Pir Mehr Ali Shah
ARID AGRICULTURE UNIVERSITY RAWALPINDI
University Institute of Biochemistry and Biotechnology

No. PMAS-AAUR/UIBB/____
May 23, 2025

Subject: **Agenda for 78th meeting of Academic Council: UIBB**

Reference to letter No. PMAS AAUR/1799 dated April 29, 2025; please find enclosed herewith the agenda item for the 78th Academic Council meeting. The agenda items have been approved in the 13th meeting of the Faculty Board of University Institute of Biochemistry and Biotechnology (UIBB) held on May 23, 2025.

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Prof. Dr. M. Javaid Asad
Director

Registrar

Agenda for the Meeting of Academic Council

Following Agenda Items are being presented for consideration:

Agenda Item: I	Revision in eligibility criterion for morning sessions of undergraduate degree programs at UIBB Except Pharm-D and BSN
Agenda Item: II	Eligibility criterion for MPhil Biochemistry and MPhil Biotechnology
Agenda Item: III	Approval of BS Medical Laboratory Technology Evening program
Agenda Item: IV	Approval for new undergraduate degree programs at UIBB
Agenda Item: V	Updating schemes of studies for existing undergraduate programs at UIBB

Agenda Item: I Revision in eligibility criterion for morning sessions of undergraduate degree programs at UIBB except Pharm-D and BSN

To attract more applicants and improve enrollment in a competitive academic environment, it is proposed that the domicile restriction for BS morning programs be relaxed to include candidates from all over Pakistan including AJK, rather than limiting admissions to Punjab/ICT only. The evening programs for all undergraduate degrees are already open to applicants nationwide

Sr. No	Degree Title	Eligible domicile
1.	BS Biochemistry (Morning and Evening)	All Pakistan
2.	BS Microbiology (Morning and Evening)	
3.	BS Biotechnology (Morning and Evening)	
4.	BS Medical Lab Technology (Morning and Evening)	

In addition, it is proposed that a minimum of 45% marks in F.Sc. shall serve as the eligibility criteria for all programs, except for those programs that require accreditation by a professional council—for which the eligibility criteria set by the respective council shall be applicable. Both of these suggestions were approved in 13th meeting of Faculty board, UIBB held on May 23rd, 2025.

The item is placed before the house for further discussion.

Agenda Item: III Eligibility criterion for M.Phil Biochemistry and M.Phil Biotechnology

It is proposed that the eligibility criteria for the existing M.Phil Biochemistry and M.Phil Biotechnology programs be expanded to include candidates with a BS in Medical Laboratory Technology and relevant. The suggestion was approved in 13th meeting of Faculty board, UIBB held on May 23rd, 2025.

The item is placed before the house for further discussion.

Agenda Item: III Approval of BS Medical Laboratory Technology, Evening program

Considering the increasing demand and success for degree program of BS Medical Laboratory Technology (MLT), it is suggested to start its evening session with an intake of 50 students. The financial assessment of the program is already provided to the university admission committee.

The Item is placed before house for discussion.

Agenda Item: V Approval for new undergraduate degree programs at UIBB

In alignment with the evolving needs of the academic market and the strategic goals of institutional growth, UIBB is proposing the initiation of new degree programs. These programs are designed not only to meet emerging educational and industry demands but also to enhance the academic profile and revenue-generating capacity of the university.

Following new degree programs are proposed to be approved from UIBB . These programs were discussed and approved in 13th meeting of Faculty board, UIBB held on May 23rd, 2025, schemes of studies are provided in Annexures I-VIII.

Approval for new undergraduate degree programs at UIBB

Sr. No	**Degree Title**	**Faculty Coordinator**	**Accreditation Body**	**Remarks Faculty Board UIBB/Annexures**
1.	Pharm D	Dr. Feroza Hamid Wattoo, Dr. M. Sheeraz Ahmed	Pharmacy Council of Pakistan (PCP)	Approved subject to NOC from PCP and faculty
2.	BS Nursing (BSN)	Prof. Dr.. M. Javaid Asad, Dr. M. Sheeraz Ahmed	Pakistan Council of Nursing and Midwifery (PCNM)	Approved subject to NOC from PCNM and faculty / Annex-**I**
3.	BS Aesthetics and Cosmetology*	Prof. Dr.M. Javaid Asad Dr. Uzma Abdullah	Allied Health Professional Council (AHPC)	Approved subject to NOC from AHPC and faculty / Annex-II
4.	BS Clinical Psychology*	Ms. Saima Amin	Allied Health Professional Council (AHPC)	Approved subject to NOC from AHPC and faculty / Annex-III
5.	BS Bioinformatics*	Dr. Pakeeza Arzoo Shaiq	HEC	Approved subject to faculty/Annex- IV
6.	M.Phil and Ph.D Microbiology	Dr. M. Sheeraz Ahmed, Dr. Bilal M. Khan	HEC	Approved subject to NOC from HEC and faculty/ Annex-V and VI
7.	M.Phil and Ph.D MLT	Dr. Tayyaba Zainab	HEC	Approved subject to NOC from HEC and faculty /Annex-VII and VIII

*50 seats

The item is placed before the house for further discussion.

Agenda Item: VI Updated schemes of studies for existing undergraduate programs at UIBB

The Higher Education Commission (HEC) has updated the curricula for BS Biochemistry, BS Biotechnology, and BS Microbiology programs. In compliance with the latest guidelines and policy, the revised curricula of UIBB are presented for discussion and approval.
The revised Curricula are provided in Annexures as detailed below

Sr. No	Name od Degree Program	Annexure
1.	BS Biochemistry	IX
2.	BS Biotechnology	X
3.	BS Microbiology	XI

The updated scheme of studies as discussed and approved in 13th meeting of Faculty board, UIBB held on May 23rd, 2025 are provided in Annexures I-VIII.

The item is placed before the house for further discussion.

-sd-
Prof. Dr. M. Javaid Asad
Director

Annexure-I

BS Nursing
(4 years)

Compulsory Requirements (the student has no choice)		General Courses to be chosen from other departments	
9 courses		**7-8 courses**	
22 Credit hours		**21-24 Cr. hours**	
Subject	**Cr. Hr.**	**Subject**	**Cr. Hr.**
1. ENGLISH I	2	1. MICROBIOLOY	3
2. ENGLISH II	2	2. ANATOMY& PHYSIOLOGY	6
3. ENGLISH III	2	3. BIOCHEMISTRY	3
4. ENGLISH IV	2	4. ETHICS	1
5. ENGLISH V	2	5. PATHOPHYSOLOGY	5
6. ENGLISH VI	2	6. NUTRITION	1
7. ENGLISH VII	2	7. PSYCHOLOGY	5
8. ENGLISH VIII	2		
9. PAKISTAN STUDIES	2		
10. ISLAMIC STUDIES / ETHICS	2		
11. MATHEMATICS I	1		
12. MATHEMATICS II / UNIV. OPTIONAL **			
13. INTRODUCTION TO COMPUTER	1		
	22		**24**

Discipline Specific Foundation Courses		Major courses including research project/internship		Elective Courses within the major	
9-10 courses		**11-13 courses**		**4 courses**	
30-33 Credit hours		**36-42 Credit hours**		**12 Credit Hours**	
Subject	**Cr. Hr.**	**Subject**	**Cr. Hr.**	**Subject**	**Cr. Hr.**
1. FON I	**4**	1. BIOSTATS	**3**	1. CHN III	**5**
2. FON II	**4**	2. RESEARCH	**3**	2. NURSING SEMINAR	**2**
3. AHN I,	**8**	3. EPIDEMIOLOGY	**2**		
4. AHN II,	**8**	4. LDSP/.MGT	**3**	3. Senior Elective: Clinical Practicum	**5**
5. CHN I,	**3**	5. CRITICAL CARE NURSING	**5**		
5. HA	**4**				
6. Culture, Health & Society	**2**	6. TEACHING/ LEARNING	**5**		
		7. CHN II	**6**		
		8. MHN	**6**		
		9. PEADIATRIC	**7**		
		10.PHARMACOLOGY	**4**		
	33		**42**		**12**

SCHEME OF STUDIES
FOR 4-YEARS BS
NURSING

Year I	Year II
1. Fundamental of Nursing-I 2. Microbiology 3. Anatomy and Physiology-I 4. Biochemistry 5. Computer Skills 6. English-I 7. Fundamental of Nursing -II 8. Anatomy and Physiology-II 9. Applied Nutrition 10. Community Health Nursing I 11. English-II 12. Islamiat 13. Pak. Studies	1. Adult Health Nursing-I 2. Pathophysiology-I 3. Health Assessment-I 4. Pharmacology-I 5. Mathematics 6. English-III 7. Adult Health Nursing-II 8. Pathophysiology-II 9. Pharmacology-II . Health Assessment -II 11.Developmental Psychology 12. English-IV 13. Nursing Ethics

Year III	Year IV
1. Pediatric Health Nursing 2. Community Health Nursing II 3. Teaching/Learning: Principles/Practices 5. English-V 6. Mental Health Nursing 7. Intro to Biostatics 8. Behavioral Psychology 9 Epidemiology 10.Culture/Health/Society 11.English-VI (Academic Writing)	1. Critical Nursing Care 2. Introduction to Nursing theories 3. Leadership/Management in Nursing 4. Nursing Research 5. English-VII (Professional Writing) 6. Community Health Nursing-III 6. Nursing Seminar 7. Senior electives in clinical nursing Practicum 8. English-VIII

