Mahatma Education Society's

Pillai College of Arts, Commerce & Science (Autonomous)

Affiliated to University of Mumbai

'NAAC Accredited 'A' grade (3 cycles)'
'Best College Award' by University of Mumbai
ISO 9001:2015 Certified

SYLLABUS

Program: Master of Science (M. Sc.) in Biotechnology

M.Sc.- Part II Biotechnology

PCACS/MSCBT/SYL/2024-25/PII

As per National Education Policy
Choice Based Credit & Grading System

Academic Year 2024-25

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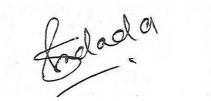
10	Dr. Pankaj Mundada	Alumni	
11	Dr. P. S. Goyal	Faculty Specialist	
12	Dr. Gajanan Wader	Principal	

1. INTRODUCTION

The present M.Sc. Biotechnology Second Year (Semester III and IV) syllabus has been designed with the idea of incorporating outcome-based learning for fruitful engagement of learners. The syllabus has undergone several curriculum revision exercises based on the remodelled M.Sc. Biotechnology Curriculum, May 2017, Department of Biotechnology, Ministry of Science and Technology, Government of India. The revised syllabus is an outcome of several rounds of deliberations, discussions, feedback and multiple brainstorming sessions involving various contributors & stakeholders- academicians, industry experts and students. Course Objectives and Course Outcomes have been clearly defined for each paper in the syllabus to guide teachers in order to make the learning process more effective. A lot of focus has been given in the syllabus to cover latest developments in the area of biotechnology and to equip students with necessary knowledge and skills. Relevant papers to make students industry ready have also been included. Attempts have been made to draft a robust, well defined syllabus keeping in view the best learning outcome which shall enable students to pursue high quality research or increase employability of the students. It is hoped that the revised syllabus shall serve its objective of promoting outcome-based learning to meet the changing needs of the biotechnology sector.

2. PROGRAMME OUTCOMES:

Sr No	PO Title	PO in brief
PO1	Advanced Knowledge and Expertise	Demonstrate a systematic, extensive and coherent knowledge and understanding of their academic discipline as a whole and its applications, and links to related disciplinary areas/subjects of study; demonstrate a critical understanding of the latest developments in the subject, and an ability to use established techniques of analysis and enquiry within the subject domain with a global perspective.
PO2	Research and Innovation	Acquire comprehensive knowledge about current research and innovation, and acquire techniques and skills required for identifying problems and issues to produce a well-researched written work that engages with various sources employing a range of disciplinary techniques and scientific methods applicable.
PO3	Interdisciplinary Perspective	Commitment to intellectual openness and developing understanding beyond subject domains; answering questions, solving problems and addressing contemporary social issues by synthesizing knowledge from multiple disciplines.
PO4	Leadership Abilities & Entrepreneurial Mindset	Inculcate Leadership skills, including the ability to lead teams, manage projects, and make strategic decisions. innovation and entrepreneurship, business development, technology commercialization, and startup creation
PO5	Communication Competence	Demonstrate effective oral and written communicative skills to covey disciplinary knowledge and to communicate the results of studies undertaken in an academic field accurately in a range of different contexts using the main concepts, constructs and techniques of the subject(s) of study
PO6	Ethical Conduct and Research Integrity	Understanding and adherence to ethical standards and research integrity by developing commitment towards professional ethics and responsibilities as a social endeavor.
PO7	Career development	Demonstrate subject-related knowledge and skills that are relevant to academic, professional, soft skills and employability required for higher education and placements.
PO8	Commitment to the society and to the Nation	Recognise the importance of social, environmental, human and other critical issues faced by humanity at the local, national and international level; appreciate the pluralistic national culture and the importance of national integration.

3. PROGRAMME SPECIFIC OUTCOMES:

PSO1	Students will be able to design, conduct experiments, analyze and interpret data for investigating problems in Biotechnology and allied fields.
PSO2	To equip the students to apply knowledge of molecular mechanisms of cellular processes in living systems including microbes, plants, and higher order organisms to applied aspects.
PSO3	Understand the potentials, and impact of biotechnological innovations on environment and their implementation for finding sustainable solution to issues pertaining to environment, health sector, agriculture, etc.
PSO4	Address the increasing need for skilled scientific manpower with an understanding of research ethics involving animals and humans to contribute to application, advancement, and impartment of knowledge in the field of biotechnology globally.

Course Structure

Semester III						
Course Code	**Course Type**	**Course Title**	**Theory/ Practical**	**Marks**	**Credits**	**Lectures/ Week**
PMSBT301	**Major**	Applied Virology and Microbiology	Theory	100	4	4
PMSBT302		Molecular Enzymology and Enzyme Technology	Theory	100	4	4
PMSBT303		Food Technology	Theory	100	4	4
PMSBT304	**Major Elective**	Biologics and Regulatory Affairs	Theory	50	2	3
		Reproductive Biology and Embryology				
		Cosmetic Biotechnology				
PMSBT305P	**Major Practical**	Practicals (Course 1 + Course 2)	Practical	100	2	8
PMSBT306P	**Major + Elective Practical**	Practicals (Course 3 + Course 4)	Practical	100	2	8
PMSBT307	**OJT/FP/RP**	Internship (90 hours)	-	100	4	-
Total				650	22	28
All Subjects having Field Project as part of Continuous Assessment-2						

Abbreviations:

OJT : On Job Training: Internship/ Apprenticeship

FP : Field Projects

RP : Research Project

Semester IV						
Course Code	**Course Type**	**Course Title**	**Theory/ Practical**	**Marks**	**Credits**	**Lectures / Week**
PMSBT401	**Major**	Nanobiotechnology	Theory	100	4	4
PMSBT402		Environmental Biotechnology	Theory	100	4	4
PMSBT403		OMICS and Systems Biology	Theory	100	4	4
PMSBT404P	**Major Practical**	Practicals (Course 1 + Course 2)	Practical	100	2	16
PMSBT405	**RP**	Dissertation Project	-	250	8	-
Total				650	22	28
All Subjects having Field Project as part of Continuous Assessment-2						

Abbreviations:

RP : Research Project

Evaluation Pattern

Marking Code	Marking Scheme
A	60 Marks Final Exam, 20 Marks Continuous Assessment I, 15 Marks – Field Project/ Continuous Assessment II - Review article/ Research proposal writing, 05 Marks Attendance
B	50 marks distributed within Quiz/Project/Case study based assignment
C	100 Marks Practical Examination. Course1 Practical (50 Marks) + Course 2 Practical (50 Marks) =100
D	100 marks within Internship of minimum 90 hours duration/ report/powerpointt presentation and viva
E	250 marks distributed within project dissertation (4 months duration) / Research Guide evaluation of bench work / Thesis with certificate from research institute or industry where project completed /Power point presentation and viva (internal and external examiner evaluation)

Semester III				
Course Code	**Course Type**	**Course Title**	**Evaluation Pattern**	**Marks**
PMSBT301	**Major**	Applied Virology and Microbiology	A	100
PMSBT302		Molecular Enzymology and Enzyme Technology	A	100
PMSBT303		Food Technology	A	100
PMSBT304	**Major Elective**	Biologics and Regulatory Affairs	B	50
		Reproductive Biology and Embryology		
		Cosmetic Biotechnology		
PMSBT305P	**Major**	Practicals (Course 1 + Course 2)	C	100
PMSBT306P	**Major + Elective**	Practicals (Course 3 + Course 4)	C	100
PMSBT307	**OJT/FP/ RP**	Internship (90 hours)	D	100
Total				650

Semester IV				
Course Code	**Course Type**	**Course Title**	**Evaluation Pattern**	**Marks**
PMSBT401	**Major**	Nanobiotechnology	A	100
PMSBT402		Environmental Biotechnology	A	100
PMSBT403		OMICS and Systems Biology	A	100
PMSBT404P		Practicals (Course 1 + Course 2)	C	100
PMSBT405	**RP**	Dissertation Project	E	250
Total				650

SEMESTER III

BOS	Biotechnology
Class	M.Sc II
Semester	III
Course Name	Applied Virology and Microbiology
Course Code	PMSBT301
Type of Course	Major
Level of the Course	Advanced
Total Credits for the Course	04 Theory+01 Practical

Course Objectives:

1. To provide an insight on the epidemiological principles in prevention, control and management of pandemic disease.
2. To develop an understanding of antimicrobial resistance for management of drug resistance in the population along with insights into latest development of diagnostics & therapeutics for such diseases.

