RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR

M.Sc. Biotechnology Syllabus

As per NEP 2020

With Effect from 2023-24

SEAL OF RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY

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1/8/23

01/08/23

Scheme of teaching and examination for M. Sc. BIOTECHNOLOGY (CBCS) As per NEP 2020

Structure and Credit Distribution of PG Degree Program for Two years

Choice Based Credit System (Semester Pattern)

With Effect from 2023-2024

M. Sc. Semester I BIOTECHNOLOGY

Course Category	Code	Theory / Practical	Teaching scheme (Hours / Week)			Credits	Examination Scheme					
			Theory	Practical	Total		Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks	
								SEE	CIE		Theory	Practical
DSC	MBT1T01	Paper 1 :Cell Biology, Enzymology and Genetics	4	-	4	4	3	80	20	100	40	-
DSC	MBT1T02	Paper 2: Biomolecules	4	-	4	4	3	80	20	100	40	-
DSE	MBT1T03	Paper 3: Electives Any one A) Clinical Research OR B) Nanobiotechnology	4	-	4	4	3	80	20	100	40	-
RM	MBT1T04	Paper 4: Research Methodology	4	-	4	4	3	80	20	100	40	-
DSC	MBT1P01	Practical 1 Cell Biology, Enzymology and Genetics	-	6	6	3	3-8*	50	50	100	-	50
DSC	MBT1P02	Practical 2 Biomoleculesand Research Methodology	-	6	6	3	3-8*	50	50	100	-	50
		TOTAL	**16**	**12**	**28**	**22**	--	**420**	**180**	**600**	**160**	**100**

CIE = Continuous Internal Evaluation and SEE = Semester End Examination

M. Sc. Semester II													
Course Category	Code	Theory / Practical	Teaching scheme (Hours / Week)			Credits	Examination Scheme						
			Theory	Practical	Total		Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks	
								SEE	CIE		Theory	Practical
DSC	MBT2T05	Paper 5: Microbiology	4	-	4	4	3	80	20	100	40	-
DSC	MBT2T06	Paper6: Molecular Biology	4	-	4	4	3	80	20	100	40	-
DSE	MBT2T07	Paper 7:Electives (Choose any one) A) Industrial Biotechnology OR B)Environmental Biotechnology	4	-	4	4	3	80	20	100	40	-
OJT	MBT2P03	Practical 3:On Job Training/ Field Project	-	8	8	4	3-8*	50	50	100	-	50
DSC	MBT2P04	Practical4: Microbiology	-	6	6	3	3-8*	50	50	100	-	50
DSC	MBT2P05	Practical 5:Molecular Biology	-	6	6	3	3-8*	50	50	100	-	50
		TOTAL	**12**	**20**	**32**	**22**	-	**390**	**210**	**600**	**120**	**150**

CIE = Continuous Internal Evaluation and SEE = Semester End Examination

M. Sc. Semester III

Course Category	Code	Theory / Practical	Teaching scheme (Hours / Week)			Credits	Examination Scheme					
			Theory	Practical	Total		Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks	
								SEE	CIE		Theory	Practical
DSC	MBT3T08	Paper9: Immunology	4	-	4	4	3	80	20	100	40	-
DSC	MBT3T09	Paper 10: Biophysical Techniques	4	-	4	4	3	80	20	100	40	-
DSC	MBT3T10	Paper11: Fundamentals of Genetic Engineering	4	-	4	4	3	80	20	100	40	-
DSE	MBT3T11	Paper 12: Elective (Choose any one) A) Plant Biotechnology OR B)Animal Biotechnology	4	-	4	4	3	80	20	100	40	-
DSE	MBT3P06	Practical 6: A)Plant Biotechnology OR B) Animal Biotechnology	-	4	4	2	3-8*	50	50	100	-	50
RP	MBT3P07	Research Project (RP) Minor	-	8	8	4	3-8*	50	50	100	-	50
		TOTAL	16	12	28	22	-	420	180	600	160	100

CIE = Continuous Internal Evaluation and SEE = Semester End Examination

M. Sc. Semester IV												
Course Category	Code	Theory / Practical	Teaching scheme (Hours / Week)			Credits	Examination Scheme					
							Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks	
			Theory	Practical	Total			SEE	CIE		Theory	Practical
DSC	MBT 4T12	Paper 13: Applied Molecular Biology	4	-	4	4	3	80	20	100	40	-
DSC	MBT 4T13	Paper14:Genetic Engineering and Its Applications	4	-	4	4	3	80	20	100	40	-
DSC	MBT 4T14	Paper 15: Bioinformatics	4	-	4	4	3	80	20	100	40	-
DSE	MBT 4T15	Paper 16: Elective (Choose any one)A) Agriculture Biotechnology OR B)Medical Biotechnology	4	-	4	4	3	80	20	100	40	-
RP	MBT 4P08	Research Project (RP) Major	-	12	12	6	3-8*	100	100	200	-	100
		TOTAL	16	12	28	22	-	420	180	600	160	100

