Progressive Education Society's
Modern College of Arts, Science and Commerce (Autonomous)
Shivajinagar, Pune 5

(An Autonomous College Affiliated to Savitribai Phule Pune University)

Framework of Syllabus

For

M.Sc. Microbiology

(Based on NEP 2020 framework)
(To be implemented from the Academic Year 2023-24)

Semester 1 (First Year)

Course Type	Code	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory Theory (4+4+4+2)	23ScMicP111	Major Theory Paper 1	Microbial Taxonomy & Systematics	4	4	50	50	100
	23ScMicP112	Major Theory Paper 2	Biochemistry and Metabolism	4	4	50	50	100
	23ScMicP113	Major Practical 1	Practical course based on Microbial Taxonomy & Systematics	8	4	50	50	100
	23ScMicP114	Major Practical 2	Practical course based on Biochemistry	4	2	25	25	50
Major Elective Theory (4)	23ScMicP121	Major Elective 1 (Theory + `Practical)	Instrumentation & Molecular biophysics (Theory)	2	2	25	25	50
			Practical based on Biophysics	4	2	25	25	50
	23ScMicP122	Major Elective 2 (Theory + Practical)	Cell cytology & Communication Biology (Theory)	2	2	25	25	50
			Practical Based on Communication Biology	4	2	25	25	50
RM (4)	23ScMicP131	RM Section 1	Research Methodology Basics & Research in Microbiology	2	2	50	50	100
		RM Section 2		4	2			
OJT (4)		–	–	–	–	–	–	–
Total				32	22	275	275	550

Semester 2 (First Year)

Course Type	Code	Course	Course / Paper Title	Hours/ Week	Credit	CIA	ESE	Total
Major Mandatory Theory (4+4+4+2)	23ScMicP211	Major Theory Paper 1	Industrial Wastewater Treatment & Management	4	4	50	50	100
	23ScMicP212	Major Theory Paper 2	Enzymology, Bioenergetics and Metabolism	4	2	25	25	50
	23ScMicP213	Major Practical 1	Practical course I: Based on Industrial Wastewater Treatment	8	4	50	50	100
	23ScMicP214	Major Practical 2	Practical course II: Based on Enzymology	4	2	25	25	50
Major Electives (4)	23ScMicP221	Major Elective 1 (Theory + Practical)	Quantitative Biology	2	2	25	25	50
			Practicals based on Quantitative Biology	4	2	25	25	50
	23ScMicP222	Major Elective 2 (Theory + Practical)	Microbial & Plant Physiology	2	2	25	25	50
			Practicals based on Microbial & Plant Physiology	4	2	25	25	50
RM (4)		–	–	–	–	–	–	–
		–	–	–				
OJT (4)	23ScMicP241	OJT	On Job Training	8	4	50	50	100
Total				32	22	275	275	550

Semester 3 (Second Year)

Course Type	Code	Course	Course / Paper Title	Hours/ Week	Credit	CIA	ESE	Total
Major Mandatory Theory (4+4+4+2)	23ScMicP311	Major Theory Paper 1	Immunology	4	4	50	50	100
	23ScMicP312	Major Theory Paper 2	Molecular Biology & Biotechnology I	4	4	50	50	100
	23ScMicP313	Major Practical 1	Practical Course I : Practicals based on 23ScMicP312	8	4	50	50	100
	23ScMicP314	Major Practical Paper 2	Practical Course II : Practicals based on 23ScMicP311	4	2	25	25	50
Major Electives (4)	23ScMicP321	Major Elective 1 (Theory + Practical)	Microbial Technology (T + P)	6	4	50	50	100
	23ScMicP322	Major Elective 2 (Theory)	Microbial Technology and Pharmaceutical Microbiology	4	4	50	50	100
RP (4)	23ScMicP352	RP	Research Project	8	4	50	50	100
OJT (4)								
Total				38	22	275	275	550

Semester 4 (Second Year)

Course Type	Code	Course	Course / Paper Title	Hours/ Week	Credit	CIA	ESE	Total
Major Mandator Theory (4+4+4)	23ScMicP411	Major Theory Paper 1 (Theory)	Pharmaceutical & Medical Microbiology	4	4	50	50	100
	23ScMicP412	Major Theory Paper 2 (Theory)	Virology	4	4	50	50	100
	23ScMicP413	Major Practical 1	Practical Course I : Practicals based on 23ScMicP411 & 23ScMicP412	8	4	50	50	100
Major Electives (4)	23ScMicP421	Major Elective 1 (Theory)	Molecular Biology & Biotechnology II	4	4	50	50	100
	23ScMicP422	Major Elective 2 (Theory)	Virology and Molecular Biology	4				
RP (4)	23ScMicP452	RP	Research Project	12	6	75	75	150
OJT (4)								
Total				22	22	275	275	550

OJT : On Job Training: Internship/Apprenticeship
FP : Field Project
RM: Research Methodology
RP: Research Project

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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP111
Course Name: Microbial Taxonomy and Systematics

Teaching Scheme: Theory: 4 Hours/Week **Credit: 04**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisite Courses:
- Basics principles and concepts of microbial systematics, evolution, diversity, and bioinformatics

Course Objectives:
- Understand the theories of microbial evolution.
- Introduce the concept of eukaryotic and prokaryotic species.
- Understand the relationship between microbial diversity and phylogeny.
- Know various principles and concepts in the evolution and diversity of microorganisms.
- Study bacterial systematics.
- Explore the diversity of unculturable bacteria.
- Study the various methods used in genome sequencing.
- Use of various tools in bioinformatics for the identification of microbes and construction of phylogenetic trees.

Course Outcomes: On completion of the course, student will be able to –
- Define the basic principles and concepts in microbial evolution, diversity, systematics, genome sequencing, and bioinformatics.
- Explain the molecular clock hypothesis as well as the neutral theory of molecular evolution and their application.
- Illustrate the evolutionary process which results in the formation of new species.
- Estimate the diversity of microorganisms in an ecological niche using measures and indices of diversity.
- Understand the concepts of phylogeny, construction, and interpretation of phylogenetic trees, and tree distances.
- Familiar with Bergey's Manuals of systematic and determinative bacteriology as well as various approaches for the classification of bacteria.
- Know the characteristics of unculturable as well as viable but unculturable bacteria.
- Describe the culture-independent methods for the identification of unculturable bacteria.
- Know the methods used for the extraction of DNA from environmental samples and its metagenomic analysis.
- Apply the principles of systematics to characterize the microbiome.
- Elucidate the vectors, enzymes, and recent methods used in genome sequencing and identification of microorganisms.
- Comprehend the basic concepts in bioinformatics such as data, databases, sequences, and sequence analysis tools as well as their use in the identification of microorganisms.

Course Contents:

Unit 1	**Microbial Evolution and Diversity**	**No. of Lectures**

	1. Microbial evolution a. Micro- and Macroevolution b. The concept of prokaryotic and eukaryotic species: (biological-, morphological-, evolutionary-, and phylogenetic species concept) c. The neutral theory of molecular evolution d. The molecular clock hypothesis in molecular evolution e. The concept of speciation f. Phylogeny: Phylogenetic tree and its features, tree distances, types of phylogenetic trees, their interpretation, and applications 2. Microbial diversity a. Introduction to microbial diversity: the concept of species richness, abundance, and evenness b. The expanse of microbial diversity c. Biodiversity hotspots: a brief overview d. Measures of diversity: alpha-, beta- and gamma diversity e. Indices of Diversity: Shannon index, Simpson's index of diversity, reciprocal Simpson's index, Shannon-Winner diversity index, Pielou's Evenness index * (*Note: only numerical questions will be asked in the examination)	20
Unit 2	**Bacterial Systematics and Introduction to Bergey's Manuals**	
	1. Systematics of Bacteria a. Characterization b. Classification c. Nomenclature d. Identification e. Application of principles of taxonomy and diversity in the characterization of the microbiome 2. The science of classification a. Taxonomic hierarchy b. Binomial nomenclature c. Dichotomous keys d. Diversity leads to phylogeny 3. Systems of classification: a. The 5-Kingdom classification system b. The 3-Domain classification system 4. Bergey's manuals and the classification of prokaryotes a. Determinative Bacteriology (Phenetic approach) b. Systematic Bacteriology (Phylogenetic approach) c. Polyphasic Approach	10
Unit 3	**Explorations of Unculturable bacteria**	
	1. Unculturable bacteria a. The concept of unculturable bacteria, viable but nonculturable bacteria b. The reasons behind the unculturability of bacteria c. Approaches for the cultivation of unculturable bacteria. d. Identification of uncultivable bacteria.	15

	e. Methods of extracting total DNA from environmental sample and its metagenome analysis.	
Unit 4	**Genome Sequencing and Bioinformatics**	
	1. Characterization of DNA by sequencing a. Vectors and enzymes used in DNA sequencing b. Outlines of techniques used for DNA sequencing i. Dideoxy chain termination sequencing or Sanger sequencing ii. Next-generation sequencing: Pyrosequencing, Ion torrent, nanopore sequencing Illumina Solexa 2. Bioinformatics a. Basic principles and concepts in bioinformatics: Data, database, biological sequences, sequence alignments, and analysis b. Introduction to nucleotide databases: Various types of databases based on nature and source of data, their significance c. Types of sequence alignments i. Local sequence alignment ii. Global sequence alignment iii. Pairwise sequence alignment iv. Multiple sequence alignment d. BLAST analysis and identification of bacteria	15

References

Unit 1 - Microbial Evolution and Diversity

- Beaumont, M. A., Ibrahim, K. M., Boursot, P., & Bruford, M. W. (1998). Measuring Genetic Distance. Molecular Tools for Screening Biodiversity, 315–325. doi:10.1007/978-94-009-0019-6_58
- Begon, M., Townsend, C. R. (2020). Ecology: From Individuals to Ecosystems (5th ed.). West Sussex, United Kingdom: John Wiley & Sons Ltd.
- Berg, G., Rybakova, D., Fischer, D. et al. (2020). Microbiome definition re-visited: old concepts and new challenges. Microbiome 8, 103. https://doi.org/10.1186/s40168-020-00875-0
- Bromham, L., & Penny, D. (2003). The modern molecular clock. Nature Reviews Genetics, 4(3), 216-224.
- Brown, J. W. (2015). Principles of Microbial Diversity. Washington, DC, United States of America: American Society for Microbiology Press.
- Campbell, N. A., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P V., & Orr, R. B. (2021). Biology - A Global Approach (12th ed.). Harlow, United Kingdom: Pearson Education Limited.
- Chibucos, M. C., Zweifel, A. E., Herrera, J. C., Meza, W., Eslamfam, S., Uetz, P., Siegele D. A., Hu J. C. & Giglio, M. G. (2014). An ontology for microbial phenotypes. BMC Microbiology, 14(1), 1-8.
- Colwell, R. K. (2009). Biodiversity: concepts, patterns, and measurement. In S. A. Lewin (Ed.). The Princeton Guide to Ecology, (pp. 257-263). New Jersey, United States of America: Princeton University Press
- Futuyma, D. J., & Kirkpatrick, M. (2017). Evolution (4th ed.). Sunderland, Massachusetts, United States of America: Sinauer Associates, Inc.
- Galloway-Peña, J., Hanson, B. (2020). Tools for Analysis of the Microbiome. Digestive Diseases and Sciences 65, 674–685. https://doi.org/10.1007/s10620-020-06091-y
- Gautam, P. (2020). Divergent Evolution. In: Vonk, J., Shackelford, T. (eds.). Encyclopaedia of Animal Cognition and Behavior. Springer, Cham. https://doi.org/10.1007/978-3-319-47829-6_501-1
- Given, D. R. (2002). Plant conservation and biodiversity: The place of microorganisms. In K. W. Dixon, R. L. Barrett, & K. Sivasithamparam (Eds.). Microorganisms in plant conservation and biodiversity (pp. 1-18). Dordrecht, Netherlands: Kluver Academic Publisher.
- Gregory, T. R. (2008). Understanding evolutionary trees. Evolution: Education and Outreach, 1(2), 121-137
- Hartl, D. L. (2020). Essential Genetics and Genomics (7th ed.). Massachusetts, United States of America: Jones & Bartlett Publishers.
- Ho, S. (2008). The molecular clock and estimating species divergence. Nature Education 1(1):168
- Keller, M., & Zengler, K. (2004). Tapping into microbial diversity. Nature Reviews Microbiology, 2(2), 141-150.
- Losos, J. B., Baum, D. A., Futuyma, D. J., Hoekstra, H. E., Lenski, R. E., Moore, A. J., Peichel, C. L., Schluter, D., & Whitlock, M. C. (2014). The Princeton Guide to Evolution. New Jersey, USA: Princeton University Press