Unit No.	Name of the Unit	Topic No.	Content	Hours
I	Pandemic diseases, pathogenesis, diagnosis and treatment	1.1	Introduction to Pandemic diseases, causative agent, Structure of these viruses, genome composition, Pathogenesis, Acute Clinical manifestations, Diagnosis, and Treatment of:	15
			H1N1(Swine flu), Rabies, SARS, COVID-19, Nipah virus	
		1.2	Eradication and management of pandemics in the past - smallpox and polio	
		1.3	Economic and Social loss due to Viruses	
II	Epidemiology of infectious diseases	2.1	Concept of Host, Reservoir, Source ofinfection, Carrier , Epidemic, Endemic, Pandemic, Outbreak	15
		2.2	History , Definition scope, importance of Epidemiology, Epidemiology, Health & Public Health, Epidemiological principles in prevention & control of disease	
		2.3	Measures of disease frequency –Concept of incidence, prevalence,Incidence rate, cumulative incidence, caseFatality Epidemiological studies Organizations in disease control &Research – WHO, CDC, UNICEF, NACO,ICMR, NARI, NIV & NGOs	

III	Medical Microbiology	Emerging Pathogens / Infections : Causative agent, Name of disease caused, History, Antigenic structure, virulence factors, source of infection, Transmission, Pathogenesis, Clinical manifestations, Laboratory diagnosis, Treatment, Prophylaxis, vaccines , Current research and developments of:		15
		3.1	Diseases caused by Bacteria- Bacteria as emerging pathogens / Diseases caused by bacteria : MOTT, *Legionella*, Conditions caused by *Helicobacter pylori*	
		3.2	Viruses as emerging pathogens / Diseases caused by viruses : HIV (AIDS), Chikungunya, Dengue	
		3.3	Parasites as emerging pathogens / Diseases caused by parasites : Malaria , *Entamoeba histolytica* (Amoebic dysentery)	
IV	Biofilms & Antimicrobial Activity	4.1	Structure of Biofilm – Extracellular polymeric substances, Biofilm architecture. Stages in formation of Biofilm. Microbial interactions in Biofilms (Quorum sensing)	15
		4.2	Need for formation of Biofilms by Microorganisms. Microorganisms commonly associated with biofilms on indwelling medical devices; Response of biofilms to host defense mechanisms & antimicrobial agents Recent advances in biofilm management.	
		4.3	Conventional methods of drug susceptibility testing (Kirby-Bauer disc diffusion, Stoke's method, E test) Advanced methods- Macro & Micro broth dilution methods, Time kill curves, serum killing curves, checker-board assays.	
		4.4	Detection of drug resistance in *Staphylococci, Streptococci, Enterococci*. Automated methods of sensitivity testing. Concept of CLSI standards	
Total Lectures				**60**

Course outcomes:

By the end of the course the student will be able to:

1. Describe virus structure, process of virus attachment and entry, virus assembly and release.
2. Outline the most important areas of medical microbiology i.e. etiology, transmission, pathogenesis, clinical manifestations, laboratory diagnosis,prophylaxis, and treatment of various diseases.
3. Determine public health measures for prevention, control and management of pandemic disease by understanding their route of transmission and epidemiology.
4. Differentiate epidemiological study designs, recognize the most appropriate circumstances in which to use each design, and describe the measures of disease occurrence that can be generated using each design
5. Appraise the management and eradication of pandemics in the past - smallpox and polio.
6. Develop an understanding of biofilm formation and antimicrobial resistance for management of drug resistance in population along with insights into latest development of diagnostics & therapeutics for such diseases.

References:

1. Microbiology An introduction (2010) - 10th edition - Gerald Tortora, BurdellFunke, Christine Case, Pearson Education Inc. Publication
2. Basic Epidemiology (2006), 2nd Edition - R. Bonita, Bealglehole, T. Kjellstrom, WHO
3. Principles of Epidemiology in Public Health Practice (2012),Third edition- US Department of Health & Human Services, CDC
4. Ananthanarayan and Paniker's Textbook of Microbiology, by Reba Kanungo, 10th edUniversities Press; Tenth edition, 2017
5. Koneman'sColour Atlas & Textbook of Diagnostic microbiology, 7th edition, 2017,Lippincott, Williams & Wilkins.
6. Mackie & McCartney Medical Microbiology, J. G. Collee, J. P.Duguid, A. G. Fraser, B. P. Marmion, Thirteenth edition, Churchill Liviingston

Case Study:

1.	Rabies, a zoonotic viral encephalitis, continues to be a serious public health problem in India and several other countries in Asia and Africa. Survival is rarely reported in rabies, which is considered to be almost universally fatal. Out of 1,20,000 cases reported in 2022-23, 400 cases of fatality were reported. Among the persons who survived the illness, with the exception of one patient who recovered with mild sequelae, all survivors had poor functional outcomes. The reported survival from rabies in recent years may reflect an increased awareness of the disease and greater access to better critical care facilities in rabies-endemic countries. Nonetheless, there is an urgent need to focus on preventive strategies to reduce the burden of this dreadful disease in rabies-endemic countries.

2.	COVID-19 is a serious infection that has led to thousands of cases of severe pneumonia, ARDS, and even deaths across the globe. As of now there are no approved treatments for this viral pandemic. While several medications have shown to be effective in clinical trials, further studies are needed to establish dosing, treatment course, and side effects of these medications. In India, a township of 1 lakh population, more than 20000 people died due to COVID 19. As the number of cases and deaths continue to increase in the world, the race to develop faster testing modalities to rapidly diagnose and manage these patients earlier continues to be the focus of the global healthcare system.

PRACTICALS

1	Viral Titering – Plaque Assay, Tissue Culture Infectious Dose (TCID), Chicken Embryo Infectious Dose (CEID)
2	Immunoassays: For detection of the virus antigens by ELISA
3	Detection techniques for COVID like RT- PCR and various RAPID tests
4	Diagnosis of dengue (kit method)
5	Diagnosis of Chikungunya (kit method)
6	Antibiotics susceptibility testing by broth Macro dilution method & Micro broth dilution method
7	Study of microbial biofilm formation on various surfaces & Biofilm visualization by staining
8	Demonstration of minimum biofilm inhibition concentration of antibiotics/disinfectants.

BOS	Biotechnology
Class	M. Sc II
Semester	III
Course Name	Molecular Enzymology and Enzyme Technology
Course Code	PMSBT302
Type of Course	Major
Level of the Course	Advanced
Total Credits for the Course	04 Theory+01 Practical

Course Objectives:

1. To get familiarity with the basic concepts of enzymes and its regulation as well as learn the techniques of enzyme purification.
2. To understand the need for enzyme engineering and the role of enzymes as a diagnostic tool, for industrial applications and as biosensors.