CIE = Continuous Internal Evaluation and SEE = Semester End Examination

SYLLABUS for M. Sc. BIOTECHNOLOGY
Choice Based Credit System (Semester Pattern)
Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur
Effective from 2023-2024

M. Sc. Biotechnology Semester I

Paper 1

Cell Biology, Enzymology and Genetics

Course Outcomes:

CO1: Comprehend and correlate the structure and function relationship of cells, sub-cellular organelles, Cellular communication and Cell cycle.
CO2: Realize the basic concepts of Enzymology and Enzyme Kinetics.
CO3: Gain familiarity with the concept of Enzyme Engineering and immobilization.
CO4: Develop proficiency in the fundamental molecular principles of genetics and basics of genetic mapping

UNIT I: Cell Biology & Signalling

Structure and function of cell organelles:
Plasma membrane: transport of nutrients, ions and macromolecules.
Cell walls: Archaea, Bacteria, Plant cells.
Mitochondria: Electron Transport Chain and Oxidative Phosphorylation.
Chloroplasts: Chlorophyll, Carotenoids and Photosynthesis.
Golgi complex: Endoplasmic reticulum, Lysosomes, Peroxisomes (functions).
Cell cycle: Molecular events in *S. cerevisiae*.
Cell signalling: Signal transduction in animal and plant cells (tyrosine kinase, light induced signalling)

UNIT II: Enzymes

Basics Enzymology: Enzyme nomenclature, classification and specificity. Concept of coenzymes.
Mechanism of enzyme action: Models, catalysis by proximity effect, acid-base catalysis, electrostatic interaction, metal ion catalysis, nucleophilic and electrophilic catalysis,
Concept of multienzyme complexes: Fatty acid synthase and pyruvate dehydrogenase complexes.
Concept of enzyme regulation: Allosteric (example ATCase), chemical modification and calmodulin mediated regulation.

UNIT III: Enzyme Kinetics

Basic aspects of enzyme kinetics: Michaelis-Menten equation (derivation, significance and transformation).
Two substrate kinetics: Modifying factors of enzyme kinetics, enzyme inhibition and types of inhibitors.
Enzyme Engineering: Introduction, Principle, steps involved in enzyme engineering, examples and applications of enzyme engineering.
Immobilization of Enzymes: Material used, methods and applications.

UNIT IV: Genetics

Physical basis of Heredity: Introduction, concepts and theories of Mendelian genetics, chromosome theory of inheritance, Nucleus, nucleolus and extra chromosomal inheritance.
Population Genetics: Gene pools, allele frequencies, Hardy Weinberg equation, non-random breeding, genetic drift, gene flow, selection, speciation.
Genetics of bacteria and bacteriophages: Mapping of genes in bacterial and phage chromosomes by classical genetic crosses; fine structure analysis of a gene; genetic complementation and other genetic crosses using phenotypic markers; phenotype to genotype connectivity prior to DNA-based understanding of gene.

References:

1. Stryer, L. (2015). Biochemistry. (8th ed.) New York: Freeman.
2. Lehninger, A. L. (2012). Principles of Biochemistry (6th ed.). New York, NY: Worth.
3. Voet, D., & Voet, J. G. (2016). Biochemistry (5th ed.). Hoboken, NJ: J. Wiley & Sons.
4. Dobson, C. M. (2003). Protein Folding and Misfolding. Nature, 426(6968), 884-890. doi:10.1038/nature02261.
5. Richards, F. M. (1991). The Protein Folding Problem. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.
6. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). Molecular Biology of the Cell (5th Ed.). New York: Garland Science.
7. Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman.
8. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's Genes XI. Burlington, MA: Jones & Bartlett Learning.
9. Cooper, G. M., & Hausman, R. E. (2013). The Cell: a Molecular Approach (6th Ed.). Washington: ASM ; Sunderland.
10. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's World of the Cell.
11. Boston (8th Ed.). Benjamin Cummings. 6. Watson, J. D. (2008). Molecular Biology of the Gene (5th ed.). Menlo Park, CA: Benjamin/Cummings.
12. David Freifelder. (2004). *Microbial genetics*. 10th edition, Norosa publisher, New Delhi.
13. Gardner/Simmons/Snustad. (2006). *Principal of Genetics. 8th Edn.* John Wiley & sons.
14. Klug, W.S.,Cummings. (2003). *Concepts of genetics, 7th Edn*. Pearson Education.
15. Dale, J.W. (1994). *Molecular Genetics of bacteria*, John Wiley & Sons.
16. Streips and Yasbin. (2001). *Modern microbial Genetics*. Niley Ltd.
17. John Ringo (2004). *Fundamental Genetics*. Cambridge University Press.
18. Hartl, D. L., & Jones, E. W. (1998). *Genetics: Principles and Analysis*. Sudbury, MA: Jones and Bartlett.
19. Pierce, B. A. (2005). *Genetics: a Conceptual Approach*. New York: W.H. Freeman.
20. Tamarin, R. H., & Leavitt, R. W. (1991). *Principles of Genetics*. Dubuque, IA: Wm. C. Brown.