SCHEME OF STUDIES
FOR BS NURSING BASED ON SEMESTER WISE

Year 1 Semester I

Serial #	Course Title	Theory	Clinical	Skills/Lab	Total Credit
1	Fundamental of Nursing-I	2.00		2.00	4.00
2	Microbiology	2.50		0.5	3.00
3	Anatomy and Physiology-I	3.00			3.00
4	Biochemistry for Nurses	2.00		1.00	3.00
5	English-I	2.00			2.00
6	Computer Skills			1.00	1.00
	Total				**16.00**

Year 1 Semester II

Seria 1 #	Course Title	Theory	Clinical	Skills/ Lab	Total Credit
1	Fundamental of Nursing-II	2.00	1	1.00	4.00
2	Anatomy and Physiology- II	3.00			3.00
3	Community Health Nursing-I	2.00	1.00		3.00
4	Applied Nutrition	1.00			1.00
5	English-II	2.00			2.00
6	Islamiat*	2.00			2.00
7	Pak. Studies*	2.00			2.00
Total					**17.00**

Year 2 Semester III

Serial #	Course Title	Theory	Clinical	Skills/ Lab	Total Credit
1	Adult Health Nursing I	4.00	**3**	1.00	8.00
2	Pathophysiology I	1.75		0.25	2.00
3	Health Assessment -I	1.00		1.00	2.00
4	Pharmacology-I	2.00			2.00
5	Mathematics	1.00			1.00
6	English-III	2.00			2.00
Total					**17.00**

Year 2 Semester IV

Serial #	Course Title	Theory	Clinical	Skills/ Lab	Total Credit
1	Adult Health Nursing-II	4.00	3.00	1.00	8.00
2	Pathophysiology II	2.75		0.25	3.00
3	Health Assessment-II	1.00		1.00	2.00
3	Developmental Psychology	2.00			2.00
4	Pharmacology II	2.00			2.00
5	English III	2.00			2.00
6	Nursing Ethics	1.00			1.00
Total					**20.00**

Year 3 Semester V

Serial #	Course Title	Theory	Clinical	Skills/ Lab	Total Credit
1	Pediatrics Health Nursing	3.00	3.00	1.00	7.00
2	Community Health Nursing -II	2.50	2.50	1.00	6.00
3	Teaching/Learning :Principles and Practices	3.00			3.00
4	English V	2.00			2.00
Total					**18.00**

Year 3 Semester VI

Serial #	Course Title	Theory	Clinical	Skills /Lab	Total Credit
1	Mental Health Nursing	3.00	3.00		6.00
2	Introduction to Biostatics	2.50		**0.50**	3.00
3	Behavioural Psychology	3.00			3.00
4	Epidemiology	2.00			2.00
5	English-VI	2.00			2.00
6	Culture, Health and Society	2.00			2.00
Total					**18.00**

Year 4 Semester VII

Serial #	Course Title	Theory	Clinical	Skills/ Lab	Total Credit
1	Critical Care Nursing	2.50	4.00	**0.50**	7.00
2	Introduction to Nursing Theories	2			2.00
3	Leadership and Management in Nursing	2.00	**1.00**		3.00
4	Nursing Research	3.00			3.00
5	**English VII**	2.00			2.00
Total					**17.00**

Year 4 Semester VIII

Serial #	Course Title	Theory	Clinical	Tutoria l	Total Credit
1	Community Health Nursing-III	2.00	3.00		5.00
2	Nursing Seminar / role transition	2.00			2.00
3	Clinical Practicum		4.00	1.00	5.00
Total					**12.00**

Annexure-II

BS Aesthetic & Cosmetology

(4 years)

	Course Title	Credit Hours
Semester I	Anatomy	3
	Physiology	3
	Biochemistry	3
	English I (Functional)	3
	Islamic Studies	2
	Introduction to Information and Communication Technology	3
		17
Semester II	English II (Expository Writing)	3
	Ideology and Constitution of Pakistan	2
	Pathology	3
	Anatomy & Physiology of Skin	3
	International Relations	2
	Fundamentals of Skincare	3
		16
Semester III	Electronic Therapies	3
	Quantitative Reasoning I (Mathematics)	3
	Nutrition Sciences	3
	Organic Chemistry	3
	Social Entrepreneurship Program	3
	Medical Physics	3
		18
Semester IV	Behavioral Sciences	2
	Cosmetic Sciences-I (manufacturing, labeling, packaging & dispensing)	3
	Healthcare Entrepreneurship	3
	Physical Education	2
	Quantitative Reasoning II (Biostatistics)	3
	Skin Diseases-I (Infection & Infestation)	4
		17
Semester V	Basic Instrumentation of Aesthetics	3
	Clinical Therapeutics	3
	Cosmetic Sciences-II (chemical analysis & stability)	3
	Medical Ethics	2
	Patient Care & Consultation	3
	Skin Disease-II (inflammatory skin diseases)	3

		17
Semester VI	Biostatistics and Research Methodology (Evidence-Based Practices)	3
	Business Operations & Service Marketing (Healthcare Management)	2
	Clinical Pharmacology	3
	Perfumery & Aroma Therapy	3
	Skin Diseases-III (adverse effects of cosmetics & drugs)	3
	Supervised Cosmetic Procedures-I	3
		17
Semester VII	Clinical Rotations (Internship)	3
	Introduction to Public Health & Safety in Aesthetic Procedures	2
	Photobiology & Phototherapy	2
	Regulation & Legislation of Cosmetic Products	2
	Skin Diseases-IV (disorders of pigmentation)	3
	Supervised Cosmetic Procedures-II	3
	Wound Management	2
		17
Semester VIII	Biomedical Waste Management & Infection Control	3
	Capstone Project/Research Project	3
	Health Economics & Community Dermatology	3
	Laser Treatments in Aesthetics	3
	Skin Diseases-V (appendageal disorders)	3
		15
	Total	134

Annexure-III

Bachelor of Science (BS) in Clinical Psychology
(4 years Program)

1. Introduction

The Bachelor of Science (BS) in Clinical Psychology is a four-year undergraduate program that explores the scientific study of human thoughts, emotions, and behaviors. This program is designed to provide students with a comprehensive understanding of psychological theories, principles, and research methods. The curriculum emphasizes both theoretical knowledge and practical skills, enabling students to critically analyze human behavior, understand mental health challenges, and apply psychological principles in real-life settings. The program also fosters ethical awareness, critical thinking, and effective communication skills

2. Program Objectives

To develop a strong theoretical and practical understanding of human behavior.

To train students in psychological assessment, counseling, and research.

To enhance analytical thinking and ethical awareness among students.

To prepare students for advanced education and professional roles in psychology-related fields.

3. Admission Criteria

• Qualification: Intermediate (F.A/F.Sc or equivalent) with at least 45% marks.

• Duration: 4 years (8 semesters)

• Total Credit Hours: 132

• Minimum CGPA for Graduation: 2.00/4.00

• Admission Test: May be conducted as per university policy.

4. Infrastructure Requirements

Well-equipped psychology laboratory (for testing & practicals)

Classrooms with multimedia facilities

Library with psychology textbooks, journals, and digital resources

Access to psychological testing tools and software

Internet and computer lab access

Counseling and internship placement offices

5. HR Requirements

The core academic faculty must include at least two to three Assistant Professors holding PhDs in Psychology, along with three to four Lecturers possessing MPhil or MS degrees in Psychology. In addition to faculty, support staff is crucial for operational efficiency. The department should have one to two lab assistants or technicians to manage psychology laboratories, assist students during practical sessions, and prepare psychological testing material.

Scheme of Studies (Semester-wise)

General Breakdown:

Category	Courses	Credit Hours
Compulsory (General Education)	9	25
Discipline-Specific Foundation Courses	9–10	30–33
Major Courses (including Research)	11–13	36–42
Electives within Major	4	12
Total		132

Semester 1

Course Title	Cr. Hr
Functional English (Eng-I)	3
Introduction to Psychology (Theory + Lab)	4
Islamic Studies / Ethics	3
Pakistan Studies	3
Introduction to Biochemistry	3

Semester 2

Course Title	Cr. Hr
Writing & Presentation Skills (Eng-II)	3
History and Schools of Psychology	4
Communication Skills (Eng-III)	3
Statistics for Psychology	3
Neurobiochemistry	3

Semester 3

Course Title	Cr. Hr
English IV /	2
Introduction to Social Psychology	3
Personality Theories – I	3
Developmental Psychology	3
Clinical Biochemistry	3

Semester 4

Course Title	Cr. Hr
Experimental Psychology	3
Personality Theories – II	3
Mental Health & Psychopathology – I	3
Psychopathology	3
Elective – I	3

Semester 5

Course Title	Cr. Hr
Psychological Testing – I	3
Research Methods – I	3
Mental Health & Psychopathology – II	3
Neurogenetics	3
Elective – II	3

Semester 6

Course Title	Cr. Hr
Psychological Testing – II	3
Research Methods – II	3
Cognitive Psychology	3
Health Psychology	3
Elective – III	3

Semester 7

Course Title	Cr. Hr
Forensic Psychology	3
Applied Statistics	3
Internship	2

Behavioral Neuroscience	3
Elective – IV	3

Semester 8

Course Title	Cr. Hr
Advanced Social Psychology	3
Neurological Bases of Behavior	3
Cross-Cultural Psychology	3
Research Project / Thesis	4
Ethics in Clinical Psychology	3

Any four of the courses may be opted from the following elective

1. Psychological Testing - II
2. Research Methods – I
3. Research Methods – II
4. Elementary Statistics
5. Applied Statistics
6. Advance Social Psychology
7. Positive Psychology
8. Educational Psychology
9. Cross Cultural Psychology
10. Cognitive Psychology
11. 12. Research Project
12. 13. Internship

Annexure-IV

Scheme of Studies BS Bioinformatics

(4 Years Program)

As Per HEC, Undergraduate Education Policy

Introduction

The **BS in Bioinformatics** program at UIBB, PMAS-AAUR aims to integrate biological sciences with computational techniques to address challenges in genomics, proteomics, and systems biology. This interdisciplinary field is pivotal in advancing research in agriculture, medicine, and biotechnology.