Unit No.	Name of Unit	Topic No.	Content	Hours
I	Basic concepts	1.1	Basics of Enzymology	15
		1.2	Enzyme kinetics: Michaelismenten equation, Lineweaver Burk plot, EadieHofstee plot, Hanes- Woolf plot. Factors affecting enzyme activity; non protein enzymes; coenzymes and cofactors.	
		1.3	Competitive, non- competitive, uncompetitive, linear-mixed type inhibitions and their kinetics. Allosteric enzymes, qualitative description of "concerted" & "sequential" models for allosteric enzymes. Half site reactivity, Flipflop mechanism, positive and negative co-operativity with special reference to aspartate transcarbamoylase& phosphofructokinase. Protein-ligand binding measurement, analysis of binding isotherms, Hill and Scatchard plots.	
		1.4	General mechanisms of enzyme regulation, product inhibition. Reversible (glutamine synthase & phosphorylase) and irreversible (proteases) covalent modifications of enzymes. Feedback inhibition and feed forward stimulation.	
II	Techniques of Enzyme purification and studies/enzyme engineering	2.1	Based on molecular size (Dialysis/ ultrafiltration, density gradient centrifugation, size exclusion chromatography)	15
		2.2	Based on solubility of proteins (Isoelectric precipitation, salting out); based on electric	

			charge (Ion exchange chromatography, Electrophoresis, capillary electrophoresis, 2D electrophoresis)	
		2.3	Based on adsorption properties (Adsorption and Affinity chromatography). Other techniques: Immobilized metal ion affinity chromatography, Hydrophobic interaction chromatography, Reverse Phase chromatography and Chromatofocusing.	
		2.4	Enzyme engineering – Introduction, Objectives, Principles, Examples and Steps involved in enzyme engineering. Random mutagenesis and molecular breeding of DNA. Recent advances in Rational approaches for Enzyme engineering. Applications of enzyme engineering.	
III	Industrial & medical application of enzymes	3.1	Textile Industry, Detergent Industry, Pulp and Paper Industry, Animal Feed Industry: Enzyme Technology for Detoxification of Mycotoxins in Animal Feed , Phytases for Feed Applications and Leather Industry. Enzyme Applications for Human and Animal Nutrition.	15
		3.2	Biosensors – Introduction, instrumentation, Types and examples. Enzymes based sensors as diagnostic tools- Biosensors for Blood Glucose, Biosensors for Urea in Blood and Urine, Biosensors for Uric Acid, Biosensors for Arginine, Biosensors for Asparagine, Biosensors for Creatinine, Biosensors for Cholesterol, Allosteric enzyme based biosensors.	
IV	Enzyme deficiencies/ diagnostic enzymes/ therapeutics	4.1	Disorders of amino acid metabolism Phenylketonuria, Alkaptonuria, Homocystinuria. Disorders of carbohydrate metabolism – Galactosemia, Hereditary fructose intolerance, Hereditary lactose intolerance.	15
		4.2	Disorder of lipid metabolism - Gaucher disease, Fabry disease. Disorders of purine and pyrimidine metabolism HGPRT deficiency , Adenosine deaminase deficiency, Orotic aciduria.	
		4.3	Enzymes in diagnosis of diseases Liver disorders, Cancer, Cardiac disorders. Role of Other enzymes Lysozyme, Butyrylcholinesterase and Lipases.	
		4.4	Therapeutic uses of enzymes - enzymes in replacement therapy,	
Total Lectures				**60**

Course outcomes: By the end of the course the student will be:

1. Describe the concepts of co-operative behaviour, enzyme inhibition and allosteric regulation.
2. Explain the methods of enzyme engineering to enhance its activity or half life
3. Illustrate the major applications of enzymes in various industries and in Biosensors.
4. Characterize different enzymes based on their kinetic properties.
5. Compare methods for production, purification, characterization and immobilization of enzymes.
6. Discover the current and future trends of applying enzyme technology for the commercialization purpose of biotechnological products.

References:

1. Lehninger Principles of Biochemistry - 4th Ed (2005) - Nelson, D., and Cox, W.H. Freeman and Company, New York,
2. Biochemistry (2013) -Satyanarayan and Chakrapani, New Delhi, Elsevier Health Sciences APAC,.
3. Biochemistry, 5th Ed, (2002) - Berg JM, Tymoczko JL, Stryer L Freeman WH and Co., New York.
4. Understanding enzymes (3rd edition). Edited by Trevor Palmer, Ellis Horwood, Chichester, 1991.
5. Protein purification principles, High Resolution Methods, and Applications, 3rd Edition, Jan-Christer Janson, John Wiley & Sons, Inc., Hoboken, New Jersey.
6. Fundamentals of Enzyme Engineering, Young Je Yoo, Yan Feng, Yong-Hwan Kim, Camila Flor J. Yagonia, : Springer Netherlands 2017.

Case study:

1.	Prime tannery specializing in high-quality leather production seeks to improve its processing efficiency and environmental sustainability. By adopting enzyme technology, the tannery introduces enzyme-assisted processes across its leather processing operations. Proteases and lipases are employed in the dehairing and degreasing stages, resulting in cleaner and more uniform hides with reduced processing time and water usage. Carbohydrases are utilized in bating and softening processes, yielding leather with enhanced softness and flexibility.In dyeing and finishing, enzymes are incorporated to improve dye penetration and color fixation, enabling the tannery to achieve vibrant and consistent colors while minimizing dye consumption and wastewater generation.As a result of implementing enzyme-assisted processes, the tannery significantly reduces its environmental footprint, improves processing efficiency, and produces high-quality leather products that meet customer demands for sustainability and performance.
2.	Amy, a 32-year-old female, presented with symptoms indicative of a rare disorder characterized by the inability of her body to produce the enzyme globotriaosylceramide (GL-3). The deficiency in the enzyme required for the metabolism of GL-3, leading to its accumulation in various tissues and organs. Amy exhibited symptoms such as neuropathic pain, gastrointestinal disturbances, and progressive renal dysfunction. This disorder can result in significant morbidity and mortality if left untreated. Amy's condition necessitates enzyme replacement therapy (ERT) using agalsidase alfa and agalsidase beta. Enzyme replacement therapy has emerged as a promising approach to alleviate symptoms and slow disease progression in patients like Amy.

PRACTICALS

1	Microbial Enzyme production: a. Partial purification using ammonium sulphate precipitation. b. Dialysis of the salt-precipitated protein. c. Assessing the enzyme activity and the protein content.
2	Effect of inhibitors/ chemicals on enzyme activity.
3	Extraction of enzymes from plant sources.
4	Measurement of Enzymatic Activity by Using a Colorimetric Assay.
5	Purification of Acid Phosphatase from Wheat Germ.
6	Enzyme Immunoassays. a. Methods for Enzyme Immunoassays. b. Non-competitive Solid-phase Enzyme Immunoassay. c. Competitive, Solid-phase Enzyme Immunoassay.
7	Determining of Alkaline Phosphatase (ALP) Concentration in Blood Plasma.
8	Measuring Lactase Enzymatic Activity
9	Screening of new microbial strains for production of enzymes and perform its activity staining (zymogram).
10	To determine Specific activity of α Amylase from different sources

BOS	Biotechnology
Class	M.Sc II
Semester	III
Course Name	Food Technology
Course Code	Major
Type of Course	PMSBT303
Level of the Course	Medium
Total Credits for the Course	04 Theory+01 Practical

Course Objectives:

1. To provide an understanding of the scope of Food technology with focus on development of Nutraceuticals, functional foods, probiotics and prebiotics and their applications in management of health and diseases.
2. To comprehend basic concepts of food processing and preservation, and understanding the concept of toxicology in food.