M. Sc. Biotechnology Semester I

Paper 2

Biomolecules

Course Outcomes:

CO1: Gain insights into the biochemistry and diversity of Carbohydrates and their involvement in biological functions.

CO2: Comprehend the biochemistry and diversity of Lipids and lipoproteins

CO3: Recognize the importance of Protein structure function relationship and interactions

CO4: Demonstrate the understanding of nucleic acid structure and its dynamics.

UNIT I: Carbohydrates

Carbohydrates chemistry and classification-monosaccharides, disaccharides, oligosaccharides & polysaccharides

Different types of one sugar molecules: Aldoses, Ketoses

Homo polysaccharides: Starch and glycogen (storage polysaccharides), Cellulose and chitin (structural polysaccharides)

Hetero polysaccharides: Heparin, Hyaluronic acid, Chondroitin-sulphate, Keratin-sulphate

Cell surface molecules – glycolipids, glycoproteins

UNIT II: Lipids

Classification of lipids

Triacylglycerol, Phospholipids, Glycolipids, Fatty acids, Steroids, Terpenes

Chemistry and properties of storage and membrane Lipids

Types of lipoproteins (LDL, VLDL, HDL, IDL) and chylomicrons

Liposomes

UNIT III: Proteins

Physical and chemical properties of Primary, secondary, tertiary and quaternary structure

Globular and fibrous proteins, Protein sequencing, Ramachandran plot, Domain structure

Protein folding models and mechanisms

Molten globules, chaperons, Protein misfolding and diseases

Protein –protein interactions

UNIT IV: Nucleic Acids

Chemistry of DNA and RNA

Structure and properties of purines, pyrimidines, nucleosides, nucleotides

A, B, and Z forms of DNA

Models of DNA bending and bendability

Denaturation and renaturation studies of DNA and their applications

Nucleic acid hybridization, Topological structure of DNA

References:

1. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox (7th edition, 2017).

2. Fundamentals of Biochemistry by V.Voet and J.G. Voet (5th edition available at https://www.vet-ebooks.com/fundamentals-of-biochemistry-by-voet-and-voet-pdf/).
3. Principles of Genetics, Gardner EJ and Sunstad DP, John Wiley and Sons, (8th edition,2006)
4. Molecular Biology of the Cell, B. Alberts et al., Garland Publishers, (4th edition,2002)
5. DNA recognition and bending, Rudolf K Allemann and Martin Egli, available at (http://biomednet.com/elecref/1074552100400643)

M. Sc. Biotechnology Semester I

Paper 3: Electives

A) Clinical Research or B) Nanobiotechnology

A) Clinical Research

Course Outcomes:

CO1: Analyze and evaluate the reporting and reviewing processes of clinical trials, including the role of legislation and good clinical practice.

CO2: Apply the principles of informed consent and ethical considerations in the context of clinical trial design and management.

CO3: Evaluate and address the ethical issues and challenges in clinical trials, including the use of humans in scientific experiments and the role of ethical committees.

CO4: Demonstrate an understanding of pharmacovigilance, research governance, and the process of trial closure.

Unit I Fundamentals of Clinical trials

Fundamentals of clinical trials; Reporting and reviewing clinical trials; Legislation and good clinical practice; International perspectives; Principles of International Committee on Harmonisation (ICH)-GCP; CDSCO Guidance.

Unit II Clinical Trial Design and Requirements

Drug development and trial planning - pre-study requirements for clinical trials; Regulatory approvals for clinical trials; Regulatory submissions; Consort statement; Trial responsibilities and protocols - roles and responsibilities of investigators, sponsors and others; Requirements of clinical trial protocols; Legislative requirements for investigational medicinal products. Consent- principles of informed consent; Consent processes; Medical Writing, Clinical Study Report; Investigational New Drug Application (INDs); Biologics License Application (BLA); Common Technical Document (CTD) for application dossiers

Unit III Project Management and Data management

Project management in clinical trials - principles of project management; Application in clinical trial management; Risk assessment; Research ethics and Bioethics - Principles of research ethics; Ethical issues in clinical trials; Use of humans in scientific experiments; Ethical committee system including a historical overview; informed consent

Data protection; Legislation and its application.

Unit IV Reporting and reviewing clinical trials and ethics
Quality assurance and governance - quality control in clinical trials; Monitoring and audit; Inspections; Pharmacovigilance; Research governance; Trial closure and pitfalls trial closure; Reporting and legal requirements; Common pitfalls in clinical trial management; Adverse event & serious adverse event reporting; Drug Recall. Introduction to ethical codes and conduct.

