CURRICULUM FOR

BIOTECHNOLOGY

4 YEAR DEGREE PROGRAM

BS (BIOTECHNOLOGY)

DEPARTMENT OF BIOTECHNOLOGY

University of Karachi

2024

SCHEME OF COURSES FOR BACHELOR OF SCIENCE (BS) FOUR YEAR PROGRAMME IN BIOTECHNOLOGY

		Sr. No.	Course No.	Course Title	Credit Hours	Category
Year -1	Semester - I	1	BTH-351	Cell Biology	3 (2+1)	Major
		2	BTH-353	Organic Chemistry	3 (2+1)	Interdisciplinary
		3	BTH- 355	Biochemistry I	3 (2+1)	Interdisciplinary
		4	300.1 (N.Sc)	Natural Science- Principles of Biology	3 (3+0)	General Education
		5	300.1 (U)	Arts and Humanities (Urdu)	2 (2+0)	General Education
		6	300.1 (I.S)	Islamic Studies (Ethics for non-Muslim students)	2 (2+0)	General Education
		7	300.1 (Civ/Com)	Civics and Community Engagement	2 (2+0)	General Education
				Total Credit Hours	18	
	Semester - II	1	BTH-352	Microbiology	3 (2+1)	Major
		2	BTH-354	Ecology and Biodiversity	3 (3+0)	Interdisciplinary
		3	BTH-356	Biochemistry- II	3(2+1)	Interdisciplinary
		4	300.2 (Soc.Sc)	Social Science (Economics)	2 (2+0)	General Education
		5	300.2 (F. Eng)	Functional English	3 (3+0)	General Education
		6	300.2 (P.S)	Ideology and Constitution of Pakistan	2 (2+0)	General Education
		7	300.2(P.St.)	Pakistan Studies	2 (2+0)	General Education
		8	300.2 (Entr)	Entrepreneurship	2 (2+0)	General Education
				Total Credit Hours	20	

		Sr. No.	Course No.	Course Title	Credit Hours	Category
Year -2		1	BTH-451	Introduction to Biotechnology	3 (3+0)	Major
	Semester - III	2	BTH-453	Principles of Genetics	3 (3+0)	Major
		3	BTH-455	Immunology	3 (2+1)	Interdisciplinary
		4	BTH-457	Physical Chemistry	3 (2+1)	Interdisciplinary
		5	BTH-459	Time Management and Organizing Skills	2 (2+0)	General Education
		6	400.1 (E. Writ)	Expository Writing	3 (3+0)	General Education
		7	400.1 (Q. Reas)	Quantitative Reasoning- I	3 (3+0)	General Education
		Total Credit Hours			20	
	Semester - IV	1	BTH-452	Molecular Biology	3 (2+1)	Major
		2	BTH-454	Virology	3 (2+1)	Major
		3	BTH-456	Analytical Chemistry and Instrumentation	3 (2+1)	Interdisciplinary
		4	BTH-458	Biophysiscs	3 (3+0)	Interdisciplinary
		5	400.2 (ICT)	Applications of Information & Communication Technologies (ICT)	3 (2+1)	General Education
		6	400.2 (Q.Reas)	Quantitative Reasoning- II	3 (3+0)	General Education
				Total Credit Hours	18	

		Sr. No.	Course No.	Course Title	Credit Hours	Category
Year -3	Semester - V	1	BTH-551	Microbial Biotechnology	3 (2+1)	Major
		2	BTH-553	Agriculture Biotechnology	3 (2+1)	Major
		3	BTH-555	Biostatistics	3 (3+0)	Major
		4	BTH-557	Bioinformatics	3 (2+1)	Major
		5	BTH-559	Recombinant DNA Technology	3 (2+1)	Major
			500.1	Internship	3 (0+3)	Compulsory
				Total Credit Hours	18	
	Semester - VI	1	500.2	Capstone	3 (0+3)	Compulsory
		2	BTH-554	Food Biotechnology	3 (2+1)	Major
		3	BTH-556	Methods in Molecular Biology	3 (2+1)	Major
		4	BTH-558	Scientific Inquiry and Research Methods	3 (3+0)	Major
		5	BTH-560	Principles of Biochemical Engineering	3 (2+1)	Major
				Total Credit Hours	15	

		Sr. No.	Course No.	Course Title	Credit Hours	Category
Year - 4	Semester - VII	1	BTH- 651	Industrial Biotechnology	3 (2+1)	Major
		2	BTH-653	Health Biotechnology	3 (3+0)	Major
		3	BTH-655	Biosafety, Biosecurity and Bioethics	2 (2+0)	Major
		4	BTH-657	Artificial Intelligence in Biotechnology	2 (2+0)	Major
		5	BTH-659	Genomics and Proteomics	3	Major
		6	BTH-6XX	Elective I / Thesis*	3	Major
				Total Credit Hours	16	
	Semester - VIII	1	BTH-652	Nanobiotechnology	3 (3+0)	Major
		2	BTH-654	Environmental Biotechnology	3 (2+1)	Major
		3	BTH-6XX	Elective II	3	Major
		4	BTH-6XX	Elective III	3	Major
		5	BTH-6XX	Elective IV / Thesis* / Project**	3	Major
				Total Credit Hours	15	

Total Credit Hours of the Program: 140

Note:
The course code of General Education courses will be opted in accordance with the university BS policy unless otherwise.
Internship of 6-8 weeks (3 credit hours); Must be graded by a faculty member in collaboration with the supervisor in the field.

* Thesis in lieu of two elective courses

** Project in lieu of one elective course

List of Elective Courses

S. No.	Course No.	Course Title	Credit Hours
1	BTH-656	Biotechnology Business Applications	3 (2+1)
2	BTH-658	Plant Tissue Culture and Regeneration	3 (2+1)
3	BTH-660	Marine Biotechnology	3 (2+1)
4	BTH- 661	Animal Cell and Tissue Culture	3 (2+1)
5	BTH-662	Medical Biotechnology	3 (2+1)
6	BTH-663	Advances in Immunology	3 (2+1)
7	BTH-664	Biofuels and Biorefineries	3 (2+1)
8	BTH-665	Molecular Diagnostics	3 (2+1)
9	BTH-666	Fungal Biotechnology	3 (2+1)
10	BTH-667	Forensic Biotechnology	3 (3+0)

CURRICULUM FOR BIOTECHNOLOGY

First Year Semester I

BTH-351 **Cell Biology** **3 (2+1)**

Course objectives
To acquaint students with the features of eukaryotic and prokaryotic cells, functions and structure of different organelles and the overall structure / ultrastructure of cells.

Course Learning Outcomes
By the end of this course, students will be able to:
- Describe the structure and function of cellular organelles.
- Explain the processes of cell division, differentiation, and signaling.
- Analyze the mechanisms of cellular communication and transport.

Course Content
Introduction to cell theory including historical perspective; prokaryotic and eukaryotic cell, overview of membrane structure, brief introduction of metabolism, chemical constituents of the cell; carbohydrates, proteins, lipids, nucleic acids, enzymes: induced fit model, cofactors and co-enzymes, factors affecting enzyme activity, enzyme inhibition, function, isolation and molecular organization of cellular organelles specifically the endoplasmic reticulum, ribososmes, lysosome, micro-bodies, golgi apparatus, mitochondrial ultra-structure and function, chloroplast ultra-structure and the mechanism of photosynthesis; composition and structure of membranes; membrane receptors and transport mechanisms: diffusion, osmosis, tonicity, facilitated transport, active and passive transport, exocytosis and endocytosis; cell movement - structure and function of cytoskeleton, centriole, cilia and flagella; nucleus; structure and function of chromosomes; cell cycle, mitosis and meiosis.

Labs
Laboratory safety rules. Study of prokaryotic, eukaryotic, plant and animal cells. Cell Organelles: microscopy and isolation and marker enzyme assays. Study of different types of plastids; cellular reproduction; Mitosis: smear/squash preparation of onion roots.

Recommended Books

- Plopper G, Ivankovic DB, (2020). Principles of cell biology.Jones& Bartlett Learning, LLC.
- Karp G, Iwasa J, Marshall W, (2020). Karp's Cell and molecular biology; Wiley.
- Alberts B, Hopkin K, Johnson, AD, Morgan D, Raff MC, Roberts K, Walter P, (2019). Essential cell biology. W.W. Norton.
- Arthur S.R, Baluska F, Miller W, (2023). OUP Oxford.
- Dr. K. Vasudha, (2023). A text book of cell biology and genetics. Academic Guru Publishing House.

BTH-353 **Organic Chemistry** **3 (2+1)**

Course Objectives
To acquire knowledge about basic concepts of organic chemistry, chemistry of hydrocarbons and functional groups and the mechanism of organic reactions.

Course Learning Outcomes
By the end of this course, students will be able to:
- Understand the structure, properties, and reactions of organic molecules.
- Understand principles of organic synthesis and reaction mechanisms.

Course Content
Introduction to organic chemistry. Optical activity: polarimeters, chiral compounds, properties of enantiomers and racemic mixtures, mutarotation of glucose. Alkanes, alkenes and alkynes. Aromatic hydrocarbons. Electrophilic substitution reactions. Alcohols, aldehydes and ketones. Carboxylic acids, carboxylic acid derivatives. Ethers. Introduction to chromatography.

Labs
Determining: boiling Point, density, refractive index, melting points, mixture melting points. Simple distillation at the semi-microscale level. Fractional distillation at the semi-microscale level. Solvent extraction. Paper and thin-layer chromatography. Measurement of Specific rotation. Isolation of caffeine from tea and lactose from milk. Synthesis of cyclic carboxylic acid anhydrides.

Recommended books

- Brown, W. H., & Poon, T. (2016). Introduction to Organic Chemistry. John Wiley & Sons.
- Carroll, F. A. (2023). Perspectives on Structure and Mechanism in Organic Chemistry. John Wiley & Sons.
- Cranwell, P. B., Harwood, L. M., & Moody, C. J. (2017). Experimental organic chemistry. John Wiley & Sons.
- Solomons, T. G., Fryhle, C. B., & Snyder, S. A. (2016). Organic Chemistry, 12e Binder Ready Version Study Guide & Student Solutions Manual. John Wiley & Sons.
- Wirth, T. (Ed.). (2013). Microreactors in organic chemistry and catalysis. John Wiley & Sons.

BTH - 355 **Biochemistry I** **3 (2+1)**

Course Objectives
To provide students with fundamental knowledge of biomolecules as well as their functions.

Course Learning Outcomes:
By the end of this course, students will be able to:
- Explain the structure and function of carbohydrates, lipids and proteins.
- Understand enzymes, enzyme activity and kinetics
- Understand the chemical nature of nucleic acids.
- Evaluate the role of vitamins and hormones in metabolic processes.

Course Content
Introduction to biochemistry; water, pH, buffers, and biochemical composition of cells; Introduction to proteins: amino acids and their properties. Primary, secondary, tertiary and quaternary structure of proteins. Structure function relationships. Enzyme classification, specificity of enzymatic reactions. Allosteric enzymes. Enzyme inhibition. Carbohydrates: monosaccharides, derivatives of monosaccharides, oligosaccharides, polysaccharides. Glycoproteins, sugar derivates, Structural polysaccharides, storage polysaccharides, Structure and function of bacterial cell-walls. Classification, structure, properties and functions of different types of lipids, fatty acids, triglycerides, glycerophospholipids, sphingolipids, cholesterol, Micelles, bilayers and liposomes. Properties and functions of lipoproteins, Fat and water-soluble vitamins, Structural and functional aspects of nucleic acids, Chemical structures of nucleotides, nucleosides and bases.

Labs
The demonstration of beer's law. Qualitative and quantitative analysis of proteins. Qualitative and quantitative analysis of carbohydrates. Titration curves of amino acids. Isolation and solubilization of proteins from plant and animal tissues, Estimation of proteins using different methods, Determination of acid value of fat. The saponification value of fat. Determination of iodine number of a fat. Enzyme assays and the effect of pH, temperature and substrate concentration on enzyme activity.

Recommended Books

- Campbell Mary.K and Farell Shawn.O, (2017). Biochemistry, Ninth Edition; Cengage Learning Inc.

- Murray et al., (2022). Harper's Illustrated Biochemistry. 32nd Edition; McGraw-Hill Medical Publishing. New York. USA.
- Nelson, D.L and Cox, M.M., (2021). Lehninger Principles of Biochemistry. Eighth Edition; WH Freeman, New York. USA.
- Stryer et al., (2023). Biochemistry. Tenth Edition; Macmillan Learning.UK.
- Voet D and Voet TG, (2018). Biochemistry. Fifth Edition; John Wiley and Sons, New York.

300.1 (N.Sc) Natural Science- Principles of Biology (G) 3(3+0)

Course Objectives:
To make students understand the basis of biology and to describe to them the fundamentals of genetics and evolution.

Course Learning Outcomes
By the end of this course, students will be able to:
- Understand the basics of biology.
- Describe the fundamentals of genetics, evolution, and ecology.
- Explain biological concepts as they apply to organismal physiology and behavior.

