Physiological activities , b. Model systems for new drug screening, c. Biomedical assay applications d.Biotechnology oriented applications. e. Projections for the future		01
	UNIT III (15 L)	3.1 Antitumor and cytotoxic compounds from marine organisms:(6 L) a. Polyketides ,b. Terpenes ,c. Nitrogen-containing compounds ,d. Polysachharides 3.2 Antiviral substances: (4 L) a. Marine-derived antiviral program at the university of Illinois, b. Antiviral assays,Very active antiviral agents,Active antiviral agents,Modestly active antiviral agents 3.3 The search for antiparasitic agents from marine animals:(5 L) a. Screening methods for anthelmintics, Anthelmintic-active natural products b. Screening methods for antiprotozoal agents,Antiprotozoal active natural products c. Future prospects		01

	UNIT IV (15 L)	4.1 Dinoflagellates as sources of bioactive molecules:(4 L) a. Saxitoxin and Gonyautoxin derivatives: Sodium channel blockers, b. Brevetoxins and cigautoxins: Sodium channel activators c. Other polyether compounds produced by dinoflagellates , d. Miscellaneous: Maitotoxin e. Biosynthesis of Dinoflagellate products and metabolism 4.2 Production of β-carotene and vitamins by halotolerant alga Dunaliella: (2 L) Dunaliella and its environment,β-carotene production,Cell composition,Biotechnology of Dunaliella,Products of dunaliella cultivation 4.3 Marine micro-organisms: a new biomedical resource: (5 L) a. Microbial diversity in marine environment b. Bioactive metabolites from marine microorganisms c. Discussion and prospects for the future 4.4 Academic chemistry and the discovery of bioactive marine natural products:(4 L) a. Introduction,The historical record, b. The current status of academic research c. Collection and identification of marine organisms,Screening of crude extracts for bioactivity,Isolation and identification of bioactive natural products,Pharmacological screening of pure compounds Commercial development of marine natural products		01
Course Code & Title	**Unit**	**Topic Headings**	**Credits**	**Lec/Week**
PSMMB404 Remote Sensing;Laws & Regulations, IPR & Enterpreneurship (60 Lec/Sem)	UNIT I (15 L)	1.1 GIS: Introduction & Features 1.2 Remote Sensing:Introduction, Basic processes, Passive & Active Remote sensing, Advantages	04	01
	UNIT II (15 L)	2.1 Entrepreneurial Ventures: a) Marine aquaculture ,Setting, Sustaining and restoring b) Marine fisheries, Fish Feeds, facilities required, Licensing ,Financial support, c) Development of a value chain		01

	UNIT III (15 L)	3.1 Legislations and Regulations- Coastal and Marine environments. 3.2 Acts concerning water bodies, Pollution Control Boards & their role . 3.3 Social Movements & their role in conservation. 3.4 Agreements with foreign countries, Basel convention & IMO guidelines. Ethics in Marine Microbiology		01
	UNIT IV (15 L)	IPR & Patent laws 4.1 Introduction , Trade secrets, Patents, Copyrights, WIPO 4.2 Patenting genes, GMOs .DNA sequences and genetic resources, Fishes 4.3 Management of IPR in India 4.4 Benefits and Problems		01

PRACTICALS:(SEMESTER-IV)

Course Code	**Experiment/Report/Assignment/Project**	**Credits**	**Practical Periods/Week**
PSMMB4P1	1. Report Writing and Case study Of a patented GMO 2. Case study : Invention- a value chain approach	02	04

PSMMB4P2	1.Bioinformatics Practicals:(Online/Offline) (a) Study of databases (b) Sequence alignment :- (i) Nucleotide BLAST (ii) Protein BLAST (iii) Study of orthologous and paralogous sequences using BLAST (c) Sequence alignment and applications :- (i) Multiple sequence alignment, Phylogenetic analysis (ii) Studying consensus sequences (iii) Generation of sequence Logo using multiple aligned sequences 2.Genomics Practicals:(Demonstration) (a) Determination of DNA & RNA content from yeast,(b) Isolation of DNA from yeast,(c) mRNA preparation from yeast,(d) PCR amplification of 16srRNA,(e) Extraction of genomic DNA from bacteria,(f) Creation of genomic library 3.Proteomics Practicals:(Demonstration) (a) Polyacrylamide gel electrophoresis,(b) Horizontal gel electrophoresis,(c) SDS PAGE,(d) Protein gel staining techniques,(e) Protein purification techniques,(f) Instrumentation & data interpretation of:-2D Electrophoresis,Mass Spectrometry,MALDI-TOF 4.Poster Presentation of Research Project & Viva Voce	02	04
PSMMB4P3	1. Collection and identification of marine organisms. 2. Screening of crude extracts for bioactivity. 3. Isolation and identification of bioactivity of natural products 4. Beta carotene production using Algae	02	04
PSMMB4P4	Research Project Work & Dissertation Report	02	04

Each Theory and Practical period shall be of one hour duration.