Recommended Textbooks and References:

1. Fundamentals of Clinical Trials. (Authors: Friedman, Lawrence M., Furberg, Curt D., DeMets, David; LA; Latest Edition; Publisher: Springer).
2. The Oxford Textbook of Clinical Research Ethics (Authors: Ezekiel J. Emanuel, Christine C. Grady, Robert A. Crouch et. al.; Latest Edition; Publisher:Oxford Univ. Press)
3. ICH guidelines for Good Clinical Practice (https://www.ich.org/fileadmin/Public_Web_Site/ICH_Products/Guidelines/Efficacy/E6/E6_R1_Guideline.pdf)
4. ICH: Structure and Content of Clinical Study Reports (E3)
5. "Guidance for Industry, ICH M4: Organization of the CTD" U.S. Department of Health and Human Services Food and Drug Administration Center for Drug Evaluation and Research (CDER) Center for Biologics Evaluation and Research (CBER) August 2001
6. CDSCO – Guidance for Industry

B) Nanobiotechnology

Course Outcomes
After successful completion of this Course, students will be able to:
CO 1. Gain insights into the multidimensional attributes of nanotechnology.
CO 2. Appreciate the importance of microelectronics in the field of life sciences.
CO 3. Develop new and exciting cross-disciplinary technologies.
CO 4. Demonstrate the knowledge application of nanotechnology for improving our everyday life

Unit I Introduction to nanobiotechnology
Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.

Unit II Nano particles and Nano Films
Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterization.

Unit III Nano toxicity

Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different strata of environment; Ecotoxicity models and assays; Life cycle assessment, containment. Ethical, safety and regulatory issues of nanomedicine.

Unit IV Application of Nanobiotechnology

Applications of nanobiocatalysis in the production of drugs and drug intermediates. Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy

Nanoarrays for diagnostics, detection of single DNA, self-assembled protein nanoarrays, protein nanobiochip nanoparticles for molecular diagnostics, DNA nanomachines, Nanobiosensors, CNT biosensor, DNA nanosensors, Nanowire biosensor, application of nanodiagnostics.

Recommended Textbooks and References:

1. GeroDecher, Joseph B. Schlenoff, (2003); Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials, Wiley-VCH Verlag GmbH & Co. KGaA
2. David S. Goodsell, (2004); Bionanotechnology: Lessons from Nature, Wiley-Liss
3. Neelina H. Malsch, Biomedical Nanotechnology, CRC Press
4. Greg T. Hermanson, (2013); Bioconjugate Techniques, (3rd Edition); Elsevier
5. Recent review papers in the area of Nanomedicine.

M. Sc. Biotechnology Semester I

Paper 4: Research Methodology

Research Methodology

Course Outcomes

After successful completion of this Course, students will be able to:

CO 1. Appreciate and recognise the methods to arrive at research objectives

CO 2. Demonstrate the understanding about research and experimental designing

CO 3. Apply the principles of Biostatistics in Biotechnology research for validated depiction of research data.

CO 4. Acquire the knowledge of practices used for scientific reading, writing and presentations

Unit I Research Objective and Formulation

Foundation of Research – Motivation and objectives – Research methods vs. Methodology; Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical

Problem Identification & Formulation– Defining and formulating the research problem, Scope and objectives of research problem, Development of working hypothesis
Literature review – Importance of literature review, Primary and secondary sources; Research Papers, Reviews through offline and online sources

Unit II Research Design and Methods

Research design – Basic Principles, Need of research design, Features of good research design
Important concepts relating to research design – Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction, Development of Models
Developing a research plan - Exploration, Description, Diagnosis, Experimentation; determining experimental and sample designs.
Experimental Design - Concept of Independent & Dependent variables.

Unit III Data Analysis and Biostatistics

Execution of the research - Observation and recording of data; Maintaining a lab notebook with date-wise entry.
Sampling Methods- Characteristics of a good sample, Methods of sampling, sample distribution, Determining size of the sample - Practical considerations in sampling and sample size.
Data Processing and Analysis strategies- Data analysis - Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis - Cross tabulations and Chi-square test including testing hypothesis of association including Chi test, correlation and regression analysis.
Measures of central tendency-mean, mode, and median. Measures of dispersion: range, mean deviation, standard deviation, standard error.

Unit IV Scientific Communication and IPR

Reporting and writing - Structure and components of scientific reports - Types of report ; Technical reports and thesis - Layout, Structure and Language of Thesis; Illustrations and tables; Plagiarism, Bibliography and referencing.
Preparing Research papers for journals- Calculations of Impact factor of a journal, citation Index, ISBN & ISSN; Citation and acknowledgement.
Nature of Intellectual Property- Patents, Designs, GI, Trade Mark and Copyright, Process of Patenting and Development: Technological research, Innovation, patenting & development. Procedure for grants of patents, Scope of Patent Rights, Patent information and databases.

