

**Syllabus for Ph.D. Entrance Test (Marine Microbiology)**  
**To be placed in Board of Studies on 19.04.2022 for approval**  
**Effective from: September, 2022**

**Microbial Biochemistry:** Biological Molecules -Proteins: Amino acids: features, properties, Structures. Carbohydrates: Monosaccharides, Disaccharides, oligosaccharides, polysaccharides: types, characteristics and properties. Lipids: saturated and unsaturated fatty acids, structure and properties. Metabolic pathways -Central pathways of carbohydrate metabolism – regulatory mechanisms, bioenergetics and significance. Biosynthesis of fatty acids, Amino acid biosynthetic pathways and their regulation. Purine and pyrimidine nucleotides, Deoxyribonucleotides: biosynthesis and regulation. Biosynthesis of nucleotide coenzymes. Fundamental processes in Photosynthesis. Photosynthetic electron transport and photophosphorylation. Alternative pathways for carbon fixation in autotrophs. Chemosynthetic processes and bioenergetics of metabolism. Salt-in-cytoplasm mechanism, Organic-Osmolyte mechanism, Proton-motive force, Osmolyte transporters, Osmosensing.

**Microbial Genetics and Gene Regulation:** Introduction to microbial genetics. Chromosomal DNA packaging and histone modifications. Genomic islands. Chromosomal aberrations. DNA Damage (Spontaneous/induced), DNA Repair, genetic recombination (Homologous/nonhomologous). Holliday junctions. Antigenic and phase variation in bacteria. Transposition. Gene expression controls. Genetic switches, transcriptional attenuation, Riboswitches, Alternate splicing, RNA editing, RNA Interference.

**Fundamentals of Oceanography:** Physical properties of the sea - temperature, salinity, density, mixed layer depth, ocean circulation- wind-driven and thermohaline circulation, ocean currents, water mass, Coriolis effect, upwelling, Ekman transport, tides, ENSO. Elemental composition of seawater, salinity, chlorinity, residence time, dissolved gases, nutrients, carbonate system, pH and alkalinity, calcium carbonate precipitation and dissolution, carbonate compensation depth, lysocline. Habitat - estuaries, mangroves, salt marshes, rocky and intertidal, coral reefs, seagrass, coastal and open ocean, hydrothermal vents and cold seeps, marine zonation, pelagic and benthic communities, marine photosynthesis, phytoplankton and primary production.

**Microbial Taxonomy and Systematics:** Concepts of taxonomy (characterization, classification and nomenclature) and systematics; classification of microorganisms, development of classification systems starting from two kingdom to three domain, six-kingdom and 8-kingdom systems; endosymbiotic theory for the origin of eukaryotic organelles. Concepts of species, numerical taxonomy and polyphasic taxonomy.

**Mathematics and Statistics in Biology:** Characteristics of biological data: Variables and constants, discrete and continuous variables, derived variables (ratio, index, rates), types of measurements of biological data (interval scale, ratio scale, ordinal scale, nominal scale, discrete and continuous data). Data handling: relative frequency distribution, cumulative frequency distribution. Graphical representation: types of graphs, preparation and their applications. Measures of central tendency: Arithmetic mean, Median, Mode; Relationship between mean, median and mode. Measure of dispersion: Range, mean deviation, coefficient of mean deviation, standard deviation (individual observations, grouped data, continuous series), variance, coefficient of variance, limitation. Correlation analysis: Karl Pearson's

Coefficient, Rank Correlation coefficient, scatter and dot diagram (graphical method). Regression analysis – simple and multiple, linear and non-linear.

**Techniques and Instrumentation in Microbiology:** GC, HPLC, detectors, column/s matrix-Ion-exchange, affinity and molecular exclusion. Density gradient centrifugation; Ultracentrifugation. Atomic Absorption Spectrophotometry (AAS), UV-Visible, fluorimetry, Fourier transformation infra-red spectroscopy (FTIR), NMR, IR, MS, MALDI-TOF. Epifluorescence filter technique (DEFT), SEM, TEM, Confocal microscopy. Autoradiography. Primary and secondary/established cell lines, Monolayer and suspension cultures, Fluorescence activated cell sorting (FACS). PAGE, IEF, PFGE, DGGE, TGGE.