Course Content
Introduction of scientific process, (the nature of biological inquiry, and data analysis and Interpretation, Hypotheses, predictions, and scientific theories); Evolution and natural selection; Unity and diversity of life; Systematics – (taxonomy, classification, phylogeny); Organic molecules; Microscopy; Origins of life; Cells and Membranes; Structure and function of prokaryotic and eukaryotic cells; Energy Relationships, (Characteristics of metabolic reactions, Structure and function of enzymes, Structure and function of adenosine triphosphate (ATP), Electron transport chains/systems, Photosynthesis, Aerobic and anaerobic cellular respiration); Cell Division, (Mechanisms of cell division, Eukaryotic cell cycle, Mitosis and Meiosis); Genetics (Principles of Mendelian genetics, The chromosomal basis of inheritance, X-linked recessive inheritance, Human inheritance, Overview of molecular genetics, Structure and function of deoxyribonucleic acid (DNA), DNA replication and gene expression); Reproduction and Development (Viral replication, Life cycles, Growth and development of angiosperms, both monocots and dicots).

Recommended Books:

- Campbell, N. A., & Reece, J. B. (2017). Biology (11th ed). Pearson.
- Raven, P. H., & Johnson, G. B. (2017). Principles of biology (3rd ed). McGraw-Hill Education.
- Pierce, B. A. (2017). Genetics: A conceptual approach (6th ed). W. H. Freeman and Company.
- Molles, M. C. (2019). Ecology: Concepts and applications (6th ed). McGraw-Hill Education.
- Brooker, R. J., Widmaier, E. P., Graham, L. E., &Stiling, P. D. (2023). Principles of Biology. McGraw-Hill Higher Education.

300.1 (U) Arts and Humanities (Urdu) (2+0)

As per BS curriculum of the university.

300.1 (IS) Islamic Studies / Ethics (for non-Muslim students) 2 (2+0)

As per BS curriculum of the university.

300.1 (Civ/Com.) **Civics and Community Engagement** **2 (2+0)**

Course Objectives

To teach students the importance and role of active citizenship in promoting a productive, harmonious and developed society/world and to educate them about the importance of community linkages in developing a sustainable society.

Course Learning Outcomes

By the end of this course, students will be able to:

- Understand the overall organization of the society and exercise their rights, responsibilities and the significance of active citizenship in positive societal development
- Identify and critically evaluate social issues and implement practicable community-based solutions
- Understand the concept of human rights and its significance and appreciate diverse viewpoints and inter-cultural harmony

Course Content

Introduction to Citizenship Education and Community Engagement; Meaning & History. Attributes of Active Citizenship, Different Approach, Dimensions of Active Citizenship, Rights, Membership, Participation, Identity. Culture, and Social Harmony; Sociological Theories of Self Formation. Cultural & Religious Harmony, Pluralism & Diversity, Democracy & Democratic Norms. Concept and Development of Identity & Components of Cultural and Social Harmony. Inter-Cultural Dialogue (me versus you), Principles & Purpose, Ability to Support, learn and share through dialogue, Policy Dialogue (encourage young people to share their opinion and perspective with policy makers and opinion makers. Local & Global Communities; Concept of Community, Needs, Issues & Conflicts, Conflict Resolution, Communication & Networking, Social Cohesion, Social Capital, Social Networking, Advocacy & Social Entrepreneurship & Partnership. Social Action Planning; Skills in project Planning & Management, Project Cycle, Stakeholder Analysis, Problem Identification, Writing Project Plan, Monitoring & Evaluation & Risk Analysis. Population Dynamics in Pakistan; Population Growth Pakistan, Factors behind High Fertility Rate, Legislative Actions, Dearth of Medical Facilities, Delayed VS Early Age Marriages, Poverty, Women Empowerment, Population Theory & How to Control Population Growth.

Recommended Books

- An Introduction to Civics and Citizenship Education: A Machine-Generated Literature Overview. (2024). Singapore: Springer Nature Singapore.
- Crawford, B. (2024). A Republican's Lament: Mississippi Needs Good Government Conservatives. United States: University Press of Mississippi.
- Driscoll, T., McCusker, S. W. (2023). Becoming Active Citizens: Practices to Engage Students in Civic Education Across the Curriculum. Australia: Hawker Brownlow Education.
- Group Analysis and Psychodynamic Group Therapy with Children and Adolescents: Creative, Innovative, and Practical Inspiration. (2024). Germany: Vandenhoeck& Ruprecht.
- The International Association for, Evaluation of Educational Achievement (2023).W. Schulz et al., IEA International Civic and Citizenship Education Study 2022. Assessment Framework, https://doi.org/10.1007/978-3-031-20113-4_1
- Transformative Civic Education in Democratic Societies. (2023). United States: Michigan State University Press.

First Year Semester II

BTH- 352 **Microbiology** **3 (2+1)**

Course Objectives
To introduce basic principles of microbiology.

Course Learning Outcomes
By the end of this course, students will be able to:

- Assess the roles of microorganisms in various fields of biotechnology.
- Apply techniques for the cultivation, manipulation, and utilization of microorganisms.
- Evaluate microbial metabolic pathways for biotechnological applications

Course Content
Introduction and scope of microbiology. Historical foundations of Microbiology. Microscopy & diversity of microbial world. General characteristics of microbes. Bacterial forms and ultra structures. Comparative study of prokaryotic and eukaryotic cells. Taxonomy, classification and nomenclature of microorganisms. Methods of microbiology. Nutrition, cultivation, reproduction and growth of microorganisms. Metabolic characteristics and interactions. Methods for isolation and purification of microorganisms. Control of microorganisms. Chemotherapeutic agents & their mode of action. Role of microbes in human welfare. Microbial biotechnology.

Labs
Basic rules for microbiology laboratory safety. Basic microbiological lab equipment, culture vessels and supplies. Aseptic techniques. Culture transfer instruments and methods. Microscopy. Wet mounts and smear preparation. Simple and differential staining. Microscopic examination of fungi. Media preparation and sterilization. Culture techniques. Bacterial growth enumeration. Study of cultural and colonial characteristics. Growth pattern in broth. Biochemical characteristics. Identification of unknown bacterial culture.

Recommended Books

- Dubey, R. C., & Maheshwari, D. K. (2023). A textbook of microbiology. S. Chand Publishing.
- Okoń, S., Zimowska, B., & Rai, M. (Eds.). (2024). Microbial Genetics. CRC Press.
- Pelczar, M. J., Chan, E. C. S., &Kriec, N. R. (2017). Microbiology. Mc Graw Hill Education.
- Pommerville, J. C. (2013). Fundamentals of microbiology. Jones & Bartlett Publishers.
- Tortora, G. J., Funke, B. R., & Case, C. L. (2007). Microbiology: an introduction (p. 912). San Francisco, CA: Pearson Benjamin Cummings.

BTH-354 **Ecology and Biodiversity** **3 (3+0)**

Course Objectives
To make students understand the principles of ecology, biodiversity and conservation and to describe them the interactions between organisms and their environments.

Course Learning Outcomes
By the end of this course, students will be able to:

- Explain the principles of ecology, biodiversity and conservation.
- Describe the interactions between organisms and their environments.
- Analyze the impact of human activities on biodiversity and ecosystems with special emphasis on climate change.

Course Content
Introduction; ecosystem and ecological pyramids; role of environment on phenotype of organisms; food chain, webs and trophic levels; factors influencing environment; impact of urbanization and industry on environment; population: air, water, land, thermal, radiation and noise; community ecology; atmosphere – composition and cycles; pollution; climate change greenhouse effect and global warming; ozone layer – composition and state across the globe; waste and sewerage processing and disposal; microbes, plants and animal species; comparative study of life forms; features and characteristics of bacteria, archaea and eukaryotes; Introduction to animal kingdom: features of protists, protozoa, annelids, arthropods, myriapods, echinoderms, chordates, amphibians, reptiles and birds. Plant biodiversity – history, importance, usefulness and evolution; importance of plants, their conservation and domestication; improvement of crops; impact of environment on loss of genetic diversity and speciation, Global warming and environment conservation; industrialization and its impacts on biodiversity; sustainable development goals (SDG's)

Recommended Books:

- Francis, R. A. (2021). Book Review: Ecology: A Very Short Introduction.
- Karasov, W. H., & del Rio, C. M. (2020). Physiological ecology. Princeton University Press.
- Kosal, E. (2023). Population Ecology. *Introductory Biology: Ecology, Evolution, and Biodiversity*
- Mittelbach, G. G., & McGill, B. J. (2019). Community ecology. Oxford University Press.
- Molles, M. C. (2021). *Ecology: Concepts and applications* (4th ed). Oxford University Press.

BTH-356 Biochemistry – II 3 (2+1)

Course Objective
This course is a continuation of Biochemistry I, and aims to familiarize students with the key concepts of intermediary metabolism of proteins, nucleic acids, carbohydrates and lipids.

Course Learning Outcomes:
By the end of this course, students will be able to:

- Describe the fundamental biochemical pathways and their regulation.
- Understand and apply the principles of bioenergetics and biochemical thermodynamics to analyze metabolic pathways
- Explain the biochemical principles of metabolic integration and regulation.

Course Content
Introduction to metabolism and basic aspects of bioenergetics and biochemical thermodynamics (endergonic and exergonic reactions); phosphoryl group transfer and ATP production; metabolism, oxidation-reduction; carbohydrate metabolism and regulation (glycolysis and its regulation with deficiency diseases, glycogenolysis and its regulation with deficiency diseases; glycogenesis with deficiency diseases; gluconeogenesis and its regulation with deficiency diseases; pentose phosphate pathway); citric acid cycle (reactions, energetics and control), electron transport chain, oxidative phosphorylation, shuttle mechanisms, lipid metabolism (energy yield from fatty acid oxidation, ketone bodies regulation and related diseases, acyl glycerol, compound lipids, cholesterol and its diseases); photosynthesis; Calvin Cycle; metabolism of nitrogenous compounds.

Labs
The isolation of protein (casein) from milk. The isolation and enzyme essay for glycogen from liver. Paper chromatography of amino acids. Paper chromatography of sugars. Hydrolysis of starch, extraction of glycogen from liver, acid and enzymatic hydrolysis of glycogen. Extraction and estimation of Lipids from grains. The effect of detergents on the erythrocyte membrane. The isolation of chloroplast from spinach leaves. To study the acid digestion of proteins. Preparation of stock and working solutions.

Recommended Books

- Campbell Mary.K and Farell Shawn.O, (2017). Biochemistry, Ninth Edition; Cengage Learning Inc.
- Ferrier, D.R., (2017). Lippincott's Biochemistry. Seventh Edition; Lippincott Williams &Wilkin Publishing Company
- Murray et al., (2022). Harper's Illustrated Biochemistry. 32nd Edition; McGraw-Hill Medical Publishing.
- Nelson, D.L and Cox, M.M., (2021). Lehninger Principles of Biochemistry. Eighth Edition; WH Freeman, New York.
- Stryer et al., (2023). Biochemistry. Tenth Edition; Macmillan Learning.

BTH-461 Social Sciences (Economics) 2 (2+0)

Course Objectives

To introduce students to the fundamentals of economic analysis and reasoning and to develop in them a systematic approach to decision making and the ability to recognize, use, and interpret economic information from both within the organization and the wider environment.

Course Learning Outcomes:

By the end of this course, students will be able to:

- Understand and differentiate between macroeconomics and microeconomics, including key concepts such as demand, supply, and market equilibrium.
- Analyze the production function and cost concepts, and evaluate the relationship between production decisions and cost efficiency in various market conditions.
- Examine different market structures and pricing strategies, and assess the impact of international trade and globalization on economic systems.

Course Content

Introduction to economics: Basic concepts, nature, and scope of economics, macro and microeconomics definition, scope, merits, and demerits. Demand, supply and market equilibrium, Theory of Consumption: Different concepts of demand, demand curve, determinants of demand, law of demand, demand forecasting methods. Concept of supply, supply curve, conditions of supply, elasticity of supply. Theory of Production and costs: The production function, short-run and long-run production function, fixed, variable and other cost concepts, least cost-input combination, relationship between production and cost. Market structure and factors of production: Market, types, structures, features, price determination (long run and short run) in perfect competition, monopoly, monopolistic and oligopoly markets, pricing strategies. International trade and the impact of globalization on the economies.

Recommended Books

- Field, B. C., Field, M. K. (2024). Environmental Economics: An Introduction; 2024 Release. United Kingdom: McGraw-Hill Education.
- Musgrave, F., Kacapyr, E., Redelsheimer, J. (2023). AP Microeconomics/Macroeconomics Premium, 2024: 4 Practice Tests + Comprehensive Review + Online Practice. United States: Barrons Educational Services.
- Riley, T. (2023). Year 12 Economics Textbook 2024. Australia: Tim Riley Publications.
- Sario, A. U. H. (2024). Cambridge Economics A Level Qualification: Draft2digital.
- Karlan, D. S. & Morduch, J. J. (2024) Economics (4th Ed). McGraw Hill

300.2 (F. Eng) (Functional English) 3 (3+0)

Course Objectives

To enhance language skills and develop critical thinking.

Course Learning Outcomes
By the end of this course, students will be able to:

- Demonstrate proficiency in the parts of speech, sentence structure, and verb usage, including active and passive voice.
- Effectively engage in comprehension exercises, discussions, and everyday conversations on a variety of topics.
- Develop translation skills from Urdu to English and enhance presentation abilities, including self-introduction and paragraph writing.