Unit No.	Name of Unit	Topic No.	Content	Hours
I	Nutraceuticals and functional foods	1.1	Food Security - Introduction, Dimensions, Measuring food security	15
		1.2	Nutraceuticals and functional foods Definition, characteristic features, and classification, phytonutraceuticals	
		1.3	Prebiotics and Probiotics, Sources (with examples e.g. microbes, plants, algae, animals), Significance, Different Stages in production of Probiotics	
		1.4	Blue Biotechnology, Seafood Processing By-products	
II	Technology in Food development and Health management	2.1	Biofortification – Introduction, Approaches, examples, advantages and limitations	15
		2.2	Food Packaging - Introduction, Basic functions, materials and packaging systems	
		2.3	Nutraceuticals in management of health and disease, Nutraceutical adjuvants	
		2.4	Development of designer foods for specific chronic diseases	
		2.5	Food Safety and Regulatory guidelines	
III	Food processing and preservation	3.1	Introduction to food processing of various foods including dairy, bakery, brewing, fruit and vegetable products, plantation products, oilseeds, meat, fish, poultry;	15

		3.2	Principles of food preservation by dehydration, thermal treatments & non-thermal processes.	
		3.3	Chemical preservation/ bio-preservation, traditional methods like salting/ syruping, pickling, fermentation etc.,	
		3.4	Use and application of enzymes and microorganism in processing and preservation of foods; Food additives; Definition, types and functions, permissible limits and safety aspects.	
IV	Food Toxicology	4.1	Principles of Toxicology: classification of toxic agents; characteristics of exposure; spectrum of undesirable effects; interaction and tolerance; biotransformation and mechanisms of toxicity.	15
		4.2	Natural toxins in food: natural toxins of importance in food- toxins of plant and animal origin; microbial toxins (e.g., bacterial toxins, fungal toxins and Algal toxins), natural occurrence, toxicity and significance,	
		4.3	Environmental contaminants and drug residues in food. Food adulteration and potential toxicity of food adulterants.	
		4.4	Food allergies and sensitivities: natural sources and chemistry of food allergens; true/untrue food allergies; handling of food allergies;	
Total Lectures				**60**

Course outcomes:

By the end of the course the student will be able to:

1. Define the concept of food security and its dimensions; classify nutraceuticals and functional foods.
2. Explain processing of different types of foods; discuss the food safety and regulatory guidelines.
3. Apply blue biotechnology for development of foods and health products; Identify suitable preservation methods for different food items.
4. Outline steps involved in food processing, preservation and packaging; Analyze the action of different toxic compounds of chemical and biological origin.
5. Justify the role of nutraceuticals & functional foods in management of health and disease.
6. Designing safe and nutritious foods considering factors like sources, toxins and allergens, enhanced nutritive value and applicability in boosting health/ treating specific chronic diseases.

References:

1. Handbook of Nutraceuticals and Functional Foods - Robert E.C. Wildman - Taylor & Francis Inc
2. Handbook of Probiotics and Prebiotics (2nd Edition) - Yuan Kun Lee Seppo Salminen – John Wiley & Sons
3. Handbook of Food Processing: Food Preservation - TheodorosVarzakas and ConstantinaTzia – CRC Press
4. The Orange Book (1st Edition) – RijutaPandav – SNF portal
5. Handbook of food toxicology by S. S. Deshpande
6. Ramaswamy H. and Marcott M. (2005), Food Processing Principles and Applications. CRC Press

Case study:

1.	With rising cases of cancer worldwide, novel effective solutions have to be developed immediately. Nutriwings food industry developed a novel nutraceutical health product. The product is a combination of compounds obtained from plants and seafood byproducts (waste).The industry claims that their product cannot be used as a mainline treatment method but can be used as a supplement alongside treatment methods so that patients can recover fast. The compounds used do not have any side effects and the product is very promising and will improve the quality of life of cancer patients.
2.	John, a 45-year-old man, presents to the emergency department complaining of severe abdominal pain, nausea, vomiting, and diarrhea. He reports that his symptoms began approximately six hours after consuming a seafood meal at a local restaurant. John mentions that his wife, who also ate the same meal, is experiencing similar symptoms. Upon further questioning, John reveals that the seafood dish they consumed appeared and smelled normal, and it was the only meal they had eaten together that day. He denies any recent travel, medication changes, or known food allergies.

PRACTICALS

1	Estimation of total sugars from food products (dairy, fruit juices, bakery)
2	Determination of acid value of natural fats and oils.
3	Determination of iodine number of fats and oils.
4	Estimation of vitamin B by HPLC (demonstration)
5	Study of nutraceuticals important plants like *Zingiber*, *Curcuma*, *Aloe vera*, *Asparagus, Ocimum* etc.
6	Estimation of antioxidant property of phytochemical by DPPH.
7	Qualitative test for tannins, phenols, isoflavones, alkaloids using TLC.
8	Estimation of food preservatives/additives (Parabens) from food sample by HPLC (demonstration).
9	Estimate Cholesterol contents in given sample by Zak's methods.
10	Estimation of bio-burden by viable counts.
11	Estimation of gluten from food sample.
12	To study nutritional components (protein, carbohydrate, secondary metabolites, lipids, vitamin C) of following: Bee honey, Mushrooms, Lentils, Soya, Dairy product, Amla, Papaya, Spinach

BOS	Biotechnology
Class	M. Sc II
Semester	III
Course Name	(a) Biologics & Regulatory Affairs
Course Code	PMSBT304
Type of Course	Major Elective
Level of the Course	Advanced
Total Credits for the Course	02 Theory+01 Practical

Course Objectives:

1. Make students familiar with the basic concepts and significance of Biologics/Biosimilar in addition to having knowledge about its therapeutic applications and the Knowledge of the steps involved in the production of Biologics/Biosimilars
2. Make aware of the protocols/techniques required for characterization of the Biosimilar relative to the Reference Biologic and acquaint with the regulatory aspects for approval of Biosimilars.

Unit No.	Name of the Unit	Topic No.	Content	Hours
I	Introduction to Biologics and Biosimilars	1.1	Definition: Drugs, Small molecules, Large Molecules/Biologics. Similarities and Differences: Small molecules versus generics, Biologics versus Biosimilars. Categories of Biologics: protein-based hormones, enzymes, monoclonal antibodies, vaccines, blood products, and gene/ cellular therapies.	15
		1.2	USFDA Approved Small Molecules and USFDA Approved Generics, USFDA Approved Biologics and USFDA Approved Biosimilars. Introduction to Regulatory Affairs and approvals of Biosimilars, Products approved under the FD&C.PHS/BCPI Act 2009.	
		1.3	Indian Regulatory Scenario in relation to Small Molecules and Biologics Therapeutic uses of some of the Biologics/Biosimilars Acceptable quality differences between approved Biosimilar and innovator's product	
II	Production of Biologics and Biosimilars	2.1	Reference Biologic and its significance, Choice of expression system/s and stability of cell lines. Difference between bioreactor and fermentor, Development of upstream and downstream processes and scale up to manufacturing.	15