REFERENCES

PSMMB301- (All units)

1. Microbes in the Marine Environment © Garland Science 2011
2. D.S. Bhakuni & D.S. Rawat, Bioactive Marine Natural Products
3. Exploring potential of Marine Microorganisms, international Journal of Scientific and Research Publications, Volume 3, Issue 1, January 2013 1 ISSN 2250-3153
4. Olumide Adedokun Odeyemi Current Pharmaceutical Biotechmology.2007.8,253
5. Natural Bioactive compounds & potential of Marine microorganisms Debnath, Paul www.marineboard.eu

PSMMB302 – (Unitwise)

Unit I

1. Encyclopaedia of Marine Natural Products, 2nd Edition. Jean-Michel Komprobst 2014, Wiley - VCH Verlag GmbH and Co., KGaA
2. Seshagiri Raghukumar, Indian journal of Marine Sciences, December 2006, Volume 35 (4), pp. 388 - 398.

Unit II

1. Fish and Fisheries of India, V.G. Jhingran, 2nd Edition, 1982, pp. 4 - 66., Hindustan publishing corporation (India) Delhi. (For Unit 2.1)
2. Fish and Fisheries of India, V.G. Jhingran, 2nd Edition, 1982, pp. 539 - 551., Hindustan publishing corporation (India) Delhi. (For Unit 2.2)
3. Fish and Fisheries of India, V.G. Jhingran, 2nd Edition, 1982, pp. 551 - 557 and 601-603., Hindustan publishing corporation (India) Delhi. (For Unit 2.3)
4. Marine Fisheries, D.V. Bal and K. Virabhadra Rao, 1984, Tata Mc Graw-Hill publishing company limited - New Delhi

Unit III

1. Fish and Fisheries of India, V.G. Jhingran, 2nd Edition, 1982, pp. 486 - 491., Hindustan publishing corporation (India) Delhi.
2. Fish and Fisheries of India, V.G. Jhingran, 2nd Edition, 1982, pp. 467 - 477., Hindustan publishing corporation (India) Delhi.
3. Marine Fisheries, D.V. Bal and K. Virabhadra Rao, 1984, pp. 432 - 440, Tata Mc Graw-Hill publishing company limited - New Delhi (for man made hazards)
4. Viral diseases of Marine Invertebrates, P. T. Johnson, National Marine Fisheries Service, Northeast Fisheries Centre, Oxford, Maryland, U.S.A., 1984, Helgolander Meeresuntersuchungen, Helgolander Meeresuntersuchungen, 37, 65-98.
5. Commensals of Mytilus ... , G.V.Murina and A.I. Solonchenko, Hydrobiologia: 227, 385-387, 1991

Unit IV

1. Digital Libraries, Seafood Safety and Foodborne Illnesses, National Sea Grant Library, University of R. I. Bay Campus, Ocean Science and Exploration Centre, nsgl@gso.wi.edu
2. Douglas L. Park, Sonia E. Guzman-Perez and Rebeca Lopez-Garcia, Aquatic Biotoxins: Design and Implementation of Seafood Safety Monitoring Programs, Rev Enivron

Contam Toxicol, 161:157-200, 1999, Springer-Verlag.
3. Handbook of Neurotoxicology by N. R. Towers and I. Garthwaite, 2002, Springer.

PSMMB303- (All Units)

