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: Bachelors of Science (B. Sc.) in Biotechnology

S.Y.B.Sc.Biotechnology

PCACS/BSCBT/SYL/2024-25/SY

As per National Education Policy
Choice Based Credit & Grading System

Academic Year 2024-25

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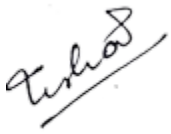
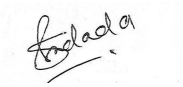
Board of Studies of Department of Biotechnology

1	Mrs. Suparna Deepak Assistant Professor, PCACS	Chairperson (Head of Department of Biotechnology)	
2	Mrs. Meenakshi Johri Assistant Professor, PCACS	Member	
3	Mr. Gopakumar Pillai Assistant Professor, PCACS	Member	
4	Mrs. Bindu Rajaguru Assistant Professor, PCACS	Member	
5	Dr. C. K. Prashant Assistant Professor, PCACS	Member	
6.	Mrs Suprita Rao Assistant Professor, PCACS	Member	
7	Dr. D.B. Thakare Former Chairman,BOS of Microbiology,University of Mumbai	Vice Chancellor Nominee	
8	Dr. Mansee Thakur Director,MGM School of Biomedical	Subject Expert From outside Parent University	

	Sciences,Kamothe,Navi Mumbai		
9	Dr.Usha Padmanabhan Senior Scientific Officer&Head,Cell Biology Department,Haffkine Institute of Testing,Training,Research,Parel,Mumbai	Industry Representative (Industry/Corporate/Allied sector)	
10	Dr. Thakamani Marar Dean,Faculty of Science and Technology,Professor,School of Biotechnology, D.Y Patil University,Navi Mumbai	Subject Expert From outside Parent University	
11	Dr. Pankaj Mundada Asistant Production Head, Agri Division Warkem Biotech Pvt Ltd,Mumbai	Post Graduate Meritorious Alumni	
12	Dr. P. S. Goyal Dean, R&D, Pillai College of Engineering	Faculty Specialist	
13	Dr. Gajanan Wader	Principal, PCACS	
14.	Mrs Deepika Sharma	Vice Principal PCACS	

1. Introduction to B. Sc Biotechnology

The interdisciplinary nature of biotechnology integrates living systems including animal, plant and microbes and their studies from molecular biology to cell biology, from biochemistry to biophysics, from genetic engineering to stem cell research, from bioinformatics to genomics- proteomics, from environmental biology to biodiversity, from microbiology to bioprocess engineering, from bioremediation to material transformation and so on. The relevance and application of these studies on living organisms and their bioprocesses is extensively covered in the syllabus B.Sc. Biotechnology program.

The B.Sc. Biotechnology program is a three-year degree. In these three years, students will tackle core subjects to ensure that they receive a solid grounding in fundamentals. In the final year, students can make their choice from a wide range of options and research projects. Biotechnologists are always in demand as an efficient work force in fundamental research and industries. Education and research sectors require such interdisciplinary trained workforce to develop future generations of science leaders.

2. Programme Outcomes for B. Sc. Biotechnology Programme

Sr. No.	PO Title	POs in brief
PO 1	**Theoretical Knowledge**	Demonstrate strong theoretical background which they would be able to use in Biotech industry, hospitals, community and institutes or any other profession they would like to pursue.
PO 2	**Practical skills**	Demonstrate the knowledge to manipulate living cells to create and manufacture various products that will help in diagnosis and treatment of diseases as well as in areas like food, agriculture and environment.
PO 3	**Planning Experiments**	Ability to design and conduct experiments, as well as to analyse and interpret scientific data.
PO 4	**Biosafety**	Demonstrate competency in laboratory safety and in routine and specialized biotechnological laboratory skills applicable to biotechnology research or clinical methods, including accurately reporting observations and analysis.
PO 5	**Communication**	Communicate scientific concepts, experimental results and analytical arguments clearly and concisely, both verbally and in writing and also ability to present their work through written, oral, and visual presentations, including an original research proposal
PO 6	**Ethics**	Awareness of the impact of biosolutions in a global, economic, environmental, and societal context and understanding of professional and ethical responsibilities.
PO 7	**Innovation**	Inculcate an attitude of enquiry towards developing innovative ability and enhancing entrepreneurship skills.
PO 8	**Life-long learning**	Interdisciplinary approach helps in providing better solutions and new ideas for the sustainable developments, recognition of the need for, being a better human being and an ability to engage in life-long learning.

3. Programme Specific Outcomes for B. Sc. Biotechnology Programme.

Sr. No	PSO Brief
PSO-1	Apply biotechnology skills (including molecular & micro biology, immunology & genetic engineering, bioprocess & fermentation, enzyme & food technology and bioinformatics) and its applications in core and allied fields.
PSO-2	Exhibit in-depth practical oriented knowledge to students in various thrust areas of biotechnology, so as to meet the demands of industry and academia.
PSO-3	Identify and formulate healthcare, textile, cosmetics, agriculture, marine products for commercialization.
PSO-4	Develop concepts and research approaches for higher career in the field of biotechnology and develop scientific interest required for research.