- Lozupone, C. A., & Knight, R. (2008). Species divergence and the measurement of microbial diversity. FEMS microbiology reviews, 32(4), 557-578.
- Luo, A., & Ho, S. Y. (2018). The molecular clock and evolutionary timescales. Biochemical Society Transactions, 46(5), 1183-1190.
- Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley M. W., & Stahl, D. A. (2022). Brock Biology of Microorganisms (16th ed.). Harlow, United Kingdom: Pearson Education Limited.
- Mason, K. A., Losos, J. B., & Duncan, T., (2020). Biology (12th ed.). New York, United States of America: McGraw-Hill Education.
- McLennan, D. A. (2010). How to read a phylogenetic tree. Evolution: Education and Outreach, 3(4), 506-519.
- Molles, M. C. (2016). Ecology: Concepts and Applications. United Kingdom: McGraw-Hill Education.
- Mora, C., Tittensor, D. P., Adl, S., Simpson, A. G., & Worm, B. (2011). How many species are there on Earth and in the ocean? PLoS biology, 9(8), e1001127.
- Muralikrishna, I. V., & Manickam, V. (2017). Natural resource management and biodiversity conservation. Environmental Management, 23-35.
- Nelson, D. L., & Cox, M. M. (2017). Lehninger principles of biochemistry (7th ed.). New York: United States of America: W. H. Freeman and Company.
- Nichols, R. (2001). Gene trees and species trees are not the same. Trends in Ecology & Evolution, 16(7), 358-364.
- Ogunseitan, O. (2005). Microbial diversity: form and function in prokaryotes. Massachusetts, United States of America: Blackwell Science Ltd.
- Page, R. D. & Holmes, E. C. (1998). Molecular Evolution: A Phylogenetic Approach. Oxford, England: Blackwell Science Ltd.
- Petersen, G., Seberg, O. (1998). Gene Trees vs Species Trees. In: Karp, A., Isaac, P.G., Ingram, D.S. (eds) Molecular Tools for Screening Biodiversity. Springer, Dordrecht. https://doi.org/10.1007/978-94-009-0019-6_66
- Pielou, E. C. (1966). The measurement of diversity in different types of biological collections. Journal of Theoretical Biology, 13, 131–144. doi:10.1016/0022-5193(66)90013-0
- Ridley, M. (2004). Evolution. (3rd ed.). Malden, Massachusetts, United States: Blackwell Science Ltd.
- Rossello-Mora, R., & Amann, A. (2001). The Species Concept for Prokaryotes. FEMS Microbiology Reviews 25, 39-67.
- Schleifer, K. H. (2004). Microbial diversity: facts, problems, and prospects. Systematic and applied microbiology, 27(1), 3.
- Shannon, C.E. (1948). A Mathematical Theory of Communication. The Bell System Technical Journal, 27, 379-423.
- Sharma, R., Polkade, A. V., & Shouche, Y. S. (2015). 'Species concept' in microbial taxonomy and systematics. Current science, 1804-1814.
- Simpson, E.H. (1949). Measurement of diversity. Nature, 163, 688. doi:10.1038/163688a0
- Szöllősi, G. J., Tannier, E., Daubin, V., & Boussau, B. (2015). The inference of gene trees with species trees. Systematic biology, 64(1), e42-e62.
- Willey, J. M., Sherwood, L. M., & Woolverton, C. J. (2017). Prescott's Microbiology (10th ed.). New York, United States of America: McGraw-Hill Education.
- Yi, S. (2013). Neutrality and Molecular Clocks. Nature Education Knowledge 4(2):3

Unit 2 - Bacterial Systematics and Introduction to Bergey's Manuals

- Arora, D. K., Das, S., & Sukumar, M. (Eds.). (2013). Analyzing microbes: manual of molecular biology techniques. Heidelberg: Springer.
- Black, J. G., & Black, L. J. (2015). Microbiology: Principles and explorations. (9th ed). New Jersey, United States of America: John Wiley & Sons, Inc.
- Brenner, D.J., Krieg, N.R., Staley, J.T. & Garrity, G.M. (eds.) (2005). Bergey's Manual of Systematic Bacteriology, 2nd ed., vol. 2, parts A, B, and C, Springer-Verlag, New York, NY.
- Brown, T. A. (2002). Molecular phylogenetics. In Genomes (2nd ed.). New York, United States of America: Garland Science, Taylor & Francis Group, LLC
- Das, S., Dash, H. R., Mangwani, N., Chakraborty, J., & Kumari, S. (2014). Understanding molecular identification and polyphasic taxonomic approaches for genetic relatedness and phylogenetic relationships of microorganisms. Journal of microbiological methods, 103, 80-100.
- De Vos, P., Thompson, F., Thompson, C., & Swings, J. (2017). A flavor of prokaryotic taxonomy: systematics revisited. In Microbial resources (pp. 29-44). Academic Press.
- Garrity, G.M., Boone, D.R. & Castenholz, R.W. (eds.) (2001). Bergey's Manual of Systematic Bacteriology, 2nd ed., vol. 1, Springer-Verlag, New York, NY
- Gillis, M., Vandamme, P., Vos, P. D., Swings, J., & Kersters, K. (2015). Polyphasic Taxonomy. Bergey's Manual of Systematics of Archaea and Bacteria, 1–10. doi:10.1002/9781118960608.bm00021
- Guerrero, R. (2001). Bergey's manuals and the classification of prokaryotes. International Microbiology, 4(2), 103-109.
- Herschleb, J., Ananiev, G. & Schwartz, D. (2007). Pulsed-field gel electrophoresis. Nat Protoc 2, 677–684.

https://doi.org/10.1038/nprot.2007.94
- Holt, J. G., Krieg, N. R., Sneath, P. H. A., Staley, J. T. Williams, S. T., (2000). Bergey's Manual of Determinative Bacteriology (9th ed.). Philadelphia, United States of America: Lippincott, Williams & Wilkins.
- Hug, L. A., Baker, B. J., Anantharaman, K., Brown, C. T., Probst, A. J., Castelle, C. J., ... & Banfield, J. F. (2016). A new view of the Tree of Life. Nature Microbiology, 1(5), 1-6.
- Kämpfer, P., & Glaeser, S. P. (2012). Prokaryotic taxonomy in the sequencing era–the polyphasic approach revisited. Environmental Microbiology, 14(2), 291-317.
- Krieg, N.R., Ludwig, W., Whitman, W.B., Hedlund, B.P., Paster, B.J., Staley, J.T., Ward, N. & Brown, D. (eds.) (2010). Bergey's Manual of Systematic Bacteriology, 2nd ed., vol. 4, Springer-Verlag, New York, NY.
- Madigan, M. T., Martinko, J. M., Stahl, D. A., & Clark, D. P. (2012). Brock biology of microorganisms (13th ed.). San Francisco, United States of America: Pearson Education, Inc.
- Moore, E. R., Mihaylova, S. A., Vandamme, P., Krichevsky, M. I., & Dijkshoorn, L. (2010). Microbial systematics and taxonomy: relevance for a microbial common. Research in microbiology, 161(6), 430-438.
- Nelson, D. L., & Cox, M. M. (2017). Lehninger principles of biochemistry (7th ed.). New York: United States of America: W. H. Freeman and Company
- Oren, A. (2019). Prokaryotic Nomenclature. In Bergey's Manual of Systematics of Archaea and Bacteria (eds M.E. Trujillo, S. Dedysh, P. DeVos, B. Hedlund, P. Kämpfer, F.A. Rainey and W.B. Whitman). 1-12. John Wiley & Sons, Inc. https://doi.org/10.1002/9781118960608.bm00004.pub2
- Pommerville, J. C. (2011). Alcamo's Fundamentals of Microbiology (9th ed.). Massachusetts, United States of America: Jones & Bartlett Publishers, LLC
- Prakash, O., Verma, M., Sharma, P., Kumar, M., Kumari, K., Singh, A., Kumari, H., Jit, S., Gupta, S. K., Khanna M. & Lal, R. (2007). Polyphasic approach of bacterial classification—an overview of recent advances. Indian Journal of Microbiology, 47(2), 98-108.
- Raina, V., Nayak, T., Ray, L., Kumari, K., & Suar, M. (2019). A polyphasic taxonomic approach for designation and description of novel microbial species. In Microbial diversity in the genomic era (pp. 137-152). Academic Press.
- Sarethy, I. P. , Pan, S., & Danquah, M. K. (2014). Modern Taxonomy for Microbial Diversity. In (Ed.), Biodiversity - The Dynamic Balance of the Planet. IntechOpen. https://doi.org/10.5772/57407
- Schleifer, K. H. (2009). Classification of Bacteria and Archaea: past, present, and future. Systematic and applied microbiology, 32(8), 533-542.
- Sharma-Kuinkel, B. K., Rude, T. H., & Fowler, V. G., Jr (2016). Pulse Field Gel Electrophoresis. Methods in molecular biology (Clifton, N.J.), 1373, 117–130. https://doi.org/10.1007/7651_2014_191
- Smith, H. R., Cowan, M. K. (2017). Microbiology: A Systems Approach (5th ed.). New York, United States of America: McGraw-Hill Education.
- Sneath, P. H. (2005). Numerical taxonomy. In Bergey's manual® of systematic bacteriology (pp. 39-42). Springer, Boston, MA.
- Sofi, M. Y., Shafi, A., & Masoodi, K. Z. (2021). Bioinformatics for everyone. Academic Press.
- Sokal, R. R. (1986). Phenetic Taxonomy: Theory and Methods. Annual Review of Ecology and Systematics, 17(1), 423–442. doi:10.1146/annurev.es.17.110186.002231
- Stackebrandt, E. (2006). Defining Taxonomic Ranks. The Prokaryotes: Vol. 1: Symbiotic Associations, Biotechnology, Applied Microbiology, 1, 29-57.
- Talaro, K. P., & Chess, B. (2018). Foundations in Microbiology, Basic Principles (10th Ed.). New York, United States of America: McGraw-Hill Education
- Tortora, G. J., Funke, B. R., & Case, C. L. (2021). Microbiology: an introduction (13th ed.). Harlow, United Kingdom: Pearson Education Ltd.
- Vandamme, P., Pot, B., Gillis, M., De Vos, P., Kersters, K., & Swings, J. (1996). Polyphasic taxonomy, a consensus approach to bacterial systematics. Microbiological reviews, 60(2), 407-438.
- Vos, P., Garrity, G., Jones, D., Krieg, N.R., Ludwig, W., Rainey, F.A., Schleifer, K.-H. & Whitman, W.B. (eds.) (2009). Bergey's Manual of Systematic Bacteriology, 2nd ed., vol. 3, Springer-Verlag, New York, NY.
- Whitman, W.B., Goodfellow, M., Kämpfer, P., Busse, H.-J., Trujillo, M.E., Ludwig, W. & Suzuki, K.-i. (eds.) (2012). Bergey's Manual of Systematic Bacteriology, (2nd ed.) vol. 5, parts A and B, Springer-Verlag, New York, NY.
- Whittaker, R. H. (1959). On the Broad Classification of Organisms. The Quarterly Review of Biology, 34(3), 210–226. doi:10.1086/402733
- Willey, J. M., Sherwood, L. M., & Woolverton, C. J. (2017). Prescott's Microbiology (10th ed.). New York, United States of America: McGraw-Hill Education
- Woese, C. R., & Fox, G. E. (1977). Phylogenetic structure of the prokaryotic domain: the primary kingdoms. Proceedings of the National Academy of Sciences of the United States of America, 74(11), 5088–5090. https://doi.org/10.1073/pnas.74.11.5088
- Woese, C. R., Kandler, O., & Wheelis, M. L. (1990). Towards a natural system of organisms: proposal for the domains Archaea, Bacteria, and Eucarya. Proceedings of the National Academy of Sciences of the United States of America, 87(12), 4576–4579. https://doi.org/10.1073/pnas.87.12.4576