			Major factors contributing to the maintenance of product quality: raw materials and manufacturing conditions, virus filtration, mycoplasma removal, ultrafiltration. Biologics Pharmcokinetics.	
		2.2	Post market data for biosimilars and biologics, Biosimilar development to commercialization – case study (new mAB approval – Avelumab for metastatic Merkel cell carcinoma (mMCC)	
		2.3	Patent protection for small molecules Vs. Innovators biologics Introduction to the concept of Biobetters vs Biosimilars	
III	Characterization of Biologics and Biosimilars with Quality assurance & Regulatory affairs	3.1	Critical quality attributes (CQAs), quality by design (QbD) parameters, Appearance, particulates, particle size Molecular Weight, Amino acid composition, Primary sequence, Peptide Mapping, Secondary and High‑Order Structure Analysis: Circular Dichroism Spectropolarimetry.	15
		3.2	Posttranslational Modification: Glycan Analysis, Glycosylation, Sialylation, Phosphorylation, Acetylation, and Myristylation, if any Sulfhydryl groups(s) and di-sulphide bridges. HILIC, cation exchange chromatography, Size and Purity on HPLC. Capillary Isoelectric Focusing, CE–SDS, Western blot, FTIR spectrum, characterization using Monoclonal Antibody as an example, Bioassays	
		3.3	Innovator Biologics Approval, Biosimilar Pathway, Totality of Evidence, Information required to demonstrate bio similarity, Interchangeability, Product Switching, Product Naming, Global regulatory framework	
Total Lectures				**45**

Course outcomes:

By the end of the course the student will be able to:

1. Describe the types of biologics &biosimilars& their similarities and differences
2. Explain the development and production of biologic with optimum functionality and minimized side effects
3. Develop understanding towards scientific documentation for patent protection of biologics and biosimilars
4. Examine biologics and biosimilars using different characterization tools.

5. Inspect the various regulatory guidelines for biosimilars.
6. Elaborate the biosimilar development pathway and quality assurance.

References:

1. Biosimilars: Regulatory, Clinical and Biopharmaceutical Development, Editors: HitenJ.Gutka, Harry Yang,ShefaliKakar, AAPS Advances in the Pharmaceutical,Sciences Series,Volume 34.
2. Biosimilars of Monoclonal Antibodies, A Practical Guide to Manufacturing,Preclinical, andClinical Development. *Edited by Cheng Liu, Ph.D., K. John Morrow, Jr., Ph.D.,* Copyright 2017 by John Wiley & Sons, Inc. All rights reserved. Published by John Wiley & Sons, Inc.,Hoboken, New Jersey.
3. Introduction to Biologic and Biosimilar Product Development and Analysis, Karen M. Nagel,AAPS Introductions in the Pharmaceutical Sciences, Editor-in-Chief: Robin M. Zavod,Midwestern University, Downers Grove, IL, USA.
4. Regulatory Requirements of 'Similar Biologics' for Marketing Authorization in India. ReviewArticle. Sharmila*et al.,* International Journal of Drug Regualtory Affairs; 2017, 5(1), 20-24.
5. Introduction to Biosimilars and Regulatory Requirements. Fact Sheet 3. International Federation of Pharmaceutical Manufacturers & Association (Geneva) & International Allianceof Patients Organization (UK)
6. https://www.fda.gov/drugs/drug-approvals-and-databases/approved-drug-products-therapeuticequivalence-evaluations-orange-book.

PRACTICALS

1	Electrophoresis {PAGE (native, SDS, reducing, non- reducing)} to characterize the protein with regard to its molecular weight, structure/subunits/SS bonds etc., or for detection of impurities in the product
2	Determination of concentration of protein with Folin Lowry
3	Western blot/dot blot for purity of product demonstration/ dummy sandwich preparation of semi-dry or wet western blot sandwich.
4	HPLC /FTIR/NMR spectrum based theory questions may be asked for interpretation
5	Visit to a facility manufacturing Biosimilar

BOS	Biotechnology
Class	M.Sc II
Semester	III
Course Name	(b) Cosmetic Biotechnology
Course Code	PMSBT304
Type of Course	Major Elective
Level of the Course	Advanced
Total Credits for the Course	02 Theory+01 Practical

Course Objectives:

1. To provide an insight on the ecology and applications of microbes in the pharmaceutical industry and to learn various parameters involved in quality control and quality assurance of products.
2. To make students aware about the basics of cosmetic technology – formulation, herbal cosmetics, stability and safety tests, etc.

Unit No.	Name of Unit	Topic No.	Content	Hours
I	Basics of Cosmetic technology	1.1	Classification of cosmetic and cosmeceutical products	15
		1.2	Definition of cosmetics as per Indian and EU regulations, Evolution of cosmeceuticals from cosmetics, cosmetics as quasi and OTC drugs	
		1.3	Cosmetic excipients: Surfactants, rheologymodifiers, humectants, emollients, preservatives. Classification and application	
		1.4	Basic structure, function and common problems related to skin, hair and oral cavity	
II	Cosmetic formulations	2.1	Liquid, semisolid and solid formulations	15
		2.2	Design of cosmeceutical products: Sunscreen agents, Anti-ageing products, Oral care agents, Shampoos and Baby care products	
		2.3	Herbal Cosmetics - Introduction, Advantages, History, development and role of natural product in cosmetic, Herbs Used in Cosmetics/Cosmeceuticals	
III	Stability and Safety of cosmetics	3.1	Methods of stabilizations and Methods of stability testing	15
		3.2	Cosmetic safety: Basic concept, safety test items and evaluation methods – skin irritation, sensitization, testing on human (patch test, usage test), animal test alternatives. Recently developed methods for test of cosmetics.	
		3.3	Hazards in cosmetic laboratory and necessary precautions.	
Total Lectures				**45**

Course outcomes:

By the end of the course the student will be able to:

1. Define cosmetics according to Indian and EU regulations and outline the evolution of cosmeceuticals from cosmetics.
2. Explain the classification and application of cosmetic excipients including surfactants, rheology modifiers, humectants, emollients, and preservatives.
3. Demonstrate understanding of the basic structure, function, and common problems related to skin, hair, and oral cavity.
4. Differentiate between liquid, semisolid, and solid formulations used in cosmetic products.
5. Assess the advantages, historical development, and role of natural products in cosmetics, including the herbs commonly used in cosmetics/cosmeceuticals.
6. Develop designs for cosmeceutical products such as sunscreen agents, anti-aging products, oral care agents, shampoos, and baby care products.

References:

1. Cosmetic Science and Technology Vol I, II, III - Sagarin.
2. Harry's Cosmeticology, Wilkinson, Moore, Seventh Edition, George Godwin.
3. Cosmetics – Formulations, Manufacturing and Quality Control, P.P. Sharma, 4th Edition, Vandana Publications Pvt. Ltd., Delhi.
4. New Cosmetic Science - Takeo Mitsui
5. Hand book of Cosmetic science & Technology - Marc paye, Andre O. Barel
6. Formulation Manufacturing & Quality control - P.P. Sharma

PRACTICALS

1	Preparation of herbal extracts
2	Identification of phytochemicals in the extract by qualitative tests.
3	Formulation of skin cream/lotion.
4	Evaluation of the herbal skin cream –Appearance, pH, Homogeneity, After feel, Dye test, Irritancy test, Microbial contamination, Antibacterial activity. –Stability tests: Centrifugation and vibration test
5	Visit to Cosmetic laboratory

BOS	Biotechnology
Class	M.Sc II
Semester	III
Course Name	(c) Reproductive Biology and Embryology
Course Code	PMSBT304
Type of Course	Major Elective
Level of the Course	Advanced
Total Credits for the Course	02 Theory+01 Practical

Course Objectives:

1. Understand the critical stages of reproduction, from fertilization to early embryonic development, and the molecular mechanisms involved.
2. Explore the interdisciplinary aspects of reproductive health, including infertility causes, reproductive vaccines, and ethical dilemmas in reproductive medicine.