Course Contents
Basics of grammar parts of speech and use of articles. Sentence structure, active and passive voice Practice in unified sentence Analysis of phrase, clause and sentence structure. Transitive and intransitive verbs Punctuation and spelling. Comprehension answers to questions on a given text, discussion on general topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students). Listening to be improved by showing documentaries/films carefully selected by subject teachers. Translation skills urdu to English, paragraph writing (topics to be chosen at the discretion of the teacher). Presentation skills, self introduction.
Note: Extensive reading is required for vocabulary building

Recommended Books

- Keizer, E., (2015). A Functional Discourse Grammar for English. Oxford University Press.
- Banks, D. (2019). A systemic functional grammar of English: A simple introduction. Routledge.
- Ma'arif, I. B., &Meishanti, O. P. Y. (2020). English Grammar Book 1. Lembaga Penelitian dan Pengabdiankepada Masyarakat Universitas KH. A. Wahab Hasbullah.
- Marrouchi, R. (2021). Functional English for Potential Achievers. Functional English for Potential Achievers, 1-148.
- Nelson, G., & Greenbaum, S. (2018). An introduction to English grammar. Routledge.

300.2 (P.S)	**Ideology and Constitution of Pakistan (G)**	**2 (2+0)**

As per BS curriculum of the University

300.2 (P.St)	**Pakistan Studies (G)**	**2 (2+0)**

As per BS curriculum of the University

300.2 (Entr)	**Entrepreneurship**	**2 (2+0)**

Course Objectives
To provide students with the knowledge and skills necessary to translate innovative ideas into viable business opportunities**.**

Course Learning Outcomes
By the end of this course, students will be able to

- Able to recognize potential market opportunities.
- Learn to create detailed business plans.
- Develop the ability to articulate their business ideas clearly and persuasively.

Course Content
Introduction to Entrepreneurship. The entrepreneurial mindset and characteristics. Challenges of Entrepreneurship. Opportunity Recognition and Idea Generation. Business Planning Fundamentals. Market Research and Analysis. Conducting a Feasibility Analysis and Crafting a Winning Business Plan. Forms of Business Ownership. Franchising and the Entrepreneur. Building a Powerful Marketing Plan. E-Commerce and the Entrepreneur. Pricing Strategies. Financial Planning and Funding Options. Marketing Strategies for Startups. Legal Considerations and Business

Structure. Operations Management in Startups. Scaling and Growth Strategies. Pitching and Presentation Skills. Project Presentations.

Recommended Books

- Devi, S., Sabesan, G. S., & Ismail, S. A. (Eds.). (2024). Opportunities for Biotechnology Research and Entrepreneurship. Bentham Science Publishers.
- Hisrich, R. D., Peters, M. P., & Shepherd, D. A. (2017). Entrepreneurship. McGraw-Hill Education.
- Laverty, M., & Littel, C. (2024). Entrepreneurship. OpenStax, Rice University.
- Ratten, V. (2024). Entrepreneurial Business Venturing. Springer Nature Singapore.
- Shimasaki, C. (Ed.). (2020). Biotechnology entrepreneurship: starting, managing, and leading biotech companies. Academic Press.

Second Year Semester III

BTH-451 **Introduction to Biotechnology** **3 (3+0)**

Course objectives

To explain the scope, concepts, and terminology of biotechnology as well to investigate and explain current events and advances in biotechnology.

Course Learning Outcomes

By the end of this course, students will be able to:

- Understand the history of biotechnology and its role in basic biological sciences.
- Explain the fundamental concepts, principles and scope of biotechnology.
- Demonstrate knowledge of major biotechnological tools and techniques.

Course Content

Introduction, history and scope of biotechnology. Biotechnology and its scientific basis. Public perception of biotechnology. Different areas of study in biotechnology: Genetic Engineering, plant biotechnology, food biotechnology, medical biotechnology, fermentation technology, bioprocess engineering, enzyme technology, bioinformatics and agricultural biotechnology. Protection of Biotechnological products, Safety in Biotechnology; Public Perception of Biotechnology; Biotechnology and Ethics; Biotechnology and the Developing world. Careers and employment in biotechnology

Recommended Books

- Khan, F. A. (2020). Biotechnology fundamentals. CRC Press.
- Vitolo, M. (2021). Fundamentals of Biotechnology. In Pharmaceutical Biotechnology (pp. 1-28). CRC Press.
- Wink, M. (Ed.). (2020). An introduction to molecular biotechnology: fundamentals, methods and applications. John Wiley & Sons.
- Suzy Hills. (2022). Biotechnology; from Science to Applications. States Academic Press.
- Firdos Alam Khan. (2020). Biotechnology Fundamentals Third Edition. CRC Press.

BTH-453 **Principles of Genetics** **3 (3+0)**

Course Objectives

By the end of this course, students will be able to explain the principles of classical and modern genetics. Analyze genetic data to predict inheritance patterns and gene interactions.

Course Learning Outcomes
By the end of this course, students will be able to:

- Explain the principles of classical and modern genetics.
- Analyze genetic data to predict inheritance patterns and gene interactions.

Course Content
Classical Mendelian genetics; monohybrid crosses, dominance, re-cessiveness, co-dominance, and semi-dominance; principle of independent assortment; dihybrid and trihybrid ratios; gene interactions; epistasis and multiple alleles; ABO blood type alleles and Rh factor alleles in humans; probability in Mendelian inheritance; structure of chromosomes; organization of genes and genomes; nucleic acid function; DNA as warehouse of genetic information; experimental evidence that DNA is genetic material; sex determination; linkage and crossing over; chromosomal aberrations and gene mutations; factors involving genetic mutations; population genetics and genetic drift.

Recommended Books:

- Brooker, R. J. (2020). Genetics: Analysis and Principles (6th ed). McGraw-Hill Education.
- Klug, W. S., & Cummings, M. R. (2019). Concepts of genetics (14th ed). Pearson.
- Pierce, B. (2019). Genetics: A conceptual approach (6th ed). W. H. Freeman.
- Pierce, B. A. (2017). Genetics: A Conceptual Approach (6th ed). W. H. Freeman and Company.
- Snustad, D. P., & Simmons, M. J. (2016). Principles of genetics (7th ed). Wiley.

BTH-455 Immunology 3 (2+1)

Course Objectives
To acquaint students with the basic principles of innate and adaptive immune systems

Course Learning Outcomes
By the end of this course, students will be able to:

- Describe the components and functions of the immune system.
- Explain the mechanisms of immune responses to pathogens.
- Analyze the principles and applications of vaccination and immunotherapy.

Course Content
Introduction. Historical perspectives. Innate and Acquired Immunity. Immune systems, organs constituting immune system, their location and basic architecture. The immunocompetent cells (T-cells, B-cells) their origin, surface markers and population. Antigen, types and properties. Immunoglubulins, types, properties, induction and production. genetics of antibody structure and diversity. Expression of immunoglobulin genes; VDJ recombination. Antigen-Antibody reaction, types and mechanism. Immune responses: Humoral and Cellular responses. Complement fixation and neutralization. Antigen processing and presentation. Hypersensitivity reaction. vaccine development and production. cytokines, resistance and immune response to infectious diseases, leukocyte migration and inflammation, vaccines, diseases of the immune system - autoimmunity, transplantation immunology.

Labs
Blood typing for ABO and Rh system. Total leukocyte count. Total erythrocyte count. Differential blood cell count. Rapid slide agglutination. Tube agglutination. Widal test. Bactericidal power of normal serum. Non-specific chemical barriers against microorganisms.

Recommended Books

- Abbas, A. K., & Shiv Pillai, M. B. B. S. (2023). Basic Immunology: Functions and Disorders of the Immune System, 7e. Elsevier.
- Chalamcherla, V. (2021). Principles of Immunology. Horizon Books (A Division of Ignited Minds Edutech P Ltd).

- Coico, R. (2021). Immunology: a short course. John Wiley & Sons.
- Kuby J, (2007). Immunology. Sixth Edition; WH Freeman, New York.
- Mitsuru, M. (2024). Basic Immunology and its clinical application. Springer.

BTH-457 **Physical Chemistry** **3 (2+1)**

Course Objectives

By the end of this course, students will be able to understand the principles of thermodynamics, kinetics, and quantum chemistry. Understand the physical factors affecting chemical reactions. Explain mathematical models to describe physical and chemical phenomena.

Course Learning Outcomes

By the end of this course, students will be able to:

- Understand the principles of thermodynamics, kinetics, and quantum chemistry.
- Understand the physical factors affecting chemical reactions.
- Explain mathematical models to describe physical and chemical phenomena.

Course Content

Spontaneity of chemical and biological processes, micronutrients in biological system e.g. effect of iron and copper etc., selected features of biological electron transfer (e.g. nitrogen fixation and its comparison with industrial production of ammonia with particular reference to energetics and catalytic aspects, Introduction of Electrochemistry. Voltaic cells. Normal Hydrogen Electrode and Standard EMF of Half cells. Standard cell potential of a coupled reaction as calculated from Half-cell potentials and their Concentration cells; Nerst Equation. Introduction to methods of study of biomolecules. Application of electrochemistry and thermodynamics to a specific biological system e.g. cytochromes. Chemical Kinetics; Methods of measuring rates of reactions; Specific rate constants, Order and Molecularity; Rate Laws and Rate equations, concept of rate determining step in a multi-step reaction; Arrhenius theory, Effect of temperature on rate constants; Activation energy; Catalysis. Chemical Equilibrium, Kc and Kp; Numerical problems involving Equilibrium constants, Equilibrium Quotients (Qc and Qp). Bronsted Acids and Bases; Strong and Weak acids and bases; Equilibria involving acids and bases; Ka Kb and Kw and pKapKb and pKw Henderson–Hassel balch equation, Buffers. Solubility and complex ion equilibria with an introduction to Co-ordination chemistry. pH titration.

Labs

Viscosity and parachor values of liquids. Percent composition of liquid solutions by viscometer. Refractive index and molar refractivity. Percent composition of liquid solutions by refractive index measurements. Molecular weight determination by elevation of boiling point and lowering of freezing point. Heat of solution by solubility method. Heat of neutralization of an acid with a base. Kinetic study of acid catalyzed hydrolysis of ethyl acetate. Partition coefficient of a substance between two immiscible liquids.

Recommended Books

- Atkins, P., & de Paula, J. (2018). Elements of Physical Chemistry (5th ed). Oxford University Press.
- Burrows, A., Holman, J., Lancaster, S., Overton, T., Parsons, A., Pilling, G., & Price, G. (2021). Chemistry3: Introducing inorganic, organic and physical chemistry. Oxford university press.
- Hofmann, A. (2018). Physical chemistry essentials (pp. 1-499). Springer International Publishing.
- Kuhn, H., Waldeck, D. H., &Försterling, H. D. (2024). *Principles of physical chemistry*. John Wiley & Sons.
- Pizzini, S. (2015). Physical chemistry of semiconductor materials and processes. John Wiley & Sons.

BTH-459 **Time Management and Organizing Skills** **2 (2+0)**

Objectives
To make students learn to prioritize tasks and manage their time to achieve academic and professional goals as well to develop personalized organizational systems to streamline their workflow, reduce stress, and increase productivity.

Course Learning Outcomes:
By the end of this course, students will be able to:

- Develop effective goal-setting, prioritization, and scheduling techniques to manage academic and personal responsibilities efficiently.
- Implement strategies for task management, note-taking, and creating organized systems for both physical and digital workspaces to enhance productivity.
- Foster resilience and motivation while building professional relationships and networking skills that support career development and post-graduation planning.

Course Content
Goal-setting strategies, Prioritization techniques, Scheduling and calendar management, Task management and delegation, Avoiding procrastination, Managing distractions and minimizing stress, Effective use of technology for time management, Balancing academic and personal responsibilities, Creating a research schedule, Meeting deadlines and managing multiple projects, Note-taking and record-keeping strategies, Creating a filing system, Managing digital files and documents, Setting up a home office or workspace, Developing a daily routine, Creating to-do lists and checklists, Effective communication with advisors and colleagues, Building relationships with peers and mentors, Productivity strategies, Goal-setting and achievement, Stress management and self-care, Overcoming obstacles and staying motivated, Building resilience and perseverance, Balancing work and personal life, Creating a post-graduation plan, Career development and professional networking

Recommended books

- "Time Management for Graduate Students: Strategies for Success" by Lynn F. Jacobs and Jeremy S. Hyman (2024)
- "Effective Time Management for Research Students" by Allan Hackshaw and Lois Thomas (2024)
- "Organizing Your Academic Life: A Guide for Graduate Students" by Karen L. Levin and Cynthia A. Cochran (2024)
- "Graduate Student Survival Skills: Organizing, Writing, and Communicating" by Patricia L. Conway and Sharon E. Matthews (2024)

"The Organized Graduate Student: A Guide to Managing Your Time, Tasks, and Responsibilities" by Kerry M. Escott and Susan C. Robison (2024)

400.1 (E. Writ) **Expository Writing** **(3+0)**

Course Objectives
To equip students with essential reading and writing skills, enabling them to critically analyze texts, effectively organize and express their ideas in various writing formats, and engage in constructive peer review, thereby fostering their overall communication competence in academic and professional contexts.

Course Learning Outcomes
By the end of this course, students will be able to:

- Develop effective reading skills, including skimming and scanning, to identify main ideas and critically engage with texts.
- Master the fundamentals of essay writing, including prewriting activities, drafting, and revising, while understanding different writing genres and styles.
- Enhance the ability to critically examine and review writing, including peer reviews, and design effective research and interview questions.