Course Structure

Semester III						
Course Code	**Course Type**	**Course Title**	**Theory/ Practical**	**Marks**	**Credits**	**Lectures/ Week**
PUSBT301	Major	Biochemistry	Theory	100	2	4
PUSBT302	Major	Bioprocess Technology	Theory	100	2	4
PUSBT303	Major	Genetics	Theory	100	2	4
PUSBT304	DISC MIN	Functional Foods and Nutraceuticals	Theory	100	3	4
PUSBT305	SEC	Mini Project	Theory	100	2	3
PUSBT306P	Major Practicals	Biochemistry Practicals	Practical	50	2	4
PUSBT307P	Major Practicals	Bioprocess Technology Practicals	Practical	50	2	4
PUSBT308P	Major Practicals	Genetics Practicals	Practical	50	2	4
PUAEC30	AEC	To be taken from the Pool	Theory	100	2	3
PUIDC30	IDC	To be taken from the Pool	Theory	100	3	4
Total				850	22	38
All Subjects having Field Project as part of Continuous Assessment-2						

Abbreviations:

SEC: Skill Enhancement Course
AEC: Ability Enhancement Course
IDC: Interdisciplinary Course

Semester IV						
Course Code	**Course Type**	**Course Title**	**Theory/ Practical**	**Marks**	**Credits**	**Lectures/ Week**
PUSBT401	Major	Cell Biology	Theory	100	2	4
PUSBT402	Major	Molecular Biology	Theory	100	2	4
PUSBT403	Major	Biophysics and Instrumentation	Theory	100	2	4
PUSBT404	DISC MIN	Food Microbiology/ Biodiversity and Conservation	Theory	100	3	4
PUSBT405	SEC (SWAYAM)	From the Department Pool	Theory	100	2	3
PUSBT406P	Major Practicals	Cell Biology Practicals	Practical	50	2	4
PUSBT407P	Major Practicals	Molecular Biology Practicals	Practical	50	2	4
PUSBT408P	Major Practicals	Biophysics and Instrumentation Practicals	Practical	50	2	4
PUAEC40-	AEC	To be taken from the Pool	Theory	100	2	3
PUIDC30	IDC	To be taken from the Pool	Theory	100	3	4
Total				850	22	38
All Subjects having Field Project as part of Continuous Assessment-2						

Abbreviations:

SEC: Skill Enhancement Course
AEC: Ability Enhancement Course
IDC: Interdisciplinary Course

Evaluation Pattern

Marking Code	Marking Scheme
A	60 Marks Final Exam, 20 Marks Internal Exam, 20 Marks Project.
B	50 Marks Continuous Exam, 50 Marks Practical Exam.
C	100 marks distributed within report /case study/ project/ presentation etc.
D	50 Marks Practical Examination.

Semester III

Course Code	Course Type	Course Title	Evaluation
PUSBT301	Major	Biochemistry	A
PUSBT302	Major	Bioprocess Technology	A
PUSBT303	Major	Genetics	A
PUSBT306P	Major Practicals	Biochemistry Practicals	D
PUSBT307P	Major Practicals	Bioprocess Technology Practicals	D
PUSBT308P	Major Practicals	Genetics Practicals	D
PUSBT304	DISC Minor	Functional Foods and Nutraceuticals	B

Semester IV

Course Code	Course Type	Course Title	Evaluation
PUSBT401	Major	Cell Biology	A
PUSBT402	Major	Molecular Biology	A
PUSBT403	Major	Biophysics and Instrumentation	A
PUSBT406P	Major Practicals	Cell Biology Practicals	D
PUSBT407P	Major Practicals	Molecular Biology Practicals	D
PUSBT408P	Major Practicals	Biophysics and Instrumentation Practicals	D
PUSBT404	DISC Minor	Food Microbiology	B

Semester III

BOS	Biotechnology
Class	S. Y. B. Sc
Semester	III
Course Name	Biochemistry
Course Code	PUSBT301
Type of Course	Major
Level of the Course	Medium
Total Credits for the Course	4 Theory + 1 Practical

Course objectives:

1. To understand the general aspects of metabolic reactions associated with carbohydrates, lipids and amino acids and the importance of bioenergetics, high energy compounds, electron transport chain, synthesis of ATP under aerobic and anaerobic conditions.
2. Students will be exposed to the fact that perturbations in the carbohydrate, lipids and amino acid metabolism can lead to various disorders.

Unit No.	Name of Unit	Topic No.	Name of the topic	Hours
I	Carbohydrate & Lipid Metabolism	1.1	Types of metabolism: Anabolism & Catabolism	10
		1.2	Metabolism of carbohydrates: Glycolysis – energetics and regulation. Entry of other carbohydrates into the glycolytic pathway. Fates of pyruvate – conversion of pyruvate to lactate, alcohol and acetyl Co-A. Warburg effect. Citric acid cycle and its energetics. Amphibolic integrating roles of TCA cycle. Cori cycle. Pentose phosphate pathway and its significance. Gluconeogenesis – pathway, significance	
		1.3	Metabolism of lipids: Beta, Alpha and Omega Oxidation of Saturated Fatty Acids. Energetics of beta oxidation. Oxidation of Unsaturated Fatty Acids; Oxidation of Odd Chain Fatty acids. Synthesis and utilization of ketone bodies. Sequence of Reactions, Regulation, Energy Yield and Metabolic Disorders of the above Pathways.	
II	Amino Acid and Nucleic acid Metabolism	2.1	Amino Acid metabolism: General reaction of amino acid degradation – Transamination, deamination and decarboxylation. Urea cycle - pathway, significance, disorders.	10
		2.2	Metabolism of phenylalanine. Inborn errors – Phenylketonuria, Alkaptonuria	
		2.3	Nucleic acid synthesis - De Novo and Salvage pathways.	

III	Plant Metabolism	3.1	Photophosphorylation: Light driven electron flow, Concepts of photosystems, Reaction centers, Cyclic and Non-cyclic photophosphorylation. Water splitting complex, ATP synthesis.	
		3.2	Photosynthetic carbon reduction cycle (PCR), RUBISCO, Photo-oxidation; C3, C4, and CAM pathways.	
		3.3	Biological nitrogen fixation, symbiotic nitrogen fixation in leguminous plants. Biochemistry of Nitrogen fixation. Export of fixed nitrogen from nodules. Ammonia assimilation, assimilation of nitrate.	
IV	Bioenergetics & Biological oxidation	4.1	Introduction to Bioenergetics. Standard free energy. Endergonic and exergonic reactions. Coupled reactions.	10
		4.2	High energy compounds – structural features of ATP and other high energy compounds.	
		4.3	Biological oxidation: Electron transport chain Sequence of electron transport, Electron transport complexes Complex I, II, III and IV. Uncouplers and inhibitors of respiration (Rotenone, antimycin. cyanide and 2,4 DNP). Oxidative phosphorylation, P/O ratio. Formation of ATP-Outline of Mitchell's hypothesis. FoF1 ATP synthase, Substrate level phosphorylation with examples.	