Recommended Textbooks and References:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., (2002). An Introduction to Research Methodology, RBSA Publishers.
2. John W Creswell (2006). Designing and Conducting Mixed Method Research. Sage Publication. (CA) 275 pages. Sinha, S.C. and Dhiman, A.K., (2002). Research Methodology, EssEss Publications. 2 volumes.
3. Trochim, W.M.K., (2005). Research Methods: the Concise Knowledge Base, Atomic Dog Publishing. 270p.
4. Research Methods for Communication Science - http://www.cios.org/readbook/rmcs/rmcs.htm

5. Scientific Writing for Agricultural Research Scientists-http://www.authoraid.info/uploads/resources/scientific-writing-for-agricultural-research-scientists-a-trainingresource-manual.pdf
6. Scientific Communication and Research Methodology - http://www.academia.edu/5318451/Scientific_Communication_and_Research_Methodology

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M. Sc. Biotechnology Semester I

Practical 1

Cell Biology, Enzymology and Genetics

1. Determination of activity of calcium ATPase of plasma membrane.
2. Subcellular fractionation and assay of marker enzymes.
3. Assay of activity of LDH.
6. Determination of activity of sodium/potassium ATPase of plasma membrane.
7. Isolation of neutrophils and demonstration of phagocytosis.
8. Determination of osmotic fragility of RBC membrane.
9. Assay of activity of acid phosphatase,
10. Enzyme purification by crystallization - urease.
11. Immobilization of enzymes (Invertase/ Protease/ Amylase.) by Na alginate method.
12. Whole cell immobilization (Yeast) by Na Alginate and the estimation of alcohol produced.
13. Effect of NaCl on amylase activity
14. Inhibition of alkaline phosphatase activity by EDTA
15. Estimation of lipase activity by titrimetric method
16. Effect of Temperature on activity of Amylase / Alkaline phosphatase and determination of optimum temperature.
17. Effect of Substrate concentration on activity of Amylase / Alkaline phosphatase and determination of optimum substrate concentration.
18. Effect of pH on activity of Amylase / Alkaline phosphatase and determination of optimum pH.

M. Sc. Biotechnology Semester I

Practical 2

Biomolecules and Research Methodology

1. Introduction to measurements: balance and pipetting, preparation of solutions of given molarity and normality.
2. Measurement of pH: buffering capacity, to determine pKa value and hence the dissociation constant of a given acid using pH meter.
3. Fractionation of proteins: Salt precipitation, solvent precipitation, isoelectric precipitation, dialysis, centrifugation.
4. Separation of proteins / lipids by ion exchange chromatography
5. Polyacrylamide gel electrophoresis: a) native enzyme preparation, b) SDS-PAGE of proteins.
6. Separation of lipids / amino acids by thin layer chromatography.
7. Colorimetry: Assay of DNA by diphenylamine method.
8. Colorimetry: Assay of RNA by orcinol method.
9. Estimation of proteins by Lowry"s and Bradford method.
10. The validity of beers law for colorimetric estimation of creatinine.
11. Spectrophotometry: To study the absorption spectrum of hemoglobin and NADH.
12. Estimation of protein by E280/E260 method.
13. Determination of Tm of nucleic acid.
14. Demonstration of immunochemical reactions (blood group, Widal, VDRL, pregnancy, ELISA)
15. Blood film preparation and identification of cells.
16. Ouchterlony immunodiffusion,
17. Determination of albumin by radial immunodiffusion.
18. Calculation of mean, mode, and median
19. Calculation of standard deviation and standard error
20. Correlation and Regression: Estimation of correlation coefficient, to fit regression equations from bivariate data

M. Sc. Biotechnology Semester II

Paper 5

Microbiology

Course Outcomes

After successful completion of this Course, students will be able to:

CO 1. Gain insight into the structure and classification concepts for bacteria and archaea

CO 2. Appreciate and recognise major categories of microorganisms and viruses.

CO 3. Develop proficiency in principles of bacterial physiology and growth requirements.

CO 4. Identify and demonstrate how to control microbial growth

UNIT I: General Microbiology and Taxonomy

Introduction to microbiology and microbes, Bacterial morphology and structure
Archaeabacteria- Structure & Classification
Microbial classification: Bergey's Manual, 16S rRNA sequence and bacterial phylogeny.
Bacterial genetic system: recombination (transformation, conjugation, transduction and transposition)

UNIT II: Microbial Diversity and Viruses

Algae: General characteristics, Applications in biotechnology.
Fungi and slime moulds: General characteristics, applications in biotechnology.
Viruses: Nature, symmetry, capsid structure, nucleic acids,
Quantification of viruses, important viruses in biotechnology: M13, fd, Mu, lambda, Adenovirus, retrovirus & adeno-associated viruses.
Life cycles: T4, lambda & retrovirus.
Viroids and prions

UNIT III: Bacterial Physiology

Nutrition: Basic nutritional requirements, nutritional classification
Cultivation: Isolation methods, Concept of Pure culture, maintenance of pure cultures.
Growth: Measurement of growth, growth curve, continuous and synchronous cultures, factors affecting microbial growth, Quorum sensing, Biofilms

UNIT IV: Microbial Control

Microbial control: methods of sterilization (physical, chemical & gaseous), biocontrol
Mechanisms of cell injury
Concept of chemotherapy, chemotherapeutic agents, mechanisms of action.
Mechanisms of Drug resistance, MDR, assessment and management of drug resistance.

References:

1. Brock Biology of Microorganisms, Michael.T.Madigan, John.M.Martinko, Paul V. Dunlap
2. David P. Clark- 12th edition, Pearson International edition 2009, Pearson Benjamin Cummings.