Objectives

1. **Interdisciplinary Education**: Provide students with a robust foundation in bioinformatics, biochemistry, computer science, and mathematics.
2. **Research and Innovation**: Equip students with the skills to conduct research in bioinformatics, contributing to advancements in genomics and biotechnology.
3. **Industry Collaboration**: Foster partnerships with research institutions and industries to enhance practical learning and employment opportunities.
4. **Global Competence**: Prepare graduates to meet international standards in bioinformatics research and application.

Admission Criteria

Academic Requirements: Intermediate with Pre-Medical, Pre-Engineering, ICS or an equivalent qualification with a minimum of 45% marks.

Infrastructure requirements

Well-equipped Bioinformatics lab with high-performance computers, bioinformatics software (e.g., BLAST, ClustalW), and access to online databases.

HR requirements

2-3 faculty members with Ph.D. degrees in Bioinformatics, Computational Biology, or related fields. Computer Engineer for Lab maintenance.

Scheme of Studies BS Bioinformatics

(4 Years Program)

As Per HEC, Undergraduate Education Policy

I **A single major** (Minimum of 120 credit hours), that requires;

i. General education courses: 30 credit hours
ii. Major: minimum 72 credit hours
iii. Interdisciplinary/allied courses: minimum 12 credit hours
iv. Field experience/internship: 03 credit hours
v. Capstone project: 03 credit hours

The courses distribution along with their credit hours is given below:

S#	Division/Courses	Total Number	Credit hours
1.	Major	26	72
2.	General	12	30
3.	Interdisciplinary	04	12
5.	Internship/Field Experience	01	3
6.	Capstone Project	01	3
	Total Credits		**120**

List of Major Courses

S.#	Course Code	Course Title	Credits
1.	BI-301	Introduction to Bioinformatics	3(2-2)
2.	BI-302	Fundamentals of Biochemistry	3(2-2)
3.	BI-303	Cell Biology	3(2-2)
4.	BI-304	Linux for Biological Sciences	3(2-2)
5.	BI-401	Biotechnology	2(2-0)
6.	BI-402	Fundamentals of Genetics	3(2-2)
7.	BI-403	Developmental Biology	3(2-2)
8.	BI-404	Advanced Biochemistry	3(2-2)
9.	BI-405	Molecular Biology	3(2-2)
10.	BI-406	Microbiology and Immunology	3(2-2)
11.	BI-407	Bioinformatics Colloquium	3(3-0)
12.	BI-501	Bioinformatics Analysis	3(2-2)
13.	BI-502	Introduction to Genomics and Proteomics	2(2-0)
14.	BI-503	Bioinformatics Database Development	3(1-4)
15.	BI-504	Bioinformatics Scripting-I	3(2-2)
16.	BI-505	Structural and Functional Bioinformatics	2(2-0)
17.	BI-506	Bioinformatics Software Development	3(2-2)
18.	BI-507	Biological Modeling and Simulation	2(2-0)
19.	BI-508	Bioinformatics Database Development	3(2-2)
20.	BI-601	Bioinformatics Scripting-II	3(2-2)
21.	BI-602	Artificial Intelligence in Bioinformatics	3(3-0)
22.	BI-603	Bioinformatics Software Development	3(3-0)
23.	BI-604	Biological Modeling and Simulation	3(2-2)
24.	BI-605	Ethical and legal issues in Bioinformatics	3(3-0)
25.	BI-606	Current Trends in Bioinformatics	3(3-0)
26.	BI-620	Seminar	1(1-0)

List of General Education Courses

S.#	Course Code	Course Title	Theory	Practical	Credits
1	SOS-301	Moral Foundation of Education	2	0	2(2-0)
2	CHEM-401	Organic Chemistry	2	1	3(2-2)
3	SOC-308	Introduction to Sociology	2	0	2(2-0)
4	ENG-301	Functional English	3	0	3(3-0)
5	ENG-302	Expository Writing	3	0	3(3-0)
6	QR-401	Quantitative Reasoning-I	3	0	3(3-0)
7	QR-402	Quantitative Reasoning-II	3	0	3(3-0)
8	IS-302/ET-302	Islamic Studies/Ethics	2	0	2(2-0)
9	SSH-301	Ideology & Constitution of Pakistan	2	0	2(2-0)
10	IT-302	Introduction to Information and Communication Technology	2	1	3(2-2)
11	MGT-402	Digital Entrepreneurship	2	0	2(2-0)
12	SCS-302	Social and Civic Skills	2	0	2(2-0)

List of Interdisciplinary/Allied Courses (12 credit hours)

S.#	Course Code	Course Title	Theory	Practical	Credits
1.	ZOOL-402	Human Physiology	2	1	3(2-2)
2.	CHEM-301	Inorganic Chemistry	2	1	3(2-2)
3.	CHEM-501	Physical Chemistry	2	1	3(2-2)
4.	MIC-311	General Microbiology	2	1	3(2-2)

List of Biochemistry/Minor Courses

S. No	Course Code	Course Name	Theory	Practical	Credit Hours
1.	BI-301	Introduction to Bioinformatics	2	1	3(2-2)
2.	BI-304	Linux for Biological Sciences	2	1	3(2-2)
3.	BI-502	Introduction to Genomics and Proteomics	2	1	3(2-2)
4.	BI-504	Bioinformatics Scripting -1	2	1	3(2-2)
5.	BI-505	Structural and Functional Bioinformatics	2	1	3(2-2)
6.	BI-507	Biological Modelling and Simulation	1	2	3(1-4)
7.	BI-602	Use of Artificial Intelligence in Bioinformatics	3	0	3(3-0)
8.	BI-605	Ethical and Legal issues in Bioinformatics	3	0	3(3-0)

Semester wise courses

Semester	Course Code	Course Title	Theory	Practical	Credits
First	BI-301	Introduction to Bioinformatics	2	1	3(2-2)
	BI-303	Fundamentals of Biochemistry	2	1	3(2-2)
	CHEM-401	Organic Chemistry	2	1	3(2-2)
	ENG-301	Functional English	3	0	3(3-0)
	QR-401	Quantitative Reasoning-I	3	0	3(3-0)
	TOQ-301	Translation of Quran	1	0	1(1-0)
			12	**3**	**15**
Second	BI-303	Cell Biology	2	1	3(2-2)
	BI-304	Linux for Biological Sciences	2	1	3(2-2)
	SCS-302	Social and Civic Skills	2	0	2(2-0)
	IT-302	Introduction to Information and Communication Technology	2	1	3(2-2)
	IS-302/ET-302	Islamic Studies/Ethics	2	0	2(2-0)
	QR-402	Quantitative Reasoning-II	3	0	3(3-0)
			11	**3**	**16**
Third	BI-401	Biotechnology	2	0	2(2-0)
	BI-402	Fundamentals of Genetics	2	1	3(2-2)
	BI-403	Developmental Biology	2	1	3(2-2)
	BI-404	Advanced Biochemistry	2	1	3(2-2)
	SSH-301	Ideology & Constitution of Pakistan	2	0	2(2-0)
	SOS-301	Moral Foundation of Education	2	0	2(2-0)
	TOQ-401	Translation of Quran	1	0	1(1-0)
			14	**3**	**15**
Fourth	BI-405	Molecular Biology	2	1	3(2-2)
	BI-406	Microbiology and Immunology	2	1	3(2-2)
	BI-407	Bioinformatics Colloquium	3	0	3(3-0)
	SOC-308	Introduction to Sociology	2	0	2(2-0)
	ENG-302	Expository Writing	3	0	3(3-0)
	MGT-402	Digital Entrepreneurship	2	0	2(2-0)
			14	**2**	**16**
Fifth	BI-501	Bioinformatics Analysis	2	1	3(2-2)
	BI-502	Introduction to Genomics and Proteomics	2	0	2(2-0)
	BI-503	Bioinformatics Database Development	1	2	3(1-4)
	BI-504	Bioinformatics Scripting-I	2	1	3(2-2)
	MIC-311	General Microbiology	2	1	3(2-2)
	CHEM-301	Inorganic Chemistry	2	1	3(2-2)
	TOQ-501	Translation of Quran	1	0	1(1-0)
			12	**6**	**17**