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

1. Outline the concept of anabolism, catabolism and role of high energy compounds like carbohydrates, lipids and amino acids in the cell and acquire knowledge related to regulation of various pathways.
2. Explain the correlation upon how the living organisms exchange energy and matter with the surroundings for their survival, and store free energy in the form of energy-rich compounds
3. Express the role of TCA cycle in central carbon metabolism, importance of anaplerotic reactions, redox balance will be explained.
4. Interpret various biochemical changes that obey the basic thermodynamic principles and learn basic concepts of Bioenergetics, mechanisms of oxidative phosphorylation and photophosphorylation
5. Discover the importance of high energy compounds, electron transport chain, synthesis of ATP under aerobic and anaerobic conditions will be understood.

6. Determine how the catabolic breakdown of the substances is associated with release of free energy; whereas, free energy is utilized during synthesis of biomolecules i.e., anabolic pathway

References:

1. Outlines of Biochemistry: 5th Edition, (2009), Erice Conn & Paul Stumpf; John Wiley and Sons, USA
2. Principles of Biochemistry, 4th edition (1997), Jeffory Zubey, McGraw-Hill College, USA
3. Lehninger, Principles of Biochemistry. 5th Edition (2008), David Nelson & Michael Cox, W.H. Freeman and company, NY.
4. Fundamentals of Biochemistry. 3rd Edition (2008), Donald Voet & Judith Voet , John Wiley and Sons, Inc. USA
5. Biochemistry – 4th Edition by U. Satyanarayan and U. Chakrapani (Elsevier).

6. Fundamentals of Biochemistry – Revised Edition by J. L. Jain, Sunjay Jain and Nitin Jain (S. Chand).

	Case Study:
1	A 3-year-old boy was brought to the emergency department after several episodes of vomiting and lethargy. After a careful history, it was observed that these episodes occur after ingestion of certain types of food, especially high in fructose. His blood sugar was checked in the emergency department and was extremely low (42 mg/dl) The test for reducing sugar in urine was positive.
2	A one-year-old male child was born to a consanguineous parent. It was found that both the parents were carriers for a metabolic disorder. The child cried after birth and weighs 3.5kgs.He had been advised for Urine and serum amino acid test, thyroid hormone stimulation test, serum lactate pyruvate tests. Urine metabolic screening reports are positive for ferric chloride tests. Hence the child was started with the treatment of supplementation of large neutral amino acids (including tyrosine, tryptophan, threonine, methionine, valine, isoleucine, leucine and histidine) which is a standard practice.

Practicals:	
1	Determination of Lactate Dehydrogenase (LDH) Activity in Blood Serum.
2	Liver Function Tests: Liver (SGPT, SGOT); Kidney (Urea from Serum).
3	Qualitative Detection of Ketone Body in Urine.

4	Determination of Serum amylase
5	Determination of serum acid phosphatase
6	Determination of serum lipase.
7	Study of Hill‘s reaction
8	Isolation, separation and analysis of carbohydrate and lipid molecules
9	Demonstration of the effect of auxins on rooting and respiration of root

BOS	Biotechnology
Class	S. Y. B. Sc
Semester	III
Course Name	Bioprocess Technology
Course Code	PUSBT 302
Type of Course	Major
Level of the Course	Moderate
Total Credits for the Course	4 Theory + 1 Practical

Course objectives:

1. The objective of this course is to understand the basics skills applied in fermentation technology.
2. To build a foundation for more advanced studies in bioprocess technology.

Unit No.	Name of Unit		Content	Hours
I	Screening and Inoculum development	1.1	Isolation and screening of Industrially important Organisms: Primary Screening and Secondary Screening.	10
		1.2	Preservation of industrially important microorganisms; Strain improvement of industrially important microorganisms.	
		1.3	Development of inoculum for yeast process,bacterial process ,mycelial process.	
II	Design of fermenter and media	2.1	Basic Design of a fermentor; Types of fermentor: Stirred tank, air-lift, tower, acetators and cavitators	10
		2.2	Media for industrial fermentation; Characteristics, raw materials. Sterilisation of fermenter and media.	
		2.3	Scale up in stirred tank fermenters and airlift reactors; Scale down methods	
III	Fermentation process	3.1	Antibiotic production- Streptomycin and Penicillin	10

		3.2	Production of Vitamin B12, Organic acid production- Citric acid & Acetic acid	
		3.3	Amino acid production- Glutamic acid, L-Lysine	
IV	Down stream processing	4.1	Introduction of DSP, Foam separation, Types of Precipitation, Filtration, Centrifugation	10
		4.2	Cell disruption- physical and chemical methods, Chromatography in DSP	
		4.3	Solvent recovery, Two phase aqueous extraction, Membrane process, Drying Crystallization and Whole broth processing	
	Total lec			40

Course outcomes:

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

1. Outline knowledge of different types of fermentors, their characteristics, and applications in industrial fermentation processes.
2. Demonstrate proficiency in the isolation and primary screening of industrially important microorganisms,
3. Apply strategies for strain improvement through genetic and metabolic engineering approaches.
4. Develop expertise in designing and optimizing inoculum including considerations for growth media formulation, culture conditions, and scaling up/down.
5. Utilize the knowledge of media formulation and sterilization Techniques
6. Design downstream processing (DSP) techniques for product recovery and purification