3. Ingraham J. L. and Ingraham C.A. (2004). Introduction to Microbiology. 3nd Edition.Thomson Brooks / Cole.
4. Michael J Pelczar, JR. E.C.S. Chan, Noel R. Krieg. (1993) Microbiology, 5th Edition, Tata MacGraw Hill Press.
5. Prescott, Lancing. M., John, P. Harley and Donald, A. Klein (2006) Microbiology, 6th Edition, McGraw Hill Higher Education
6. Willey J. M., Sherwood L. M. and Woolverton C. J. (2013) Prescott's Microbiology, 8thEdition, McGraw-Hill Higher Education
7. Salle A.J. (1971) Fundamental Principles of Bacteriology. 7th Edition. Tata MacGrawHillPublishing Co.
8. Stanier R.Y., Adelberg E.A. and Ingraham J.L. (1987) General Microbiology, 5th Edition.Macmillan Press Ltd.
9. Tortora G.J., Funke B.R., Case C.L. (2006). Microbiology: An Introduction. 8th Edition. Pearson Education Inc
10. Field's Virology - 2 volumes, 5th edition, (2006), Bernard.N. Fields, Lippincott and Williams Wilkins, USA
11. C.B. Powar, Sunita Bundale (2023) Virology: Fundamentals & Applications, Himalaya Publishing House

Web Resources:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4078662
https://microbewiki.kenyon.edu/index.php/Bacterial_endospores
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2599877/
https://jb.asm.org/content/182/24/6865#F1
The bacterial Min system – ScienceDirect

M. Sc. Biotechnology Semester II

Paper 6

Molecular Biology

Course Outcomes

After successful completion of this Course, students will be able to:

CO 1. Acquire knowledge of the fundamental concepts of DNA Replication, Mutations and Repair

CO 2. Evaluate the principle differences in the transcription mechanisms of prokaryotic and eukaryotic systems.

CO 3. Demonstrate the proficiency in regulatory aspects of transcription through classical experiments involved in it

CO 4. Relate the concepts of RNA modifications relayed into protein expression.

UNIT I: DNA Replication, Mutation & Repair

DNA Replication: Prokaryotic and Eukaryotic DNA replication, mechanisms of DNA replication, fidelity of replication, enzymes and accessory proteins involved in DNA replication.

Models of Replication: theta, rolling circle, mitochondrial & chloroplast.

Gene mutations: Types of mutations. Suppression. Ames' test.

DNA Damage: Alkylation, deamination, oxidation, UV radiation.

DNA Repair: Direct repair, Ada protein, NER, BER, MMR, SOS repair, Transcription-repair coupling, repair of double-strand breaks.

UNIT II: Prokaryotic & Eukaryotic Transcription

Prokaryotic Transcription: RNA Polymerase holoenzyme and apoenzyme, different sigma factors, details of initiation, elongation, termination.

Eukaryotic Transcription: Three types of RNA polymerases. Promoter of RNA polymerase II. Enhancers.

General and inducible transcription factors.

UNIT III: Regulation of expression in prokaryotes & eukaryotes

Regulation of expression in prokaryotes: lac operon, ara operon, trp operon, negative autogenous control.

Regulation of expression in eukaryotes: Britten-Davidson model. DNA binding and activation domains of transcription factors. Packaging of chromosomes and its relation to transcription regulation. Regulation of translation by 3' and 5' UTR motifs.

UNIT IV: Modifications of RNA, Genetic Code & Protein Biosynthesis

Modifications of RNA: 5' cap formation, polyadenylation, splicing of nuclear pre-mRNA, mRNA stability.

Genetic code: characteristics, deciphering the code.

Protein biosynthesis: Prokaryotic and eukaryotic translation, the translational machinery, mechanism of initiation, elongation and termination.

Mitochondrial & Chloroplast translation.

References:

1. Freifelder D (2012). *Molecular Biology, 5th edition*. Narosa Publishing House, India.
2. Allison A. Lizabeth (2012) *Fundamental Molecular Biology, 2nd Edition*. J Willey and Sons, Hoboken,New Jersey.
3. Freifelder D and Malacinski GM (2005) *Essentials of Molecular Biology, 4th Edition*, John and Bartlett Publishing, UK
4. Krebs JE., Kilpatrick ST and Goldstein ES. (2013). *Lewin' GENES XI*, Jones & Bartlett Learning. Burlington, MA.
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M. Sc. Biotechnology Semester II

Paper 7: Electives

A) Industrial Biotechnology or B) Environmental Biotechnology

A) Industrial Biotechnology

Course Outcomes

After successful completion of this Course, students will be able to:

CO 1. Acquire understanding about the design and functioning of different types of bioreactors

CO 2. Develop knowledge of bio-processing methods and immobilization techniques

CO 3. Acquisition of the knowledge in process optimization strategies.