Course Content
Reading skills (skimming, scanning, SQW3R, previewing, annotating, detailed reading, note-taking). Identification of main idea. Introduction to basics of writing. Introduction to steps of essay writing. Prewriting activities (brainstorming, listing, clustering, free-writing). Introduction to learning styles. Critical examination of writing. Revising documents in light of critical reviews. Review reports. Characteristics of narrative; descriptive, and argumentative paragraphs. Difference of fact and opinion. Identification of tone, diction, voice. Drafting of interview questions. Research question designing. Genres of writing. Types of letter writing. Letter to editor. Peer-review of documents.

Recommended Books

- Curl, M. J. (2021). Expository Writing. Project Gutenburg
- Denenga, M. S. (2019). Writing Mastery. Munaii.
- Fulton, M. G. (2018). Expository Writing (Classic Reprint). Fb&c Limited.
- Uchenna, O. I. (2021). Handbook of English Essay. Independently Published.
- Yeo, E. (2022). Blueprint for PSLE Success: Composition. Marshall Cavendish International (Asia) Private Limited.

400.1 (Q. Reas) Quantitative Reasoning- I 3 (3+0)

Course Objectives
To prepare students with the essential tools of algebra to apply the concepts and the techniques in their respective disciplines.

Course Learning Outcomes
By the end of this course, students will be able to:
- Demonstrate a strong grasp of fundamental mathematical concepts.
- Solve complex mathematical problems using techniques such as Cramer's rule and the binomial theorem.
- Derive and manipulate trigonometric identities and apply them effectively in practical contexts.

Course Content
Preliminaries: Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions. Matrices: Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer's rule. Quadratic Equations: Solution of quadratic equations, qualitative analysis of roots of a quadratic equation, equations reducible to quadratic equations, cube roots of unity, relation between roots and coefficients of quadratic equations. Sequences and Series: Arithmetic progression, geometric progression, harmonic progression. Binomial Theorem: Introduction to mathematical induction, binomial theorem with rational and irrational indices. Trigonometry: Fundamentals of trigonometry, trigonometric identities.

Recommended Books

- Boston,Swokowski EW, Fundamentals of Algebra and Trigonometry (6th edition), 1986, PWS-Kent Company, Boston
- Dolciani MP, Wooton W, Beckenback EF, Sharron S, Algebra 2 and Trigonometry, 1978, Houghton & Mifflin, B., Kaufmann JE. (1987). College Algebra and Trigonometry. PWS-Kent Company.
- Huys, N. (2023). Mathematics for beginners E-book.
- Quantitative Reasoning in Mathematics and Science Education 2023
- Quantitative Reasoning: Mastering Elementary Maths Skills By Richard Anderson. 2022 Amazon Digital Services LLC – Kdp
- Zaslow, E. (2020). Quantitative Reasoning, 1st edition, Cambridge University Press.

Second Year Semester IV

BTH-452 **Molecular Biology** **3 (2+1)**

Course Objectives
To acquaint students with the chemistry and biology of macromolecules.

Course Learning Outcomes
By the end of this course, students will be able to:
- Understand the Central Dogma of molecular biology.
- Understand gene regulation and expression in prokaryotes and eukaryotes.
- Explain the mutations, DNA damage and repair mechanisms.

Course Content
Introduction to molecular biology; Definition, History of molecular biology, Application of Molecular Biology, Techniques of molecular Biology, DNA Structure and Replication; Structure of DNA, Components of DNA, Steps in prokaryotic DNA synthesis, Eukaryotes DNA Replication, Organization of Eukaryotes DNA, DNA damage and mutation, DNA repair, RNA Structure and Synthesis; Structure of RNA, Transcription of prokaryotic genes, Transcription of Eukaryotic genes, Posttranscriptional modification of RNA, Study of Lac Operon as a model for Gene Expression, recombination and transposable elements, Protein synthesis; The Genetic code, Characteristic of Genetic code, Component required for translation, Codon recognition by tRNA, Steps in Protein synthesis, Regulation of translation, Posttranscriptional modification.

Labs
The genetic material: Isolation of DNA from animal, plant and bacterial sources. Gel electrophoresis of DNA. Quantitation of DNA & RNA. Protein estimation methods.

Recommended Books

- De la Cruz, F. (Ed.). (2020). Horizontal Gene Transfer: Methods and Protocols. Humana Press.
- Fasman, G. D. (2018). CRC Handbook of Biochemistry and Molecular Biology: Physical and Chemical Data. CRC press.
- Jain, A., Jain, R., & Jain, S. (2020). Basic Techniques in Biochemistry, Microbiology and Molecular Biology. New York, NY, USA: Springer.
- Karp, G., Iwasa, J., Marshall, W., (2020). Karp's Cell and Molecular Biology 9th Edition. Wiley.
- Lodish et al., 2012. Molecular Cell Biology. Seventh Edition; WH Freeman, New York

BTH- 454 **Virology** **3 (2+1)**

Course Objectives
To provide students with the cognitive and methodological tools necessary to understand the structure and life cycle of viruses.

Course Learning Outcomes
By the end of this course, students will be able to:
- Explain the fundamental characteristics and functions of virus particles, including their symmetry and architecture.
- Demonstrate knowledge of the various viral classification systems and categorize viruses based on their genome type, structure, and host range.
- Explain the genetic makeup of viruses, including the processes of viral genome replication and expression in both prokaryotic and eukaryotic host cells.

Course Content
Foundations of virology. Function and formation of virus particles; symmetry and virus architecture. Viral classification systems. Viral visualization and enumeration. Virus cultivation, detection and genetics. Architecture of cell surfaces of viral hosts. Virus attachment, penetration and uncoating. Expression and replication of viral genomes (DNA and RNA) in prokaryotic and eukaryotic hosts. Assembly, maturation and release of virions.

Labs
Isolation of bacteriophages from sewage sample. Study of plaque formation by bacteriophages. Purification of bacteriophages. Titration of bacteriophages. Single step growth curve for bacteriophage.

Recommended Books

- Hewlett, M. J., Camerini, D. and Bloom D. C. (2021). Basic Virology.4th edition. Wiley- Blackwell.
- Howley, P. M., Knipe, D. M., & Enquist, L. W. (2023). *Fields Virology: Fundamentals*. Lippincott Williams & Wilkins. USA
- Voyles, B. A. (2002) The Biology of Viruses. 2nd ed. McGraw-Hill. USA.
- Wagnes, E.K.K., Hewlett, M.J. and Hewlett, M.J. (2003) Basic Virology. 2nd ed. Blackwell Publisher. USA.
- Wreghitt, T., & Kudesia, G. (2024). *Clinical and diagnostic virology*. Cambridge university press.

BTH-456 Analytical Chemistry and Instrumentation 3 (2+1)

Course Objectives
To acquaint students with key analytical chemistry concepts involving identification and analysis at the molecular level.

Course Learning Outcomes
By the end of this course, students will be able to:
- Describe the principles and techniques of common analytical instruments.
- Apply analytical methods to identify and quantify chemical / biochemical substances.
- Interpret data obtained from analytical techniques to solve chemical problems.

Course Content
Introduction to various analytical techniques; principles and applications of various types of chromatography including paper, thin layer, gel filtration, ion-exchange, affinity, high performance liquid chromatography (HPLC), gas chromatography, GC-MS and LC–MS; spectroscopy types including nuclear magnetic resonance (NMR), visible, ultraviolet, luminescence, flame, atomic absorption, fluorescence, principles and applications of flow cytometry; introduction to X-ray diffraction; general analytical instrumentations and methods of fractionation and characterization of proteins and nucleic acids including dialysis, ultra-filtration, lyophilization, ultracentrifuge and amino acid analyzer.

Labs

Demonstration of different parts of HPLC, lyophilizer, ultraviolet, GC-MS and their working, visit to different Institutions and organizations for demonstrating the working of LC-MS, X-ray, atomic absorption and others state of the art instruments used in analytical chemistry.

Recommended Books

- Egbuna H, Kingsley C. Iwuanyanwu P, Ajmal MS Jonathan C, Rasul A, (2021). Analytical Techniques in Biosciences: From Basic to Applications; Elsevier Science.
- Lottspeich F and Engels JW, (2018). Bioanalytics: Analytical methods and concept in biochemistry and molecular biology; Wiley.
- Manz A, Dittrich PS, Pamme N, Iossifidis D, (2015), Bioanalytical Chemistry. Second Edition, World Scienctific.
- Rudolf Bock, Reinhard Nießner (2023). Separation techniques in analytical chemistry. De Gruyter.
- Thomas J. Bruno, James W. Robinson, George M. Frame II, Eileen M. Skelly Frame, (2023), Undergraduate Instrumental Analysis. CRC Press.

BTH-458 **Biophysics** **3 (3+0)**

Course Objectives

To impart fundamental concepts of physics in the context of biological systems.

Course Learning Outcomes

By the end of this course, students will be able to:

- Describe the physical principles governing biological systems.
- Understand biophysical techniques to study the structure and function of biomolecules.
- Analyze the dynamics of molecular interactions in biological processes.

Course Content

Conformational analysis and forces determining macromolecular structures, Biochemical thermodynamics and kinetics. Solution of macromolecules, transport processes. Absorption and emission of radiation, scattering circular dichroism, optical rotator dispersion X-ray diffraction and NMR. Computer modeling, 3-D structure information and drug design. (Computer aided drug design). Hemoglobin as a model drug receptor. Physical properties (viscosity and archaeology) of microbial polysaccharides and their industrial applications with particular reference to food industry and secondary oil recovery.

Labs

Determination of absorption spectrum of colored compounds. Determination of solution concentrations through spectrophotometery. Determination of DNA, proteins and amino acids by ultraviolet absorption. Computer aided drug design. Conformational analysis of proteins: confirmation of alpha helices and beta pleated sheets. Free energy of unfolding of proteins. Molecular models. Measurement of viscosity. Using software to build molecular models. Determination of pK values.

Recommended Books

- Ashrafuzzaman. (2023). Introduction to modern biophysics. CRC press.
- Brian Fertig. (2024). Metabolism and medicine: The physics of biological engines. CRC press.
- Davidovits P. (2013) Physics for Biology & Medicine. 4th Edition; Academic Press
- Hagai Meirovilch. (2022). Entropy and free energy in structural biology: From thermodynamics to statistical mechanics to computer simulations. CRC press.
- Tuszynski, J.A., Basu, D.K. and Kurzynski, M. (2003) Introduction to Molecular Biophysics. CRC Press. UK.

400.2 (ICT) Applications of Information & Communication Technologies (ICT) 3 (2+1)

400.2 (Q.Reas) Quantitative reasoning II (Biomathematics) 3 (3+0)

Course Objectives
To provide students with the essential concepts of biomathematics and how these can be employed for analyzing real data.

Course Learning Outcomes
By the end of this course, students will be able to:

- Understand and apply key concepts in calculus, including limits, continuity, and the binomial theorem, to solve equations and inequalities.
- Demonstrate proficiency in differentiating various types of functions and evaluating indefinite integrals using techniques such as substitution and integration by parts.
- Apply calculus concepts to real-world problems in biotechnology, including modeling exponential growth and solving first-order differential equations.

Course Content
Preliminaries: Real-number line, functions and their graphs, solution of equations involving absolute values, inequalities, binomial theorem and its use. Limits and Continuity: Limit of a function, left-hand and right-hand limits, continuity, continuous functions. Derivatives and their Applications: Differentiable functions, differentiation of polynomial, rational and transcendental functions, derivatives.
Integration and Definite Integrals: Techniques of evaluating indefinite integrals, integration by substitution, integration by parts, change of variables in indefinite integrals. Application and importance of calculus for biotechnology; the exponential growth curve and growth equation. First order differential equations and their solutions.

Recommended Books

- Bassanezi, R. C. (2018). The Biomathematics in IMECC. In Advances in Mathematics and Applications (pp. 25-65). Springer, Cham.
- Mack, T. (2023). The Math You Need: A Comprehensive Survey of Undergraduate Mathematics. MIT Press.
- Mondaini, R. P. (2020). Trends in Biomathematics: Modeling Cells, Flows, Epidemics, and the Environment. Springer International Publishing.
- Neuhauser C, 2010. Calculus for Biology and Medicine. Prentice Hall
- Skopenkov, A. (2021). Mathematics Via Problems: Algebra. MSRI Mathematical Sciences Research Institute.

Third Year Semester V

BTH-551 Microbial Biotechnology 3 (2+1)

Course Objectives
To enable students to utilize microbial systems in creating sustainable solutions for industries like agriculture, pharmaceuticals, and environmental management.

Course Learning Outcomes
By the end of this course, students will be able to:

- Assess the roles of microorganisms in various fields of biotechnology.
- Apply techniques for the cultivation, manipulation, and utilization of microorganisms.

- Evaluate microbial metabolic pathways for biotechnological applications.

Course content
Microbial diversity and applications in biotechnology. Microorganisms of industrial interest. Culture collections. Maintenance of culture. Improvement of strains of industrial interest. Selection of mutants. Genetic recombination techniques. GMOs. Substrates for industrial microbiology. Microbial metabolism. Fermentations and oxidations. Primary and secondary metabolites of industrial interest. Bioprocessing for pharmaceuticals and vaccines, enzymes, food and beverage, bioenergy and biofuels. Role of microbes in waste management, biofertilizer and biopesticide production. Single Cell Protein production. Quality control and regulatory aspects. Global challenges.