Sixth	BI-505	Structural and Functional Bioinformatics	2	0	2(2-0)
	BI-506	Bioinformatics Software Development	2	1	3(2-2)
	BI-507	Biological Modeling and Simulation	2	0	2(2-0)
	BI-508	Bioinformatics Database Development	2	1	3(2-2)
	CHEM-501	Physical Chemistry	2	1	3(2-2)
	ZOOL-402	Human Physiology	3	0	3(3-0)
			13	**2**	**16**
Seventh	BI-601	Bioinformatics Scripting-II	2	1	3(2-2)
	BI-602	Use of Artificial Intelligence in Bioinformatics	3	0	3(3-0)
	BI-603	Bioinformatics Software Development	3	0	3(3-0)
	BI-604	Biological Modeling and Simulation	2	1	3(2-2)
	BI-605	Ethical and legal issues in Bioinformatics	3	0	3(3-0)
	TOQ-501	Translation of Quran	1	0	1(1-0)
			13	**2**	**15**
Eighth	BI-606	Current Trends in Bioinformatics	3	0	3(3-0)
	BI-620	Seminar	1	0	1(1-0)
	BI-299	Internship/Fiend Experience	0	3	3(0-6)
	BI-399	Capstone project	0	3	3(0-6)
			4	**6**	**10**

Annexure-V

M.PHIL PROGRAM IN MICROBIOLOGY

M.Phil Degree Program (2-Year)

S No.	Category	No. of Courses	Credit Hours
1	**Course work** Major	5	15
	Minor	3	9
	Total	8	24
2	**Research Thesis**	1	06

Semester-wise break down

Courses		**Credit Hours**
Year-1 (Semester-I)		
Major		
MIC-701	Molecular Microbial Pathogenesis	3(3-0)
MIC-702	Microbial Enzymology	3(3-0)
MIC-703	Molecular Virology	3(3-0)
MIC-720	Seminar-I	1(1-0)
Minor		
	To be opted from other department	3(3-0)
Year-1 (Semester-II)		
Major		
MIC-704	Research Techniques in Microbiology	3(3-0)
MIC-705	Fermentation Technology	3(3-0)
MIC-706	Trends in Industrial Microbiology/ Optional	3(3-0)
MIC-720	Seminar-II	1(1-0)
MIC-719	Special Problem	1(1-0)
Minor		
STAT-702	Biostatistical Analyses	3(3-0)
	To be opted from other department	3(3-0)
Year-2 (Semester-III & IV)		
Research Thesis (Compulsory)		6
Total Credit Hours for M.Phil Program		**30**

List of elective courses for M. Phil in Microbiology

S No.	Course Code	Course Title	Credit Hours
1.	MIC-701	Molecular Microbial Pathogenesis	3(3-0)
2.	MIC-702	Microbial Enzymology	3(3-0)
3.	MIC-703	Molecular Virology	3(3-0)
4.	MIC-704	Research Techniques in Microbiology	3(3-0)
5.	MIC-705	Fermentation Technology	3(3-0)
6.	MIC-706	Trends in Industrial Microbiology	3(3-0)
	Optional Courses		
7.	MIC-707	Biosafety and Biosecurity	3(3-0)
8.	MIC-708	Microbial Strain Development	3(3-0)
9.	MIC-709	Molecular Mycology	3(3-0)
10.	MIC-710	Molecular Parasitology	3(3-0)
11.	MIC-711	Vaccinology	3(3-0)
12.	MIC-712	Microbial Biotechnology	3(3-0)

Detail of Courses for M.Phil in Microbiology

CONTENTS

MIC-701	Molecular Microbial Pathogenesis	3(3-0)

THEORY

Molecular mechanisms of pathogenicity, Pathogen persistence. Immune mediated pathogenesis. Molecular mechanism of pathogenesis of infectious diseases of animals and humans; Anaplasma and other emerging tick borne diseases. Molecular mechanism of pathogenesis of parasitic agents including recent gene knockout strategies for discovery of pathogenic mechanisms. Mechanisms of pathogenesis of viral diseases, Immune response and resistance to viral infection, Viral infections in patients with detective immunity, Control of viral disease by vaccine. Bioinformatics; Whole genome analysis for understanding through molecular approaches pathogenic mechanisms. Molecular approaches toward diagnosis and control of either parasitic or viral and bacterial diseases. Examples: Tuberculosis, HIV, Dengue virus. Control and prevention strategies of microbial infections.

Recommended Books

1. Anthony, A.K., 2003. Principles of Molecular Pathology. 1st edition, Humana Press New Jersey
2. Debra, G.B.L., 2003. Diagnostic Molecular Pathology.1st edition, Saunders.
3. Decker, J. and Reischl, U. eds., 2004. Molecular Diagnosis of Infectious Diseases (Vol. 94). Totowa, NJ: Humana Press.
4. Digard, P., Nash, A.A. and Randall, R.E., 2005. Molecular Pathogenesis of Virus Infections (No. 64). Cambridge University Press.
5. Killeen, A, 2003. Principles of Molecular Pathology. Springer Science & Business Media

MIC-702	Microbial Enzymology	3(3-0)

THEORY

Introduction to enzymes. Nature, structure and function: Biological role of enzymes, sources, Biosynthesis. Mechanism of enzyme action: Classes of enzymes. Multi-enzyme complexes: Kinetics of enzyme reaction. Mechanism of enzyme reaction: Reversible and irreversible changes. Regulatory enzymes and control of metabolic pathways. Industrial enzymes. Immobilization of enzymes. Methods of immobilization. Examples of industrial enzymes: Lipases, Catalases, Peroxidases. Enzymes as biosensors. Enzymes in therapeutic.

Recommended Books

1. Chróst, R. ed., 2012. Microbial Enzymes in Aquatic Environments. Springer Science & Business Media.
2. Chrost, R.J., 2012. Microbial Enzymes in Aquatic Environments. Springer-Verlag New York, LLC.
3. Subramaniyan, S. and Prema, P., 2002. Biotechnology of Microbial Xylanases: Enzymology, Molecular Biology, and Application. Critical reviews in biotechnology, 22(1), pp.33-64.
4. Thomas, R.N., 2011. Microbial Extracellular Polymeric Substances. Springer publisher.
5. Vijai, K., 2013. Application of Microbial Genes in Enzyme Technology. Nova Science Pub. Inc.

MIC-703	Molecular Virology	3(3-0)

THEORY

Introduction to viruses. Genomic evolution of viruses. Genomic diversity among viruses: Shape, Size, Nucleic acid, Strandedness, Sense. Structure and complexity of virus genomes. Genetic interactions between viruses: Site specific and Illegitimate recombination, Transduction, Transfection, Complementation, Gene re-assortment, Phenotypic mixing. Mutations in viruses: Mutation in bacterial, Plant and animal viruses, Frequency of mutation, Mechanism of mutation, Site directed mutagenesis, Antigenic drift and Antigenic shift. Control of gene functions in viruses: Coliphage T4, Lambda, Simian virus 40, P1. Genetic map of viral genomes: Mu, Coliphage T4, Lambda, Hepatitis B, HIV, Dengue. Exploitation of phages in genetic engineering and DNA recombinant technology: Viral vectors. Oncoviruses: Human papilloma virus, Kaposi's sarcoma-associated herpesvirus, Epstein-barr virus, Human cytomegalovirus, Human T-lymphotropic virus, HCV. Oncolytic viruses: Adenovirus, Reovirus, Poliovirus, Herpes simplex virus, Vaccinia virus, Parvo virus. Viral selection markers. Advance techniques in molecular virology.

Recommended Books

1. Dimmock, N.J., 2001. Introduction of Modern Virology. Blackwell Science.
2. Nicholas, H., 2007. Fundamentals of Molecular Virology. John Wiley and Sons.
3. Primrose, S.B., 2006. Principles of Gene Manipulation and Genomic. Blackwell publisher.
4. Sidhu, S.S., 2005. Phage Display in Biotechnology and Drug Discovery. CRC Press

MIC-704	Research Techniques in Microbiology	3(3-0)

THEORY

Application of the course. Gene delivery techniques: Vectors and types, Transfection and transformation methods. Cell lysis, Macromolecules isolation and quantification techniques. Nucleic acid and protein separation techniques: Agarose gel electrophoresis, Sodium dodecyle sulfate polyacrylamide gel electrophoresis (SDS-PAGE), Two dimensional gel electrophoresis (2-DE), Chromatography. Polymerase chain reaction (PCR), Types of PCR, Primer designing, Ribotyping and related softwares. Gene and protein expression tools: Real time PCR, DNA and protein microarray, Blotting techniques. Macromolecules interaction tools: Yeast two hybrid, Chromatin CHIP, Co immunoprecipitation, Confocal microscopy, FRET. DNA, RNA and peptide sequencing. Softwares related to metagenomics, Proteomics and interactomics. Recent advances in molecular microbiology.

Recommended Books

1. Bramble., 2006. Biochemistry and Molecular Biology. American Society for Microbiology.
2. Copeland, R.A. ed., 2013. Methods for Protein Analysis: A Practical Guide for Laboratory Protocols. Springer Publisher.
3. Fung, F.T., 2004. Proteins analysis: Methods and Protocols. HB Publisher
4. Papachristodoulou, D., Snape, A., Elliott, W.H. and Elliott, D.C., 2014. Biochemistry and Molecular Biology. Oxford University Press.
5. Philopose., 2006. Analytical Biotechnology. HB Publisher.