Unit No.	Name of Unit	Topic No.	Content	Hours
I	Fertilization and Embryonic Development	1.1	Events during fertilization, in-vitro fertilization, Zona pellucidaa, glycoprotein, Oelemma protein and their role in fertilization	15
		1.2	Molecular and biochemical events during sperm function	
		1.3	early embryonic development, establishing multi-cellularity	
		1.4	Formation of blastula, embryonic germ layer	
II	Molecular and immunological aspects, Reproductive Technologies	2.1	Molecular mechanism of sex hormone action and regulation of gene expression.	15
		2.2	Immunology of pregnancy - Implantation and endometrial antigens Immunotherapy in reproductive disorders	
		2.3	Superovulation, embryo culture and embryo transfer technology.	
IV	Infertility, vaccines and ethical issues	3.1	Infertility - Definition and prevalence of infertility, Causes and risk factors	15
		3.2	Reproductive vaccines: Vaccines targeting common pathogens affecting reproductive health, such as human papillomavirus (HPV) and hepatitis B virus (HBV). Ethical considerations and controversies surrounding the development and use of reproductive vaccines.	
		3.3	Frontiers in contraceptive research	
		3.4	Cryopreservation of sex gametes and embryos. Ethical issues related to embryo research	
Total Lectures				**45**

Course outcomes:

By the end of the course the student will be able to:

1. Recall the events and processes involved in fertilization, in-vitro fertilization, and early embryonic development.
2. Comprehend the molecular and biochemical mechanisms underlying sperm function and the formation of blastula and embryonic germ layers.
3. Apply knowledge of reproductive technologies such as superovulation, embryo culture, and transfer to understand their role in assisted reproduction.
4. Analyze the molecular mechanisms of sex hormone action and their regulation of gene expression during early embryonic development.
5. Evaluate the immunological aspects of pregnancy, including implantation processes and the role of endometrial antigens, and assess the potential of immunotherapy in treating reproductive disorders.
6. Synthesize information on infertility causes, reproductive vaccines, and ethical considerations to propose solutions and future directions in contraceptive research and embryo cryopreservation**.**

References:

1. Langman‟s Medical Embryology (9th Edition 2004) - T. W. Sadler – Lippincott Williams & Wilkins
2. Essential Developmental Biology (2nd Edition2006) -J. M. W. Slack - Blackwell Publishing
3. Developmental Biology (8th Edition 2006) - Scott F. Gilbert- Sinauer Associates, Inc
4. Reproductive Immunology - D.M. Wallach and G.R. Bock
5. Molecular Biology of the Cell - Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter
6. Ethics in Reproductive Medicine - Steven G. Horrowitz

PRACTICALS

1	Candling, Observing chick embryo –stages of development; prepared slides/ preserved specimens
2	Observing Embryonic Development: Microscopic Examination of Zebrafish Embryos
3	Effects of Environmental Factors on Development: Investigating Temperature and pH on Drosophila Development
4	Videos of latest developments in the field
5	Visit to embryology laboratory

SEMESTER IV

BOS	Biotechnology
Class	M. Sc II
Semester	IV
Course Name	Nanobiotechnology
Course Code	PMSBT401
Type of Course	Major
Level of the Course	Advanced
Total Credits for the Course	04 Theory+01 Practical

Course Objectives:

1. The course aims at providing a general and broad introduction to multi-disciplinary field of nanotechnology and it will familiarize students with the synthesis and applications of nanomaterials in the field of medicine.
2. The course will also give an insight into complete systems where nanotechnology can be used to improve our everyday life.

Unit No.	Name of Unit	Topic No.	Content	Hours
I	Introduction to nanomaterials and their synthesis	1.1	Introduction: Nanotechnology, Nature's biological pathway, Examples of nanomaterials and nanostructures found in nature. Nanometer-scale materials: Nanometer-Scale Metals Nano Metal Oxides, Nanopolymers, Quantum Dots, Carbon nanostructures.	15
		1.2	Synthesis of nanometer- scale materials- Top down and Bottom up approaches. Self-Assembly of nanoparticles and its mechanism. Bio-directed synthesis and assembly of nanomaterials	
II	Properties of nanomaterials and its characterization	2.1	Properties of nanomaterials: Optical, Elastic, Mechanical, Hardness, Structural, Electrical, Magnetic, Luminescence, Melting of nanoparticles.	15
		2.2	Characterization of nanomaterials – UV- Vis Spectrophotometer, FTIR, XRD, TEM, SEM, AFM, STM, SNOM, Dynamic light scattering (DLS), Zeta potential, Vibrating sample magnetometer (VSM).	
III	Nanotechnology in drug delivery	3.1	Biological Barriers to Nanocarrier-Mediated Delivery of Therapeutic and Imaging Agents	15
		3.2	Nanomedicine: biopharmaceutics, implantable materials, implantable chemicals, surgical aids	
		3.3	Nano-Sized Carriers for Drug Delivery,	

			nanoenabled drug delivery system, nanorobotics in medicine.	
IV	Applications of nanotechnology and Nanotoxicology	4.1	Applications of Nanomaterials	15
		4.2	Nanotoxicology: Unique Properties, Toxicity of Nanomaterials, Factors Responsible for the Nanomaterial Toxicity, Routes of Exposure, Mechanisms of Nanoparticle Toxicity,	
		4.3	In Vitro Testing Methods for Nanomaterials, Ecotoxicity, Analyses of Nanomaterials	
Total Lectures				**60**

Course outcomes:

By the end of the course the student will be able to:

1. Describe the type of nanomaterials & explain different ways to synthesize nanomaterials
2. Outline various properties of nanomaterials
3. Develop understanding towards types of characterization techniques to be used for particular type of nanomaterial
4. Examine the types of interactions of nanomaterials within the human environment and develop tissue specific drug targeting
5. Determine the applications of nanotechnology in the field of energy conductance, data storage, medicine, biosensor, manufacturing, automobile industry, defense, environmental monitoring, cosmetics etc.
6. Estimate the cumulative effects of nanomaterials with various cytotoxicity testing and model organism study in different environments.

References:

1. A laboratory course in nanoscience and nanotechnology-Poinern, Gerrard Eddy Jai -. CRC, Press, 2014.
2. Nanotechnology - Principles and Practices -Sulabha K. Kulkarni (auth.) – Nanotechnology - Principles and Practices - Springer, International Publishing (2015)
3. The Nanoscope: Encyclopedia of Nanoscience and Nanotechnology-Diwan, Parag, and Ashish Bharadwaj, eds. - Pentagon Press, 2005. (Vol 1 - 6)
4. Textbook of Nanoscience and Nanotechnology - B.S. Murty, P. Shankar, Baldev Raj, B BRath, James Murday, University Press IIM series in Metallurgy & Material Science (2012)
5. Nanomedicine in drug delivery - Arun Kumar - CRC Press - Taylor & Francis (2013)
6. Toxicology of Nanomaterials - Yuliang Zhao, Zhiyong Zhang, and Weiyue Feng - Wiley-VCH, 2016.

Case Study:

1	In general, chemotherapy against cancer entails very high toxicity and debilitating effects on the patient. A possible nanotech based strategy where a cancer expressing an overexpressed surface marker can ideally be targeted so that an ideal therapeutic dose of the drug can be delivered to cancer tissue specifically. Such a system may also serve to diagnose micro-metastatic sites and act on the therapeutic front simultaneously. This is an ideal scenario where we drastically reduce chemo-induced systemic toxicity, improve patient compliance and achieve better clinical outcomes.