References:

1. Industrial Microbiology- A. H. Patel
2. Principles of fermentation Technology, -second edition P.F. Stanbury, A. Whitaker, and S.J. Hall
3. Microbiology- Frobisher
4. Blanch, H.W., Clark, D.S., & Rudolf, F.B. (2019). Biochemical Engineering (2nd ed.). CRC Press.
5. Bailey, J.E., & Ollis, D.F. (1986). Biochemical Engineering Fundamentals. McGraw-Hill Education.
6. Stanbury, P.F., Whitaker, A., & Hall, S.J. (2013). Principles of Fermentation Technology (3rd ed.). Butterworth-Heinemann

	CASE STUDY
1	In the quest for novel bioactive compounds, biotechnology companies have turned to the vast diversity of microorganisms as a potential source of valuable molecules. This case study delves into the journey of biotech innovations as they pioneered a comprehensive screening program to identify microorganisms with the potential for bioproduction. Biotech innovations , established in 2010, aimed to harness the power of biotechnology to develop sustainable solution for various industries, including pharmaceuticals, microbiologists, chemist and bioinformatician dedicate to unlock the hidden potential of microorganism.
2	BioGen Innovations, founded in 2015, aimed to pioneer breakthroughs in biotechnology to address global health challenges. Their team of scientists and engineers focused on leveraging synthetic biology and fermentation technologies to develop novel solutions for antibiotic production.In the early 21st century, the world faced a looming crisis: antibiotic resistance. Overuse and misuse of antibiotics led to the emergence of superbugs—bacteria resistant to traditional antibiotics. To combat this threat, scientists turned to biotechnology to revolutionize the production of antibiotics.

Practicals:	
1	Isolation of antibiotic producers by crowded plate technique and Wilkins overlay method.
2	Detection of organism producing growth factors by Auxanography
3	Isolation of streptomycin resistant mutant of E. coli by gradient plate method
4	Preservation by overlaying culture with mineral oil.
5	Lab Scale Production of Penicillin (Static and Shaker). a. Purification of Penicillin from Broth Culture of Penicillium spp. by Solvent Extraction. b. Estimation of Penicillin from Recovered Broth by Chemical (Iodometric) Method. c. Estimation of Penicillin from Recovered Broth by Biological (Bioassay) Method.
6	Estimation of vinegar.
7	Estimation of citric acid.

BOS	Biotechnology
Class	S. Y. B. Sc Biotechnology
Semester	IV
Course Name	Genetics
Course Code	PUSBT303
Level of Course	Advanced
Type of the Course	Major
Total Credits for the Course	4 Theory + 1 Practical

Course Objectives:

1. To learn the extensions of Mendelian genetics and the process of sex determination.
2. To understand genetic analysis and mapping and population genetics.

Unit No.	Name of Unit	Topic No.	Name of Topic	Hours
I	Extensions of Mendelian Genetics	1.1	Multiple alleles, ABO blood groups, Drosophila eye color, relating multiple allele to molecular genetics.	10
		1.2	Modifications of dominance relationships: incomplete dominance, complete dominance, essential genes and lethal genes,gene expression and the environment.	
		1.3	Maternal effect, gene interaction and modified mendelian ratios, extranuclear inheritance.	
II	Sex determination and Genetic linkage	2.1	Chromosomal Theory of Inheritance; Sex Determination and Sex Linkage: Mechanisms of Sex Determination (XX-XY, ZZ-ZW, XX-XO),	10
		2.2	Dosage Compensation and Barr Body.	

		2.3	Genetic Linkage, Crossing Over and Chromosomal Mapping: Early studies in genetic linkages. Tetrad Analysis; Two-point Cross; Three point Cross;	
III	Genetic analysis and mapping	3.1	Genetic analysis of bacteria, gene mapping in bacteria by conjugation, the sex factor F, HFR, F' factor	10
		3.2	Circularity of *E. coli* map Genetic mapping in bacteria by transformation,	
		3.3	Genetic mapping in bacteria by transduction, mapping bacteriophage gene	
IV	Population Genetics	4.1	Genetic Structure of Populations, Genotype Frequencies, Allele Frequencies The Hardy–Weinberg Law , Assumptions of the Hardy–Weinberg Law , Predictions of the Hardy–Weinberg Law Derivation of the Hardy–Weinberg Law , Extensions of the Hardy–Weinberg Law to Loci with More than Two Alleles,Extensions of the Hardy–Weinberg Law to X-Linked Alleles	10
		4.2	Genetic Variation in Space and Time, Genetic Variation in Natural Populations, Detailed Contents Measuring Genetic Variation at the Protein Level, Measuring Genetic Variation at the DNA Level	
		4.3	Forces That Change Gene Frequencies in Populations, Mutation, Random Genetic Drift, Migration, Natural Selection, Balance between Mutation and Selection, Assortative Mating, Inbreeding	
TOTAL LECTURES				**40**

Course outcomes:

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

1. Describe the Mendelian genetics and its extensions. .
2. Determine the process of sex determination and doses compensation.
3. Evaluate the outcome of population genetics.
4. Classify the different crosses, two point and three point cross.
5. Analyze the mechanisms of chromosomal inheritance, dosage compensation and Barr body.
6. Predict the genetic linkage between genes using methods like tetrad analysis, two point and a three point cross.