1. HACCP system in sea food industry
   Implementation Of Hazard Analysis Critical Control Point (HACCP) System To The Fish/Seafood Industry: A Review
   http://www.foodsafety.govt.nz/elibrary/industry/Guide_Hazard-assist_Application.pdf
2. Hurdle Technology
   http://archimer.ifremer.fr/doc/2006/publication-6492.pdf
   https://openagrar.bmel-forschung.de/servlets/MCRFileNodeServlet/Document_derivate_00008879/2000_Leistner_int-j-food-Microbio-181ff.pdf
   http://link.springer.com/chapter/10.1007/978-1-4615-2105-1_1#page-1
3. Preservation Of Sea Food:- http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/12655/StationCircular164.pdf?sequence= HPP Technology http://www.hiperbaric.com/en/hpp http://www.hiperbaric.com/en/high-pressure
4. Salting and drying
   http://www.spc.int/digitallibrary/doc/fame/manuals/tuara_97_preservseafood.pdf
5. Food Microbiology 4th ed,- William C. Frazier Dennis C. Westhoff.-TataMcGraw-Hill
6. Modern Food Microbiology- James M Jay 6th ed.
7. Innovations in sea food preservation and storage
   http://www.researchgate.net/profile/Alessandro_Giuffrida/publication/26654710_Innovations_in_seafood_preservation_and_storage/links/02bfe50ea9be6b2d15000000.pdf
8. Different methods of preserving fish
   http://cooking.knoji.com/different-methods-of-preserving-fish/
9. Food Microbiology 4th ed,- William C. Frazier Dennis C. Westhoff.-TataMcGraw-Hill
10. Modern Food Microbiology- James M Jay 6th ed.
11. Processing and preservation of seafood
    http://nptel.ac.in/courses/120108002/module5/lecture9.pdf
12. TOTAL QUALITY MANAGEMENT - Presentation in Seafood Safety and Trade wokshop -17-12-2013
13. Enumeration Methods, Conventional and DNA based methods of detections
14. Marine Microbiology-Ecology and applications-2nd edition-Colin Munn.Garland Science.N.Y.And London
15. Marine Microbiology-Claude E.ZoBell 1946 Waltham, Mass.,U.S.A. Pub- Chronica Botanica Company
    ..http://archimer.ifremer.fr/doc/00066/17730/15252.pdf,http://www.researchgate.net/profile/John Mckillip/publication/8086336 A review of conventional detection and enumeration

16. Sampling, analysis and certification for export and import of seafood
http://www.inspection.gc.ca/food/fish-and-seafood/exports/eccp/eng/1369429100324/1369429168211
http://www.fda.gov/Food/GuidanceRegulation/ImportsExports/Importing/ucm248706
17. Eco.labeling- An introduction
http://www.globalecolabelling.net/docs/documents/intro_to_ecolabelling.pdf

PSMB 304 – (All Units)

1. Research Methodology : Methods and Techniques :Kothari, C R ,& Garg Gaurav 3rd Ed.2014 ISBN : 978-81-224-3623-
2. Data collection, sampling and sampling distributions. sample size:1) Kothari & Garg,
3. Research Methodology :R.Panneerselvam,2nd ed.,2012,PHI Learning Pvt.Ltd.,New Delhi
4. Comparative data, report writing.: 1) Kothari & Garg
5. Biostatistics: Research Methodology :D.K. Bhattacharya 2nd ed,2006,Excel Books,New Delhi
6. Fundamentals Of Biostatistics:Khan Irfan Ali,2008,Ukaaz Publications
7. Fundamentals Of Biostatistics:Rosner B.A.,2011,Cengage Learning

PSMB401 -(All units)

1) Marine Microbial Diversity: David Karl & Merry Buckley
2) Microbial Ecology of the Oceans: Ralph Metchell
3) Ocean & health: Pathogens of the Marine Environment Rita Colwell &ShinishonBelkin
4) Biological Oceanography-Charles MellerMM-302 Marine Microbial Prospecting and Technology
5) Brock's Biology of Microorganisms – Michael T. Madigan and John M. Martinko. (11th edn.) 2006.
6) Marine Microbiology Ecology and Applications by Colin Munn, Garland Sc, Taylor and Francis N.Y
7) Belkin, S. and Colwell RR. 2005. Oceans and Health: Pathogens in Marine environment. Springer
8) Hester and Harrison. 2011. Marine Environment and Human Health (http://pubs.rsc.org/en/content/ebook/978-1-84973-240-6)
9) Aquatic Microbiology by Rheinheimer
10) Bacteria from Fish and Other Aquatic Animals: A Practical Identification Manual (Cabi Publishing)
by Nicky B. Buller and John A. PlumbMM-305: Marine Extremophilic Microorganisms
11) Brock, T. D.: Thermophilic Microorganisms and Life at High Temperatures, Springer, New York,
1978, 465 pages
12) Environment stress and fish diseases by Gary A. Wedemeyer, Fred P. Meyer and Lynnwood Smith
13) Health maintenance and principal microbial diseases of cultured fishes by John a. Plumb
14) Marine Pollution by Clark
15) Textbook of fish health by George Post.
16) Fish diseases and disorders: Vol3 : viral, bacterial and fungal infections by Woo and Bruno
17) Diseases of carps and other cyprinid fishes by D. Hoole, D. Buck, P. Burgess and I. Welby.