MIC-705	Fermentation Technology	3(3-0)

THEORY

Introduction to fermentation process: Microbial growth phases, Wild type microorganisms and its fermentation products. Isolation and preservation of microbes for inoculum preparation. Types of fermentation: Batch fermentation, Fed batch fermentation, Continuous culture system. Types of bioreactor: Packed cell, Batch, Air lift. Steps of fermentation: Sterilization, Inocula preparation, pH and temperature adjustment, Feeds, Product separation, Liquid wastes removal. Upstream processing steps: Development of inocula for pilot scale fermentation, Media composition, Nutrients requirements, Media optimization, pH, Temperature and other requirements. Downstream processing steps: Introduction to downstream processing, primary separation, Removal of microbial cells and solid matter, Foam separation, Precipitation filtration, Centrifugation, Cell disruption techniques. Product purification: Solvent extraction, Adsorption, Aqueous two-phase system and precipitations. Purification techniques: Chromatography (ion-exchange, gel-permeation and affinity), Filtration (microfiltration, Ultrafiltration and reserve osmosis) and electrophoresis. Industrial Applications: Biomass production, Food production, Chemicals products, Health care products, Industrial enzymes.

Recommended Books

1. Chris, B., 2001. Brewing Yeast and Fermentation. Blackwell Publishing Incorporated.
2. El-Mansi., 2006. Fermentation Microbiology and Biotechnology. Second Edition, Taylor and Francis Group.
3. Groves., 2005. Pharmaceutical Biotechnology. CRC Press.
4. Mansi, E.l., 2011. Fermentation, Microbiology and Biotechnology. CRC Press.
5. Stanbury., 2003. Principles of Fermentation Technology. Second Edition. Butterworth Heinemann.

Optional Courses

MIC-706	Trends in Industrial Microbiology	3(3-0)

THEORY

Introduction to industrial microbiology: Primary metabolites, Secondary metabolites, Chemicals used in industry. Bacterial growth laws: Optimality and sub-optimality in a bacterial growth law. Metabolic pathways for metabolite production: Pyruvic acid, Lactic acid, Tryptophan. Industrial ethanol production: Sources of feedstock, Types of microorganism used for ethanol production. Production of vitamins and amino acids: Aspartic acid production, Vitamin C production. Microbial lipid production: Enhanced production in *Yarrowia lipolytica* by engineering cytosolic redox metabolism, enhanced production of biodiesel in *Escherichia coli.* Microorganisms as food: Single cell protein, Poultry feed. Recombinant protein production system: Production of human insulin, Human growth factor, Clotting factors. Immobilization techniques: Cell display technology, Immobilization of microorganisms on beads. Secretion system: Type I, type II, Type III, Type IV, Type V, and Type VI. Yeast expression system. Fungal expression system. Discovery of small therapeutic antimicrobial peptides: Anionic peptides, Cationic peptides. Advances in soluble protein expression: Chaperone system, Solubility tags. Advances in protein purification.

Recommended Books

1. Dahod, S.K., Greasham, R. and Kennedy, M., 2010. Raw Materials Selection and Medium Development for Industrial Fermentation Processes. In Manual of Industrial Microbiology and Biotechnology, Third Edition (pp. 659-668). American Society of Microbiology.
2. El-Mansi., 2006. Fermentation Microbiology and Biotechnology. 2nd Edition. Taylor and Francis Group.
3. Groves, M.J., 2005. Pharmaceutical Biotechnology. CRC Press.
4. Hope, A., Timmel, S. and Hodzi, C., 1995. Training for Transformation: A Handbook for Community Workers. Book 2. Mambo Press.
5. Prescott, S.C. and Dunn, C.G., 1949. Industrial Microbiology. Industrial microbiology..

MIC-707	Biosafety and Biosecurity	3(3-0)

THEORY

Introduction to biosafety, Biosecurity, Biorisk management. Primary controls of biosafety. Engineering controls: Locks on door, Biosafety cabinet, Autoclave, Sinks, HEPA filters etc. Personal protective equipment (PPE): Gloves, lab coats, N95, PAPR etc. Standard operating procedures: Waste disposal, Spill cleanup, Emergency evacuation, Medical emergencies etc. Leadership: Training, Vaccinations, SOP compliances surveillance, SOPs. Evaluation/validation, Background checks. Principles of biological risk management: Risks identification, Risks assessment, Risks management, Risks communication. Laboratory organization and risk management: Documentation and records, Specimen collection and transport, SOPs for specimen processing, Equipment and consumables management, Collaboration with other laboratories, Data and information management. Standard operating procedures for research involving microbes and recombinant DNA. Designing of containment facilities: Laboratories, Biosafety cabinets, Greenhouses. Biosafety procedures: Assigning of Biosafety levels, BSL-I, BSL-II, BSL-III, BSL-IV. Laboratory organization and management: Documentation and records, Specimen collection and transport, SOPs for specimen processing, Equipment and consumables management, Collaboration with other laboratories, Data and information management. Challenges of biosafety and biosecurity: Bioterrorism, Bio-warfare, Biocrimes etc.

Ethical issues: Working with microbes, GMOs and recombinant DNA research, Dual Use Research of Concern (DURC), Do-it-yourself-biology (DIYBio), International Genetically Engineered Machine (iGEM). Audits/Certification/Accreditation.National Policies and guidelines on biosafety, Biosecurity and biorisk management.International conventions, Treaties and guidelines on biosafety and biosecurity: International Health Regulations (IHRs), Biological Weapons Convention (BWC), The WHO Laboratory Biosafety Manual (LBM) etc.

Recommended Books

1. Centers for Disease Control and Prevention and National Institutes of Health, 2012. Biosafety in Microbiological and Biomedical Laboratories: Centers for Disease Control and Prevention.
2. Fleming, D.O., Richardson, J.H., Tulis, J.J. and Vesley, D., 1995. Laboratory Safety: Principles and Practices. American Society for Microbiology (ASM).
3. Joshi, R., 2006. Biosafety and Bioethics. Gyan Publishing House.
4. Rappert, B., 2009. The Definitions, Uses, and Implications of Biosecurity. Biosecurity: Origins, Transformations and Practices. Basingstoke: Palgrave Macmillan.
5. Sateesh, M.K., 2008. Bioethics and Biosafety. IK International Pvt Ltd.
6. World Health Organization, 2004. Laboratory Biosafety Manual. World Health Organization.

MIC-708	Microbial Strain Development	3(3-0)

THEORY

Introduction to microbial strains used in various industries: Health, Agriculture, Food, Environment. Isolation: Plate method, Tube method, Chemical modification. Screening in population, Blue/white screening method, Library formation. Strain conservation: Lyophilization, Liquid nitrogen, Glycerol. Methods of strain development: Protoplast fusion, Gene cloning. Strain optimization: Metabolic engineering, Flux engineering. Mutagenesis approaches: Chemicals, Radiation, Knock down, Knock out, Cre-loxP, Marker less deletion. Analysis: Nucleic acid purification, Protein purification, Enzymatic assays. Product detection: Detection methods and types, Carbohydrates, Lipids, Proteins, Amino acids, And other chemicals.

Recommended Books

1. Braun., 2001. Microbial Fundamentals of Biotechnology. Wiley-VCH.
2. James., 2007. Directory of Toll Fermentation and Cell Culture Facilities. Seventh Edition. Bio-Endeavors International, Illinois.
3. Jose., 2005. Microbial Enzymes and Bio-transformations: Humana Press Publisher.
4. Misener., 2000. Methods in Molecular Biology. Science publisher.
5. Robert., 2006. Microbiology and Technology of Fermented Foods. Blackwell.

MIC-709	Molecular Mycology	3(3-0)

THEORY

Introduction, Types of fungi, Toxins and fungal pathogenesis. Genetics of phytogenetic fungi. Molecular markers of mycotoxin production: Fusaria, Aspergillus spp. Molecular markers for *Fusarium Oxysporum* formae speciales. Gene regulation of hydrolase expression: Fungus *Trichoderma Reesei* (hypocrea jecorina). Transcriptional regulation of enzymes: Lignocellulolytic fungus. Diversity and genotypic identification: Ultrastructural and phylogenetic characterization of zygomycetes, nuclear ribosomal markers, DNA barcode markers. Molecular identification and characterization of indoor wood decay fungi. Molecular tools for identification and differentiation of different human pathogenic candida and Aspergillus species. Advances in diagnostic tools: Environmental mycology, medical mycology.

Recommended Books

1. Coste AT, 2015. Antifungals: From Genomics to Resistance and the Development of Novel Agents. Caister academic press.
2. Gherbawy Y, 2009. Current Advances in Molecular Mycology. Nova sciences publishers.
3. Hay RJ, 2010. Mycology. Rooks Text Book of Dermatology. Wiley publishers.
4. Machida M, 2010. Aspergillus: Molecular Biology and Genomics. Caister academic press.
5. McGinnis MR, 2012. Current Topics in Medical Mycology. Springer publishers

MIC-710	Molecular Parasitology	3(3-0)

THEORY

Overview of parasitology, Nature of parasitism, Advantages and disadvantages of parasitism. Life cycle: Common parasites of man and animal. Molecular and cell biology of parasite: Dynamics of gene expression and protein interaction, Motility and host invasion. Parasites pathology: Malaria, Trichoderma, Helminthes, Flukes. Drug targeting in parasite infection: Anti parasitic drugs and mechanism of action. Immunology of parasite infections: Intrinsic and extrinsic immune mechanisms. Vector borne diseases: Dengue, Malaria, Leishmaniasis. Diagnosis of parasitic infections. Prevention, control and treatment.