References:

1. iGenetics A Molecular Approach Third Edition
2. Molecular Biology of the Cell, 5th Edition (2007) Bruce Alberts, Alexander Johnson,Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Garland Science, USA.
3. Cell Biology, 6th edition, (2010) Gerald Karp. John Wiley & Sons., USA
4. The Cell: A Molecular Approach, 6th edition (2013), Geoffrey M. Cooper, Robert E. Hausman, Sinauer Associates, Inc. USA
5. Developmental Biology; Scott Gilbert; 9th Edition

	CASE STUDY
1	"Genetic Dynamics in a Population of Endangered Amphibians: Assessing Hardy-Weinberg Equilibrium" A small population of a rare species of amphibian, known as the Golden-eyed Frog (Litoria aurea), inhabits a fragmented habitat in a tropical rainforest. Conservation efforts are underway to protect this species from extinction. Researchers have collected genetic samples from individuals within this population to understand its genetic dynamics and assess its long-term viability.
2	Across species, different sexes are often characterized by different types and numbers of sex chromosomes. In order to neutralize the large difference in gene dosage produced by differing numbers of sex chromosomes among the sexes, various evolutionary branches have acquired various methods to equalize gene expression among the sexes. Because sex chromosomes contain different numbers of genes, different species of organisms have developed different mechanisms to cope with this inequality. Replicating the actual *gene* is impossible; thus organisms instead equalize the *expression* from each gene. For example, in humans, females (XX) silence the transcription of one X chromosome of each pair, and transcribe all information from the other, expressed X chromosome. Thus, human females have the same number of expressed X-linked genes as do human males (XY), both sexes having essentially one X chromosome per cell, from which to transcribe and express genes.

Practicals:	
1	Isolation, Quantitative Analysis and AGE of Genomic DNA from Yeast.
2	Determination of Sex based on barr body analysis.
3	Mapping based on Tetrad Analysis and Three Point Cross.
4	Mapping based on Tetrad Analysis and Two Point Cross.
5	Sums on Hardy–Weinberg principle.
6	Transformation.
7	Conjugation.
8	Culturing of drosophila and study different mutations.

BOS	Biotechnology
Class	S. Y. B.Sc
Semester	III
Course Name	Functional Foods and Nutraceuticals
Course Code	PUSBT304
Course type	Disciplinary minor
Level of Course	Basic
Total Credits for the Course	4 Theory + 1 Practical

Course Objectives:

1. The objectives of this course are to provide undergraduate students with a foundational understanding of the science, technology, and applications of functional foods and nutraceuticals.
2. to provide students with an in-depth understanding of the production techniques, health benefits, and commercial aspects of functional foods and nutraceuticals.

Unit No.	Name of Unit	Topic No.	Contents	Hours
I	Functional Foods	1.1	Definition and classification of functional foods Historical development and emergence in the food industry Importance in addressing nutritional deficiencies and promoting wellness	15
		1.2	Nutritional profiling and labeling requirements Dietary guidelines and recommendations Role of functional foods in addressing specific nutritional needs	
		1.3	Evidence-based health benefits of functional foods Applications in disease prevention and management (e.g., cardiovascular health, diabetes, obesity)	
II	Prebiotics and Probiotics	2.1	Introduction to Probiotics,Prebiotics and Synbiotics Prebiotics: Non Digestible Carbohydrates/ Oligosaccharides, Dietary Fiber, Resistant Starch, Gums	15
		2.2	Probiotics: Taxonomy and Important Features of Probiotic Microorganisms Health Effects of Probiotic Microorganisms	

		2.3	Probiotics in Various Foods Quality Assurance of Probiotics and Safety	
III	Bioactive Compounds	3.1	Polyphenols: Flavonoids, Catechins, Isoflavones, Tannins	15
		3.2	Omega-3 fatty acids and Pigments: Carotenoids, Lycopene, Curcumin	
		3.3	An introduction to Active Biodynamic Principles in Spices, Condiments and Plant extracts	
IV	Nutraceuticals and remedies	4.1	Food as Remedies: Nutraceuticals Bridging the Gap between Food and Drug.	15
		4.2	Nutraceuticals in Treatment for Cognitive Disorders. Medicinal Plant Derived Nutraceuticals: Anti Aging, Anti- Inflammatory Compounds.	
		4.3	Nutraceutical Remedies for Arthritis, Bronchitis, Hypoglycemia. Nutraceutical Remedies for Nephrological Disorders, Liver Disorders, Osteoporosis.	
			Regulatory frameworks for functional foods and Nutraceuticals.	
Total Lectures				**60**

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

1. Classify functional foods based on their bioactive components and health-promoting properties.
2. Explain the significance of functional foods in addressing nutritional deficiencies and promoting overall wellness.
3. Interpret labeling requirements for functional foods to ensure accurate consumer information.
4. Evaluate the applications of functional foods in addressing specific nutritional needs and promoting overall health.
5. Describe regulatory frameworks governing functional foods and nutraceuticals.
6. Evaluate the use of nutraceuticals in the treatment and management of different disorders.

References:

1. Functional Foods: Concept to Product by Maria Saarela.
2. Biotechnology in Functional Foods and Nutraceuticals by Debasis Bagchi.
3. Phytochemicals: Nutrient-Gene Interactions by Mark S. Meskin and Wayne R. Bidlack.
4. Nutraceuticals and Natural Product Derivatives: Disease Prevention & Drug Discovery" edited by A. Douglas Kinghorn, Heinz Falk, and Simon Gibbons.
5. Functional Food Ingredients and Nutraceuticals: Processing Technologies" edited by John Shi, Chi-Tang Ho, and Shahidi Fereidoon.

Practicals:	
1	Isolation of beneficial bacterial strains from fermented foods or probiotic supplements using selective media and biochemical tests.
2	Identification of beneficial bacterial strains from fermented foods or probiotic supplements using biochemical tests.
3	Enumeration of probiotic bacteria in food products or supplements using plate counting methods.
4	Assessing the antimicrobial activity of probiotic bacteria against pathogenic microorganisms using agar diffusion assays or co-culture experiments.
5	Fermentation of a substrate using probiotic bacteria to produce a probiotic-rich food product such as yogurt or fermented vegetables.
6	Determining the antioxidant capacity of nutraceuticals using DPPH radical scavenging.