CO 4. Appreciate the importance of Downstream processing and Evaluate the production of Primary and Secondary Metabolite

UNIT I: Bioreactors & Types of Bioreactors

a) Design/configuration of a basic fermentor; individual parts and probes for on-line monitoring of process. b) Concept of Batch and Continuous process, fed-batch semi-continuous systems; aerobic and anaerobic fermentors c) Submerged/liquid state and solid state fermentations

Types of Bioreactors with examples: Continuous stirred tank and plug flow reactors · Packed bed and fluidized bed reactors · Trickle bed, immobilized bed, air lift, rotary disc reactors. Reactors with cell recycle.

UNIT II: Bioprocess Engineering Concepts & Immobilization

Bioprocess Engineering Concepts: · Mass transfer, heat transfer, mixing, rheology of fermentation fluids, residence time distribution, substrate utilization and yield-coefficients, oxygen transfer and oxygen sag.

Immobilized reactor systems: Immobilization techniques for cells (physical adsorption, ionic binding, covalent binding, lattice entrapment, membrane entrapment, micro encapsulation) and enzymes (covalent binding, entrapment, micro encapsulation, cross-linking, adsorption, ionic binding, affinity binding, chelation, disulfide bonds) ·

Unit III: Screening, process Optimization & process control

Primary & secondary screening for- antibiotic producers, vitamin producers, organic acid producers, enzyme producers

Process Optimization · Optimization parameters, medium formulation, process optimization techniques: Classical, Plackett Burman design, ANOVA, central; composite design, response surface methodology with example.; medium formulation: classical, experimental design technique, fractional factorial design with examples.

Concept of control: turbidostatic and chemostatic control, open loop and feedback control · Advanced control policies: model predictive control, cascade control, PID control, programmed control

Unit IV DSP & Production of Primary & Secondary Metabolite

Importance of Down Stream Processing (DSP) in biotechnology, criteria for selection of bio-separation techniques

Removal of cell mass & other solid matter- a) Foam separation b) Sedimentation, centrifugation; c) Filtration- Different types- Batch filters, plate frame, pressure leaf . Continuous filters, rotary drum filters, string discharge filters , pre-coat/vacuum filters, use of filter aids; e) Extraction of products from broth-i) liquid-liquid extraction–principles, single stage, multistage extractor. ii) Chromatographic separation-different column chromatographic techniques. iii) Distillation, iv) precipitation, v) Membrane filtration, microfiltration, ultrafiltration, reverse osmosis.

Cell disruption for intracellular products- Mechanical methods & Non-mechanical methods
Finishing of product- Crystallization & recrystallization. Polishing and Packaging
Production of primary & Secondary metabolites on industrial scale with flow sheets – (a) Solvents- Bioethanol from molasses, (b) Acids- Citric acid by surface culture process. (c) Amino acid: Glutamic acid (d) Enzymes: alpha -amylase by Solid-State Fermentation, and Glucose oxidase by the submerged culture process (e) Antibiotics- Penicillin d) Vitamins- Cyanocobalamin

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OR

B) Environmental Biotechnology

Course Outcomes

After successful completion of this Course, students will be able to:

CO 1. Comprehend the basic principles of Environmental Science

CO 2. Recognise the importance of bioremediation

CO 3. Evaluate the functioning of technology involved in Waste water treatment

CO 4. Analyze the effects of recalcitrant compounds and study their biodegradation in environment

UNIT I: Basics of environmental Science

Ecosystem structure and functions, abiotic and biotic component, Energy flow, food chain, food web, Ecads and ecotypes, Non-conventional or renewable sources of energy Environmental ethics: Need for environmental education. Environmental laws, Concepts of Environmental Impact Assessment, Environmental Pollution: Air pollution, Water pollution, Noise pollution, Soil pollution, Composting, Vermicomposting, Biofertilizers: Bacterial, Algal, Aquatic ferns, & Fungi as biofertilizers

UNIT II: Bioremediation

Bioremediation and its applications, Phytoremediation, Bioabsorption and Bioleaching of heavy metals: Cadmium, Lead, Mercury, Metal binding targets and organisms, Metal microbial interaction, Biomethylation of elements (Methylation of mercury and arsenic), Commercial biosorbants, bioleaching, metal precipitation, advantages and disadvantages of bioleaching, Biosensors in detection of environmental contaminants

UNIT III: Waste water Treatment

Biological treatment system for Sewage (Oxidative ponds, aerobic and anaerobic ponds, facultative ponds, aerated ponds), activated sludge treatment, microbial pollution in activated sludge, percolating filters, waste water treatment by biofilms, Sequencing batch reactor (SBR), Treatment scheme of Dairy, Distillery, Tannery, Sugar, Fertilizers, Refinery, Chemical and Antibiotic waste.