Unit 3 - Explorations of Unculturable bacteria

- Cheung, V. G., Nowak, N., Jang, W., Kirsch, I. R., Zhao, S., Chen, X. N., Furey, T. S., Kim, U. J., Kuo, W. L., Olivier, M., Conroy, J., Kasprzyk, A., Massa, H., Yonescu, R., Sait, S., Thoreen, C., Snijders, A., Lemyre, E., Bailey, J. A., Bruzel, A., … BAC Resource Consortium (2001). Integration of cytogenetic landmarks into the draft sequence of the human genome. Nature, 409(6822), 953–958. https://doi.org/10.1038/35057192
- Díaz-García, L., Huang, S., Spröer, C., Sierra-Ramírez, R., Bunk, B., Overmann, J., & Jiménez, D. J. (2021). Dilution-to-stimulation/extinction method: a combination enrichment strategy to develop a minimal and versatile lignocellulolytic bacterial consortium. Applied and environmental microbiology, 87(2), e02427-20.
- Ercolini, D., & Cocolin, L. (2014). Identification Methods, Culture-Independent Techniques. Encyclopedia of Food Microbiology, 259–266. doi:10.1016/b978-0-12-384730-0.00438-9
- Espina, V., Wulfkuhle, J. D., Calvert, V. S., VanMeter, A., Zhou, W., Coukos, G., ... & Liotta, L. A. (2006). Laser-capture microdissection. Nature Protocols, 1(2), 586-603.
- Green, S. J., Leigh, M. B., & Neufeld, J. D. (2010). Denaturing Gradient Gel Electrophoresis (DGGE) for Microbial Community Analysis. Handbook of Hydrocarbon and Lipid Microbiology, 4137–4158. doi:10.1007/978-3-540-77587-4_323
- Lever MA, Torti A, Eickenbusch P, Michaud AB, Šantl-Temkiv T and Jørgensen BB (2015). A modular method for the extraction of DNA and RNA, and the separation of DNA pools from diverse environmental sample types. Front. Microbiol. 6:476. doi: 10.3389/mice.2015.00476
- Lewis, K., Epstein, S., D'onofrio, A., & Ling, L. L. (2010). Uncultured microorganisms as a source of secondary metabolites. The Journal of Antibiotics, 63(8), 468-476.
- Lewis, K., Epstein, S., D'onofrio, A., & Ling, L. L. (2010). Uncultured microorganisms as a source of secondary metabolites. The Journal of Antibiotics, 63(8), 468-476.
- Puspita, I. D., Kamagata, Y., Tanaka, M., Asano, K., & Nakatsu, C. H. (2012). Are uncultivated bacteria really uncultivable? Microbes and environments, ME12092.
- Robinson, R. K. (2014). Encyclopedia of food microbiology. Academic press
- Sharma, R., Ranjan, R., Kapardar, R. K., & Grover, A. (2005). 'Unculturable'bacterial diversity: An untapped resource. Current Science, 72-77.
- Siqueira Jr, J. F., & Rôças, I. N. (2005). Exploiting molecular methods to explore endodontic infections: part 1—current molecular technologies for microbiological diagnosis. Journal of Endodontics, 31(6), 411-423.
- Speicher, M. R., & Carter, N. P. (2005). The new cytogenetics: blurring the boundaries with molecular biology. Nature reviews. Genetics, 6(10), 782–792. https://doi.org/10.1038/nrg1692
- Stewart, E. J. (2012). Growing unculturable bacteria. Journal of Bacteriology, 194(16), 4151-4160.
- Vartoukian, S. R., Palmer, R. M., & Wade, W. G. (2010). Strategies for culture of ‘unculturable’ bacteria. FEMS microbiology letters, 309(1), 1-7.
- Wael N. Hozzein (2020). Introductory Chapter: Metagenomics and Metagenomic Approaches. In (Ed.), Metagenomics - Basics, Methods, and Applications. IntechOpen. https://doi.org/10.5772/intechopen.87949

Unit 4 - Genome Sequencing and Bioinformatics

- Adékambi, T., Drancourt, M. & Raoult, D. (2009). The rpoB gene as a tool for clinical microbiologists. Trends Microbiol 17, 37–45.
- Alberts B., Johnson A., Lewis J., et al. (2002). Molecular Biology of the Cell (4th ed.). New York, United States: Garland Science; Available from: https://www.ncbi.nlm.nih.gov/books/NBK26837/
- Altschul, S. F., Gish, W., Miller, W., Myers, E. W., & Lipman, D. J. (1990). Basic local alignment search tool. Journal of Molecular Biology, 215(3), 403–410. doi:10.1016/s0022-2836(05)80360-2
- Bagchi, A. (2018). Introduction to Bioinformatics. Oxford, United Kingdom: Alpha Science International Limited.
- Baum, D. (2008) Reading a Phylogenetic Tree: The Meaning of Monophyletic Groups. Nature Education 1(1):190. https://www.nature.com/scitable/topicpage/reading-a-phylogenetic-tree-the-meaning-of-41956/
- Brown, T. A. (2018). Genomes (4th ed.). New York, United States: Garland Science, Taylor & Francis Group, LLC.
- Choudhuri, S. (2014). Bioinformatics for beginners: genes, genomes, molecular evolution, databases, and analytical tools. London, United Kingdom; Academic Press
- Christensen, H. (Ed.). (2018). Introduction to bioinformatics in microbiology. Gewerbestrasse, Switzerland: Springer Nature Switzerland
- Clark, D. P., & Pazdernik, N. J., McGehee M. R. (2019). Molecular biology (3rd ed.). London, United Kingdom: Academic Press
- England, R., Pettersson, M. (2005). Pyro Q-CpG™: quantitative analysis of methylation in multiple CpG sites by Pyrosequencing®. Nat Methods 2, i–ii. https://doi.org/10.1038/nmeth800
- Futuyma, D. J., & Kirkpatrick, M. (2017). Evolution (4th ed.). Sunderland, Massachusetts, United States: Sinauer Associates, Inc.
- Gautam, S. S., Kc, R., Leong, K. W., Mac Aogáin, M., & O'Toole, R. F. (2019). A step-by-step beginner's protocol for whole genome sequencing of human bacterial pathogens. Journal of biological methods, 6(1), e110. https://doi.org/10.14440/jbm.2019.276

- McGinnis, S., & Madden, T. L. (2004). BLAST: at the core of a powerful and diverse set of sequence analysis tools. Nucleic acids research, 32(Web Server issue), W20–W25. https://doi.org/10.1093/nar/gkh435
- Nyrén, P. (n.d.). The History of Pyrosequencing®. Pyrosequencing Protocols, 1–14. doi:10.1385/1-59745-377-3:1
- Phylogenetic Trees. (2021, March 6). https://bio.libretexts.org/@go/page/13526
- Primrose, S. B., & Twyman, R. (2006). Principles of gene manipulation and genomics (7th ed.). Massachusetts, United States: Blackwell Publishing
- Qi, H., Lu, H., Qiu, H. J., Petrenko, V., & Liu, A. (2012). Phagemid vectors for phage display: properties, characteristics, and construction. Journal of molecular biology, 417(3), 129–143. https://doi.org/10.1016/j.jmb.2012.01.038
- Ravi, R. K., Walton, K., & Khosroheidari, M. (2018). MiSeq: A Next Generation Sequencing Platform for Genomic Analysis. Disease Gene Identification, 223–232. doi:10.1007/978-1-4939-7471-9_12
- Ridley, M. (2004). Evolution. (3rd ed.). Malden, Massachusetts, United States: Blackwell Science Ltd.
- Rodriguez, R. L., & Denhardt, D. T. (Eds.). (2014). Vectors: a survey of molecular cloning vectors and their uses. Butterworth-Heinemann.
- Sanger, F., Nicklen, S., & Coulson, A. R. (1977). DNA sequencing with chain-terminating inhibitors. Proceedings of the National Academy of Sciences of the United States of America, 74(12), 5463–5467. https://doi.org/10.1073/pnas.74.12.5463
- Shanker, A. (Ed.). (2018). Bioinformatics: Sequences, Structures, Phylogeny. Singapore: Springer Nature Singapore Pte Ltd.
- van Embden J. (1983). The Use of Cosmids as Cloning Vehicles. In: Walker J.M., Gaastra W. (eds) Techniques in Molecular Biology. Springer, Dordrecht. https://doi.org/10.1007/978-94-011-6563-1_17
- Wheeler D, Bhagwat M. (2007). BLAST QuickStart: Example-Driven Web-Based BLAST Tutorial. In: Bergman NH, editor. Comparative Genomics: Volumes 1 and 2. Totowa (NJ): Humana Press. Chapter 9. Available from: https://www.ncbi.nlm.nih.gov/books/NBK1734/

Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous)

Shivajinagar, Pune – 5

First Year of M.Sc. Microbiology

(2023 Course under NEP 2020)

Course Code: 23ScMicP112

Course Name: Biochemistry and Metabolism

Teaching Scheme: Theory: 4 Hours/Week **Credit: 04**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Course Objectives:

- To inculcate the basic concepts of biochemistry in the students.
- To teach students about how carbohydrates, proteins, lipids and nucleic acids are metabolized.

Course Outcomes: On completion of the course, student will be able to –

- Understand the basic concepts in biochemistry and metabolism.
- Understand the chemical composition of the living system.
- Describe structure and metabolism of carbohydrate
- Explain structure and metabolism of proteins
- Understand structure and metabolism of lipids
- Describe structure and metabolism of nucleic acids.

Course Contents:

Unit 1	**Carbohydrate Chemistry and Metabolism**	**No of**

		Lectures
	1. Mono, di, oligosaccharides and polysaccharides, with examples 2. Isomerism in sugars: asymmetric centres in sugars, dextro, laevo-rotatory, sugar anomers (reducing and non-reducing sugars), sugar epimers 3. Sugar derivatives such as sugar alcohols, amino sugars, sugar acids, deoxy sugars 4. Glycolysis and gluconeogenesis, Regulation of glycolysis and gluconeogenesis, 5. Synthesis of microbial exopolysaccharides (alginate) 6. Cellulose synthesis and breakdown 7. Regulation of Glycogen synthesis; breakdown, 8. Metabolic flux and its regulation by various metabolic intermediates 9. TCA cycle- regulation, role in energy generation, Role in generating biosynthetic intermediates and glyoxylate cycle	15
Unit 2	**Lipid Chemistry and Metabolism**	
	1. Classification of lipids according to chemical structure, 2. Fatty acids, saturated, unsaturated, branched, nomenclature system, 3. Structure and function of: triglycerides, phospholipids, sphingolipids, terpenes, prostaglandins, waxes, and steroids. 4. Synthesis of storage lipids: Fatty acids and triacylglycerols, 5. Synthesis of membrane lipids: Glycerophospholipids, sphingolipids, sterols, 6. Degradation of fatty acids (beta oxidation and unsaturated fatty acid) and fats in animals 7. Lipids as signal molecules (eg phosphatidyl inositol and eicosanoids).	15
Unit 3	**Protein Chemistry and Metabolism**	
	1. Henderson Hasselbalch equation and its role in buffer formulation 2. Structural features of amino acids 3. classification of amino acids, 4. amino acids as buffers, 5. chemical reactions of amino acids, peptide linkage, partial double bond nature of peptides, 6. structural classification of proteins : primary, secondary, tertiary, quaternary structures of proteins 7. Overview of amino acid biosynthesis relationship between glycolysis, citric acid cycle, pentose phosphate pathway and various amino acids. 8. Biosynthesis of following amino acid a. Pyruvate family b. α keto glutarate family c. serine family d. aspartate e. aromatic amino acid 9. Importance of glutamine synthetase and it's role in amino acid metabolism. 10. Regulation of amino acid biosynthetic Pathway (aspartate family).	

Unit 4	Nucleic Acid Chemistry and Metabolism	
	1. Structure of bases, nucleosides, nucleotides, phospho-diester linkages, 5' phosphate, 3' hydroxyl polarity of nucleic acids, 2. tautomeric forms of bases and their implication in pairing of bases, 3. structure of DNA (A, B and Z forms), 4. Tm value, 5. Structure of t-RNA, r-RNA, and m-RNA. 6. De Novo biosynthesis of purine nucleotide, 7. Salvage pathway 8. De Novo biosynthesis of pyrimidine. 9. Ribonucleotide reductase and its role in nucleic acid metabolism.	15

References

- Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford Press
- Jerry March, Advanced Organic Chemistry, John Wiley
- Campbell M. K. (2011). Biochemistry, 6th edition Harcourt Brace College Publishers, New York , R. H., and Grisham, C. M. (2012). Biochemistry. 5th edition. Brooks/Cole, Publishing Company, California.
- Nelson D. L. and CoxM. M. (2005). Lehninger's Principles of Biochemistry, 6th edition, McMillan
- Worth Pub. Co. New Delhi
- Segel Irvin H. (1997). Biochemical Calculations. 2nd edition. John Wiley and Sons, New York.
- Berg Jeremy, Tymoczko John, Stryer Lubert (2001) Biochemistry. 6th Edition, W. H. Freeman, New York.
- Conn Eric, Stumpf Paul K., Bruuening George, Doi Roy H., (1987) Outlines of Biochemistry. 5th Edition , John Wieley and Sons, New Delhi..
- White Abraham, Handler Philip, Smith Emil, Hill Rober, Lehman J. (1983) Principles of Biochemistry, Edition 6, Tata Mc-Graw Hill Companies, Inc.
- White David (2000) Physiology and Biochemistry of Prokaryotes. 2nd Ed. Oxford University Press, New York.

Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous)

Shivajinagar, Pune – 5

First Year of M.Sc. Microbiology

(2023 Course under NEP 2020)

Course Code: 23ScMicP113

Course Name: Practical course based on Microbial Taxonomy and Systematics

Teaching Scheme: Practical: 8 Hours/Week **Credit: 04**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Course objectives:

- Understand media design for isolation of microorganisms from environmental samples.
- Inculcate use of Bergey's manual for identification of microorganisms.
- Understand microbial systematics.

Course outcomes: On completion of the course, student will be able to –

- Use Bergey's manual to create keys for the identification of pure cultures of bacteria. Constructing identification keys for yeasts and molds.
- Develop logic of media designing for isolation of a particular group of microorganisms from a particular environment
- Become competent in various molecular techniques for isolation and purification of chromosomal DNA, use of software in microbial systematics.

- Develop the basic skills required to work in research laboratories working in the field of molecular taxonomy.

Course Contents:

I	**Isolation and identification of bacteria and fungi**	**No. of practicals**
	Isolation of actinomycetes from natural samples and identification to at least genus level	2
	Isolation of thermophiles from natural samples and identification to at least genus level	2
	Isolation of molds from natural samples and identification to at least genus level	2
	Isolation of yeasts from natural samples and identification to at least genus level	2
	Isolation of cyanobacteria from natural samples and identification to at least genus level	2
II	**Molecular Taxonomy**	
	Isolation, purification and checking purity of isolated chromosomal DNA of bacteria	2
	Isolation, purification and checking the purity of total DNA isolated from environmental sample	2
	16S rRNA amplification using PCR, purification of PCR products and determination of molecular weight of PCR products	2
III	**Bioinformatics**	
	Use of nucleotide databases (various databases and features available on database websites, sequence retrieval, steps in sequence submission to NCBI, reading sequence descriptions)	2
	Sequence matching by BLAST analysis.	1
	Phylogenetic tree construction using related sequences	1
*Any 15 practicals from the above list can be conducted.		

References:

Unit I – Isolation and identification of bacteria and fungi

- Breed and Buchanan (1982). Bergey's Manual of Determinative Bacteriology. 9th Edition,
- Breed and Buchanan (2001 –2003). Bergey's Manual of Systematic Bacteriology. 2nd Edition, (Volumes. 1 – 5)
- Sykes, G. and F. A. Skinner (Eds) (1973).*Actinomycetales*: Characteristics and Practical Importance. Society for Applied Bacteriology Symposium Series Academic Press.
- Barnett, H. L., and Hunter, B. B. (1960). Illustrated Genera of Imperfect Fungi. Burgess Publishing Co.,Minnesota.
- Lodder J. (1974). The Yeasts: A Taxonomic Study, North Holland Publishing Co. Amsterdam.
- Breed and Buchanan (1982). Bergey's Manual of Determinative Bacteriology. 9th Edition
- Boone, David R.; Castenholz, Richard W. (Eds.) (1984). Bergey's Manual of Systematic Bacteriology. 2nd Edition Volume One: The Archaea and the Deeply Branching and Phototrophic Bacteria. Originally published by Williams & Wilkins.

Unit II – Molecular Taxonomy

- Sandy Primrose, Richard Twyman, Bob Old (2001). Principles of Gene Manipulation 6thEdition, Blackwell Science Ltd.
- Sambrook, J., Fritsch, E. F., and Maniatis, T. (1989). Molecular Cloning: A Laboratory Manual, 2ndedition. Cold Spring Harbor: Cold Spring Harbour Laboratory Press
- Ausubel F. M. And Brent R. (1994). Current Protocols in Molecular Biology, John Wiley & Sons Inc, New York

Unit III – Bioinformatics

- URLs:

- **National Center for Biotechnology Information** www.ncbi.nlm.nih.gov/**Ribosomal Database Project-Release 10** rdp.cme.msu.edu/ **rdp.cme.msu.edu/** seqmatch/**Building phylogenetic trees** **www.itu.dk/~sestoft/bsa**
- **/dinaws/**phylogeny**.html Reading a Phylogenetic Tree - Nature** www.nature.com//reading-a-**phyloge**

Progressive Education Society's
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Shivajinagar, Pune – 5

First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP114
Course Name: Practical course based on Biochemistry

Teaching Scheme: Practical: 4 Hours/Week **Credit: 02**
Examination Scheme: CIA: 25 Marks **End-Sem: 25 Marks**

Course objectives:
- Know SOP of various instruments.
- Use tools to study Ramachandran plot and protein conformation.
- Know calculations required for preparation of various solutions and buffers.
- Know estimation of sugars, proteins, RNA and DNA.

Course outcomes: On completion of the course, student will be able to –
- Prepare SOPs for instruments frequently used in biology.
- Prepare buffers, stock and working solutions.
- Interpret Ramachandran plot of a given protein and study its conformation.
- Estimate concentration of sugars, proteins, RNA and DNA.

Course Contents:

I	Biochemistry	No. of practicums
	Preparation of Percent, Molar, and Normal stock solutions (solid and liquid compounds) and their dilutions to obtain working solutions.	1
	Designing SOP for instruments (autoclave, incubator, spectrophotometer, PCR, pH meter, Incubator shaker, centrifuge, micropipette, hot air oven, weighing balance, laminar air flow hood)	1
	Determination of pKa of a monoprotic weak acid.	1
	Preparation of acidic, basic, and neutral buffers.	1
	Interpretation of Ramachandran Plot and study of conformations of a protein molecule using Molecular Graphics Visualization Tool (e.g., Swiss PDB viewer)	1
	Estimation of sugars by DNSA method	1
	Estimation of protein by Folin-Lowry method	1
	Estimation of RNA by orcinol method	1
	Estimation of DNA by DPA method	1
*Any 8 practicals from the above list can be conducted.		

References:

- Plummer M. and Plummer D.T. (2001). Introduction to practical biochemistry. 3rd Edition, Tata McGraw- Hill Edition.
- Segel I. H. (2010). Biochemical Calculations, 2nd Edn. India: Wiley India Pvt. Ltd.
- Sadasivam S. and Manickam A. (2008). Biochemical methods. 3rd Edition, New Age International Publishers, India.
- Jayaraman J. (2004). Laboratory Manual in Biochemistry. India: New Age International (P) Limited Publishers.
- Bansal M. and Srinivasan N. (2013). Biomolecular Forms and Functions: A Celebration of 50 Years of the Ramachandran Map. Singapore: World Scientific.
- Bourne P. E. (2011). Structural Bioinformatics. Germany: Wiley.
- Ramachandran G.N., Ramakrishnan C. and Sasisekharan V. (1963). Stereochemistry of Polypeptide Chain Configurations. J. Mol. Biol. 7: 95-99
- Pazos F. and Chagoyen M. (2014). Practical Protein Bioinformatics. Germany: Springer International Publishing.
- Webster D. M. (2000*)*. Protein Structure Prediction: Methods and Protocols. Ukraine: Humana Press

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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP121
Course Name: Instrumentation and Molecular Biophysics Theory (Elective 1)

Teaching Scheme: Theory: 2 Hours/Week **Credit: 02**
Examination Scheme: CIA: 25 Marks **End-Sem: 25 Marks**

Course Objectives:

- To enrich students' knowledge related to basic concepts in Instrumentation and Molecular Biophysics
- To inculcate concepts of instrumentation of HPLC, GC, FACS, Mass spectrophotometry and FTIR
- To make students acquainted with the concepts of NMR and X ray crystallography
- To introduce basics on nanotechnology.

Course Outcomes: On completion of the course, student will be able to –

- Understand instrumentation, principle, role and applications of different instruments used in molecular biophysics.
- Interpret data obtained from different biophysical techniques.
- Understand basics of synthesis and characterization of nanoparticles.

Course Contents:

Unit 1	**Chromatography and Spectroscopy**	**No. of lectures**
	1. **Chromatography** a. Introduction: Partition Coefficient, Selectivity, Resolution, Column Efficiency, Van Deemter equation, Interpretation of chromatograms. b. Principle, components of the instrument, operation, and applications of: Gas chromatography and High- Performance Liquid Chromatography	15

	2. **Spectroscopy** a. Introduction: The electromagnetic spectrum, atomic orbitals, Molecular orbitals, Electronic, Rotational and Vibrational transitions in spectroscopy, Interpretation of spectra. b. Fluorescence spectroscopy: Instrumentation, Quantum yield, Quenching, FRET, Binding and Folding studies, Flow cytometry and FACS c. Infrared spectroscopy: Principle, Instrumentation, Absorption bands, FTIR and its advantages. d. Mass spectroscopy: Principles of operation, Ionization, Ion fragmentation, Mass Analyzers, GC-MS, MALDI-TOF.	
Unit 2	**X-ray crystallography, NMR and Nanotechnology**	
	1. **X-ray crystallography:** a. Instrumentation. b. Crystallization of proteins. c. Basic principles of x-ray diffraction and Acquisition of the diffraction pattern. d. Crystal Structures (Bravais Lattices), Crystal planes, Miller Indices, Direct Lattice and Reciprocal lattice. e. Fourier Transform and Inverse Fourier f. Electron density maps 2. **NMR spectroscopy:** a. Basic Principles of NMR, Chemical shift, Intensity, Line width, Relaxation parameters, Spin coupling. b. Nuclear Overhauser Effect Spectroscopy and Correlation Spectroscopy. 3. **Brief overview of synthesis and characterization of nanoparticles.**	15

References:

- Hofmann A., Walker J. M., Wilson K. and Clokie S. (2018). Wilson and Walker's Principles and techniques of biochemistry and molecular biology. United Kingdom: Cambridge University Press.
- Desiderio D. M., Kraj A. and Nibbering N. M. (2009). Mass spectrometry: instrumentation, interpretation and applications. United Kingdom: Wiley.
- Nölting B. (2013). Methods in modern biophysics. Germany: Springer Berlin Heidelberg.
- Pattabhi V. and Gautham N. (2002). Biophysics. India: Springer Netherlands.
- Rutherford T. (2019). Principles of analytical biochemistry. Alexis Press LLC. New York.
- Cavanagh John et.al. (1995). Proteins NMR Spectroscopy: Principles and Practice, Academic Press.
- Keeler, J. (2002) Understanding NMR Spectroscopy. John Wiley & Sons, England.
- Narayanan P. (2007). Essentials of biophysics. India: New Age International.
- David J Holme, Hazel Peck (1998) Analytical Biochemistry,3rdedition., Prentice Hall, Pearson Education Limited, Harlow England.
- Rodney F. Boyer (2000). Modern Experimental Biochemistry 3rd edition.,BenjaminCummings.
- Feldheim D. L. and Foss C. A. Jr. (2002). Metal nanoparticles synthesis and characterization and applications Marcel Dekker, Inc.
- Mishra P. (Serial editor). Blackman J. A. (Editor). Metallic Nanoparticles. (2008). Netherlands: Elsevier Science.
- Schmid G. (Editor). (2006). Nanoparticles: From Theory to Application. Germany: Wiley.
- Rai M. and Duran N. (2011). Metal nanoparticles in Microbiology. Springer Verlag Berlin Heidelberg.
- Nasrollahzadeh M., Isaabadi Z., Sajadi M. S. and Atarod M. (2019). An Introduction to Green Nanotechnology.United Kingdom: Elsevier Science.
- Niemeyer C. M. and Mirkin C. A. (2006). Nanobiotechnology. John Wiley & Sons.
- Mirkin C. A. and Niemeyer C. M. (2007). Nanobiotechnology II: More Concepts and Applications. Germany: Wiley.

- Omran B. A. (2020). Nanobiotechnology: A Multidisciplinary Field of Science. Germany: Springer International Publishing.

Progressive Education Society's
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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP121
Course Name: Practical course based on Biophysics (Elective 1)

Teaching Scheme: Practical: 4 Hours/Week **Credit: 02**
Examination Scheme: CIA: 25 Marks **End-Sem: 25 Marks**

Course objectives:
- Understand the principle and handling of TLC.
- Understand the principle and handling of ion exchange chromatography.
- Know synthesis of nanoparticles and characterize it using UV-Vis spectroscopy.
- Know isolation of pigment producing bacteria and characterize it using molar extinction coefficient.