2.	A study was conducted focusing on the cytotoxicity of silver nanoparticles (AgNPs) using human lung epithelial cells (A549) as a model system. The AgNPs were synthesized via a green chemistry approach and characterized for size, shape, and surface properties. Exposure of A549 cells to increasing concentrations of AgNPs revealed a dose-dependent decrease in cell viability, as assessed by MTT assay. Further investigation through fluorescence microscopy and flow cytometry indicated cellular uptake of AgNPs, leading to oxidative stress and mitochondrial dysfunction, ultimately culminating in apoptosis.

PRACTICALS

1	Comparison of green vs chemical synthesis of gold nanoparticles.
2	Understanding SPR through gold nanoparticles and size characterization using UV-VIS spectrophotometer.
3	Synthesis of polymeric nanoparticles with entrapped drug molecule using solvent evaporation method.
4	Study of temporal drug release kinetics from drug-entrapped polymeric nanoparticles.
5	Study of intracellular ROS generation by metallic and non-metallic nanoparticles through NBT assay.
6	Preparation of fluorescent carbon nanoparticles from candle flame soot.
7	Green synthesis of silver nanoparticles and testing their water disinfectant and purification ability.

BOS	Biotechnology
Class	M. Sc II
Semester	IV
Course Name	Environmental Biotechnology
Course Code	PMSBT402
Type of Course	Major
Level of the Course	Advanced
Total Credits for the Course	04 Theory+01 Practical

Course Objectives:

1. This course aims to introduce learners to latest concepts in environmental biotechnology, various types of pollutions, monitoring, latest mitigation strategies and management of the same
2. It would give an overview of the distribution of pollutants in the environment, their entry, movement and transformation within the environment and concept of environment management.

Unit No.	Name of the Unit	Topic No.	Content	Hours
I	Soil	2.1	Soil Pollution: Point source and diffuse pollution, Sources of soil pollutants – Natural and Anthropogenic (Industrial, mining, urban and transport, waste and sewage, military activities and war, Agricultural and livestock activities) Causes and impacts of soil salinity; Metallic pollution of agricultural soil	15
		2.2	Bioleaching of metals	
		2.3	Bioaugmentation & Biostimulation for soil remediation. Phytostabilization - Contaminant removal, Soil cover, Rhizosphere modification, Geotextile capping solid waste	
		2.4	Industrial solid waste; Domestic solid waste; Agricultural solid waste; Municipal solid waste; Major sources of solid wastes; Effects of solid waste generation on quality of air, water and public health; solid waste management, Disposal of organic and medical waste; Recovery and recycling of metallic waste; Disposal of plastic waste and hazardous wastes.	
II	Water	2.1	Biofilms in treatment of waste water; Biofilm development and biofilm kinetics; types of treatment processes	15
		2.2	Marine pollution-Sources from seabased activities, major pollutants (heavy metal,	

			pesticide, oil, thermal, radioactive, plastics, litter and microbial, microplastics);	
		2.3	Biological indicators (Marine microbes, algae and crustaceans) and accumulators:	
		2.4	Use of microbial systems, Biotechnological application of hazardous waste management of water	
		2.5	Phytoremediation strategies in constructed wetlands, Designing constructed wetlands, Substrate, Hydraulic loading rate, Hydraulic retention time, The selection of plant species, Surface area of wetland, Mechanisms to remove pollutants from constructed wetlands	
III	Air pollution and Environmental toxicology	3.1	Air pollution & Air Quality Monitoring, Sampling, Source Apportionment. Air Pollution Management in Urban Settlement & Rural Areas, Integrated Air Pollution Management, Green Belt. Biofilters/ Bioscrubber. Catalytic Systems. Green Technology.	15
		3.2	Toxic chemicals in the environment: biochemical aspects of arsenic, cadmium, lead, mercury, carbon monoxide, ozone PAN and pesticides	
		3.3	Absorption of Toxicants: Interaction of Toxicants with Cells, Cellular Absorption, Uptake of Toxicants, Routes of Absorption	
		3.4	Carcinogens in environment, chemical carcinogenicity, mechanism of carcinogenicity, environmental carcinogenicity testing	
IV	Environment Monitoring & Management	4.1	Biosensors in Environmental Monitoring – Working & its application for monitoring environment pollutants, Application of protein biomarkers; Biosensors and biochips. IOT for water quality monitoring – General working, Application, water Parameters	15
		4.2	Introduction and scope of environmental management, basic concepts of sustainable development, industrial ecology and recycling industry. Environmental Impact Assessment (EIA) – Introduction, Evolution and History, EIA Process, Stakeholders in the EIA Process, Salient Features of 2006 Amendments to EIA Notification, Importance and shortcomings.	
Total Lectures				**60**

Course Outcomes:

By the end of the course the student will be able to:

1. Describe soil and marine pollution, toxic chemicals in the environment, its cellular interaction and routes of absorption.
2. Illustrate the technology used for air pollution monitoring and management.
3. Identify techniques and strategies for environmental monitoring and remediation of soil and water.
4. Analyze potential impacts of pollution using biological indicators, carcinogen testing, etc.
5. Evaluate the likely environmental impacts of a proposed project or development.
6. Develop capacity to design sustainable measures for environment management.

References:

1. Environmental biotechnology: principles and applications (2012) - Rittmann, B. E., & McCarty, P. L., Tata McGraw-Hill Education
2. Environmental microbiology (Vol. 397) (2009) - Maier, R. M., Pepper, I. L., &Gerba, C. P. Academic press.
3. Environmental science: A study of interrelationships (2000) - Enger, E. D., Smith, B. F., &Bockarie, A. T., Boston, MA: McGraw-Hill.
4. Environmental chemistry – A. K. De
5. Essentials of Environmental Toxicology - W. William Hughes - Taylor & Francis
6. Advances in agronomy (Vol. 112, pp. 145-204). Academic Press.

Case Study:

1.	A former industrial site, contaminated with heavy metals, posed a significant environmental threat to surrounding ecosystems and communities. Traditional remediation methods were costly and invasive. To address this challenge, a phytoremediation approach was employed, utilizing plants to naturally extract and detoxify heavy metals from the soil. Bioindicators such as specific plant species were strategically chosen for their ability to accumulate metals, signaling the effectiveness of the remediation process. Over time, the area witnessed a notable reduction in heavy metal concentrations, restoring soil health and promoting ecological recovery.
2.	River Ganga is the fifth most polluted river in the world. The main sources of pollution are discharge of domestic sewage, industrial waste, people bathing and washing clothes, and religious offerings such as food, flowers, and idols. Ganga Action Plan (GAP) was launched in 1986 by the government of India to clean the Ganga and to prevent its pollution. A number of measures were suggested such as renovation of existing and installation of new sewage treatment plants to prevent the release of sewage into the river, construction of interceptors to divert flow of sewage and other liquid wastes into the river, sanitation schemes, and control of agricultural run-off. The plan also laid emphasis on public awareness and involvement to keep the river clean. This programme has helped to reduce pollution to some extent, although a lot more was required to free the Ganga from pollution. In 2014, the government of India launched 'Namami Gange Programme' or the National Mission for Clean Ganga (NMCG) to clean the river Ganga. Huge funds and schemes were announced for this programme.