Recommended Books

1. August TM, 2001. Molecular Parasitology. Academic Press, Inc, New York
2. Gershwin KO, 2007. Immunology and Immunopathology of Domestic Animals. Mosby.
3. Hyde JE, 2002. Molecular Parasitology. Van Nostrang Reinhold New York
4. Maizels RM, 2001. Parasite Antigens, Parasite Genes. A Laboratory Manual for Molecular Parasitology. Cambridge University Press, New York.
5. Warren KS, 2004. Immunology and Molecular Biology of Parasitic Infections, Blackwell scientific publications, Oxford.

MIC-711	Vaccinology	3(3-0)

THEORY

An introduction to vaccinology. History of vaccines. Immune system, Recognition of self and nonself. Humoral immunity, Immunoglobulins, Basic structure, Classes and subclasses. Cellular immunity, Lymphocytes, Lymphokines, Cytokines and interones; Antigen recognition-membrane receptors for antigens. MHC classification and functions, Super antigen. Viral proteins as potential targets for vaccine. Recombinant vaccines; Polynucleotide as vaccines, Naked DNA vaccines, Subunit vaccine, Human mucosal vaccines, Combination vaccines, Edible vaccines produced in transgenic plants and microencapsulation. Adjuvants: Classification and properties. Antigen and vaccine delivery strategies. Animal models of vaccine testing. Practical issues in relation to trials. Ethical issues related to clinical evaluation of vaccines.Vaccine safety. Review of vaccines in current use. Cost-effective approaches for production of new vaccines. Role of multinational companies in vaccines production.

Recommended Books

1. Bloom, B.R. and Lambert, P.H. eds., 2002. The Vaccine Book. Academic Press.
2. Brown, F., Lewis Jr, A.M., Peden, K. and Krause, P., 2001. Evolving Scientific and Regulatory Perspectives on Cell substrates for vaccine Development. Karger AG Publishers.
3. Evans, A.S., 2013. Viral Infections of Humans: Epidemiology and Control. Springer Science & Business Media.
4. Gregoriadis, G., McCormack, B. and Allison, A.C. eds., 2012. Vaccines: New Generation Immunological Adjuvants (Vol. 282). Springer Science & Business Media..
5. Nathanson, N., 2007. Viral Pathogenesis and Immunity. Academic Press.
6. Orentas, R., Hodge, J.W. and Johnson, B.D., 2007. Cancer Vaccines and Tumor Immunity. John Wiley & Sons.

MIC-712	Microbial Biotechnology	3(3-0)

THEORY

Scope of microbial biotechnology. Genetically modified microorganisms. Principles of microbial growth; Introduction, The ways of growing microorganisms, Ways to increase yield of microbes, Batch, Fed-batch and continuous cultures. Commercial production of microorganisms; Industrial fermenters, Single-cell protein. Products from microorganisms; Metabolites, Enzymes, Antibiotics. Bioconversions; Biomining and bioleaching of ores (use of thermophilic microorganisms in industrial microbiology, Bio-gas, Bio-leaching, Bio-diesel. Microorganisms & agriculture; Microorganisms in agricultural, Biofertilizers, Microbial pesticides, Waste water treatment, Vermiculture. Bioremediation, Biodegradation of oil and petroleum products, Wastewater treatment, Chemical degradation, Bioremediation of heavy metals (e.g. Copper, Uranium).

Recommended Books

1. Ahmad, I., Ahmad, F. and Pichtel, J. eds., 2011. Microbes and Microbial Technology: Agricultural and Environmental Applications. Springer Science & Business Media.
2. Arora, R., 2012. Microbial Biotechnology: Energy and Environment. CABI.
3. Glazer, A.N. and Nikaido, H., 2007. Microbial Biotechnology: Fundamentals of Applied Microbiology. Cambridge University Press.
4. Kreuzer, H. and Massey, A., 2005. Biology and Biotechnology: Science, Applications And Issues. ASM Press.
5. Kun, L.Y. ed., 2003. Microbial Biotechnology: Principles and Applications. World Scientific Publishing Co Inc.
6. McCarty, P.L., 2012. Environmental Biotechnology: Principles and Applications. Tata McGraw-Hill Education..

Annexure-VI

SCHEME OF STUDIES FOR Ph.D. MICROBIOLOGY PROGRAMME

PhD Microbiology Semester-wise Courses Distribution

Course Code	Course Title	Credit Hours
PhD Microbiology (1st Semester)		
Major Courses		
MIC-851	Advances in Microbiology (Compulsory)	3(3-0)
MIC-XXX	Optional	3(3-0)
MIC-820	Seminar I	1(1-0)
MIC-819	Special Problem	1(1-0)
Minor Courses		
XXX	Opt one 3 credit hrs course	3(3-0)
STAT-702	Biostatistical Analyses (Compulsory)	3(3-0)
2nd Semester		
Major Courses		
MIC-XXX		3(3-0)
MIC-XXX		3(3-0)
BCH-820	Seminar II	1(1-0)
Minor Courses		
	Opt one 3 credit hrs course	3(3-0)
3rd Semester onwards		
BCH-899	Thesis	50(0-100)

Optional Courses:

Optional courses requirement to be fulfilled by those offered by the Department for PhD studies in consultation with major supervisor.

List of Optional Courses for PhD in Microbiology

Sr. No.	Course Code	Course Title	Credits Hours
1	MIC-801	Anti-Microbial Peptides	3(3-0)
2	MIC-802	Bio-Chemical Engineering	3(3-0)
3	MIC-803	Metabolomics	3(3-0)
4	MIC-804	Bacteriophages and Phage Therapy	3(3-0)
5	MIC-805	Microbial Metagenomics	3(3-0)
6	MIC-806	Human Microbiome	3(3-0)

Course Contents

Contents

MIC-851	Advances in Microbiology	3(3-0)

THEORY

Theory

Advanced level course will cover all recent advances in Microbiology including microbial ecology, antimicrobial resistance, microbial genetics, biotechnology, food microbiology, clinical microbiology, virology, medical microbiology, bacterial pathogenicity, microbial genomics and proteomics etc. The Nobel laureates and their research findings in the recent past.

Recommended Books

1. Nature and Science series
2. Current Topics, Critical Reviews and other research journals
3. Recent topics on Microbiology Journals and web Sources

MIC-801	Antimicrobial Peptides	3(3-0)

Theory

Introduction to antimicrobial peptides: History and evolution. Amphipathic and hydrophobic properties of antimicrobial peptides. Structure of antimicrobial peptides: Dermicidin, Cecropins, Andropins, Abaecin, Buforin. Diversity of antimicrobial peptides: Anionic peptides, Cationic peptides, Structure of antimicrobial peptides. Mechanism of action of antimicrobial peptides: Defensin, Cathericidin. The antimicrobial and anticancer activities of antimicrobial peptides. The role of antimicrobial peptides in animal defenses: Immunomodulation. Model for membrane interaction of antimicrobial peptides. Therapeutic potential of antimicrobial peptides: US food and drug administration (FDA) trials. Antimicrobial peptides for multidrug resistant pathogens. Analysis of antimicrobial peptides: Atomic emission microscopy, Confocal microscopy, Circular dichroism.

Recommended Books

1. David A, 2013. Antimicrobial Peptides. Wiley publishers
2. Izadpanah A, 2005. Antimicrobial Peptides. J Am Acad Dermatol
3. Pinheiro DS, 2012. Antimicrobial Peptides: Clinical Relevance and Therapeutic Implications. Peptides
4. Wiesner J, 2010. Antimicrobial Peptides: The Ancient Arm of the Human Immune System. Virulence

MIC-802	Bio-chemical Engineering	3(3-0)

Thory

Nucleic acids: Basic structure, Types, In vitro applications, Gene expression and regulation: Prokaryotic system, Eukaryotic system, Mutations: Chemicals and radiations. Genetic engineering: Current advances in biochemical production. Energetics and stoichiometry: Thermodynamics, Enzyme kinetics. Sterilization: Concept, Iindustrial scale sterilization techniques. Cell growth: Basic principle and requirement for cell growth and control for optimum cell growth. Chemostat theory and bioreactor design: Current design, Student assignment for reactor design. Immobilized cells and enzymes: Methods and applications. Biosensors: Strategies for engineering biosensors and their applications. Product recovery: Steps for product recovery, Methods.

Recommended Books

6. Brown TA 2010. Gene cloning and DNA analysis : an introduction 6th ed. Oxford : Wiley-Blackwell
7. El-Mansi et al. 2006. Fermentation Microbiology and Biotechnology, Second Edition. Taylor and Francis Group.
8. Snyder, L. and Champness W., 2007. Molecular Genetics of Bacteria, 3rd Ed, American Society for Microbiology.
9. Stanbury PF et al. 2003. Principles of Fermentation Technology. Second Edition. Butterworth Heinemann.

MIC-803	Metabolomics	3(3-0)

Theory

Metabolism: Prokaryotes and eukaryotes metabolism. Metabolic pathways: Lipid, Amino acids, Carbohydrates. Metabolites: Primary metabolic pathways and their metabolites, Secondary metabolic pathways and their metabolites. Samples preparation for metabolomics analysis: Urine, Blood, Feces, Vegetables, Meat, Milk. System biology for metabolomics analysis. Separation and detection methods for metabolomics analysis. Gas chromatography and mass spectrometry (GC-MS): From samples preparation to metabolite detection. Liquid chromatography mass spectrometry (LC-MS): From samples preparation to metabolite detection. Metabolomics for fundamental genetics: Determination of phenotypes. Metabolomics for estimation toxicity: Determination of toxic chemical levels.