SEMESTER IV

BOS	Biotechnology
Class	S. Y. B. Sc Biotechnology
Semester	IV
Course Name	Cell Biology
Course Code	PUSBT 401
Level of Course	Advanced
Type of the Course	Major
Total Credits for the Course	4 Theory + 1 Practical

Course Objectives:

1. Understanding the structural and functional aspects of the cell provides the student with a strong foundation in the molecular mechanisms underlying cellular function.
2. To develop detailed understanding of essential events of developmental biology through proper explanation of gametogenesis, fertilization, blastula formation, gastrulation as well as embryological induction as part of early embryonic development.

Unit No.	Name of Unit	Topic No.	Name of Topic	Hours
I	Cytoskeleton	1.1	Microtubules: Structure and Composition. MAPs: Functions-Role in Mitosis, Structural Support and Cytoskeleton Intracellular Motility. Motor Proteins: Kinesins, Dynein; MTOCs. Dynamic Properties of Microtubules.	10
		1.2	Microfilaments: Structure, Composition, Assembly and Disassembly. Motor Protein: Myosin.	
		1.3	Intermediate Filaments :Structure and Composition; Assembly and Disassembly; Types and Functions.	

II	Cell Membrane	2.1	Fluid Mosaic Model, Chemical composition; Membrane Lipids, Membrane Carbohydrates, Membrane Proteins.	10
		2.2	Cell Permeability. Principles of Membrane Transport- Transporters and Channels; Active Transport, Passive Transport; Types of Transporters; Types of ATP Driven Pumps -Na+, K+, Ca2+Pump.	
		2.3	Modifications of cell membrane; Cell Junctions; Desmosomes; Tight Junctions, Gap Junctions.	
III	Cell Signaling	3.1	Cell signaling and signal transduction: Introduction, General Principles of Cell Signaling	10
		3.2	Signaling via G-Protein-linked Cell-Surface Receptors**;** Signaling via Enzyme-linked Cell-Surface Receptors**;**	
		3.3	Target-Cell Adaptation **;** The role of calcium as intracellular messengers.	
IV	Cell cycle & Cancer	4.1	Cell cycle Introduction: Prokaryotic and Eukaryotic.	10
		4.2	The Early Embryonic Cell Cycle and the Role of MPF. Apoptosis, Cell-Division Controls in Multicellular Animals.	
		4.3	Cancer: Introduction, Cancer as a Micro evolutionary process. Genes involved in cancer, Types of Cancer: leukemia, carcinoma sarcoma, lymphoma, myeloma and germinoma.	
TOTAL LECTURES				**40**

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

1. Analyze genes and genetic changes affecting cycle regulation and mechanisms that lead to apoptosis and development of cancer
2. Outline the concepts of cell cycle, cell signalling.
3. Discuss the principles of membrane transport and dynamic properties of cytoskeleton and plasma membrane.
4. Determine the cellular responses to environmental or physiological changes, or alterations of cell function.
5. Summarise the intricate relationship between various cellular structures and their corresponding functions.
6. Elaborate how lipids, receptors, ion channels and signalling molecules interplay in generating cell responses to stimuli. Carry out and interpret experiments in cell biology.

References:

1. Molecular Cell Biology. 7th Edition, (2012) Lodish H., Berk A, Kaiser C., K Reiger M., Bretscher A., Ploegh H., Angelika Amon A., Matthew P. Scott M.P., W.H. Freeman and Co., USA
2. Molecular Biology of the Cell, 5th Edition (2007) Bruce Alberts, Alexander Johnson,Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Garland Science, USA.
3. Cell Biology, 6th edition, (2010) Gerald Karp. John Wiley & Sons., USA
4. The Cell: A Molecular Approach, 6th edition (2013), Geoffrey M. Cooper, Robert E. Hausman, Sinauer Associates, Inc. USA
5. Developmental Biology; Scott Gilbert; 9th Edition
6. Cell and Molecular Biology – De Robertis- Lippincott Williams & Wilkins

	CASE STUDY
1	Diabetes mellitus is a chronic metabolic disorder characterized by elevated blood glucose levels, either due to insufficient insulin production or ineffective insulin action. Insulin, a hormone secreted by the pancreas, plays a central role in regulating glucose homeostasis by facilitating the uptake of glucose into cells. The dysfunction of the insulin signaling pathway contributes to the development of diabetes mellitus.
2	Jane, a 45-year-old woman, presented with symptoms of fatigue, weight loss, and recurrent infections. Upon further investigation, it was discovered that Jane had been diagnosed with chronic lymphocytic leukemia (CLL), a type of cancer affecting the white blood cells. As part of her treatment plan, Jane's oncologist explained the role of apoptosis pathways in cancer therapy

Practicals:	
1	Osmotic fragility of RBC.
2	Effect of Colchicine on microtubules.
3	Microscopic visualization of stomata.
4	Effect of temperature on cell permeability.
5	Effect of chemicals on the permeability of cell membranes.
6	Cell death /apoptosis studies using Comet Assay.
7	Cell motility studies (bacteria, algae, cyanobacteria, protozoans,)

BOS	Biotechnology
Class	S. Y. B. Sc
Semester	IV
Course Name	Molecular Biology
Course Code	PUSBT402
Type of Course	Major
Level of the Course	Medium
Total Credits for the Course	4 Theory + 1 Practical

Course objective:

1. To understand the general aspects of: Mechanism of Gene Expression and Regulation.
2. To develop skills and impart knowledge regarding basics of Molecular Biology.