PRACTICALS

1	Soil and water quality assessment (temp, pH, salinity, water holding capacity of soil etc.)
2	Soil ecosystem analysis/ analysis of microorganisms of soil
3	Analysis of compost
4	Detection of heavy metal concentration in soil/ water
5	Study of metal tolerance of microorganisms isolated from soil/water
6	Growth curve of metal tolerant organism isolated from soil/ water.
7	EIA – Case studies
8	Case studies on Environmental Impact of lockdown measures during COVID-19

BOS	Biotechnology
Class	M.Sc II
Semester	IV
Course Name	OMICS and Systems Biology
Course Code	PMSBT403
Type of Course	Major
Level of the Course	Advanced
Total Credits for the Course	04 Theory

Course Objectives:

1. Bring awareness of the emerging fields of OMICS and Systems Biology, biological systems as a whole and how parts of a systems interact with each other.
2. Perturbation of biological systems to study various responses in the biological systems using high throughput techniques.

Unit No.	Name of Unit	Topic No.	Content	Hours
I	OMICS- the OMICS technology , a broad outlook	1.1	Epigenetics, CpG island methylation, Histone acetylation, Bisulfite sequencing.	15
		1.2	Targeted Vs Untargeted metabolomics; development of targeted assays for small molecules; Metabolic pathways, metabolite profiling, inborn errors of metabolism	
		1.3	RNA-seq analyses, Transcriptome profiling; RNA sequencing; small RNA sequencing; Differential expression,	
		1.4	Metagenomics: concept, strategies, and applications in environmental biotechnology, agriculture and health	
II	Techniques in study of OMICS and Data Analysis	2.1	Techniques used in Lipidomics- Mass Spectroscopy, TLC, HPLC, GC and Capillary electrophoresis, MALDI. Technique used in Metabolomics- Mass Spectroscopy, Electrophoresis, chromatography GC, LC & NMR.	15
		2.2	Applications of transcriptomics metabolomics and lipidomics in human diseases –screening, testing and treatment of diseases.(in clinical applications, personalised medicine, infectious diseases)	
		2.3	Multi-Omics Data Types and Repositories, Portals for Visualization and Interpretation of Multi-omics Data Sets, Proteogenomics-concepts.	

III	Introduction to systems biology	3.1	Systems biology towards systems level understanding of biological systems. Systems structure, systems dynamics,systems design and control, systems project.	15
		3.2	Models and Modelling systems in systems biology What is a model? Key properties of models, Basic of computational models, networks, data integration, standards, and model organism	
		3.3	Insilico cell simulation: Whole cell simulation, Virtual erythrocytes, Minimal gene complement and Quorum sensing	
		3.4	Biological networks: metabolic networks, gene regulatory network, PPI networks, genetic interaction (GI) networks, and signalling networks.	
IV	Data mining and application of systems biology	4.1	Introduction to Knowledge of discovery in databases (KDD) What is knowledge, need for KDD, KDD process outline, concept and goals. Data Mining methods: Statistics – classification, correlation, association analysis, regression, and clustering.	15
		4.2	Machine learning –Symbolic and statistical approaches. Text mining, and Pattern evaluation. Data mining in scientific applications	
		4.3	Application of systems biology: 1. Systems biology to systems medicine. 2. Application of systems biology in drug discovery and development 3. Systems biology and synthetic biology.	
Total Lectures				**60**

Course outcomes:

By the end of the course the student will be able to:

1. Describe methods essential for the representation of a system using some fundamental Systems Biology approaches.
2. Identify key methods for analysis and integration of OMICS data based on a given dataset.
3. Identify the key processes of data mining, data warehousing and knowledge discovery processes.
4. Use of the newest OMICS techniques and systems biology approach to understand the basic of life
5. Apply the knowledge to develop Biological models for predictions.
6. Use different biological network analysis techniques to compare different cell-types or conditions

References:

1. Bioinformatics and Functional Genomics (2003) – Jonathon Pevsner – John Wiley & Sons Publications.
2. Omictechnologies : genomics, transcriptomics, proteomics and metabolomics. Richard P. Horgan And Louise C. Kenny - Scientific advisory committee (sac) , the obstetrician and gynaecologist.
3. Baxevanis AD, Ouellette BFF (2005). Bioinformatics – A practical guide to the analysis of genes and proteins (3rd edition). Wiley India
4. Introduction To Proteomics: Principles and Applications- Nawin Mishra- John Wiley & Sons, Inc., Publication
5. The New Science Of Metagenomics – by Committee on Metagenomics: Challenges and Functional Applications, national research council, Board on Life Sciences. The National Academies Press.
6. Systems Biology A Textbook, Second Edition- Edda Klipp, Wolfram Liebermeister Christoph Wirling Axel Kowald - Wiley- VCH publication

Case Study:

1.	Biotech Therapeutics Inc. is a leading biopharmaceutical company dedicated to discovering and developing breakthrough therapies for oncology and other diseases. Biotech Therapeutics Inc. conducts an extensive literature review and data mining to identify key signaling pathways implicated in cancer progression. Using systems biology approaches, the company integrates multi-omics data from cancer patients to prioritize potential drug targets within these pathways. Computational biologists at Biotech Therapeutics Inc. construct predictive models of cancer signaling networks based on omics data. Advanced network analysis techniques are employed to identify critical nodes and interactions within the signaling pathways. In vitro and in vivo experiments are conducted to validate the function and druggability of selected targets. Based on validated targets, Biotech Therapeutics Inc. initiates a drug discovery program to identify lead compounds with therapeutic potential. High-throughput screening assays and structure-based drug design are utilized to identify small molecules or biologics that modulate target activity. Lead compounds undergo extensive preclinical testing to assess their safety, pharmacokinetics, and efficacy in animal models of cancer. Biotech Therapeutics Inc. employs systems biology approaches to analyze molecular and cellular responses to the drug candidates, optimizing dosing regimens and combination therapies. Promising drug candidates progress to clinical trials, where they are evaluated for safety and efficacy in cancer patients. Biotech Therapeutics Inc. employs biomarker-driven approaches to stratify patient populations and maximize therapeutic response. Successful completion of clinical trials enables Biotech Therapeutics Inc. to submit regulatory applications for drug approval. The company works closely with regulatory agencies to navigate the approval process and bring the anti-cancer drug to market.

2.	Sarah presents with symptoms including fatigue, weight loss, and joint pain, leading to initial diagnostic tests such as blood tests, imaging studies, and biopsies. Despite initial investigations, a definitive diagnosis remains elusive, prompting the need for a more comprehensive approach. Sarah's medical team decides to employ an omics approach to gain deeper insights into her condition. Genomic sequencing is conducted to identify potential genetic variations associated with her symptoms, including rare genetic mutations or predispositions to certain diseases. Transcriptomic analysis is performed to assess gene expression patterns and identify dysregulated pathways that may contribute to her symptoms. Proteomic and metabolomic profiling are utilized to characterize the molecular signatures of Sarah's condition, providing additional layers of information. Omics data generated from various platforms are integrated and analyzed using advanced computational methods. Bioinformatics tools and algorithms are employed to identify patterns, biomarkers, and potential therapeutic targets associated with Sarah's condition. Comparative analyses with healthy controls and disease databases aid in pinpointing relevant molecular alterations. Based on the omics profiling results, Sarah receives a personalized diagnosis that accounts for the underlying molecular mechanisms driving her symptoms. Prognostic markers are identified to assess the likely progression of her condition and inform treatment decisions. Sarah's medical team utilizes the insights gained from omics profiling to tailor a personalized treatment plan. Targeted therapies are chosen based on the specific molecular alterations identified, maximizing therapeutic efficacy while minimizing adverse effects. Additionally, lifestyle and dietary interventions may be recommended based on metabolomic findings to optimize Sarah's overall health and well-being. Sarah undergoes regular monitoring using omics-based assays to track treatment response and disease progression. Adjustments to her treatment plan are made based on evolving molecular profiles and clinical outcomes.