Recommended Books

1. Allwood JW, 2011. Plant Metabolomics and Its Potential for Systems Biology Research Background Concepts, Technology, and Methodology. Methods Enzymol. 500:299-336.
2. Antonucci R, 2010. Metabolomics: the "New Clinical Chemistry" for Personalized Neonatal Medicine. Minerva Pediatr. 62(3 Suppl 1):145-8
3. Barrett D, 2012. Advances in Metabolic Profiling. Bioanalysis. 4(6):643-4
4. Shepherd LV, 2011. Metabolomics: A Second-Generation Platform for Crop and Food Analysis. Bioanalysis.
5. Wishart DS, 2011. Advances in Metabolite Identification. Bioanalysis. 3(15):1769-82

MIC-804	Bacteriophages and Phage Therapy	3(3-0)

Theory

Discovery and brief history of bacteriophages. Phage morphology and composition. Phage general properties such as heat stability, Thermal death time, pH stability, Host range, Burst size, Latent time, Specificity of phage infection, Multiplicity of infection. Isolation of bacteriophages for different sources and prevalence of phages. Classification of bacteriophages. Mechanisms of phage adsorption and penetration, Bacteriophage receptors on cell surface, Receptors localized in cell wall of Gram-negative and of Gram-posative, Receptors localized in capsular polysaccharides, Pili and flagella. Stages in the lytic and lysogenic life cycle of a typical bacterophage (T-4 phage). Properties of T4 DNA, Genetic organization, Growth cycle and replication of T-4 DNA. Phage as biofilm control agent, Different strategies followed by bacteriophages for bacterial biofilm eradication. Application of bacteriophages: Applications in food safety, Agriculture, Aquaculture, Veterinary, Environmental sanitation and waste water treatment. Genetic recombination in phages, Genes within genes, Bacteriophage Φ X174, Phage vectors and transposons. Phage display technology and its application in target drug delivery. Phage therapy and it practical application, Phage based diagnostic systems, Phages in biotechnology. Comparison of phage therapy and antibiotics. Phage therapy- constraints and possibilities.

Recommended Books

1. Abedon ST, 2005. The Bacteriophages. Oxford University Press.
2. Birge, E.A., 2008. Bacterial and Bacteriophage Genetics. Springer Science & Business Media.
3. Kutter, E. and Sulakvelidze, A. eds., 2004. Bacteriophages: Biology and Applications. CRC Press.
4. Mc Grath, S. and van Sinderen, D. eds., 2007. Bacteriophage: Genetics and Molecular Biology. Horizon Scientific Press.
5. Murray, M.T. and Pizzorno, J.E., 2013. Textbook of Natural Medicine. Elsevier.

MIC-805	Microbial Metagenomics	3(3-0)

Theory

Introduction to metagenomics: Basic concept of metagenomics, Microbial diversity, Tools for studying microbial diversity, Culture dependent approaches, Culture independent approaches, 16S/18S metagenomics and species identification. Diversity of microbial metagenomics: Gut metagenome, marine metagenome, Extraterrestrial metagenome, Viral metagenomes, Sewage metagenome, Host specific metagenome. Metagenomic sequencing technologies: Basics of sequencing, Sanger sequencing, Advanced sequencing (Roche 454, SOLID, Ion torrent, Illumina, sequencing). Sequence analysis: Principle and interpretation, Analysis of metagenomic data. Bioinformatics tools for metagenomics (assembly and analysis): Software used for analysis, Mothur, QIIME, MG-RAST, CLC workbench, Galaxy etc. Applications of metagenomics: Bioprospecting using metagenomic approaches, Gene mining for successful biological products, Antibiotic producer genes, Enzymes producer (lipases, proteinases, amylases etc), anticancer drugs, Biodegradation, Agriculture etc. Metagenomic approaches in identification of novel viruses. Challenges in metagenomics analysis: Data quality, Reproducibility, Resources. Future perspectives in metagenomics.

Recommended Books

1. Bethesda, M.D., 2006. Metagenomics- Sequences from the Environment. National Center for Biotechnology Information (US).
2. De Bruijn, F.J., 2011. Handbook of Molecular Microbial Ecology II: metagenomics in different habitats (Vol. 2). John Wiley & Sons.
3. Higgins, D. and Taylor, W., 2000. Bioinformatics: Sequence, Structure, and Databanks: A Practical Approach. Oxford University Press Inc.
4. Wren, B. and Dorrell, N., 2002. Functional Microbial Genomics. Academic Press.

MIC-806	Human Microbiome	3(3-0)

Theory

Introduction to the human microbiome: Description of bacteria, Archaea, Viruses, Fungi and protists that comprise the microbiome, Composition at various sites in the body. Diversity of microbiome: Functional diversity, Structural diversity. The human gut microbiome: Composition and function along the gastrointestinal tract (eg., stomach, ileum and stool), Role in health and diseases (Gut microbiome and immune system, Gut microbiome and obesity, Gut microbiome and nervous system diseases etc.). The microbiome of the oral cavity, Nasopharyngeal tract and respiratory tract: Site-Specific microbiota in the oral cavity, The lower respiratory tract and lung parenchyma, Role in health and disease. The microbiome of the genitourinary system: The vaginal microflora and changes with disease and pregnancy, Microbiome of the placenta and fetal tissues, Microbiome of the breast and of milk, Acquisition of the microbiome by the newborn and development in children. Potential of the microbiome to prevent and treat diseases: The dysbiosis concept of disease, Selecting and testing prebiotics that foster a healthy microbiome. Effects of human interventions on microbiome: Effects of antibiotics, Probiotics and prebiotics, Fecal transplant, Future strategies to modify the microbiome at various sites. Study approaches and analysis of microbiome: DNA-based analysis of microbial communities, 16S rRNA gene amplicon sequencing, Shotgun metagenomics sequencing methods, Functional analysis of the microbiome from DNA sequence, Metatranscriptome, Metabolome, Proteome, Glycome. Use of the microbiome in epidemiologic research: Methodologic consideration, Statistical analytic methodologies, Bioinformatics and regression analysis. Microbiome studies, Challenges and opportunities. Human microbiome project. Ethics in microbiome studies.

Recommended Books

1. Nelson, K.E., Peterson, J.L. and Garges, S., 2011. Metagenomics of The Human Body. Springer.
2. Shreiner, A., Huffnagle, G.B. and Noverr, M.C., 2008. The "Microflora Hypothesis" Of Allergic Disease. In GI Microbiota and Regulation Of The Immune System (pp. 113-134). Springer New York.
3. Turnbaugh, P.J. and Stintzi, A., 2011. Human Health and Disease In A Microbial World. Frontiers in Microbiology. Frontiers Media SA.
4. Wilson, M., 2009. Bacteriology of Humans: An Ecological Perspective. John Wiley & Sons.

Annexure-VII

Scheme of Studies _MPhil Medical Lab Technology (MLT)

MPhil in Medical Laboratory Technology (MLT)

Program Duration: 2 years (4 semesters)
Total Credit Hours: 30–36
Structure: Coursework + Research Thesis
Eligibility Criteria:

- Educational Qualification: A 16-year education degree (BS or equivalent) in Medical Laboratory Technology, Biomedical Sciences, or a related field from an HEC-recognized institution.
- Minimum CGPA: At least a 2.5 out of 4.0.
- Admission Test: A minimum of 50% marks in a GAT-General test

1. Laboratory Facilities

- **Specialized Laboratories:** Institutions must have fully equipped laboratories relevant to Clinical Biochemistry/MLT, including:

➢ Clinical Biochemistry
➢ Hematology
➢ Microbiology
➢ Molecular Biology
➢ Histopathology

❖ **Equipment and Materials:**

Laboratories should be furnished with modern equipment, glassware, and reagents necessary for advanced research and diagnostics.

❖ **Support Staff:** Qualified laboratory personnel must be available to assist in practical sessions and research activities.

2. Faculty Requirements

- **Qualified Faculty:** A minimum of two full-time PhD faculty members is required for MPhil programs, with expertise in relevant MLT disciplines.
- **Internet Connectivity:** High-speed internet access (minimum 256 Kbps per user) to support research and learning activities.

3. Administrative and Support Services

- **Administrative Offices:** Spaces for program coordinators and administrative staff to manage program logistics.