18) Fish Pathology by R.J. Roberts
19) Environment stress and fish diseases by Gary A. Wedemeyer, Fred P. Meyer and Lynnwood
Smith
20) Extreme microorganisms and the methods to handle them by Fred A Rainey and Aharon Oren
21) Tropical Pollution, Niel Sen S.E
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17. Functional genomics: A practical approach, by Stephen Hunt and Rick Livesey, oxford University press. (Reference for above content)
18. Molecular Cloning : Laboratory Manual Vol I, 2001 , Joseph Sambrook, David William Russel, CHL Press
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PSMB 402 – BIOINFORMATICS (Unit II)

1. David Mount (2004) Bioinformatics: Sequence and Genome Analysis. 2nd edition, Cold Spring Harbor Laboratory Press, New York.
2. Jonathan Pevsner (2009) Bioinformatics and Functional Genomics. 2nd edition, John Wiley and Sons, New Jersey.

3. Andreas D. Baxevanis and B. F. Francis Ouellette (2001) Bioinformatics A Practical Guide to the Analysis of Genes and Proteins. 2nd edition, A John Wiley & Sons, Inc., Publication
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5 Jean-Michel Claverie and Cedric Notredame Bioinformatics for Dummies, 2nd edition, Wiley Publishing, Inc.
6 Introduction to bioinformatics. TK Attwoodband DJ Parry-smith, 7th edition,2004. Publisher, Pearson Education.
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8 Basic bioinformatics. S.gladis Helen Hepsyva, C. R. Hemalatha. 2009, MJP Publishers.
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PSMB 403 - (All units)

1. Pharmaceutical and bioactive natural products, volume 1;Attaway and zaborsky, Plenum press, New york and London
2. Marine Microbiology: Ecology and applications. 2nd edition, Colin Munn, Garland science, Taylor and Francis group, LLC
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4. Marine Microbiology: Ecology and applications. 2nd edition, Colin Munn, Garland science, Taylor and Francis group, LLC

PSMB 404 - REMOTE SENSING AND GIS (Unit I)

1. Thomas M Lillesand, and Ralph W Kiefer; “Remote sensing and Image Interpretation”, John Wiley & Sons, 1994, 3rd ed.
2. DeMers, M.N., “Fundamentals of Geographical Information Systems”, John Wiley & Sons, Inc., 2000. 2nd ed..
3. Burrogh, P and R. McDonnell, “Principal of Geographical Information Systems”, Oxford University Press, 1998.
4. :Chandra A.M and Ghosh S.K., “Remote Sensing & Geographical Information System”, Narosa Publishing House, 2006, 1st ed.

5. Chen, Y., Takara, K., Cluckie, I. and Smedt, F.H. (Eds.), "GIS and Remote sensing in Hydrology, Water resource and Environment", IAHS Publication 289, IAHS press. 2004.
6. Qihao Weng, "Remote Sensing and GIS Integration: Theories, Methods, and Applications", McGraw Hill Publishers, 2009, 1st

PSMB 404 –ENTREPRENEURSHIP (Unit II)

1. Aquaculture, 1989 – Pillai, T.V.R.
2. Fish and fisheries of India, 1982 – Jhingran, V.G.
3. Fish diseases – Marine ecology (Vol 4), 1983 – Kinne, O.
4. Crustacean aquaculture, 1983 Mckey, J.P. CRC series.
5. Aquaculture, 1972 – Bardach.
6. Prawn and prawn fisheries of India, 1976 – Kurian, C.V. & sebastian, V.O.
7. Environmental management for aquaculture, 1998 – Midlen.
8. Nutrition and feeding of fish, 1999 – Lovell.
9. Pond aquaculture water quality management, 1998 – Tucker.
10.Crustacean aquaculture, 1983 ,Mckey, J.P.,C.R.C. series
11.Training manual on recent advances in management of water quality parameters in for aquaculture, 1997 C.I.F.E. Publication, Mumbai.\
12.Training manual on advances in keeping and breeding ornamental fishes, 1997 C.I.F.E. Publication, Mumbai.
13.Training manual on culture of live food organisms for aqua hatcheries, 1998 C.I.F.E. Publication, Mumbai.
14.Training manual on culture of live fish for aquaculture, 1998 C.I.F.E. Publication, Mumbai
15Aquaculture, Bardach J. E et al., Wiley interscience
16Coastal aquaculture by Santhanam R et al, CBS publishers.
17Principles of aquaculture by Stickney R.R, Wiley and Sons