**Industrial Microbiology:** Upstream processing. Bioreactor design and operation: classification of reactors; designing parameters for reactors (stirred tank reactor, airlift reactor, plug flow reactor), rheology of fermentation broth, gas-liquid mass transfer, heat transfer, scale up. Fermentation monitoring and control: speed, temperature, gas, pH, Dissolved oxygen, foam, redox, air flow, weight, pressure, biomass; On-line and off-line analysis. Downstream processing. Quality control/Quality assurance, Intellectual Property Rights.

**Microbial Ecology:** Marine microbiome- diversity, evolution and function, mutualism, commensalism, parasitism, microbial symbiosis, microbiomes from plankton, fish, coral, sponge, deep-sea invertebrates, and animals, Biogeochemical cycles – carbon, nitrogen, phosphorus, sulphur, and iron. Oxygen minimum zones (OMZs). Marine Ecosystem and Global Climate Change. The deep sea environment. Basic and in-depth conceptualization of deep marine subsurface; dark ocean biosphere/aphotic pelagic ocean habitats beneath the ocean water column, such as marine sediments, oceanic crust, abyssopelagic/abyssal, hadal plains and hydrothermal vents. Types of deep sea habitats and resident microbiota: marine trenches, ridges, deep permafrost sediments, Antarctic Ocean and Southern Ocean deep environments; piezophilic/ barophilic microorganisms in the deep sea.

**Ecology, Physiology and Diversity of Archaea:** Global niches: Deep Sea, Hydrothermal vent, Dead Sea, solar salterns, geothermal vents, solfataras, Antarctica, soda lake. Study of archaeal biodiversity; unculturable archaea by metagenomics. Archaeal culture retrieval methods, novel samplers. Preservation and maintenance of archaeal cultures. Nutrition, growth and growth kinetics and physiological versatility.

**Microbial Interactions with Fish and Coral Communities:** Microbiology of Raw fish and processed fish. Bacteria/ fungal/ viral infections in finfish and shellfish (morphology, epidemiology, pathogenesis, treatment and control). Coral and microbiome dynamics. Concept of Coral holobiont and related hypothesis. Microbial causative agents associated with coral diseases and its prevention.

**Genetic Engineering:** DNA modifying enzymes: restriction endonucleases, exonucleases, DNA ligases, Terminal DNA transferase, DNA Polymerases, Reverse transcriptase, T4 polynucleotide kinases, Alkaline phosphatase, S-1 Nuclease, Mung bean nuclease, RNases. Gene cloning systems/Hosts: Gene cloning in *E. coli* and other organisms such as *Bacillus subtilis*, *Saccharomyces cerevisiae* and other microbial eukaryotes. Retroviruses and retroposons, Genomic organization T4, Lambda Phage, TMV, SV40. Sequencing Vectors: pUC 19 and M-13 Phage vector. Expression vectors. Cloning vectors.