Course outcomes: On completion of the course, student will be able to –
- Calculate molar extinction coefficient of isolated pigment.
- Separate biomolecules using TLC.
- Determine ion-exchange capacity of a given resin used in ion exchange chromatography.
- Synthesize nanoparticles by biological methods and characterize it using UV-Vis spectroscopy.

Course Contents:

I	Biophysics and Nanotechnology	No. of Practicums
	Separation of sugars by thin layer chromatography and calculation of its Rf value	1
	Separation of amino acids by thin layer chromatography and calculation of its Rf value	1
	Determination of the ion-exchange capacity and nature of given resin using anion exchange chromatography.	2
	Biological synthesis of nanoparticles (actinomycetes /fungi /yeast/ plant extract) and their characterization by UV-Vis spectroscopy.	2
	Isolation of bacterial pigment and its characterization using molar extinction coefficient	3
*Any 8 practicals from the above list can be conducted.		

References:
Unit I -- Biophysics and Nanotechnology

- Feldheim D. L. and Foss C. A., Jr. (Editors). (2002) Metal nanoparticles synthesis and characterization and applications. Taylor & Francis

- Hofmann A., Walker J. M., Wilson K. and Clokie S. (2018). Wilson and Walker's Principles and techniques of biochemistry and molecular biology. United Kingdom: Cambridge University Press.
- Mirkin C. A. and Niemeyer C. M. (2006). Nanobiotechnology: Concepts, Applications and Perspectives. Germany: Wiley.
- Rai M. and Duran N. (2011). Metal nanoparticles in Microbiology. Springer Verlag Berlin Heidelberg.

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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP122
Course Name: Cell Cytology and Communication Biology Theory (Elective 2)

Teaching Scheme: Theory: 4 Hours/Week **Credit: 02**
Examination Scheme: CIA: 25 Marks **End-Sem: 25 Marks**

Course Objectives:
- To inculcate the basic concepts of cell cytology and developmental biology in the students.
- To teach the students the mechanisms of communication and coordination among microorganisms through quorum sensing, biofilms, through the life cycle of *Dictyostelium* and *Myxobacteria*

Course Outcomes: On completion of course students will be able to -
- Understand the basic concepts of cell biology and developmental biology
- Gain basic knowledge about communication biology
- Comprehensive knowledge about life cycle of *Dictyostelium* and *Myxobacteria*
- Understand Quorum sensing Gram-negative and Gram-positive bacteria
- Gain knowledge about Biofilms and its applications.
- Comprehensive knowledge about communication biology in microorganisms

Course Contents

Unit 1	**Cell Cytology**	**No of Lectures**
	1. Structural organization and function of eukaryotic cell (Endoplasmic Reticulum, Golgi apparatus, Nucleus, Mitochondrion, chloroplast, Lysosomes, peroxisomes), Cytoskeleton and function of molecular motors (Myosin, Kinesin, Dynein) 2. Protein trafficking among various cellular compartments (by secretory and cytosolic pathway: targeting to secretory vesicles, cell membrane, lysosomes, nucleus, mitochondria and peroxisomes) 3. Cell Cycle and its Regulation, Apoptosis 4. Localization of macromolecules using electron microscopy, Immunoelectron microscopy, and Confocal Microscopy	15
Unit 3	**Communication Biology - I**	15
	1. The life cycle of *Dictyostelium discoidum,*	

	2. Molecular mechanism of quorum sensing in slime molds 3. The life cycle of myxobacteria, Molecular mechanism of quorum sensing in myxobacteria 4. Quorum sensing in Gram-positive (*Staphylococcus aureus* virulence and Gram-negative bacteria (*Vibrio fischeri* lux operon) 5. Biofilms: Their organization, signals involved in biofilm formation and dispersal of biofilms 6. Applications of study on biofilms in pathogens (*Pseudomonas aeruginosa*) and non-pathogenic environments (dental plaque).	

References:

Unit 1: Cell Cytology

- Alberts Bruce (2017). Molecular Biology of Cell.6th edition, Garland Publishing Inc, US
- Harvey Lodish, Arnold Berk, S. Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James
- Darnell (2003). Molecular Cell Biology, 5thedition, W. H. Freeman &co.,New York.
- Metzler David E. (2003). Biochemistry: The Chemical Reactions of Living Cells, 2nd edition, Volume 1&2, Academic Press California.

Unit 2: Communication Biology

- Gilbert S. F. (2010). Developmental Biology. 9th Ed. Sinauer Associates Inc. Mass. USA.
- Dworkin M. (1996) Recent advances in the social and developmental biology of the myxobacteria, Microbiological Reviews: 70–102
- Dale K., Mark R. and Lee K. (2010) Myxobacteria, Polarity, and Multicellular Morphogenesis, Cold Spring Harb Perspect Biol 2010; 2: a000380
- Peterson J. E. (1969). Isolation, cultivation and maintenance of Myxobacteria, Methods in Microbiology (Eds. Norris J. R.and W. Ribbons) Vol. 3B, Academic Press London, 185-210.
- Hamilton W. Allan, (1987). Biofilms: Microbial Interactions and Metabolic activities, in Ecology of Microbial Communities, (Eds. M. Fletcher, T. R. G. Gray, and J. G.Jones) Cambridge University Press, Cambridge.
- Toole 'O' G., Kaplan H. B. and Kolter R. (2000) Biofilm formation as microbial development Annual Review of Microbiology: 54: 49-79.
- Miller M. B. and Bassler B. L. (2001) Quorum sensing in bacteria. Annu. Rev. Microbiol. 55: 165–99.
- Waters C. M. and Bassler B. L. (2005) Quorum sensing: cell-to-cell communication in bacteria. Annu. Rev. Cell Dev. Biol. 21: 319–346.

Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous)

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First Year of M.Sc. Microbiology

(2023 Course under NEP 2020)

Course Code: 23ScMicP122

Course Name: Practical course based on Communication Biology (Elective 2)

Teaching Scheme: Practical: 8 Hours/Week **Credit: 04**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Course objectives:

- Understand stages of mitosis.
- Explain formation and disruption of biofilms.
- Study quorum sensing in bacteria

Course outcomes: On completion of the course, student will be able to –

- Examine the stages of mitosis from the growing tips of onion root cells.

- Estimate formation and disruption of biofilms.
- Isolate and observe fruiting bodies of Myxobacteria

Course Contents:

I	Communication biology	No. of Practicums
	Observation of stages of mitosis in the growing tip of onion root cells	1
	Isolation of Myxobacteria and observation of fruiting bodies	2
	Crystal violet assay for estimation of biofilm formation	2
	Disruption of biofilm using any chemical/ biological agent	1
	Bioassay for determination of quorum sensing signals produced by bacteria	2

References:

Unit I - Cell Biology

- Manzoor A., Ahmad T., Bashir M. A., Hafiz A. and Silvestri C. (2019). Studies on colchicine induced chromosome doubling for enhancement of quality traits in ornamental plants. Plants.8:194. Doi: 10.3390/plants8070194.
- Gilbert S. F. and Barresi M. J. F. (2020). Developmental Biology. United States: Oxford University Press. ISBN:9781605358222.
- Müller W. A. (2012). Developmental Biology. United States: Springer New York. ISBN: 9781461222484.
- Wolpert L., Tickle C. and Martinez Arias A. (2015). Principles of Development. United Kingdom: Oxford University Press. ISBN: 9780199678143
- O'Toole G. A. (2011) Microtiter dish biofilm formation assay. Journal of Visualized Experiments. 47:3–5. doi: 10.3791/2437.
- Toole 'O' G., Kaplan H. B. and Kolter R. (2000) Biofilm formation as microbial development Annual Review of Microbiology: 54: 49-79.
- Merritt J. H., Kadouri D. E. and O'Toole G. A. Growing and analyzing static biofilms. Curr. Protoc. Microbiol. 2006 doi: 10.1002/9780471729259.mc01b01s00.
- Dale K., Mark R. and Lee K. (2010) Myxobacteria, Polarity, and Multicellular Morphogenesis, Cold Spring Harb Perspect Biol 2010; 2: a000380

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First Year of M.Sc. Microbiology

(2023 Course under NEP 2020)

Course Code: 23ScMicP131

Course Name: Research Methodology Basics and Research in Microbiology (Section 1)

Teaching Scheme: Theory: 2 Hours/Week **Credit: 02**

Examination Scheme: CIA: 25 Marks **End-Sem: 25 Marks**

Prerequisite Courses:

- B.A., B.Sc. B.Com, B.Voc., BBA, BBA IB, BBA CA

Course Objectives:

- To make students aware about research and its importance
- To obtain knowledge regarding systematic gathering of data and get advanced knowledge in the selected topic
- To inculcate logical and organized thinking in students

- To investigate some existing situation or problem by creating new system or method
- To help students to design research problem

Course Outcomes: On completion of the course, student will be able to -

- Describe importance of research
- Differentiate between unethical and ethical practices of publication ethics
- Select research problem appropriately
- Prepare good hypothesis
- Design research problem systematically
- Analyze and organize data correctly
- Prepare good scientific research report

Course Contents:

Unit I	**Research problem and design**	**No. of lectures**
	1. **Introduction to research:** meaning and definition of research, objective of research, importance of research, characteristics of good research, purpose and role of research, classification of research. 2. **Research problem:** defining of research problem, Criteria for selecting the research problem, , importance of literature survey in defining research problem. 3. Hypothesis: Defining Hypothesis, types of hypothesis, characteristics of good hypothesis, formulation of hypothesis 4. **Research Design:** Definition and features of research design, Concept of research design, types of research design, preparation of research design, Sampling techniques, characteristics of good sampling designs	15
II	**Data analysis, report writing and publication ethics**	
	1. Definition of Data, methods of data collection, analysis of data, types of data analysis, Questionnaire, Design of Questionnaire, Testing hypothesis : parametric and non-parametric tests : T-test, Z-test, Chi-square test, ANOVA 2. **Report writing** : importance of interpretation of results, meaning, definition and significance of report /thesis writing, Principals of research report drafting, Types of reports, layout of research report, important parts of reports, precautions of preparation of report/ thesis 3. **Publication ethics:** definition, introduction and	15

	importance, best practices/ standard settings initiative and guidelines COPE, WAME, etc, conflict of interest, Publication misconduct: definition, concept problems that lead to unethical behavior, violation of publication ethics, predatory publishers and journals, software tools to identify predatory publications developed by SPPU	

References:

- C. R. Kothari (2004) Research Methodology: Methods and Techniques 2nd Edition, New age International (p) Ltd Publications, New Delhi, India
- J.W. Creswell and J.D. Creswell (2017) Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 5th Edition, SAGE Publications, USA.
- C. G. Thomas (2021) Research Methodology and Scientific Writing, 2nd Edition, Springer Nature, New York.
- M. Kheider lectures from University of Biskra (2017) https://univbiskra.dz/sites/fll/images/houadjli%20Ahmed%20Chaouki.pdf

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First Year of M.Sc. Microbiology

(2023 Course under NEP 2020)

Course Code: 23ScMicP131

Course Name: Research Methodology Basics and Research in Microbiology (Section 2)

Teaching Scheme: Practical: 4 Hours/Week **Credit: 02**

Examination Scheme: CIA: 25 Marks **End-Sem: 25 Marks**

Course objectives:

- Inculcate research aptitude in students.
- Enhance students' scientific communication skills.
- Familiarize students with the design of experiments.

Course outcomes: On completion of the course, student will be able to -

- Learn scientific communication modes like literature review, scientific paper and thesis presentation.
- Use reference management tools and data mining tools.
- Create an account on UGC-CARE.
- Write an abstract for scientific literature.
- Construct graphical abstract.
- Design experiments using statistical tools.