P404 - LAWS (Unit III)

1.Water (prevention and control of Pollution) Act, 1974
2.The Environment (Protection) Act, 1986
3.National River Conservation Plan, National Lake Conservation Plan
4.G.S.R. 378(E), (24/7/1978)- The water (Prevention and Control of Pollution) Cess Rules, 1978
5.1972 Treaty, the convention on the Prevention of Marine Pollution by Dumping of wastes and other matter (London Convention)
6.1973 The International Convention for the Prevention of Pollution from Ships (MARPOL)

P404 - IPR AND PATENTS (Unit IV)

1. P.N. Cheremisinoff, R.P. Ouellette and R.M. Bartholomew, Biotechnology Applications and Research, Technomic Publishing Co., Inc. USA, 1985
2. D. Balasubramaniam, C.F.A. Bryce, K. Dharmalingam, J. Green and K. Jayaraman, Concepts in Biotechnology, University Press (Orient Longman Ltd.), 2002
3. Bourgagaize, Jewell and Buiser, Biotechnology: Demystifying the Concepts, Wesley Longman, USA, 2000.
4. Ajit Parulekar and Sarita D' Souza, Indian Patents Law – Legal & Business Implications; Macmillan India ltd , 2006
5. B.L.Wadehra; Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd., India 2000
6. P. Narayanan; Law of Copyright and Industrial Designs; Eastern law House,

Delhi ,2010
7.Intellectual Property Rights (IPRs): TRIPS Agreement & Indian Laws by E. T. Lokganathan (author)Publisher: New Century Publications; 1st edition
8.T. M Murray and M.J. Mehlman, Encyclopedia of Ethical, Legal and Policy issues in Biotechnology, John Wiley & Sons 2000

Modality of Assessment:

[I] Theory Examination Pattern:

A] Internal examination for theory (40%):- **40 marks**

No.	
1. Active participation in routine, Class instructional deliveries	05
2 Overall conducts as a responsible learner,Communication & Leadership qualities in organizing related academic activities.	05

3. One seminar based on curriculum to be assessed by the teacher of the institution teaching P.G.learners/ publication of a research paper / presentation of a research paper in seminar or conference 30

(i)	Selection of the topic, Introduction, Contents, References	15
(ii)	Presentation with the use of ICT	15

B] External examination - 60 %

Semester End Theory Examination - **60 Marks**

i. Duration - These examinations shall be of two and half hours duration.
ii. Theory question paper pattern :-

1. There shall be **five** questions each of **12** marks. On each unit there will be one question & fifth one will be based on all the four units .
2. All questions shall be compulsory with internal choice within the questions. Each question will be of **24** marks with options.
3. Questions may be sub divided into sub questions **a, b, c & d only, each carrying six marks OR a, b, c, d, e & f only** each carrying **four** marks and the allocation of marks depends on the weightage of the topic.

[II]Practical Examination Pattern

(A)Internal Examination:-

There will not be any internal examination/ evaluation for practical.

(B) External (Semester end practical examination) per course :-

Sr.No.	Particulars	Marks
1.	Laboratory work	40
2.	Journal	05
3.	Viva	05

Semester III:

Practical examination will be held at the college / institution at the end of the semester.

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head of the Department/ Co-ordinator of the department ; failing which the student will not be allowed to appear for the practical examination.

Research proposal: Candidates are required to present duly certified research proposal (as per the BCUD format) with relevant references (minimum 25) and make the power point presentation of the same for the evaluation by the examiner. (The research proposal must be included with literature survey of the selected research topic.)

Semester IV:

Practical examination will be held at the college / institution at the end of the semester. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head of the Department/ Co-ordinator of the department ; failing which the student will not be allowed to appear for the practical examination.

Research project work: Candidates are required to present duly certified dissertation report based on the topic of research along with the laboratory notebook containing raw data and make the poster presentation of the research work for evaluation by the examiner.

Overall Examination and Marks Distribution Pattern

Semester III

Course	PSMMB 301			PSMMB 302			PSMMB 303			PSMMB 304			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	40	60	100	40	60	100	400
Practicals	-	50	50	-	50	50	-	50	50	-	50	50	200

Semester IV

Course	PSMMB 401			PSMMB 402			PSMMB 403			PSMMB 404			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	40	60	100	40	60	100	400
Practicals	-	50	50	-	50	50	-	50	50	-	50	50	200

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