Labs
Microbial isolation and identification techniques. Enumeration techniques. Pure culture study. Characterization of microorganisms of industrial significance. Selection and analysis of mutants in microbial populations. Maintenance of microbial culture collections.

Recommended Books

- Benvenuto, M. (2024). Industrial Biotechnology. Berlin, Boston: De Gruyter.
- El-Mansi. (2007). Fermentation, Microbiology and Biotechnology. 2ª Edición. CRC Taylor & Francis.
- Glazer, H. Nikaido. (2007). Microbial Biotechnology: Fundamentals of Applied Microbiology. Cambrigde University Press.
- L Demain y J.E. Davies, (Eds.) (2010): Manual of Industrial Microbiology and Biotechnology (2ª edición), ASM Press, Washington DC
- Verma, P. (Ed.). (2022). Industrial microbiology and biotechnology. Singapore: Springer.

BTH-553 Agriculture Biotechnology 3 (2+1)

Course Objectives
To understand use and applications of biotechnological techniques with in the field of agricultural biotechnology.

Course Learning Outcomes
By the end of this course, students will be able to:
- Explain the principles and applications of genetic modification in crop and livestock improvement.
- Analyze the impact of biotechnology on food security and sustainable agricultural practices.
- Discuss the ethical and regulatory issues in agricultural biotechnology.

Course Content
Agriculture biotechnology and its applications. Agriculture environment. Modern farming practice. Tissue culture. Hydroponics. Soil improvement. Biological nitrogen fixation. Agricultural waste management for biocompost and vermicompost. Biofertilizers. Biotechnological tools for plant and animal breeding. Transformation techniques. Biopesticides. GM food and biosafety concerns. Seed production, field evaluation and commercialization, Germplasm storage. Disease control by biotechnological approaches. Hydroponics. Mushroom cultivation. Horticulture. floriculture, viticulture, olericulture, sericulture, apiculture, aquaculture. Application of plant genome analysis. Veterinary diagnostics.

Labs
Study of soil. Biological control of pathogens and pests. Study of symbiotic nitrogen fixation. Aerobic/anaerobic treatment of agricultural waste. Hydroponics. Mushroom production. Biofertilizer production. Agrobacterium mediated gene transformation. Applications of ELISA & PCR in agriculture biotechnology. Field trips to farm and industry.

Recommended Books
- Chong, P. A., Newman, D. J., & Steinmacher, D. A. (Eds.). (2020). Agricultural, Forestry and Bioindustry Biotechnology and Biodiscovery. Springer International Publishing.
- Kock, M. A. (2023). Intellectual Property Protection for Plant Related Innovation. Springer Cham.
- Nollet, L. M., & Mir, S. (Eds.). (2023). Biopesticides handbook. CRC Press.
- Raman, S. (Ed.). (2024). Agricultural sustainability: principles, processes, and prospects. CRC Press.
- Roy, S., & Hossain, A. (Eds.). (2024). The Nanotechnology Driven Agriculture: The Future Ahead. CRC Press.

BTH-555 **Biostatistics** **3 (3+0)**

Course objectives
To acquaint students with statistical techniques frequently used in biology to process real data.

Course Learning Outcomes
By the end of this course, students will be able to:
- Understand basic statistical concepts and methods used in biological research.
- Apply statistical techniques to analyze and interpret biological data.
- Use software tools to perform statistical analyses for experimental results.

Course Content
Definition of Statistics and Biostatistics and applications, Data, variables, type of variables. Organization and displaying data: measurement of scales, bars charts, pie charts, graph, Stem-and-leaf plot, box-and-whiskers plot, frequency distribution and frequency polygons, and frequency curves, etc. Data Summarisation: mean, median, mode, quartiles, standard deviation, variance, coefficient of variation, moments, skewness and Kurtosis. Probability: Introduction to probability, axioms on probability, set theory, laws of probability, Independence, conditional probability and its generalisation, Expectation, probability distribution, disctete probability distribution, Binomial & Poisson, continuous probability distribution, Normal Distribution.
Inferential statistics: Hypothesis, null and alternate, hypotheses, Statistical hypothesis, hypothesis testing, test of significance, confidence interval, Z, t, Chi-square and F-test, paired t-tests. Non-parametric & distribution free tests. Sign test and Rank test. Analysis of variance: Basis Concept of Design of Experiment, Replication, Randomization and Blocking. Completely Randomized Design (CRD), Randomized Complete Block Design (RCBD). Latin Square Design Least significant difference test. Simple linear regression and correlation.

Recommended Books
- Jyothis, A. R. (2024). Essentials of Biostatistics for Medical Students: Including manual on statistical analysis using SPSS. Notion Press.
- Linde, W. (2024). Probability Theory: A First Course in Probability Theory and Statistics. Walter de Gruyter GmbH & Co KG.
- Merrill, R. M. (2024). Introduction to epidemiology. Jones & Bartlett Learning.

- Saha, I., & Paul, B. (2023). Essentials of biostatistics and research methodology. Academic Publishers.
- Zhang, Y. (2007). Fundamentals of Biostatistics. Taylor & Francis.

BTH-557 Bioinformatics 3 (2+1)

Course Objectives
To provide students with a broad-based introduction to the field of bioinformatics in biotechnology.

Course Learning Outcomes
By the end of this course, students will be able to:
- Understand types, access and retrieval of data.
- Apply the principles of database searching, sequence alignment, phylogenetic analysis and protein structure prediction.
- Apply computational methods to solve problems in genomics and proteomics.

Course Content
Introduction to Bioinformatics. Data and Databases: Why build databases. Database file format. Types of databases. Sequence and structure databases. Data retrieval. Sequence alignment algorithms. Homology VS similarity. Global VS Local alignment. Database similarity searching Pairwise and multiple sequence alignment. PSI-BLAST. HMM. Sequence alignment analysis. Phylogeny and phylogenetic analysis. Relationship between sequence and structure. Secondary and tertiary structure prediction of proteins. Updated Databases and Tools will be used.

Labs
Biological literature search. Molecular visualization. Database searches i.e. Access to databases through Entrez, SRS, PIR, ExPASy. Pairwise alignment. Multiple alignment. Molecular modeling and visualization. Phylogenetics.

Recommended Books

- Jiang, R. Zhang, X., Michael, Q. (2013). Basics of Bioinformatics. Springer.
- Khalid S., Hasan H.O. (2023). Bioinformatics: One Semester Course. Springer Nature.
- Ramsden, J. (2015). Bioinformatics. An Introduction. Springer.
- Thomas D., Meik K. (2023). Bioinformatics: An Introductory Textbook. Springer Berlin, Heidelberg.
- Yasha H. (2023). All about Bioinformatics. From Beginner to Expert. Elsevier.

BTH-559 Recombinant DNA Technology 3 (2+1)

Course Objectives
The aim of this course is to introduce the students with the basics of DNA manipulations and genetic engineering.

Course Learning Outcomes
By the end of this course, students will be able to:
- Describe the principles and techniques of recombinant DNA technology.
- Design strategies for cloning, expressing, and analyzing recombinant genes.
- Evaluate the applications of genetic engineering in research and industry.

Course Content
Introduction to recombinant DNA technology. Definitions: overview and applications. History and development in the evolution of recombinant DNA technology. Isolation of plasmids, DNA and RNA. Analytical methods for quantification of genetic material. Electrophoretic techniques. Restriction enzymes. Types, functions and applications. Vectors for cloning. Plasmids. Bacteriophages. Viral vectors. Artificial chromosomes for DNA delivery. Techniques for cloning. Genomic and cDNA library. Transformation and methods. Selectable markers. Polymerase chain reaction. Ethical considerations regarding genetic manipulations and biotechnology advancements.

Labs
Isolation of chromosomal DNA. Gel electrophoresis. Estimation of nucleic acid size using DNA ladder. DNA quantifications and purity analysis. In-vitro mutagenesis assay using physical and chemical mutagen.

Recommended Books

- Brown, T. A. (2020). Gene cloning and DNA analysis: an introduction. John Wiley & Sons.
- Jain, A., Jain, R., & Jain, S. (2020). Basic Techniques in Biochemistry, Microbiology and Molecular Biology (pp. 235-242). New York, NY, USA: Springer.
- Nicholl, D. S. T. (2023). An Introduction to Genetic Engineering (4th ed.). Cambridge: Cambridge University Press.
- Raghavachari, N., & Garcia-Reyero, N. (Eds.). (2018). Gene Expression Analysis: Methods and Protocols. Humana Press.
- Zhang, H. (2020). Analyzing High-dimensional Gene Expression and DNA Methylation Data with R. Chapman and Hall/CRC.

500.1	**Internship**	**3 (0+3)**

Third Year - Semester VI

500.2	**Capstone**	**3(0+3)**

BTH-554	**Food Biotechnology**	**3 (2+1)**

Course Objectives
To acquaint students with the concept of biotechnology in food industry.

Learning Outcomes
By the end of this course, students will be able to:
- Explain the application of biotechnology in food production and processing.
- Describe the principles of fermentation and bioprocessing in food technology.
- Analyze the impact of genetically modified organisms on food safety and nutrition.

Course Content
Introduction to Food Biotechnology, Scope of Food Biotechnology, Biotechnological approaches to improve food quality, Food composition, Elements of food and their function, Microbiology of food, Enzymes in food production, Food preservation, Food borne infections and intoxication, Biotechnological approaches towards food safety and quality control. Food safety assessment; quality systems and HACCP,

Biotechnological food products; yogurt, cheese, cultured milk, bread, beer, wine, sausages, miso, kimchi, kombucha, kefir, tempeh, natto, sauerkraut, soy sauce, sausages, food additives, Prebiotics, Probiotics, Synbiotics, Single Cell Protein, Functional food, Saccharification, GM food, Food safety Regulations and social aspects of food biotechnology. Food packaging, food marketing, Mathematical Modeling in food technology.

Labs
Isolation and handling of microbial flora of fermented products, Flavored yogurt production. Cheese production, Pickles preparation, Pectin production. Gluten separation. Determination of iodine number of fats. Malt extract preparation. Sour bread studies. Preservation techniques. DNA extraction. Detection of GM foods. Visits to industry.

Recommended Books

- Ahmad, F., Mohammad, Z. H., Ibrahim, S. A., & Zaidi, S. (Eds.). (2024). Microbial Biotechnology in the Food Industry: Advances, Challenges, and Potential Solutions. Springer Nature.
- McClements, D. J. (2019). Food Biotechnology: Sculpting Genes with Genetic Engineering. In Future Foods (pp. 261-286). Copernicus, Cham.
- Mihaylova, D., Popova, A., Savchovska, S., Lante, A., & Dimitrova-Dimova, M. (2024). Food Science and Applied Biotechnology
- Muzhinji, N., & Ntuli, V. (2021). Genetically modified organisms and food security in Southern Africa: conundrum and discourse. GM Crops & Food, 12(1), 25-35.
- Teixeira, J. A., & Vicente, A. A. (Eds.). (2019). Engineering aspects of food biotechnology. CRC Press.

BTH-556 Methods in Molecular Biology 3 (2+1)

Course Objectives
To provide students with a broad-based introduction to the applications of molecular biology.

Course Learning Outcomes
By the end of this course, students will be able to:
- Understand fundamental molecular biology techniques.
- Interpret experimental data from molecular biology assays.
- Design molecular biology experiments to investigate gene function and expression.

Course Content
Restriction and modification systems: types, enzymes, classification, nomenclature, genetics and applications, cloning vectors: Plasmids (bacterial and yeasts), phages (lambda, Mu, M13). Cosmids and plasmids. P-and Ty-elements. Isolation, purification, restriction and legation of DNA molecules. Homopolymer tailing. Selection and characterization of recombinant molecules. Verification and amplification of desired genes. Gene banks. cDNA Libraries. Techniques developed for cloning eukaryotic genes in prokaryotes. Host systems available (bacteria, yeasts, plant cell, animal cells and human cells), Applications: human genetics, medicine, agriculture, environment, criminology, role of genetic engineering in biotechnology. Genome editing tools. Introduction to Human Genome Project.

Labs
The isolation of bacterial chromosomal DNA. Plasmid isolation. Bacterial transformation and screening of transformants. Gel electrophoresis of DNA. Restriction analysis of chromosomal and plasmid DNA. In vitro DNA amplification by PCR. Analysis of PCR products. RT-PCR.

Recommended Books

- Bhat, T.A., & Al-Khayri, J.M. (Eds.). (2023). Genetic Engineering: Volume 1: Principles Mechanism, and Expression (1st ed.). Apple Academic Press.
- Jain, A., Jain, R., & Jain, S. (2020). Basic Techniques in Biochemistry, Microbiology and Molecular Biology (pp. 235-242). New York, NY, USA::Springer.Brown, T. A. (2020). Gene cloning and DNA analysis: an introduction. John Wiley & Sons.
- Krugman E. (2023). Text book of plant genetic engineering. American Academic publishers.
- Nicholl, D. S. T. (2023). An Introduction to Genetic Engineering (4th ed.). Cambridge: Cambridge University Press.
- Zhang, H. (2020). Analyzing High-dimensional Gene Expression and DNA Methylation Data with R. Chapman and Hall/CRC.

BTH-558 Scientific Inquiry and Research Methods 3 (3+0)

Course Objectives

To familiarize students how research is done scientifically and ways to systematically solve a research problem.