UNIT IV: Environmental Recalcitrant Compounds

Biodegradation of Hydrocarbons, Substituted hydrocarbons, Surfactant, Pesticides, Lignin, Tannin, Synthetic dyes, Biotransformation: Oxidation reactions (Cytochrome P450 monooxygenase system, Alcohol and aldehyde dehydrogenases, Peroxidases), Reduction reactions (Cytochrome P450 and flavin dependent reactions), Hydrolysis reactions (Carboxyl esterases), Conjugation reactions (Gluthione S transferases). Bioaccumulation, Biomagnification

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M. Sc. Biotechnology Semester II
Paper 8: On Job Training

1. Antibacterial activity of medicinal plants
2. Antifungal activity of medicinal plants
3. Anti-quorum sensing activity of medicinal plants
4. Isolation of coliphages from sewage water
5. Nanoparticle synthesis of medicinal plant extracts and evaluation of their bioactivities
6. Nanoparticle synthesis from Actinobacteria/ fungi and evaluation of their bioactivities
7. Evaluation of anti-cancer activity of medicinal plants
8. Biodegradation of dye/recalcitrant compounds from industrial wastes
9. Production of wine/ vinegar from fruits
10. Production of enzymes using bacterial/ fungal strains
11. Assessment of antibiotic sensitivity/ resistance of pathogens
12. Evaluation of anti-cancer activity of natural/ synthetic compounds
13. Preparation of microbial consortium for composting.
14. Preparation of herbal plant extract for plant growth and yield (biostimulant).
15. Isolation and identification of zinc solubilizing microbes and its impact on plant growth.
16. Isolation and identification of nitrogen fixing organisms for leguminous and non-leguminous plants.
17. Isolation of different bacterial spp. As a biocontrol agent for plant pathogens.
18. Isolation of fungal spp. Biofertilizers and biopesticides.
19. Isolation of heavy metals reducing or organisms as tool for bioremediation.
20. Isolation of heavy metals reducing or organisms as tool for bioleaching.
21. Hydrogel formulation for effective heavy metal absorption from contaminated water.
22. Plant growth response of nano fertilizers using hydroponic systems.
23. Preparation of promising nano drug candidates to control antibiotic resistant bacteria.
24. Bioinformatics-based study of hypothetical proteins
25. Bioinformatics-based study of vaccine candidates for effective antigen search
26. Plant tissue culture-based organogenesis, embryogenesis, and bioactive production
27. Molecular characterization and phylogenetic study of plants
28. Molecular characterization and phylogenetic study of microbes
29. Study of AMR genes in different environments
30. Study of diversity of bacteriophage in different environments
31. Isolation and characterization of endophytic microbes
32. Study the effect of endophytic bacteria on growth of plant
33. Micropropagation of rare or endangered or economically important plants
34. Agrobacterium-mediated transformation of plant cell

35. Studying the bioremediating potential of microbes and plants
36. Analysis of DNA Damage patterns in response to environmental stressors in selected plant/fungi/algae/bacteria
37. Investigating the expression pattern of RNAs in response to pesticides in vegetables/plants
38. Study of variable patterns of total DNA content in cancer cells.
39. PCR based Examination of genetic variation in human populations using molecular markers
40. PCR based Identification and characterization of antibiotic resistance genes in bacterial isolates
41. RFLP Analysis of gene mutations associated with genetic disorders
42. Investigation of protein-protein interactions using yeast two-hybrid system
43. Cloning and expression of recombinant proteins in bacteria for their functional analysis
44. Analysis of any one gene expression profile during development stages of an organism
45. Standardization of DNA isolation methods from milk and curd
46. In Silico Screening for novel drug targets using high-throughput screening methods
47. Examination of DNA methylation patterns in cancer cells using bioinformatic approach
48. Selection of unidentified proteins from protein data bank and creating their 3D models using online folding tools.
49. Analysis of molecular mechanisms involved in cellular apoptosis- Creating a concept map
50. Investigation of the role of non-coding RNAs in gene regulation-- Creating a concept map
51. Characterization of DNA replication and cell cycle progression in model organisms
52. Analysis of gene expression changes in response to drug treatments
53. Study of molecular mechanisms underlying microbial pathogenesis
54. Examination of genetic factors influencing plant traits and adaptation
55. Investigation of genetic diversity in natural populations using DNA sequencing techniques

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M. Sc. Biotechnology Semester II

Practical 1

Microbiology

1. Cleanliness, media preparation, sterilization, culturing methods, dilution techniques.
2. Staining techniques in microbiology; simple staining, gram staining, spore staining capsule staining, flagella staining.
3. Isolation of pure culture by different techniques: Streak plate, Serial dilution, Pour plate & spread plate.
4. Replica plating technique.
5. Propagation of viruses.
6. Assay of viruses.

7. Biochemical tests for identification of Bacteria – Oxidase, catalase, IMViC test, etc.
8. Isolation of antibiotic resistant bacteria from waste / sewage water.
9. Motility of bacteria by hanging drop method.
10. Assay of antibiotics by disc diffusion method.

M. Sc. Biotechnology Semester II

Practical 2

Molecular Biology

1. Induction of b-galactosidase in strains of E. coli (I+ and I-).
2. Southern blotting.
3. Isolation of genomic DNA.
4. Western blotting.
5. Endonuclease digestion of DNA and analysis of DNA fragments by agarose electrophoresis.
6. Restriction fragment length polymorphism.
7. Ames test.
8. Isolation of plasmid DNA (miniprep and alkaline bulk method)
9. Isolation of RNA
10. Estimation of DNA by E260 method
11. Isolation of Lambda phage DNA.