Course Contents:

I	**Scientific Communication**	**No. of practicums**
	Literature survey, advanced search (PubMed), use of	1

	reference manager	
	Verification of journal indexing opening account at UGC-CARE, Web of Science. Exploring databases (including Scopus, DOAJ) for indexed journals, searching journals, predatory journals, and their directories, retraction database.	1
	Preparing Scientific PowerPoint presentation	1
	Literature Review writing and abstract writing, constructing graphical abstract	2
II	**Design of Experiment**	
	Designing of experiments: completely randomized design, randomized block design, full factorial and fractional factorial designs (Plackett-Burman design)	3

References

1. Alley, M. (1996). The craft of scientific writing, 3rd edition. Prentice Hall, NJ. [and accompanying web site: http://filebox.vt.edu/eng/mech/writing/
2. Day, R. (1998). How to write and publish a scientific paper, 5th edition. OrynxPress
3. Day, R. (1995). Scientific English: A guide for scientists and other professionals, 2nd edition. OrynxPress
4. Irfan Ali Khan and Atiya Khanum (2009 and latest edition), Fundamentals of Biostatistics. 3rdEditionUkaaz, Publications, Hyderabad
5. Norman T. J. Bailey (2018).Statistical methods in biology, 3rd edition Cambridge University Press
6. Gupta S.P. (2012). Statistical methods, Sultan Chand &Sons Publisher, NewDelhi
7. Montgomery D.C. (2016) Design and analysis of experiments, John Wiley &Sons
8. Mary Renck Jalongo and Olivia N. Saracho (2016) Writing for Publication: Transitions and Tools that Support Scholars' Success, Springer Texts in Education.

Websites

1. https://pubmed.ncbi.nlm.nih.gov/
2. https://www.zotero.org/
3. https://www.mendeley.com/
4. https://ugccare.unipune.ac.in/apps1/home/index
5. https://mjl.clarivate.com/home
6. https://doaj.org/
7. https://predatoryreports.org/
8. https://retractionwatch.com/
9. https://www.scopus.com/sources.uri?zone=TopNavBar&origin=searchbasic

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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP211
Course Name: Industrial Wastewater Treatment and Management

Teaching Scheme: Theory: 4 Hours/Week **Credit: 04**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisite Courses:

- Types of water and basic principles as well as concepts related to wastewater treatment.
- General steps involved in the purification of water, generation of sludge and its disposal

Course Objectives:

- Know the sources, characteristics and composition of industrial wastewater.
- Understand the physical, chemical and biological methods used in the industrial wastewater and sludge processing and treatment.
- Learn the measurement of various parameters used for analysis and selection of appropriate method to treat the industrial wastewater.
- Explore various examples of treatment plants used to treat industrial wastewater in various industries

Course Outcomes: On completion of the course, student will be able to –

- Understand the need for treatment of industrial wastewater and its impact on the environment and human health.
- Recognize the sources, characteristics and composition of industrial wastewater.
- Experimental methods used for the measurement of various parameters used to characterize the quality of industrial wastewater at various stages of treatment.
- Know the layout of typical industrial wastewater treatment plant.
- Get acquainted with the strategic use of various unit operations and processes designed for the removal of various micro- and macronutrients present in organic and inorganic compounds, priority pollutants, impurities, contaminants and heavy metals present in industrial wastewater
- Understand the microbiology of various processes. For example, attached and suspended growth processes, aerobic and anaerobic growth processes, etc. and related technologies available to treat the industrial wastewater
- Know various technologies available in industrial wastewater treatment such as preliminary, primary, secondary, tertiary and advanced tertiary treatment
- Analyze the working treatment systems using various critical parameters
- Basic communication with other disciplines to design and construct the industrial wastewater treatment plants.

Course Contents:

Unit 1	Introduction to Industrial Wastewater Treatment	No. of

		Lectures
	1. The need for industrial wastewater treatment 2. Physical, chemical, microbiological characteristics of wastewater 3. Sampling and analysis of parameters such as BOD, COD, BOD:COD ratio, SVI, TS, TSS, TDS etc. to determine the quality of industrial wastewater * 4. Water quality standards, water pollution control, desirable and permissible limits of constituents for disposal in surrounding water bodies and land 5. Layout of typical wastewater treatment plant (* Note: Only numerical questions should be asked in the examination.)	15
Unit 2	**Physical and Chemical Unit Processes**	**Lectures**
	1. Physical unit operations a. Flow equalization b. Screening c. Flocculation d. Flotation e. Granular medium filtration 2. Chemical unit processes a. Coagulation b. Precipitation c. Neutralization 3. Physical – chemical processes a. Adsorption b. Sedimentation and clarification c. Disinfection	15
Unit 3	**Biological Processes**	**Lectures**
	1. Aerobic processes a. Aerobic digestion b. Activated sludge process c. Aerated lagoons d. Trickling filters e. Nitrification 2. Anaerobic processes a. Anaerobic digestion b. Anaerobic contact process c. Denitrification d. Packed bed reactors e. Biological phosphorus removal 3. Combined processes a. Trickling filter/solids contact process b. Trickling filter/ activated sludge process	18

	c. Series trickling filter, and activated sludge process 4. Working treatment system with reference to activated sludge treatment a. Critical Operating parameters: Dissolved oxygen, Mixed liquor suspended solids (MLSS), Mixed liquor volatile suspended solids (MLVSS), Hydraulic retention time (HRT), mean cell residence time (MCRT), food to Microorganism (F/M) ratio and treatment efficiency. ** (** Note: Only numerical questions should be asked in the examination.)	
Unit 4	**Sludge and Industrial Wastewater Treatment Processes**	**Lectures**
	1. Sludge processing and treatment a. Characteristics of sludge b. Preliminary sludge processing c. Thickening d. Sludge stabilization e. Aerobic and anaerobic digestion of sludge 2. Wastewater treatment processes in various industries a. Dairy industry b. Food processing industry c. Dyeing industry d. Paper and pulp manufacture industry e. Electronic industry	12

References

Unit 1: Introduction to Industrial Wastewater Treatment

- Ahuja, S. (Ed.). (2014). Comprehensive water quality & purification, Vol 1 Status & trends of water quality worldwide. Massachusetts, United States of America: Academic press
- Baird, R., Eaton, A. D., Rice, E. W. (2017). Standard Methods for the Examination of Water and Wastewater (23rd ed.). Washington, DC, United States: American Public Health Association.
- Duncan, D., Harvey, F., Walker, M. & Australian Water Quality Center. (2007). EPA guidelines–Regulatory monitoring and testing water and wastewater sampling. Adelaide, South Australia: EPA
- Karia, G. L., Christian, R. (2013). Wastewater treatment: concepts and design approach (2nd ed.). Delhi, India: PHI Learning Pvt Ltd.
- Patwardhan, A. D. (2008). Industrial Wastewater Treatment, (2nd ed.). New Delhi, India, PHI Learning Pvt. Ltd.
- Ranade, V. V., & Bhandari, V. M. (2014). Industrial wastewater treatment, recycling and reuse. Oxford, United Kingdom: Butterworth-Heinemann.
- Scholz, M. (2016). Wetlands for Water Pollution Control (2nd ed.). Amsterdam, Netherlands: Elsevier Science.
- Tchobanoglous, G., Burton, F. L., & Stensel, H. D. (2003). Wastewater engineering: treatment and reuse. McGraw Hill Companies Inc.
- Tchobanoglous, G., Stensel, H. D., Tsuchihashi, R., & Burton, F. L. (2014). Wastewater Engineering: Treatment and Resource Recovery (5th ed.). New York, United States: McGraw-Hill Education.
- van Loosdrecht, M. C., Nielsen, P. H., Lopez-Vazquez, C. M., & Brdjanovic, D. (Eds.). (2016). Experimental methods in wastewater treatment. London, United Kingdom: IWA Publishing.

Unit 2 - Physical and Chemical Unit Processes

- Alleyne, A. A., Xanthos, S., Ramalingam, K., Temel, K., Li, H., & Tang, H. S. (2014). Numerical investigation on flow generated by invent mixer in full-scale wastewater stirred tank. Engineering Applications of Computational Fluid Mechanics, 8(4), 503-517.
- Bolto, B., & Xie, Z. (2019). The use of polymers in the flotation treatment of wastewater. Processes, 7 (6), 374.
- Goel R.K., Flora J.R.V., Chen J.P. (2005). Flow Equalization and Neutralization. In: Wang L.K., Hung YT., Shammas N.K. (eds) Physicochemical Treatment Processes. Handbook of Environmental Engineering, vol 3.

Humana Press. https://doi.org/10.1385/1-59259-820-x:021
- Karia, G. L., Christian, R. (2013). Wastewater treatment: concepts and design approach (2nd ed.). Delhi, India: PHI Learning Pvt Ltd.
- Pearce, G. K. (2015). Granular Media Pretreatment Filtration. Encyclopedia of Membranes, 1–7. https://doi:10.1007/978-3-642-40872-4_2161-1
- Singh, R. (2015). Membrane Technology and Engineering for Water Purification: Application, Systems Design and Operation (2nd ed.). Massachusetts, United States: Butterworth-Heinemann, Elsevier Ltd.
- Tchobanoglous, G., Stensel, H. D., Tsuchihashi, R., & Burton, F. L. (2014). Wastewater Engineering: Treatment and Resource Recovery (5th ed.). New York, United States: McGraw-Hill Education.
- van Loosdrecht, M. C., Nielsen, P. H., Lopez-Vazquez, C. M., & Brdjanovic, D. (Eds.) (2016). Experimental methods in wastewater treatment. London, United Kingdom: IWA publishing.

Unit 3 - Biological Processes

- Achinas, S., Achinas, V., & Euverink, G. J. W. (2020). Microbiology and biochemistry of anaerobic digesters: an overview. In Singh, L., Yousuf, A., & Mahapatra D. M. (Eds.). Bioreactors, Sustainable Design and Industrial Applications in Mitigation of GHG Emissions. 17-26. Amsterdam, Netherlands: Elsevier Inc.
- Arceivala, S. J., & Asolekar, S. R. (2007). Wastewater treatment for pollution control and reuse (3rd ed.). New Delhi, India: Tata McGraw-Hill Publishing Company Limited
- Cabrera, G., Almenglo, F., Ramı´rez, M., & Cantero, D. (2019). Biofilters. In M. Moo-Young (Ed.). Comprehensive biotechnology, Scientific fundamentals of biotechnology. Volume 2. (3rd ed.) 428-445. Amsterdam, Netherlands: Elsevier B. V.
- Gurjar, R., Shende, A. D., & Pophali, G. R. (2019). Treatment of low strength wastewater using compact submerged aerobic fixed film (SAFF) reactor filled with high specific surface area synthetic media. Water Science and Technology, 80(4), 737–746. https://doi:10.2166/wst.2019.316
- Hai, F. I., Yamamoto, K., & Lee, C. H. (Eds.). (2014). Membrane biological reactors: theory, modeling, design, management, and applications to wastewater reuse. London, United Kingdom: IWA Publishing.
- Hamoda, M.F. (1995). Biotreatment of Wastewaters Using Aerated Submerged Fixed-Film Reactors. In: Moo-Young, M., Anderson, W.A., Chakrabarty, A.M. (eds) Environmental Biotechnology. Dordrecht, Springer, https://doi.org/10.1007/978-94-017-1435-8_37
- Hassard, F., Biddle, J., Cartmell, E., Jefferson, B., Tyrrel, S., & Stephenson, T. (2015). Rotating biological contactors for wastewater treatment–a review. Process Safety and Environmental Protection, 94, 285-306.
- Iorhemen, O. T., Hamza, R. A., & Tay, J. H. (2016). Membrane Bioreactor (MBR) Technology for Wastewater Treatment and Reclamation: Membrane Fouling. Membranes, 6(2), 33. https://doi.org/10.3390/membranes6020033
- Karia, G. L., Christian, R. (2013). Wastewater treatment: concepts and design approach (2nd ed.). Delhi, India: PHI Learning Pvt Ltd.
- McQuarrie, J. P., & Boltz, J. P. (2011). Moving bed biofilm reactor technology: process applications, design, and performance. Water environment research: a research publication of the Water Environment Federation, 83(6), 560–575. https://doi.org/10.2175/106143010x12851009156286
- Narayanan, C.M., Narayan, V. (2019). Biological wastewater treatment and bioreactor design: a review. Sustain Environ Res 29, 33, https://doi.org/10.1186/s42834-019-0036-1
- Ødegaard, H. (1999). The moving bed biofilm reactor. In T. Igarashi, Y. Watanabe, T, Asano, and N, Tambo (Eds.). Water Environmental Engineering and Reuse of Water. (p. 250-305)
- Patwardhan, A. W. (2003). Rotating biological contactors: a review. Industrial & engineering chemistry research, 42(10), 2035-2051.
- Poon C.P.C., Wang L.K., Wang M.H.S. (1986). Activated Sludge Processes. In: Wang L.K., Pereira N.C. (eds) Biological Treatment Processes. Handbook of Environmental Engineering, vol 3. Humana Press. https://doi.org/10.1007/978-1-4612-4820-0_6
- Qiqi, Y., Qiang, H., & Ibrahim, H. T. (2012). Review on moving bed biofilm processes. Pakistan Journal of Nutrition, 11(9), 706.
- Shammas, N.K., Wang, L.K. (2007). Aerobic Digestion. In: Wang, L.K., Shammas, N.K., Hung, YT. (eds) Biosolids Treatment Processes. Handbook of Environmental Engineering, vol 6. Humana Press. https://doi.org/10.1007/978-1-59259-996-7_6
- Tchobanoglous, G., Burton, F. L., & Stensel, H. D. (2003). Wastewater engineering: treatment and reuse. McGraw Hill Companies Inc.
- Tchobanoglous, G., Stensel, H. D., Tsuchihashi, R., & Burton, F. L. (2014). Wastewater Engineering: Treatment and Resource Recovery (5th ed.). New York, United States: McGraw-Hill Education.
- Varjani, S., Pandey, A., Gnansounou, E., Khanal, S. K., & Raveendran, S. (Eds.). (2020). Current Developments in Biotechnology and Bioengineering: Resource Recovery from Wastes. Amsterdam, Netherlands: Elsevier B. V.
- von Sperling, M. (2007). Activated sludge and aerobic biofilm reactors. Vol 5. London, United Kingdom: IWA publishing. https://doi.org/10.2166/9781780402123
- Waqas, S., & Bilad, M. R. (2019). A review on rotating biological contactors. Indonesian Journal of Science and

Technology, 4(2), 241-256.
- Yoon, S. H. (2015). Membrane bioreactor processes: principles and applications. Florida, United States of America: Taylor & Francis Group, LLC.