## References/Readings:

1. Lehninger Principles of Biochemistry (4<sup>th</sup> edn), 2004 - Cox M.C., Freeman W.H., and Nelson D.L., W. H. Freeman & Co. New York.
2. Principles of Biochemistry (4<sup>th</sup> edn), 2012 - Voet D., Voet J.G., and Pratt C.W. John Wiley and Sons Inc. New York.
3. Harper's Illustrated Biochemistry (31<sup>st</sup> edn), 2018 - Murray R.K., Bender D.A., Botham K.M., Kennelly P.J., Rodwell V.W., and Weil P.A. The McGraw-Hill Companies, Inc. New York.
4. Principles of Genetics (7th edn) 2015 - Gardner E.J., Simmons M.J., and Snustad D.P., John Wiley & Sons. New York.
5. LEWIS Genes XII (1st edn), 2018 - Krebs J. E., Lewin B., Goldstein E. S. and Kilpatrick, S.T. Jones and Bartlett Publishers, Burlington.
6. Microbial Genetics (2<sup>nd</sup> edn) 1994 - Maloy S.R., Cronan J.E., and Freifelder D., Jones and Bartlett Publishers. Boston.
7. The Ocean: Their Physics, Chemistry and General Biology, 1962 - Sverdrup, H.U. Johnson, M.W. and Flemming, R.H., Prentice-Hall, New York.
8. Descriptive Physical Oceanography: An Introduction, 1990 - Pickard, G.L. and Emery, W.J., Pergamon Press, U.K.
9. Marine Microbiology: Ecology and Applications, 2019 - Munn, C.B, CRC Press.
10. Biological Oceanography, 2012 - Miller, C.B. and Wheeler, P. A., Wiley-Blackwell Publishers.
11. Bergey's Manual of Systematic Bacteriology (Vol. 2), 1984 - Sneath, A. H. P., Mair, S. N. and Sharpe, E. M., Williams & Wilkins, Vol. 2, Academic Press, London/New York.
12. Chemical Methods in Bacterial Systematics, 1985 - Goodfellow, M. and Minnikin, D. E., The Society for Applied Bacteriology. Technical Series No. 20, Academic Press, London/New York.
13. Prescott's Microbiology (10<sup>th</sup> edition) (2011) – Willey, J. M., Sherwood, L. M., and Woolverton, C. J., McGraw Hill, New York.
14. Quantitative Techniques, 2013 – Kothari, C.R., Vikas Publishing House.
15. Biostatistics, 2012 – Arora, P.N. and Malhan, P.K., Himalaya Publishing House.
16. Principles and Techniques of Biochemistry and Molecular Biology, 2013 - Wilson, K. and Walker, J., Cambridge University Press, N.Y., USA.
17. The Tools of Biochemistry, 2011 - Cooper, T. G., Wiley India Pvt. Ltd.
18. Laboratory Manual in Biochemistry, 2011 - Jayaraman, J., New Age International Publishers.
19. Manual of Industrial Microbiology and Biotechnology, 2010 - Demain, A. L., Davies, J. E. and Atlas, R. M., ASM Press.
20. The Encyclopedia of Bioprocess Technology: Fermentation, Biocatalysis and Bioseparation (Vols. 1 – 5), 2002 - Flickinger, M. C. and Drew S. W., John Wiley Publishers.
21. Principles of Fermentation Technology (3<sup>rd</sup> Edition), 2016 - Stanbury, P. F., Whitaker, A. and Hall, S.J., Butterworth-Heinemann Publishers.
22. Microbial Ecology of the Oceans, 2018 - Gasol, J.M. and Kirchman, D. L., Wiley-Blackwell Publishers.
23. Marine Microbiology: Ecology and Applications, 2019 - Munn, C.B, CRC Press.
24. Marine Biology, 1984 - Webber, H.H. and Thurman, H.V. Harpercollins Publishers.
25. Microbiology Handbook: Fish and Seafood., 2009 – Fernandes, R., RSC Publishing.

26. Fish Diseases and Disorders, Vol 3: Viral, Bacterial and Fungal Infections (2nd edn), 2011 – Woo, P., Bruno D., CABI Publishers.
27. The Biology of Coral Reefs (2nd edn)., 2018 - Sheppard C., Davy S., Pilling G., Graham N., Oxford University Press.
28. Coral microbiome dynamics, functions and design in a changing world. 2019 - Van Oppen M. J. H., Blackall L. L., Nature Reviews Microbiology. 17(9): 557-567.
29. Principles of Gene Manipulation: An introduction to Genetic Engineering, 2001 - Old, R. W. and Primrose, S. B., University of California Press.
30. Glick, B. R., Pasternak, J. J. and Patten, C. L. (4<sup>th</sup> Edition), 1980 - Molecular Biotechnology: Principles and Applications of Recombinant DNA, ASM Press.
31. Basic Methods in Molecular Biology, 1986 - Davis, L. G., Dibner, M. D. and Battey, J. F., (eds.), Elsevier.
32. Molecular Cloning: A Laboratory Manual, 2001 - Sambrook, J. and Russell, D., Cold Spring Harbor Laboratory Press.