Course Learning Outcomes

By the end of this course, students will be able to:

- Develop hypotheses and design experiments to test scientific questions
- Apply statistical methods to analyze and interpret scientific data.
- Communicate research findings effectively through written and oral presentations.

Course Content

An overview of scientific research. Nature of scientific inquiry. Role of student and supervisor in a scientific inquiry. Choosing a project. Formulating a hypothesis. Reviewing the literature: primary sources, secondary sources. Designing an investigation: Identifying the levels within an investigation, deciding on techniques to be employed. Data collection methods. Controls, samples and replication. Results, types of results. Analysis and interpretation of data using statistical methods. Scientific record keeping. Scientific misconduct: Fabrication, falsification and plagiarism. Scientific publication and communication. Structure and components of a research paper. How to write a research proposal: Title, introduction, objectives, methodology, budget, citation of references in various styles. Ethical considerations in publishing and authorship. Preparing posters and making oral presentations. Intellectual property.

Recommended Books

- Ajimotokan, H. A. (2022). Project Report Writing and Presentations. In Research Techniques: Qualitative, Quantitative and Mixed Methods Approaches for Engineers (pp. 55-76). Cham: Springer International Publishing.
- Armstrong, J. S., & Green, K. C. (2022). The scientific method: A guide to finding useful knowledge. Cambridge University Press.
- Chu, H. (2024). Research Methods and Design Beyond a Single Discipline: From Principles to Practice. Taylor & Francis.
- Kumari, S. K. V., Lavanya, K., Vidhya, V., Premila, G. A. D. J. S., & Lawrence, B. (2023). Research methodology (Vol. 1). Darshan Publishers.
- Säfsten, K., & Gustavsson, M. (2020). Research methodology: for engineers and other problem-solvers.

BTH-560 Principles of Biochemical Engineering 3 (2+1)

Course Objectives

To provide students with a comprehensive understanding of biochemical engineering principles, focusing on microbial growth and fermentation processes**.**

Course Learning Outcomes

By the end of this course, students will be able to:

- Comprehend basic bioreactor designs and principles.
- Understand unit operations and controls in bioprocessing.
- Have knowledge about sustainable practices in biochemical engineering.

Course Content

Overview of biochemical engineering. Microbial growth and fermentation. Microbial growth kinetics. Factors affecting microbial growth. Bioreactor design. Types of bioreactors (stirred-tank, airlift, etc.). Design considerations (scalability, mass transfer, temperature control). Fermentation media and nutrient requirements. Control strategies for bioreactors. Kinetics of bioreactor. Composition and formulation of fermentation media. Sterilization methods and their importance. Instrumentation and process control. Comparison of batch vs. continuous processes. Optimization of batch fermentation parameters. Strategies for continuous fermentation. Downstream processing in fermentation. Fermentation products and applications.

Labs

Demonstration and understanding of fermenter. Set up of batch and continuous fermentation process. Screening for industrially important microbes. Determination of doubling time for different bacterial strains. Exponential growth phase determination of screened bacterial cultures. Study of cell growth by semilogarithmic graph.

Recommended Books

- Berenjian A, (2019). Essentials in Fermentation Technology. Springer.
- Koubaa, M, Francisco J, Rohinejad SR, (2021). Fermentation Processes: Emerging and Conventional Technologies. Wiley.
- Medina R, (2019). Fermentation Technology. Edtech.
- Ronchetti, F., Springer, L., & Purnhagen, K. (2024). The Regulatory Landscape in the EU for Dairy Products Derived from Precision Fermentation: An Analysis on the Example of Cheese. Springer.
- Panda, A. K. (2024). Fermentation Technology: Driving Biotechnology to Work. In Biotechnology in India-Reworking A Strategy (pp. 219-234). Singapore: Springer Nature Singapore.

Fourth Year Semester VII

BTH- 651 **Industrial Biotechnology** **3 (2+1)**

Course Objectives
To provide students with a broad-based introduction to the field of industrial biotechnology.

Course Learning Outcomes
By the end of this course, students will be able to:
- Understand industrial-scale bioprocesses.
- Evaluate the use of various biocatalysts and fermentation techniques in industrial processes.
- Understand the optimization and scaling up biotechnological processes in industry.

Course Content
Industrial biotechnology – introduction and scope. Microorganisms commonly used in industry. Screening for productive strains and strain improvement. Media and nutritional requirements of industrial organisms. Optimization and scaling up biotechnological processes: How media composition affects microbial growth, productivity, and product formation, learn to balance factors like carbon, nitrogen, vitamins, and minerals for optimal fermentation results. Fermentation and fermenters. Extraction of fermented products: Techniques used to extract, purify, and concentrate products from fermentation broths.

Labs
Screening and isolation of proteases / amylases producing bacteria. Optimization of nutrient requirements and culture conditions. Fermentation. Extraction of hydrolytic crude enzymes from microbes. Fermentation of different sugars by bacteria (or other microorganisms).

Recommended Books

- Benvenuto, M. (2024). Industrial Biotechnology. Berlin, Boston: De Gruyter.
- Debabrata, D. and Soumya P. (2021). Industrial Biotechnology. Ist ed. CRC Press.
- Mark Warner PE. (2019). Industrial Biotechnology Commercialization Handbooks. How to make proteins without animals and feul or chemicals without crude oil. Science Direct.
- Verma, P. (Ed.). (2022). Industrial microbiology and biotechnology. Singapore:: Springer.
- Wittmann, C and James, C.L. (2016). Industrial Biotechnology: Products and Process.. Wiley-VCH verlag GmbH and Co.

BTH-653 **Health Biotechnology** **3 (3+0)**

Course Objectives
To provide a comprehensive understanding of the principles and applications of biotechnology in health and medicine.

Course Learning Outcomes
By the end of this course, students will be able to:
- Describe the role of biotechnology in the development of diagnostics and therapeutics.
- Explain the principles of gene therapy and regenerative medicine.
- Evaluate the ethical and regulatory issues in health biotechnology.

Course Content
Overview of biotechnology in health. Historical milestones in health biotechnology. Key concepts and terminology. Molecular biology techniques. Genetic engineering and gene therapy. Recombinant DNA technology. Clinical trials and regulatory considerations. Biopharmaceuticals. Proteomics and metabolomics. Diagnostics and Biomarkers. Development of vaccines using biotechnological methods. Monoclonal antibodies. Immunotherapy. Regulations governing biotechnology research. Ethical considerations in health biotechnology. Public perception and societal impacts. Statistics in healthcare. Emerging Trends and Innovations.

Labs
Testing bacterial isolates for susceptibility to antibiotics. Practical applications of PCR and RT-PCR. Visualizing PCR products and analyzing DNA fragment sizes. Detection of specific proteins through ELIZA. PCR and ELISA in the detection of infectious diseases. Health Trends with Time Series Analysis. Monitoring of healthcare quality metrics.

Recommended Books

- Bose, S., Shukla, A. C., Baig, M. R., & Banerjee, S. (2024). Concepts in Pharmaceutical Biotechnology and Drug Development. Springer.
- Buse, K., Mays, N., Colombini, M., Fraser, A., Khan, M., & Walls, H. (2023). Making Health Policy, 3e. McGraw Hill.
- Crommelin, D.J.A., Sindelar, R.D. and Meibohm, B.C. (2008). Pharmaceutical Biotechnology: Fundamentals and Applications. 3rd Edition. Informa Health Care USA, Inc.
- Goering, R., Dockrell, H. M., Zuckerman, M., & Chiodini, P. L. (2023). Mims' Medical Microbiology E-Book: Mims' Medical Microbiology E-Book. Elsevier Health Sciences.
- Hench, L.L., Jones, J.R. and Fenn, M.B. (2012). New material and Technologies for Health Care. Imperial College Press.

BTH-655 Biosafety, Biosecurity and Bioethics 2 (2+0)

Course Objectives
To acquaint students with principles of biosafety, biosecurity and ethical perspectives pertaining to biotechnology.

Course Learning Outcomes
By the end of this course, students will be able to:
- Understand levels, protocols and regulations of biosafety and biosecurity.
- Evaluate biosecurity measures to prevent the misuse of biotechnological advances.
- Understand ethical considerations in biotechnology research and applications.

Course Content
Introduction to biosafety and biosecurity. Science-based assessment and management of biological threats and risks: Chemical, biological and radiation hazards and control. Fire, electrical and noise hazards and control. Waste disposal and management. Basic laboratory levels: lab design and facility. Biological safety cabinets and safety equipment. Biorisk Management- Risk Assessment. Overview of biosafety and biosecurity risk mitigation principles and practices. Laboratory Biorisk Management (BRM) System. National Biosafety Guidelines: Pakistan Biosafety Rules, 2005. Ethics and legislation in biotechnology: Role of state, Ethical issues related to Organ donation and transplantation, in vitro fertilization, experimentation with human subjects, animals, plants, microorganisms, stem cell research, before birth issues involving embryos and fetuses, ethical issues in gene therapy ad tissue engineering, environmental

issues related to accidental and deliberate release of GMOs. Philosophical and religious aspects and sustainability issues. Sensitivity to social environment, Anticorporate arguments, Protection of intellectual property rights. Research ethics: authorship, peer review.

Recommended Books

- Childress, J. F. (2020). Public bioethics: principles and problems. Oxford University Press, USA.
- De Leon, M. P., & Baclig, M. O. (2025). Biosafety and Biosecurity in the Academe. In Biosafety and Biosecurity CRC Press.
- National Biosafety Guidelines, (2005). Pakistan Environmental protection Agency (Available online).
- National Guidelines for Collection, Usage, Storage, and Export of Human Biological Materials 2020. (2020). Citiline Advertising, Islamabad, Pakistan
- Segaran P. Pillai, Stephen Allen Morse, (2023) Insights In Biosafety & Biosecurity: Novel Developments, Current Challenges, and Future Perspectives, Frontiers Media SA.
- World Health Organization. (2024). Laboratory biosecurity guidance. World Health Organization.

BTH-657 Artificial Intelligence in Biotechnology 2 (2+0)

Course Objectives

Equip students with the knowledge and skills to leverage artificial intelligence in biotechnology applications, focusing on drug discovery, biomarker identification, and clinical trial optimization.

Course Learning Outcomes

By the end of this course, the students will be able to:

- Explain the fundamental concepts of artificial intelligence and its applications in biotechnology.
- Identify the role of artificial intelligence in various biotechnological processes and research.
- Demonstrate an understanding of the ethical considerations related to artificial intelligence in biotechnology.

Course Content

Course Content:

Introduction to AI in Biotechnology. Types and sources of biological data. AI mediated statistical analysis. Concept of Deep learning and machine learning. Basics of programming tools and software related to biotechnology. Artificial Intelligence (AI) in the pharmaceutical industry. Molecular design to predictive patient reaction models. Biomarkers discovery. AI for early drug discovery. Building disease model. Design and management of clinical trials.Applications of AI in agriculture: control and automation of crops, irrigation system, monitoring livestock, pest management etc. Application of AI in structural biology: structural and functional analysis using AI tools. Ethical implications of AI in biotechnology.

Recommended books

- Artificial Intelligence for Health 4.0: Challenges and Applications. (n.d.). Denmark: River Publishers.
- Chaurasia, R. K., Maheswari, V., & Saini, A. K. (2024). Introduction to AI in Biomedical and Biotechnology. In Future of AI in Biomedicine and Biotechnology. IGI Global. PA USA.
- Hilbush, B. S. (2021). In Silico Dreams: How Artificial Intelligence and Biotechnology Will Create the Medicines of the Future. United States: Wiley.
- Khanna, A., El Barachi, M., Jain, S., Kumar, M., & Nayyar, A. (Eds.). (2024). Artificial Intelligence and machine learning in drug design and development. John Wiley & Sons.
- Trends in artificial intelligence for biotechnology (2023). New Biotechnology.

● Vargas, J. (2023). Humanity 3.0 the Era of Artificial Intelligence and Biotechnology. (n.p.): Jairo Vargas.

BTH-659 **Genomics and Proteomics** **3 (3+0)**

Course Objectives
To provide students with an overview of both the theoretical and experimental aspects of structural and functional genomics as well as proteomics.

Course Learning Outcomes
By the end of this course, students will be able to:
- Explain the principles and techniques used in genomics and proteomics.
- Analyze genomic and proteomic data to identify gene and protein functions.
- Discuss the applications of genomics and proteomics in biotechnology.

Course Content
Organization and structure of genomes. Genetic mapping (RFLP, microsatellite, SNP). High resolution physical mapping (STS, EST). Flow cytometry. Somatic cell and radiation hybrids. artificial chromosomes in bacteria and yeast; hierarchical and whole genome shotgun sequencing; DNA sequencing strategies: manual and automated sequencing, pyrosequencing, real-time and nanopore sequencing. Sequence assembly. Obstacles and solutions. Estimating gene number. Over-prediction and under-prediction. Homology searches. Exon prediction programs. Integrated gene-finding software packages. Structural variation in the genome and its applications. Microarray and RNA interference. Proteomics. Cellular communication. Signalling pathways. Protein-protein interactions and validation - yeast two hybrid system. Affinity purification Mass spectrometry (AP-MS), tandem affinity purification (TAP). Tagging. Fluorescence resonance energy transfer (FRET) and co-immunoprecipitation.