Unit 4 - Sludge and Wastewater Treatment Processes

- Barbera, M., & Gurnari, G. (2018). Wastewater Treatment And Reuse In The Food Industry (pp. 23-28). Cham: Springer International Publishing.
- Britz, T. J., Van Schalkwyk, C., & Hung, Y. T. (2006). Treatment of dairy processing wastewaters. In L. K. Wang, Y. T. Hung, H. H. Lo, & C. Yapijakis (Eds.). Waste treatment in the food processing industry.1. Boca Raton, Florida, United States of America: CRC Press
- Luduvice, M. & Fernandes F. (2007). Sludge transformation and disposal methods. In C. V. Andreoli,, M. Von Sperling, & F. Fernandes, (Eds.). Biological Wastewater Treatment Series, Sludge treatment and disposal vol. 6 (pp. 207-225). London, United Kingdom: IWA publishing.
- Patel, S., & Kasture, A. (2014). E (electronic) waste management using biological systems-overview. Int J Curr Microbiol Appl Sci, 3(7), 495-504.
- Patwardhan, A. D. (2008). Industrial Wastewater Treatment, (2nd ed.). New Delhi, India, PHI Learning Pvt. Ltd.
- Tchobanoglous, G., Stensel, H. D., Tsuchihashi, R., & Burton, F. L. (2014). Wastewater Engineering: Treatment and Resource Recovery (5th ed.). New York, United States: McGraw-Hill Education.
- Ukita, M., Imai, T., & Hung, Y. T. (2004). Food waste treatment. In L. K. Wang, Y. T. Hung, H. H. Lo, & C. Yapijakis (Eds.). Handbook of Industrial and Hazardous Wastes Treatment (pp. 1125-1153). CRC Press.

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First Year of M.Sc. Microbiology

(2023 Course under NEP 2020)

Course Code: 23ScMicP212

Course Name: Enzymology, Bioenergetics and Metabolism

Teaching Scheme: Theory: 4 Hours/Week **Credit: 04**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Course Objectives:

- To make students learn the principles of enzyme reactions with respect to types, kinetics and coupled reactions.
- To make students understand the Laws of thermodynamics, entropy, enthalpy, free energy, and its significance. with numerical problems
- To teach students how molecules are transported across membrane.
- To teach students biochemistry of aerobic and anaerobic respiration, methanogenesis and photosynthesis

Course Outcomes: On completion of the course, student will be able to -

- Learn about enzyme reactions with respect to its kinetics and coupled reactions.
- Understand the bioenergetics of biological reactions and how the reactions take place inside the cell.
- Interpret the relation between free energy, standard free energy.
- Understand the movement of molecules across the plasma membrane.
- Gain knowledge about signalling pathway in bacteria
- Describe the biochemistry of aerobic and anaerobic respiration, methanogenesis and photosynthesis with various steps involved.

Course Contents:

Unit 1	Enzymology	No of Lectures
	1. Enzymes: Introduction 2. Kinetics of single substrate enzyme-catalyzed reaction a. MM equation, b. Briggs Haldane equation, c. Lineweaver Burke plot, d. Eadie-Hofstee, e. Hans plot 3. Kinetics of reversible inhibitions enzyme-catalyzed reactions a. competitive inhibition b. non-competitive inhibition, c. uncompetitive inhibition d. Mixed Inhibition 4. Types of two substrate enzyme-catalyzed reactions a. Ping-pong mechanism b. Random-order mechanism c. Compulsory-order mechanism 5. King Altman approach to derive single substrate and two-substrate enzyme-catalyzed reactions 6. Concept of allosterism, positive and negative cooperativity, models of allosteric enzymes (Monod, Wyman, and Changeux model, Koshland, Nemethy and Filmer model), 7. Kinetics of allosteric enzyme, Hill plot, examples of allosteric enzymes and their significance in allosteric regulation 8. Problems based on calculation of Km and Vmax. Determination of type of enzyme inhibition graphically	15
Unit 2	**Bioenergetics**	
	1. Laws of thermodynamics and its significance, entropy, enthalpy, free energy, free energy and equilibrium constant, Gibbs free energy equation 2. Determination of free energy of hydrolytic and biological oxidation-reduction reactions under standard and non- standard conditions (Problem- solving) 3. High energy compounds 4. Coupled reactions (problem solving) 5. Determination of feasibility of reactions (Problem-solving) 6. Atkinson's energy charge	15
Unit 3	**Membrane transport and signal transduction**	
	1. The composition and architecture of membranes, Membrane dynamics 2. Solute transport across membranes: Passive diffusion, facilitated transport, primary and secondary active transport using P, V and F type ATPases. 3. Ionophores, Ion mediated transport, transport of ions across membranes (ion pumps), ligand and voltage gate ion channels. 4. Liposomes and model membranes	15

	5. Signal transduction pathways in bacteria, second messengers, regulation of signalling pathways, bacterial two-component systems, chemotaxis.	
Unit 4	**Respiration and Photosynthesis**	
	1. Respiration a. Aerobic respiration: Mitochondrial electron transport chain, structure and function of ATPase, generation and maintenance of proton motive force, oxidative phosphorylation, inhibitors of electron transport chain and uncouplers of chemiosmotic coupling. b. Anaerobic Respiration: Concept of anaerobic respiration, oxidized sulfur compounds and nitrate as an electron acceptor with respect to electron transport chain and energy generation, Biochemistry of methanogenesis. 2. Photosynthesis a. Structure of chloroplast, Light Absorption, light and dark reaction, electron carriers in photosynthesis b. Organization of photosystem I and II, the cyclic and non- cyclic flow of electrons, Hill reaction, photolysis of water c. C3, C4 CAM plants, Photorespiration, Regulation of photosynthesis d. Photosynthesis in bacteria	15

References

Unit 1: Enzymology

- Nelson D. L. and Cox M. M. (2005). Lehninger's Principles of Biochemistry, 6th edition, McMillan Worth Pub. Co. New Delhi
- Palmer T. (2001). Enzymes: Biochemistry, Biotechnology, and Clinical chemistry,2nd edition Horwood Pub. Co. Chinchester, England.
- Segel I. H. (1997). Biochemical Calculations 2nd edition, John Wiley and Sons, New York

Unit 2: Bioenergetics

- Garrett, R. H., & Grisham, C. M. (2010). Biochemistry. 4th edition, Belmont, CA: Brooks/Cole, Cengage Learning.
- Nelson D. L. and Cox M. M. (2005) Lehninger's Principles of Biochemistry, 6th edition, Mac Millan Worth Pub. Co. New Delhi
- Segel I. H. (1997). Biochemical Calculations 2nd edition., John Wiley and Sons, New York

Unit 3: Membrane transport and signal transduction

- Berg, J. M., Tymoczko, J. L., Stryer, L., &Stryer, L. (2015). Biochemistry. 8th edition,New York: W.H. Freeman.
- Garrett, R. H. Grisham, C. M. (2004). Biochemistry. 3rd.edition. Brooks/Cole, Publishing Company, California.
- Nelson D. L. and Cox M. M. (2005). Lehninger's Principles of Biochemistry, 6th edition, Mac MillanWorth Pub. Co. New Delhi

Unit 4: Respiration and Photosynthesis

- Madigan M.T., Martinko J.M., Stahl D.A., Clark D.P (2012). Brock Biology of Microorganisms, 13th edition, Benjamin Cummings, San Francisco.
- Moat, A. G., Foster, J. W., & Spector, M. P. (2002). Microbial physiology. 4th edition New York: Wiley-Liss.
- Nelson D. L. and Cox M. M. (2005) Lehninger's Principles of Biochemistry, 6th edition, Mac Millan Worth Pub. Co. New Delhi

First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP213
Course Name: Practical course I - Based on Industrial Wastewater Treatment

Teaching Scheme: Practical: 8 Hours/Week **Credit: 04**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Course objectives:

- To learn basic techniques required for analysis of wastewater and wastewater treatment efficiency.

Course outcomes: On completion of the course, student will be able to -

- Understand the principles of techniques used in the calculation of pollution load of wastewater, hand-on these methods, and interpretation of results.
- Develop the capacity to comment about the quality of water.

Course Contents:

I	Industrial Wastewater Treatment	No. of practicals
	Estimation of pollution load of a water sample and its interpretation using the following parameters: 1. BOD:COD ratio 2. TS 3. TSS	4
	Simulated waste decomposition using aerobic microorganisms and analysis for the following parameters: 1. Sludge volume index (SVI), 2. Mixed liquor suspended solids (MLSS), 3. Mixed liquor volatile suspended solids (MLVSS), 4. F/M ratio.	4
	Demonstration of the analysis of water sample for: 1. SOx content 2. NOx content 3. Chloride content	3
	Biosorption of dyes using biomass and study of factors affecting biosorption (any four factors such as temperature, pH, biomass concentration, incubation time)	4

References:

Unit I – Wastewater Treatment

- Environmental Impact Assessment. APH Publishing, R. R. Barthwal, (2002) Environmental Impact Assessment, New Age International.
- John Glasson, Riki Therivel, Andrew Chadwick. Routledge. (2012). Introduction to Environmental Impact Assessment. 4th Edition.
- APHA (2005). Standard Methods for the Examination of Water &Wastewater. 21st Edition. APHA.AWWA.WEF

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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP214
Course Name: Practical course II - Based on Enzymology

Teaching Scheme: Practical: 8 Hours/Week **Credit: 02**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Course objectives:
- Understand enzyme purification techniques.
- Study enzyme kinetics

Course outcomes:
- Isolate and purify enzymes through various techniques and study their kinetic parameters.
- Determine molecular weight of enzymes by using PAGE.

Course Contents:

	Enzymology	
	Obtaining crude extract of amylase and its partial purification by fractional ammonium sulphate precipitation followed by dialysis. (*Brief discussion on purification by solvent precipitation.)	3
	Purification of amylase by gel permeation chromatography by preparing suitable column.	2
	Construction of amylase enzyme purification chart	1
	Determination of molecular weight of purified amylase enzyme by Native PAGE and SDS PAGE.	2
	Determination of Km and Vmax values of amylase enzyme.	2
*Any 8 practicals from the above list can be conducted.		

References:

- David T. Plummer (1993) An Introduction to Practical Biochemistry, 3rd Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi
- Miquet J. G., González L., Sotelo A. I. and González Lebrero R. M. (2019). A laboratory work to introduce biochemistry undergraduate students to basic enzyme kinetics-alkaline phosphatase as a model. Biochem Mol Biol Educ. 47(1):93-99. doi: 10.1002/bmb.21195.
- Palmer Trevor (2001) Enzymes: Biochemistry, Biotechnology, and Clinical chemistry, Horwood Pub. Co. Chinchester, England.
- Segel Irvin H. (1997) Biochemical Calculations 2nd Edition, John Wiley and Sons, New York.
- Wilson K. and Walker J. (2005) Principles and Techniques of Biochemistry and Molecular Biolog. 6th edition. Cambridge University Press, New York.