Unit No.	Name of Unit	Topic No.	Name of the topic	Hours
I	Replication and DNA repair	1.1	Semiconservative model of replication-Meselson-Stahl experiment DNA polymerase,DNA replicating enzymes,	10
		1.2	Molecular model of DNA replication-semi discontinuous,rolling circle mechanism. DNA replication in eukaryotes.	
		1.3	Mechanism of DNA repair: Direct repair, base excision repair, nucleotide excision repair, mismatch repair, recombination repair.	
II	Gene Expression-Transcription	2.1	Gene Expression- an Overview.	10
		2.2	Transcription Process in Prokaryotes: RNA Synthesis - Promoters and Enhancers; Initiation of Transcription at Promoters; Elongation and Termination of an RNA Chain.	
		2.3	Transcription in Eukaryotes: Eukaryotic RNA Polymerases; Eukaryotic Promoters; Transcription of Protein Coding Genes by RNA Polymerase; Eukaryotic mRNA's; Transcription of other genes; Spliceosomes; RNA editing, structure of tRNA	
III	Gene Expression-Translation	3.1	Proteins: Chemical structure of proteins, Molecular structure of proteins, Nature of Genetic Code, Wobble Hypothesis	10
		3.2	Translation: Process of Protein Synthesis (Initiation, Elongation, Translocation, Termination)	

		3.3	Post Translational Modifications – Phosphorylation, glycosylation, methylation, lipidation, ubiquitination, proteolysis, Protein sorting	
IV	Regulation of Gene Expression	4.1	In Prokaryotes: In Bacteria: Lac Operon of E. coli; trp operon of E. coli. In Viruses: Lytic / Lysogenic Regulation	10
		4.2	In Eukaryotes: Operons in Eukaryotes; Control of Transcriptional Initiation; Gene Silencing and Genomic Imprinting; Post-Transcriptional Control	
		4.3	RNA Interference: The molecular biology of RNAi pathways, siRNA, miRNA.	

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

1. Outline the mechanisms associated with Replication of DNA. Gene Expression at the level of Transcription.
2. Describe the mechanisms associated with Gene Expression at the level of Transcription and Translation.
3. Explain mechanisms associated with Regulation of Gene Expression in Prokaryotes and Eukaryotes.
4. Review scientific literature in the subject Molecular Biology critically.
5. Evaluate the role of different proteins in the regulation of transcription and translation.
6. Apply the Knowledge in designing various experiments to study the regulation of expression.
7.

References:

1. i-Genetics - A molecular Approach: 3rd Edition
2. Genomes 3: 3rd Edition, T. A. Brown
3. Principles of Genetics: 7th Edition – Robert H Tamarin
4. Genetics, (2006) Strickberger MW - (Prentice Hall, India)
5. Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008) Molecular Biology of the Gene, 6th edition, Cold Spring Harbour Laboratory Press, Pearson Publication

Practicals:	
1	Study of E.coli Diauxic Growth Curve- (Lactose and Glucose).
2	Study of lac Gene Expression using Blue-White Selection.
3	Expression of β-galactosidase and Measurement of Activity.
4	Isolation and purification of RNA
5	Isolation and purification of DNA (genomic and plasmid)
6	Analysis of RNA, DNA and proteins by gel electrophoresis.

BOS	Biotechnology
Class	S. Y. B. Sc
Semester	IV
Course Name	Biophysics and Bioinstrumentation
Course Code	PUSBT403
Type of Course	Major
Level of the Course	Moderate
Total Credits for the Course	4 Theory + 1 Practical

Course Objectives:

1. Be able to relate principles of Physics to applications and techniques in the field of Biology such as Microscopy, Spectroscopy, chromatography, Centrifugation, Radioisotopes and Electrophoresis.
2. The objective of this course is to have a firm foundation of the fundamentals and applications of current biophysical theories.

Unit No.	Name of Unit	Topic No.	Name of Topic	Hours
I	Techniques using Wave-Particle duality of Light & Matter	1.1	Basic quantum theory of wave-particle duality, Single Molecule Imaging, Bimolecular fluorescence complementation (BiFC), Yeast two Hybrid system, Differential scanning fluorimetry, TEM, SEM, Cryo electron Microscopy, Immunoelectron microscopy, Single-particle cryo-electron microscopy	10
		1.2	Basic Laws of Light Absorption. Spectrophotometer: - Principle, Instrumentation and Applications; UV-Vis Spectrophotometer, Single and Dual Beam Spectrophotometer. Principle, instrumentation, working and applications of: Fluorescence Spectroscopy, Infrared Spectroscopy, Atomic absorption Spectroscopy, Surface plasmon resonance	
		1.3	Lasers: Properties of Lasers, Stimulated Emissions, Laser Action; Applications of Laser: Thermal ablation, Laser capture microdissection	
II	Bioanalytical & Biophysical Techniques	2.1	Chromatography: Principle, working and applications of: Affinity chromatography, Ion-exchange chromatography, Molecular (size) exclusion chromatography; HPLC; Gas Chromatography	10

		2.2	Centrifugation: Principle of centrifugation. Rotor design and selection. Preparative centrifugation - differential, rate-zonal, isopycnic, equilibrium isodensity centrifugation with applications. Density gradient centrifugation – nature of gradient, formation, sample application and collection.	
III	Biophysical techniques for studying Isolated Cells & Proteins	3.1	Real time recording of the activity of single ion channel (Patch clamp, Voltage clamp), optical and magnetic tweezers, Optoelectronic tweezers, Raman tweezers	10
		3.2	Instrumentation and Application of ITC (Isothermal Titration Calorimetry), Differential Scanning Calorimetry, Dielectrophoretic digital sorting (DEP), Hydrodynamic traps, Microfluidics, Scanning Ion Conductance Microscopy, Microscale thermophoresis (MST).	
IV	Electrophoretic Techniques	4.1	Electrophoresis: Migration of Ions in an applied electric field; Factors affecting Electrophoretic Mobility; Moving Boundary Electrophoresis;	10
		4.2	Principle of Electrophoresis; Supporting Matrix; Paper Electrophoresis; AGE; Native and SDS PAGE (reducing and non-reducing, continuous and discontinuous); IEF and 2D PAGE.	
		4.3	Staining and Detection Methods; Gel-Documentation. Applications in Biology.	
			TOTAL LECTURES	**40**

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

1. Describe basic physical theories.
2. Discuss bioinstrumentation principles.
3. Use physical principles to understand basic biophysical phenomena in nature.
4. Explain working of bioinstruments through the physical principles learnt.
5. Evaluate the knowledge garnered from learning about the physical phenomena.
6. Assess working of complex instruments.