Recommended Books
- Amit, K.T., Ajith, A. (2023). Datascience for Genomics. Academic Press.
- Brooke F., Xuefeng, W. (2023). Statistical Genomics. Humana Press. NewYork.
- Katherina, J., Thomas, V. (2023). Comparative Genomics. Springer Chem.
- Richard, T. (2014). Principles of Proteomics. 2nd ed. Garland Science.
- Roychoudhury, A. (Ed.). (2024). Plant Proteomics: Implications in Growth, Quality Improvement, and Stress Resilience. CRC Press.Seshasayee, A. S. N. (2015). Bacterial Genomics. Cambridge University Press.

Fourth Year Semester VIII

BTH-652 **Nanobiotechnology** **3 (3+0)**

Course Objectives
The aim of this course is to equip the students with the concepts and applications of nanobiotechnology, their preparations and applications.

Course Learning Objectives
By the end of this course, students will be able to:
- Describe the principles of nanotechnology in biotechnology.

- Explain the methods for the synthesis and characterization of nanomaterials.
- Discuss the impact of nanobiotechnology on various fields.

Course Content

Nanobiotechnology: Concept and History. Nanomaterials in nanobiotechnology. Nanosized vs Bulk m2aterials. Principles of nanomaterial synthesis. Colloids. Oxidation and reduction reactions. Ostwald ripening and coalescence. Van der waals and coulomb interactions. Nuclei formation and the control of the nano particle shape. Nanomaterials: Preparation strategies. Bottom-up and Top-down Strategies. Metallic nanoparticles: A brief overview. Preparation of metal oxide nanomaterials. Sol–Gel processing. Preparation of carbon nanomaterials. Synthesis of fullerene. Carbon nanotubes and graphene. Preparation of carbon nanodiamonds. Biomolecules and scales of biological systems. Cell compartments. Nanocellulose. Lipids. Nucleic Acids. Proteins in nanobiotechnology: Interfacing proteins. Antibodies in cancer therapy. (Bio)functionalization of nanomaterials. Self-Assembly. Modification of the nanomaterial surface. DNA-directed assembly of nanoparticles. Analytical methods in nanobiotechnology. Transmission electron microscopy. Cryogenic electron microscopy. Scanning electron Microscopy. X-ray diffraction. Energy dispersive X-ray analysis. X-ray photoelectron spectroscopy. Mass spectrometry. Scanning tunnelling microscopy. Atomic force microscopy. Ultraviolet–Visible Spectroscopy. Determining the concentration of functionalized silver nanoparticles. Fluorescence: Spectroscopy and Microscopy. Types of fluorescence microscopy. Vibrational spectroscopy: Infrared spectroscopy. Exploring biomolecular interactions on the nanoscale. DNA–nanoparticle conjugates. DNA for material design: DNA hydrogels. DNA nano structuring. DNA origami.

Recommended Books

- Ajaya, K.S. (2024). Bionanotechnology for advance applications. CRC Press.
- Bachheti, R. K., Bachheti, A., & Husen, A. (2024). Metal and Metal-Oxide Based Nanomaterials: Synthesis, Agricultural, Biomedical and Environmental Interventions. Springer.
- Fruk, L., &Kerbs, A. (2021). Bionanotechnology: Concepts and Applications. Cambridge: Cambridge University Press.
- Jie, C., Yiwei, F., Scott, M. (2022). Bionanotechnology: Engineering Concepts and applications. McGraw Hills.
- Juhi, S., Abhijeet, S., Anupam, J. (2023). Nanobiotechnology: Principals and applications. Bantham Books.
- Mandal, A. K., Ghorai, S., & Husen, A. (Eds.). (2024). Functionalized smart nanomaterials for point-of-care testing. Springer Nature Singapore.

BTH-654 Environmental Biotechnology 3 (2+1)

Course Objectives

To acquaint students with conservation and reclamation of environment through biotechnology.

Course Learning Outcomes

By the end of this course, students will be able to:

- Describe biotechnological approaches for environmental remediation.
- Explain the role of microbes and plants in waste treatment and pollution control.
- Evaluate the use of biotechnology in sustainable environmental management.

Course Content

Introduction to environmental biotechnology. Scope of environmental biotechnology. Biological interventions. Pollution indicators. Pollution control strategies. Genetic manipulation strategies in

environmental biotechnology. Air pollution management. Water purification. Waste water treatment, Industrial effluent treatment. Sludge disposal. Contaminated land treatment. Solid waste management. Landfills and composting. Concepts of integrated environmental biotechnology. Detoxification of hazardous pollutants: Biodegradation and biotransformation. Bioremediation, phytoremediation. Biotechnological products and tools for environmental sustainability.

Labs
Field trips and surveys of polluted areas and study for pollution indicators. Biodegradation of environmental pollutants by microorganisms. Bacteriology of drinking water. Microscopic studies of water specimens collected from various locations. Coliform detection. Cellulose decomposition. Biodegradation of petroleum. Bioleaching.

Recommended Books

- Bachheti, R. K., Bachheti, A., & Husen, A. (2024). Metal and Metal-Oxide Based Nanomaterials: Synthesis, Agricultural, Biomedical and Environmental Interventions. Springer.
- Chong, P. A., Newman, D. J., & Steinmacher, D. A. (Eds.). (2020). Agricultural, Forestry and Bioindustry Biotechnology and Biodiscovery. Springer International Publishing
- Ghahari, S., Ghahari, S., Ghahari, S., Nematzadeh, G. A., & Sarma, H. (2021). Environmental Biotechnology: Toward a Sustainable Future. In Biotechnology for Sustainable Environment (pp. 1-31). Springer, Singapore.
- Hakeem, K. R., Bhat, R. A., & Qadri, H. (2020). Bioremediation and biotechnology. Springer: Cham, Switzerland.
- Sanchez, G., & Hernandez, E. (Eds.). (2023). Environmental biotechnology and cleaner bioprocesses. CRC Press.

Electives

BTH-656 Biotechnology Business Applications 3 (2+1)

Course Objectives
To provide students with the knowledge and skills necessary to translate innovative ideas into viable business opportunities**.**

Course Learning Outcomes
By the end of this course, students will be able to:
- Understand entrepreneurship in biotechnology including the unique challenges and opportunities associated with it.
- Identify, analyze, and evaluate potential business opportunities in the biotechnology sector.
- Develop a comprehensive business model and plan and present a biotechnology business idea to potential investors for a biotechnology startup.

Course Content
Introduction to Entrepreneurship: Definition and types of entrepreneurships, role of entrepreneurship in biotechnology, the entrepreneurial mindset and characteristics of successful biotech entrepreneurs. Biotechnology industry overview: Current trends and future opportunities in the biotechnology sector, Key areas of innovation in biotechnology, overview of the biotech product development cycle. Identifying Business Opportunities in Biotechnology. Business Models and Planning for Biotech Ventures: components

of a biotech business plan, different business models in biotechnology. Market Research and Feasibility Studies: conducting market research for biotech products, analyzing competition and target markets, assessing market potential and product demand. Intellectual Property (IP) in Biotechnology. Overview of IP types: patents, trademarks, copyrights, and trade secrets. Financing Biotech Startups: different sources of funding for biotech ventures: venture capital, angel investors, government grants, and crowdfunding. Regulatory Framework in Biotechnology: overview of regulatory bodies (e.g., FDA, EMA) and their role in biotech, Key regulatory requirements for biotech products (drugs, diagnostics, GMOs).

Lab
Students are required to explore the possibilities of a biotechnology venture in local industry and submit a research and development project at the end of the semester.

Recommended Books

- Devi, S., Sabesan, G. S., & Ismail, S. A. (Eds.). (2024). Opportunities for Biotechnology Research and Entrepreneurship. Bentham Science Publishers.
- Hisrich, R. D., Peters, M. P., & Shepherd, D. A. (2017). Entrepreneurship. McGraw-Hill Education.
- Laverty, M., & Littel, C. (2024). Entrepreneurship. OpenStax, Rice University.
- Ratten, V. (2024). Entrepreneurial Business Venturing. Springer Nature Singapore.
- Shimasaki, C. (Ed.). (2020). Biotechnology entrepreneurship: starting, managing, and leading biotech companies. Academic Press.

BTH-658 Plant Tissue Culture and Regeneration 3 (2+1)

Course Objectives
To provide students with a thorough understanding of the importance of cell, tissue and organ culture and its application in life sciences.

Course Learning Outcomes
By the end of this course, students will be able to:
- Apply techniques for establishing plant tissue culture of any plant using, aseptically.
- Describe the types of in vitro cultures, able to understand all aspect of tissue culture including somatic embryogenesis, somaclonal variation, and synthetic seeds.
- Sufficiently equipped with practical aspect of plant tissue culture and its laboratory.

Course Contents
Plant cell and tissue culture: Introduction: Definition, applications and history. Organization of a plant tissue culture laboratory: Equipments and supplies. Tissue culture medium: components and preparation. Explants selection and sterilization. Requirements for in vitro cultures; culture facilities; sterile techniques; media preparation and handling; callus cultures; cell suspension cultures; protoplast culture; haploid cultures, organ culture; meristem culture for virus elimination; embryo culture and embryo rescue; regeneration of plants and micropropagation; somaclonal variation; industrial uses of plant cell culture; tissue culture in genetic engineering and biotechnology. somatic embryogenesis and production of synthetic seeds. Callus culture. Cell suspension culture. Secondary metabolites. Cryopreservation.

Labs
Organization of a plant tissue culture lab. Glassware preparation and sterilization. Preparation of stock solutions. Media preparation. Explant preparation. Micropropagation. Adventitious shoot proliferation. Seed culture. Callus culture. Cell suspension culture. Meristem culture for virus elimination. Somatic embryogenesis.

Recommended Books

- Khasim SM , ThammasiriK, Rao SR , RahamtullaM. Plant techniques: theory and practice, (2024). CRC Press.
- Reddy J, (2024). Plant tissue culture.CRC Press.
- Nhut DT, Yeung ECT, Tung HT, (2022). Plant tissue culture: new techniques and application in horticultural species of tropical region. Springer Nature.
- Robert NT, Dennis JG, (2018). Plant tissue culture, development and biotechnology. CRC Press.
- Lindsey K, (2014). Plant tissue culture manual-supplement 7: fundamental and applications. Springer Netherlands.

BTH-660 **Marine Biotechnology** **3 (2+1)**

Course Objectives

To impart knowledge of biotechnological applications of marine organisms, important processes and impacts on the marine ecosystems and ways to control them.

Course Learning Outcomes

By the end of this course, students will be able to:

- Understand the key marine organisms and their applications in aquaculture, disease management, genetic improvement, and sustainable practices to enhance fish and shellfish production.
- Assess the role of marine biotechnology in environmental remediation.
- Design and conduct independent research projects, employing appropriate methodologies to address specific questions in marine biotechnology.

Course Content

Introduction to marine biotechnology. Marine environment & ecological factors, physical properties of seawater, waves, currents and tides, estuaries. Classification of marine environment. Marine ecosystem; animal, plants, microorganisms, metazoans, macroalgae microalgae, thraustochytrids. Aquaculture. Algaculture. GMO's. Biotechnological production of primary & secondary metabolites; bioactive marine compounds, GFP, RFP, mussel adhesive protein, chitosan, nutraceuticals, cosmeceuticals. Biomaterials and Bioengineering. Bioprospecting and Drug Discovery. Strategies for isolating and characterizing marine-derived compounds. Marine pollution and bioremediation. Biofloc technology. Ecosystem Restoration. Ocean management.

Labs

Mangroove field trip, study of marine ecology. Isolation of marine bioactive compounds. Biochemical estimation of marine waste. Estimation of chitin in crustacean. Exploitation of biotechnological marine products. Bioremediation. Designing an aquaculture facility.

Recommended Books

- Dong, S. L., Tian, X. L., Gao, Q. F., & Dong, Y. W. (Eds.). (2023). *Aquaculture ecology*. Springer Nature.
- Hossain, J., & Jahan, R. (2021). Biofuel: Marine Biotechnology Securing Alternative Sources of Renewable Energy. In Advances in the Domain of Environmental Biotechnology.Springer, Singapore.
- Lim, C., Lee, C. S., & Webster, C. D. (Eds.). (2023). *Alternative protein sources in aquaculture diets*. CRC Press.
- Rampelotto, P. H., &Trincone, A. (Eds.). (2018). Grand Challenges in Marine Biotechnology. Springer International Publishing.
- Sumich, J. L., & Pinkard-Meier, D. R. (2016). Introduction to the biology of marine life. Jones & Bartlett Learning.
- Weis, J. S. (2024). *Marine Pollution: What Everyone Needs to Know®*. Oxford University Press.

BTH-661 **Animal Cell and Tissue Culture** **3 (2+1)**

Course Objective
The aim of the course is to provide theoretical and practical knowledge, required for dealing with animal cell and tissue culture *in vitro* and to prepare students capable to maintain animal cells and tissues under *in vitro* conditions.

Course Learning Outcomes
By the end of this course, students will be able to:

- Demonstrate a comprehensive understanding of cell culture techniques and successfully maintain cultures of animal cells and established cell lines with good viability with minimal contamination.
- Perform supportive or episodic tasks relevant to cell culture, including preparation and evaluation of media, cryopreservation and recovery, and assessment of cell growth/health.
- Recognize and troubleshoot problems common to routine cell culture.