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First Year of M.Sc. Microbiology

(2023 Course under NEP 2020)
Course Code: 23SciMicP221
Course Name: Quantitative Biology Theory (Elective 1)

Teaching Scheme: Theory: 2 Hours/Week **Credit: 02**
Examination Scheme: CIA: 25 Marks **End-Sem: 25 Marks**

Course objectives:

- To understand basic concepts in Biostatistics.
- To get acquainted with the concepts of probability distributions and their application.
- To inculcate the concepts of testing hypothesis using parametric and non-parametric tests

Course outcomes: On completion of the course, student will be able to -

- Determine the mean, mode and median of a given data set.
- Understand probability distribution.
- Explain concepts of null and alternate hypothesis, types of errors, level of significance, p value and decision rules
- Set null hypothesis to a given problem.
- Understand basic concepts and calculations of various parametric and non-parametric tests.
- Apply appropriate statistical tests to accept or reject null hypothesis.

Course Contents:

Unit 1	**Basics of statistics**	**No. of lectures**
	1. Probability distribution: Normal (x-scale and z- scale), Binomial and Poisson distributions. 2. Measures of central tendency: Mean Mode, median 3. Measures of dispersion: Mean deviation Standard deviation and Variance 4. The concepts of the null hypothesis, alternate hypothesis, level of significance, p-value, one-tailed and two-tailed tests, type I and type II errors. 5. Distribution of sample means, standard error and confidence interval, degrees of freedom	15
Unit 2	**Parametric and Nonparametric tests (Theory and Numerical)**	**No. of lectures**
	1. Parametric statistical test: a. Z-test b. t-test 2. Comparison of 3 or more samples: a. One way ANOVA and Two way ANOVA 3. Test of Significance: Chi square test (Goodness of fit and Independence) 4. Non-parametric tests: a. Kruskal Wallis test b. Sign test c. Wilcoxon's signed rank test d. Mann-Whitney test	**15**

References:

- Bailey N. T. J. (1981). Statistical Methods in Biology. United Kingdom: Hodder and Stoughton. ISBN: 9780340247563
- Brown D. and Rothery P. (1993). Models in biology: mathematics, statistics, and computing. United Kingdom: Wiley. ISBN: 9780471933229. Digitized 20th June 2009
- Chetwynd A., Chetwynd A. G. and Diggle P. J. (2011). Statistics and Scientific Method: An Introduction for Students and Researchers. Italy: OUP Oxford. ISBN:9780199543182.
- Daniel W. W. and Cross C. L. (2018). Biostatistics: A Foundation for Analysis in the Health Sciences. United Kingdom: Wiley. ISBN: 9781119282372.
- Doran P. M. (2013). Bioprocess Engineering Principles. Netherlands: Elsevier Science. ISBN: 9780122208515.
- Gupta S. P. (2021). Statistical Methods. 46th edition. Sultan Chand & Sons Publisher, New Delhi. ISBN13: 9789351611769.
- Haefner J. W. (2012). Modeling Biological Systems: Principles and Applications. United States: Springer US. ISBN: 9781461541196.
- Harvey L. and McNeil B. (2008). Practical Fermentation Technology. Germany: Wiley. ISBN: 9780470014349.
- Khan I. A. and Khanum A. (2016). Fundamentals of Biostatistics. 5th Edition. Ukaaz, Publications, Hyderabad. ISBN-13: 9788190044103.
- Lindgren B. (2017). Statistical Theory. United Kingdom: CRC Press. ISBN: 9781351414173.
- Rosner B. (2016). Fundamentals of Biostatistics. United States: Cengage Learning. ISBN:9781305268920

Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous)

Shivajinagar, Pune – 5

First Year of M.Sc. Microbiology

(2023 Course under NEP 2020)

Course Code: 23ScMicP221

Course Name: Practical course I - Based on Quantitative Biology (Elective 1)

Teaching Scheme: Practical: 8 Hours/Week **Credit: 02**

Examination Scheme: CIA: 50 Marks **End-Sem: 25 Marks**

Course objectives:

- To learn using data sheets and sorting data.
- To understand the plotting of different types of graphs.
- To know saving graphs/ figures in different formats.
- To acquaint students with knowledge of Statistical analysis of data using following tests of significance in MS Excel.

Course outcomes: On completion of the course, student will be able to -

- Students will understand the use of different statistical tests such as ANOVA, t-test, etc.
- Students will know to use data sheets and sorting data..
- Students will understand saving graphs/ figures in different formats using GIMP etc.

Course Contents:

Sr.No	Data representation and statistical analysis of data	No of Practicals
	Using data sheets, and sorting data with different parameters	1
	Plotting graphs – bar charts, line graphs, pie charts, scatter plots, error bars, semi-log graphs, regression analysis	2
	Saving graphs/ figures in different formats of image, embedding graphs	1

	in PowerPoint presentations, enhancing image quality using GIMP or other software	
	Statistical analysis of data using following tests of significance in MS Excel (stating hypothesis, level of significance, decision rule, interpretation using p-value and acceptance or rejection of null hypothesis): 1. Student t-test: independent and paired t-test 2. F test 3. ANOVA (one way and two way) 4. Chi-square test of goodness of fit and independence	4

References:

Data representation and statistical analysis of data

- Boslaugh S. (2012). Statistics in a Nutshell. Germany: O'Reilly Media Incorporated.
- Conner N. and MacDonald M. (2013). Office 2013: The Missing Manual. United States: O'Reilly Media.
- McFedries P. (2019). Microsoft Excel 2019 Formulas and Functions. Pearson Education.
- Salkind N. J. (2016). Statistics for People Who (Think They) Hate Statistics: Using Microsoft Excel2016. United States: SAGE Publications
- URL- https://www.britannica.com/technology/spreadsheet

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Modern College of Arts, Science and Commerce (Autonomous)

Shivajinagar, Pune – 5

First Year of M.Sc. Microbiology

(2023 Course under NEP 2020)

Course Code: 23ScMicP222

Course Name: Microbial and Plant Physiology Theory (Elective 2)

Teaching Scheme: Theory: 2 Hours/Week **Credit: 02**

Examination Scheme: CIA: 25 Marks **End-Sem: 25 Marks**

Course Objectives:

- To study photosynthesis in plants.
- To study about the biosynthesis of carbohydrates and amino acids
- To understand and learn the processes involved in nitrogen fixation.
- Understand the mechanisms of various metabolic and physiological processes in plants and bacteria.

Course Outcomes: On completion of the course students will be able to -

- Understand the biochemistry of biological nitrogen fixation and role of nitrogenase.
- Gain knowledge about biosynthesis of amino acids and nitrogen bases.
- Comment on biosynthesis of carbohydrates in plants and bacteria.
- Acquire basic knowledge about growth and development in plants.
- Ability to construct explanations of the mechanisms and structural features of cells that allow organisms to capture, store, utilize and invest free energy.
- Show the relationship between photosynthesis and respiration in the flow of energy through a system.

Course Contents:

Unit 1	**Biosynthesis of carbohydrates in plants and bacteria**	
	1. Calvin cycle and its regulation. 2. Transport of solute across the chloroplast membrane. 3. Synthesis of starch and sucrose. 4. Photorespiration, C4 and CAM pathways. 5. Synthesis of cellulose and peptidoglycan. 6. Integration of carbohydrate metabolism in plant cells.	15
Unit 2	**Plant Physiology**	
	1. Photosynthesis - Light-harvesting complexes, mechanisms of electron transport, photoprotective mechanisms, CO_2 fixation-C3, C4 and CAM pathway. 2. Respiration and photorespiration – Citric acid cycle, plant mitochondrial electron transport and ATP synthesis, alternate oxidase, photorespiratory pathway. 3. Plant hormones – Biosynthesis, storage, breakdown, and transport, physiological effects, and mechanisms of action. 4. Sensory photobiology - Structure, function, and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks. 5. Plant-Microbes Interactions: Plant growth-promoting rhizobacteria	15

References

Unit 1: Biosynthesis of carbohydrates in plants and bacteria

- Nelson D. L. and Cox M. M. (2005). Lehninger's Principles of Biochemistry, 6th edition, Mac Millan Worth Pub. Co. New Delhi
- Berg, J. M., Tymoczko, J. L., Stryer, L., &Stryer, L. (2015). Biochemistry. 8th edition,New York: W.H. Freeman.
- Garrett, R. H., and Grisham,C. M. (2004). Biochemistry. 3rd edition. Brooks/Cole, Publishing Company, California

Unit 2: Plant Physiology

- Nelson D. L. and Cox M. M. (2005). Lehninger's Principles of Biochemistry, 6th edition, Mac Millan Worth Pub. Co. New Delhi
- Madigan M.T.,Martinko J.M., Stahl D.A., Clark D.P (2012). Brock Biology of Microorganisms, 13thedition, Benjamin Cummings, San Francisco.
- Taiz L., Zeiger E, Møller I.M., and Murphy A.(2015), Plant Physiology and Development, 6th edition Sunderland, Massachusetts: Sinauer Associates, Inc., Publishers
- Moat, A. G., Foster, J. W., & Spector, M. P. (2002). Microbial physiology. 4th edition New York: Wiley-Liss.

Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous)

Shivajinagar, Pune – 5

First Year of M.Sc. Microbiology

(2023 Course under NEP 2020)

Course Code: 23ScMicP222

Course Name: Practical course II - Based on Microbial and Plant Physiology (Elective 2)

Teaching Scheme: Practical: 8 Hours/Week **Credit: 02**

Examination Scheme: CIA: 25 Marks **End-Sem: 25 Marks**

Course objectives:

- Explore methods to isolate and characterise bacteria that degrade various compounds.
- Explore methods to isolate PGPR.
- Understand protocols to isolate chloroplast and estimate chlorophyll content in a plant.

Course outcomes:

- Isolate and characterize starch, and pesticide degrading bacteria and study their degradative potential.
- Isolate PGPR for production of IAA and quantify the IAA produced.
- Isolate chloroplast and estimate chlorophyll content.

Course Contents:

Sr. No	Microbial and Plant Physiology	No. of practical
1	Isolation and characterization of starch degrading bacteria and determination of its starch hydrolyzing potential by calculating its Hydrolyzing Capacity (HC) ratio and amylase activity.	3
2	Isolation and characterization of pesticide degrading bacteria and determination of its degradative ability.	3
3	Isolation of chloroplast	1
4	Chlorophyll estimation	1
5	Isolation of plant growth promoting rhizobacteria (PGPR) that produces IAA and its quantification.	1
*Any 8 practicals from the above list can be conducted.		

References:

Metabolism

- Nelson D. L. and Cox M. M. (2005). Lehninger's Principles of Biochemistry, 4thedition, W. H. Freeman & Co. New York.
- Moat Albert G. and Foster John W. (1988). Microbial Physiology 2nd Edition John Wiley and Sons New York.
- Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark (2012). Brock Biology of Microorganisms,13thedition, Benjamin Cummings, San Francisco.
- David T. Plummer (1993) An Introduction to Practical Biochemistry, 3rd Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi
- Gang S., Sharma, S., Saraf M., Buck M. and Schumacher J. (2019). Analysis of Indole-3-acetic Acid (IAA) Production in Klebsiella by LC-MS/MS and the Salkowski Method. Bioprotocol 9(9): e3230. DOI: 10.21769/BioProtoc.3230.
- Mohite B. (2013). Isolation and characterization of indole acetic acid (IAA) producing bacteria from rhizospheric soil and its effect on plant growth. Journal of Soil Science and Plant Nutrition, 13(3): 638-649.
- Miranda-Hernández M. P., Valle-González E. R., Ferreira-Gómez D., Pérez N. O., Flores-Ortiz L. F. and Medina-Rivero E. (2016). Theoretical approximations and experimental extinction coefficients of biopharmaceuticals. Anal Bioanal Chem. 408:1523–1530 https://doi.org/10.1007/s00216-015-9261-6
- Wilson K. and Walker J. (2005) Principles and Techniques of Biochemistry and Molecular Biolog. 6th edition. Cambridge University Press, New York.
- Srivathsan V, Bhandari M, Swaminathan P. Isolation, and characterization of starch degrading bacteria from disparate soil samples. J App Biol Biotech. 2022;10(5):193-197. DOI: 10.7324/JABB.2022.100524.
- Pratima Gupta, Kalpana Samant, Avinash Sahu, "Isolation of Cellulose-Degrading Bacteria and Determination of Their Cellulolytic Potential", International Journal of Microbiology, vol. 2012, Article ID 578925, 5 pages, 2012. https://doi.org/10.1155/2012/578925.