References:

1. Textbook of Optics – Brjlal Subramanium
2. Bioinstrumentation: L. Veerakumari, MJP Publishers
3. Biophysical chemistry: Upadhyay Upadhyay and Nath, Himalaya Publishing House
4. Principles and Techniques of Biochemistry and Molecular Biology: Wilson and Walker
5. Developmental Biology; Scott Gilbert; 9th Edition

Practicals:	
1	Thin layer Chromatography
2	Effect of pore size and voltage on Agarose gel Electrophoresis.
3	Separation of proteins by PAGE.
4	2D Paper Chromatography.
5	Biological sample preparation for Transmission Electron Microscopy: AV Demo.
6	Biological sample preparation for Scanning Electron Microscopy: AV Demo.
7	Study of ion channels: Working of Patch Clamps-Video Demo.
8	Antibody staining procedure for immuno-electron microscopy: Demo.
9	Video demo of Flow Activated Cell Sorter.
10	Construction and working of fluorescence and Confocal Microscope.

BOS	Biotechnology
Class	S. Y. B. Sc
Semester	IV
Course Name	Food Microbiology
Course Code	PUSBT404
Type of Course	Discipline Minor
Level of the Course	Medium
Total Credits for the Course	4 Theory + 1 Practical

Course Objectives:

1. To introduce students to the fundamentals of food microbiology and its relevance to food-related diseases.
2. To analyze the principles of food safety management systems and regulatory measures

Unit No.	Name of the Unit	Topic No.	Name of Topic	Hours
I	Introduction to Food Microbiology	1.1	Introduction, Food as a substrate for microorganism a. pH, aw, O-R potential b. Nutrient Content c. Accessory food substances d. Inhibitory substances & biological structure e. Combined effects of factors affecting growth	10
		1.2	Food Control Enforcement & Control Agency: International agencies, Federal agencies (FDA, USDA), FSSAI, Introduction to HACCP	
		1.3	Food Sanitation & Hygiene: Water, potable water, Sources of contamination of water, treatment of water, pesticide residue	
II	Food spoilage	2.1	Important Microorganisms in Food Microbiology: General characteristics of the enlisted organisms to be studied wrt spoilage and transmission of infection/intoxication.	10

		2.2	**Spoilage -causing microorganisms -** **a. Yeast & Molds:** Saccharomyces, Aspergillus & Penicillium **b. Bacteria:** Bacillus, Clostridium, Flavobacterium, Pseudomonas	
		2.2	**Food-borne Illness associated Microorganisms:** Classification of Food-borne diseases (Schematic). Bacteria responsible for food -borne intoxication and infections-overview/tabulation.	
		2.3	Causes of Food Spoilage., Spoilage of Fruits, Vegetables, Meat, Soft Drinks, Eggs, Dairy products.	
III	Food Preservation	3.1	General Principles of Food Preservation	10
		3.2	Food Preservation: Radiations, Low and High temperature and Drying.	
		3.3	Food Preservation through chemicals: Acids, Salts, Sugars, Antibiotics, Ethylene oxide, Antioxidants.	
IV	Foodborne Pathogens	4.1	Bacteria: Pathogenesis and virulence factors of foodborne bacteria Transmission routes, epidemiology, and clinical manifestations of bacterial foodborne illnesses foodborne bacteria: Salmonella, Escherichia coli, Listeria monocytogenes, etc.	10
			Mechanisms of transmission and detection of viral pathogens in food Health risks and prevention strategies for viral foodborne diseases. Overview of common foodborne viruses (e.g., norovirus, hepatitis A virus)	
			Mechanisms of transmission and detection of viral and parasitic pathogens in food Health risks and prevention strategies for viral and parasitic foodborne diseases: parasites (e.g., Cryptosporidium, Giardia)	

Course Outcome:

1. Describe the factors influencing microbial growth.
2. Explain the role and functions of food control enforcement agencies.
3. Evaluate the importance of water sanitation and hygiene in preventing food contamination.
4. Identify common spoilage-causing microorganisms in food.
5. Analyze the causes and mechanisms of food spoilage in various food categories.
6. Evaluate different methods of food preservation.

References:

1. Butt, TM, Jackson CW and Magan N. Fungi as Biocontrol agent. CABI Publishing, UK.
2. Adams Food Microbiology.
3. Prajapati Fundamentals of Dairy Microbiology.
4. John C, Ayres OM, William ES. Microbiology of Foods. W. H. Freeman and Co.
5. Andrew Proctor Alternatives to conventional food processing, RSC pub.
6. Frazier WC and Westhoff DC Food Microbiology. Mcgraw Hill, New York.

Practicals:	
1	Isolation of food spoilage microorganisms from 1. Fruits 2. Vegetables
2	Isolation of organisms from canned food samples.
3	Investigation of Factors Affecting Microbial Growth in Food:
4	To investigate the effectiveness of different food preservation methods.
5	To determine the nutrient composition of food samples.
6	Case Study Analysis: Case studies of foodborne illness outbreaks and apply HACCP principles to identify potential sources of contamination and preventive measures.