Course Content:
Introduction to animal cell culture, history and application, advantages and limitations. Lab design and equipments. Biology and genetics of cultured cells. Cell and its environment, culture media, medium components, substrates for cells attachments, serum free medium. Initiation of primary cultures and establishment of cell lines, aberrant growth control and contact inhibition, immortalization, tumorigenicity. Subculture and propagation. Detection of contamination. Cryopreservation. Quantitation. Cloning and selection. Physical methods for cell separation. Cell characterization, morphology, chromosomes, karyotyping, enzyme activity and antigenic markers. Cell differentiation. Cell transfection with physical, chemical and biological agents. 3D culture systems and specialized techniques, somatic cell fusion and selection of hybrids, heterokaryons, hybridomas organ and histotypic cultures.

Labs
Handling and preservation of animal cells. Primary culture of chick embryo fibroblasts. Culture of lymphocytes and karyotyping. Cloning of animal cells. Cytotoxicity evaluation. Cell transformation.

Recommended Books

- Capes-Davis and Freshney, R. I. (2021). Freshney's Culture of Animal Cells: A manual of Basic techniques and specialized Applications. 8th edition. Wiley- Blackwell.
- Freshner, R.I. (2010) Culture of Animal Cells. 6th ed. Wiley- Blackwell .
- Helgason, C. D. and Miller, C. L. (2004) Basic Cell Culture Protocols. 3rd ed. Humana Press. USA.
- Shalini M, Manisha, S., Anil, K. (2023). Animal Cell Culture: Principles and practice. Springer Cham.
- Masters, J.R.W. (2000) Animal Cell Culture. 3rd ed. Oxford University Press. UK.

BTH-662 **Medical Biotechnology** **3 (2+1)**

Course Objectives
To understand use and applications of relevant analytical techniques with in the field of medical biotechnology.

Course Learning Outcomes
After successful completion of the course, student will have

- Comprehension of theoretical and practical concepts and principles of medical biotechnology.
- Evaluate the use of biotechnological methods in the development of diagnostic tools and therapeutic strategies, including vaccines and gene therapies.
- The ability to identify, organize and answer problems in medical biotechnology.

Course Content
Conventional medical biotechnology. Contemporary issues in medical biotechnology. Drug delivery. Introduction to principles of gene therapy and gene delivery. Introduction to principles of gene therapy and gene delivery system. Biodegradable polymers. Practical and theoretical problems of modern methods of disease therapy. Role of organ transplantation in curing & neo-organ production. Use of transgenic animals in therapy. The principles and practices of transfusion techniques. Preparation of blood components and their use. Essentials of osteopathic principles. Human and veterinary osteopathy and bone grafting. Xenotransplantation pharmacogenetics, biopharmaceuticals from plants; stem cell technology.

Labs
PCR based diagnostic. ELISA based diagnostics. Production of polyclonal antisera. Isolation of lymphocytes, lymphocyte counting and resetting technique. Rocket immunoelectrophoresis.

Recommended Books

- Bhaskar, B. (2021). Biomaterials in Tissue Engineering and Regenerative Medicine: From Basic Concepts to State of the Art Approaches. Springer Nature.
- Khan, F. A. (2014). Biotechnology in medical sciences. CRC Press.
- Marks, L. (Ed.). (2017). Engineering health: how biotechnology changed medicine. Royal Society of Chemistry.
- Pham, P. V. (2018). Medical biotechnology: techniques and applications. In Omics Technologies and Bio-Engineering (pp. 449-469). Academic Press.
- Pongracz, J., & Keen, M. (Eds.). (2009). Medical biotechnology. Elsevier Health Sciences.

BTH-663 Advances in Immunology 3 (2+1)

Course Objectives
To acquaint students with innovative immunological approaches to play a significant role in the future of biomedical, medicine and the pharmaceutical industries.

Course Learning Outcomes
By the end of this course, students will be able to:
- Demonstrate a comprehensive understanding of the molecules and receptors involved in immune function and dysfunction, and their roles in various diseases.
- Apply key immunological principles in the development of assays, drugs, vaccines, and diagnostic tests within medical and veterinary contexts.
- Utilize analytical techniques such as immunohistology and flow cytometry to analyze immune-related conditions, including autoimmunity, cancer, and graft rejection.

Course Content
Molecules and receptors involved in immune function and dysfunction. The pathophysiology of important diseases of the immune system and current approaches to diagnosis and treatment. The application of key immunological concepts in the development of various assays used in medical and veterinary laboratories. Applications of immunological concepts in the development of drugs, vaccines and diagnostic tests. Analytical techniques used in immunology: immunohistology and flow cytometry. Immune-related conditions such as autoimmunity, cancer, HIV, and transplantation and graft rejection.

Labs
Animal handling rabbit, mouse, Isolation of macrophages from the peritoneal cavity of mouse, ELISA, Immunochromatography test, Heamagglutination test, single radial immunodiffusion, double immunodiffusion, ouchterlony, ASOT, PPD test.

Recommended Books

- Frederick W.A., Kenneth, M.M. (2024). Advances in Immunology. Academic press.
- Chalamcherla, V. (2021). Principles of Immunology. Horizon Books (A Division of Ignited Minds Edutech P Ltd).
- Coico, R. (2021). Immunology: a short course. John Wiley & Sons.
- Kuby J, (2007). Immunology. Sixth Edition; WH Freeman, New York.
- Sam-Yellowe, T. Y. (2021). Immunology: Overview and Laboratory Manual. Springer Nature.

BTH-664 Biofuels and Biorefineries 3 (2+1)

Course Objectives

To acquaint students with the sources of biomass and their extraction and processing for industrial use.

Course Learning Outcomes

By the end of this course, students will be able to:

- Explain the types, applications and their impacts of biofuel and biorefineries.
- Discuss the existing and potential sources of renewable energy.
- Describe the various processes for producing.

Course Content

Biofuels: Introduction, types and sources, feedstocks and characteristics. Agro-industrial byproducts and biodegradable materials. Biorefineries. Classification of biorefineries: Conventional biorefineries (CBR), Green biorefineries (GBR), Whole crop biorefineries (WCBR), Lignocellulosic feedstock biorefineries (LCFBR), Two platform concept biorefineries (TPCBR), Thermochemical biorefineries (TCBR), Marine biorefineries (MBR). Economic, social and environmental impacts of biorefining. Current status and developmental trends of biorefineries. Technical, commercial, strategic and sustainability challenges. Bioethanol and biobutanol production. Biodiesel production. Biogas. Bioethers.

Labs

Preparation of Biogas, Preparation of compost from agriculture waste, Alcohol production.

Recommended Books

- Singh, P. (Ed.). (2024). Emerging Trends and Techniques in Biofuel Production from Agricultural Waste. Springer.
- Solarte-Toro, J. C., & Cardona Alzate, C. A. (2023). Sustainability of biorefineries: Challenges and perspectives. Energies, 16(9), 3786.
- Verts et al., (2010). Biomass to Biofuels: Strategies for Global Industries. First Edition; Wiley.
- Yan, J., & Salman, C. A. (2023). Waste Biorefineries: Advanced Design Concepts for Integrated Waste to Energy Processes. Elsevier
- Yaser, A. Z., Chin, S. X., Torre, L. S., &Haghi, A. K. (Eds.). (2024). Waste Biorefineries: Future Energy, Green Products, and Waste Treatment. CRC Press.

BTH-665 **Molecular Diagnostics** **3 (2+1)**

Course Objectives
To acquaint students with modern techniques used in molecular diagnostics.

Course Learning Objectives:
Upon successful completion of the courses, the student will be able to:

- Identify the important principles and parameters in the design of a laboratory to conduct the most commonly-used molecular diagnostics protocols.
- Become proficient with the techniques required in order to perform the most commonly-used molecular diagnostics protocols.
- Evaluate the use of biotechnological methods in the development of diagnostic tools and therapeutic strategies, including vaccines and gene therapies.

Course Content:
Introduction and applications of molecular analysis methods in medicine, agriculture, forensic and basic research. Spectrophotometric and fluorescent-based quantitation of nucleic acid, DNA amplification techniques; polymerase chain reaction, real time PCR, PCR sizing, multiplex ligation probe amplification. Single nucleotide polymorphisms (SNPs) and restriction fragment length polymorphisms (RFLPs); DNA sanger sequencing; Next generation sequencing, Blotting techniques (e.g., Southern, Northern and Western); protein electrophoresis, enzyme-linked immunosorbant assays, immunofluorescence staining and immunohistochemistry, microarrays; *in situ* hybridization, molecular cytogenetics.

Labs
ELISA, PCR, Karyotyping, Flourescent In situ hybridization Visits to various diagnostic, pathology laboratories and research institutes.

Recommended Books

- Buckingham, L. (2019). Molecular diagnostics: fundamentals, methods and clinical applications. FA Davis.
- Persing, D. H., Tenover, F. C., Hayden, R. T., Ieven, M., Miller, M. B., Nolte, F.S. van Belkum, A. (Eds.). (2020). Molecular microbiology: diagnostic principles and practice. John Wiley & Sons.
- Vasef, M.A. Auerbach, A. (2024). Diagnostic pathology: Molecular oncology. 3rd Ed. Elsevier.
- Nader, R. (2023). Tietz Fundamentals of clinical chemistry and molecular diagnostics. 9th Ed. Elsevier.
- William B.C., Gregory, J.T. (2023). Diagnostic Molecular Pathology. A guide to molecular testing. Academic Press.

BTH-666 **Fungal Biotechnology** **3 (2+1)**

Course Objectives
To acquaint students with the understanding of fungi and their utilization in industry and agriculture.

Course Learning Outcomes
By the end of this course, students will be able to:

- Describe the essential concepts of mycology.
- Demonstrate the culturing techniques of fungi

- Discuss the use of fungi for industrial benefits.

Course Content
Introduction to mycology. Fungal isolation and culturing techniques. Fungal morphology and molecular typing. Production techniques used in fungal biotechnology. Fungal metabolism in different environments. Metabolites produced by fungi. Industrial uses of fungi. Utilization of fungi in medical and agricultural biotechnology. Role of fungi in degrading environmental pollutants. Bio-deterioration and biodegradation. Fungal diseases in humans, plant and animals. Biotechnology and the control of pathogenic fungi. Current applications of fungal biotechnology and screening of fungal metabolites. Mycotoxins.

Labs
Fungal morphology. Conventional identification techniques of fungi, DNA extraction from hyphae and spores. Molecular techniques for the detection of genetic variations among different fungi. Mycotoxin detection and identification. Fungal metabolite production. Biodegradation of dyes.

Recommended Books

- Bunyard, B. A. (2024). The Little Book of Fungi. Princeton University Press. New Jersey. USA.
- Gupta, V. K., Tuohy, M. G., Ayyachamy, M., Turner, K. M., &O'donovan, A. (2022). Laboratory protocols in fungal biology. Springer International Publishing.
- Hsueh, Y. P., & Blackwell, M. (Eds.). (2024). Fungal Associations. Springer.
- Singh, K., Kaur, R., & Deshmukh, R. (2024). Biotechnological Advances for Disease Tolerance in Plants. Springer Nature Singapore, Imprint: Springer.
- Yadav, A. N., Singh, S., Mishra, S., & Gupta, A. (2019). Recent advancement in white biotechnology through fungi. Springer International Publishing.

BTH-667 Forensic Biotechnology 3 (3+0)

Course Objectives
To acquaint students with the challenging field of forensic sciences.

Course Learning Outcomes
By the end of this course, students will be able to:
- Apply advanced molecular biology techniques to analyze biological evidence and interpret results accurately in the context of forensic investigations.
- Demonstrate knowledge of the legal and ethical considerations in forensic biotechnology.
- Develop the ability to critically analyze forensic cases to formulate well-supported conclusions and recommendations.

Course Content
Forensic science and its application. Role of biotechnology in forensic science. Biological evidences and their types. Biological evidence collection and preservation. Sample mishandling and data recording errors. Uniqueness. Uncertainty about estimated frequencies. Chain of custody of evidence. Molecular biology techniques: Polymerase chain reaction (PCR), gel electrophoresis, DNA profiling, mitochondrial DNA analysis etc. Forensic DNA Analysis: STR (Short Tandem Repeat) analysis, Y-STR analysis for male lineage tracing, (Single Nucleotide Polymorphism) analysis. Advanced Techniques in Forensic Biotechnology: Next-generation sequencing (NGS) technologies, bioinformatics and data analysis, application of CRISPR technology. Toxicology in Forensics. Forensic Anthropology. Probability. Likelihood ratios and posterior odds Legal and Ethical Considerations. Case Studies. Mock crime scene investigations. Current Trends, emerging technologies and future directions.

Recommended Books

- Dash, H. R., Elkins, K. M., Al-Snan, N. R., & Dash, H. R. (2023). Advancements in Forensic DNA Analysis. Springer.
- Elkins, K. M., & Zeller, C. B. (2021). Next generation sequencing in forensic science: a primer. CRC Press.
- Houck, M. M., & Siegel, J. A. (2009). Fundamentals of forensic science. Academic Press.
- Shrivastava, P., Lorente, J. A., Srivastava, A., Badiye, A., & Kapoor, N. (Eds.). (2023). Textbook of Forensic Science. Springer.
- Spencer, J. T. (2024). Introduction to Forensic Science: the science of criminalistics. CRC Press.