List of Core Courses MPhil MLT

MLT-701	Advanced Clinical Biochemistry	3(3-0)
MLT-702	Molecular Diagnostics in Clinical Practice	3(3-0)
MLT-703	Advanced Hematology & Coagulation Disorders	3(3-0)
MLT-704	Biostatistics & Research Methodology	3(2-2)
MLT-720 (I)	Seminar-I	1(1-0)
MLT-705	Medical Microbiology and Infectious Disease	3(3-0)
MLT-706	Advanced Immunology & Immunopathology	3(3-0)
MLT-707	Quality Control and Clinical Laboratory Management	3(3-0)

MLT-708	Clinical Genetics & Genomic Medicine	3(3-0)
MLT-720 (II)	Seminar-II	1(1-0)

List of Optional Courses MPhil MLT

Course Code	Course Title	Credits
MLT-710	Molecular Oncology and Cancer Biomarkers	3(3-0)
MLT-711	Transfusion Science and Blood Banking	3(3-0)
MLT-712	Advanced Virology and Vaccine Technology	3(3-0)
MLT-713	Forensic Laboratory Science	3(3-0)
MLT-714	Biosafety & Bioethics	3(3-0)

Courses MPhil MLT (Semester Wise Distribution of Courses)

Semester	Course Code	Course Title	Credits
First	MLT-701	Advanced Clinical Biochemistry	3(3-0)
	MLT-702	Molecular Diagnostics in Clinical Practice	3(3-0)
	MLT-703	Advanced Hematology & Coagulation Disorders	3(3-0)
	MLT-704	Biostatistics & Research Methodology	3(2-2)
	XXX	Minor /Optional Course	3(3-0)
	MLT-720 (I)	Seminar-I	1(1-0)
			16
Second	MLT-705	Medical Microbiology and Infectious Disease	3(3-0)
	MLT-706	Advanced Immunology & Immunopathology	3(3-0)
	MLT-707	Quality Control and Laboratory Management	3(3-0)
	MLT-708	Clinical Genetics & Genomic Medicine	3(3-0)
			3(3-0)
	XXX	Minor/Optional Course	3(3-0)
	MLT-720 (II)	Seminar-II	1(1-0)
			16
Third	Research &Thesis		
Fourth	Research &Thesis		

MLT-701	Advanced Clinical Biochemistry	3(3-0)

THEORY

In-depth study of biochemical processes and markers in health and disease. Covers metabolic pathways, diagnostic enzymology, and biochemical interpretation.

Recommended Books (Latest available editions):

1. Richard, A., Harvey, R.A., Ferrier, D.R. Lippincott's Illustrated Reviews: Biochemistry. Lippincott Williams & Wilkins
2. Murray, R.K., Grannar, D.K., Rodwell, V.W.. Harper's Illustrated Biochemistry, McGraw Hill.
3. Nelson, D.L., Cox, M.M. Lehninger Principles of Biochemistry. W. H. Freeman Publishers.
4. Voet, D. and Voet, J. Biochemistry. John Wiley and Sons.
5. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D., Darnell, J. E. Molecular Cell Biology. W. H. Freeman & Co
6. Berg, J.M., John, L.T., Stryer, L. Biochemistry. 6th Ed. W. H. Freeman and Co.
7. Boyer, R. F. Concepts in Biochemistry, J. Wiley & Sons Inc.
8. West, E. S, Willberd, R. T., Howard, S.M. and Johan. T.V.B. Text Book of Biochemistry. Macmillan.

MLT-702	Molecular Diagnostics in Clinical Practice	3(3-0)

THEORY

Principles and applications of PCR, RT-PCR, blotting techniques, microarrays, and CRISPR-based diagnostics.

Principles and applications of PCR, RT-PCR, blotting techniques, microarrays, and CRISPR-based diagnostics.

Recommended books:

1. Molecular Diagnostics by Buckingham & Flaws 2019
2. Diagnostic Molecular Biology by Chang-Hui 2018
3. Essentials of Molecular Biology by Brown 2020
4. PCR Technology by Henry Erlich 2022

MLT-703	Advanced Hematology & Coagulation Disorders	3(3-0)

THEORY

Introduction to hematology Role of growth factors in hematopoiesis-erythropoiesis, granulopoiesis and megakariopoiesis. Morphology of red blood cells, white blood cells and platelets. Complete blood count and its importance. Introduction to hemoglobin structure, synthesis and function. Defects of RBCs. Introduction to anemia and classification Role of Vitamin B 12 and Folate deficiency

Recommended Books:

1. Essential of Hematology, A.V Hoff Brand, 6th edition 2006
2. Clinical Hematology, G.C Degrunchi, 5th edition 2002
3. Practical Hematology, Dacie J.V. 10th edition 2012
4. Hmeatology, Hoffman, 5th edition 2019
5. PCR Technology by Henry Erlich 2022.

MLT-704	Biostatistics & Research Methodology	3(2-2)

Introduction to the course, Research basics, hypothesis and its types, study design, student exercises, Types of research studies in Bio Medical sciences. Synopsis writing: Introduction, components of a research synopsis, synopsis writing skills, sample research synopsis, University format of research synopsis. Discussion of student assignments. Scientific literature search. Computer lab exercise for literature search. Scientific Communications, writing scientific assays, research articles, reviews, thesis. References: Different reference styles, use reference manager and endnote. Plagiarism: Introduction to plagiarism, types of plagiarism, plagiarism software, how to avoid it, regulations regarding, plagiarism. Using plagiarism detection software (Turnitin).

Practical:

1. Numerical variables
2. Categorical variables
3. Hypothesis testing
4. Research designs
5. Types of research articles
6. SPSS data entry
7. Chi square testing
8. T testing
9. ANOVA testing
10. Reference styles

Recommended Books:

1. Foundation of Clinical Research by Portney LG Walkais MP in 1993, Publisher by Appleton and lauge USA
2. A guide to Research Methodology, Biostatistics and Medical writing by college of physicians and surgeons Pakistan by WHO collaboration center
3. Health system research project by Corlien M Varkerisser, Indra Pathmanathan, Ann Brownlee in 1993 by International Development Research Center in New Dehli, Singapore.
4. Essentials of Research Design and Methodology, Geoffrey R, 2019

MLT-705	Medical Microbiology and Infectious Disease	3(3-0)

Study of bacterial, viral, fungal, and parasitic infections; diagnostics; antimicrobial resistance mechanisms. Infectious Disease Concepts, Antimicrobial Agents and Susceptibility Testing, Bioterrorism Agents, Outbreak Investigations and Surveillance. Molecular Epidemiology of Infectious Disease. Modeling of Infectious Disease Cyclicity of Diseases:

Recommended Books

1. Mahon, Connie R, Donald C. Lehman, and George Manulselis 2018, Textbook of Diagnostic Microbiology, 6th ed
2. Murray, P.R.,K.S. Rosenthal and M. Pfaller, 2016. Medical Microbiology. Elsevier, 8th ed
3. Krasner, R.I. and Shors, T., 2013. The Microbial Challenge: A Public Health Perspective. Jones & Bartlett Learning. 3rd ed.
4. Barer, M., W. L. Irving, Swann, A. Perera, N., 2019. Medical Microbiology: A Guide to Microbial Infections: Pathogenesis, immunity, laboratory investigation and control. 19th Ed. Amsterdam, Netherlands Elsevier.

MLT-706	Advanced Immunology & Immunopathology	3(3-0)

Immune mechanisms in health and disease, hypersensitivities, autoimmune disorders, immunoassays, and transplantation. Introduction: chronological development and scope of immunology. Immunity and immune responses. Complement system The ABO and Rh blood group systems, their chemical basis, inheritance & clinical significance. Immunoglobulins: structure and function; classes HLA & MHC and its role in immune response, disease and its significance in tissue

transplantation. Immunoregulation and tolerance. Autoimmune disorders. Cancer immunology. Introduction to immunopathology: hypersensitivity reactions, autoimmune diseases and immunodeficiencies. Immunization.

Practical:

1. Agglutination Tests
2. ELISA
3. Hemagglutination Tests
4. Precipitin Tests
5. Complement fixation
6. Immunofluorescence Assay (IFA)
7. Flow Cytometry
8. Radioimmunoassay (RIA)
9. Antinuclear antibody test
10. C- Reactive protein

Recommended Books:

1. Clinical Immunology and Serology A laboratory Perspective, 3rd edition by Christine Dorresteyn Stevens.
2. Manual of Laboratory medicine AFIP, third Edition 2005 publication Armed Forces Institute of Pathology Rawalpindi Pakistan.
4 District Laboratory practice in tropical countries Vol. 1 & 2 Monica Cheesbrough Cambridge University Press. Low price Edition 2000
5. Clinical Chemistry: principles, methods & interpretation 2nd Edition by Prof. Dr. Abdus
6. Salam Khan Gandapur 2003. Tahir Instruments Ltd Singapura Lahore-Pakistan

MLT-707	Quality Control and Laboratory Management	3(3-0)

Theory:

Quality control introduction, Concepts in total quality management, accreditation systems concept and costs, (ISO15189), lab safety, audits, and inventory control.

Assessment—audits Assessment external quality, assessment norms and accreditation, Personnel Customer service Occurrence management, Process improvement Records and management of records, Qualities of lab manager, Cost managements

Recommended Books:

1. Laboratory quality management system: handbook. World Health Organization
2. Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics, 7th edition
3. Laboratory Management: Principles and Processes 2nd Edition by Denise M. Harmening
4. Quality Assurance and Quality Control in the Analytical Chemical Laboratory: A Practical Approach by Piotr Konieczka, Jacek Namiesnik

MLT-708	Clinical Genetics & Genomic Medicine	3(3-0)

Theory:

Human genetics, cytogenetics, next-gen sequencing, and clinical implications of genetic variations. Fundamental concepts and principles in population and quantitative genetics, meta-genomics

Recommended Books:

1. Lewis M and Smith C. Molecular Evolution: Reference Source & Guide. 2015
2. CreateSpace Independent Publishing Platform. Wiley E-Text, Human Genetics and Genomics, 4th Edition. 2012
3. Thompson & Thompson Genetics in Medicine 2020
4. Emery's Elements of Medical Genetics 2019

5. Human Molecular Genetics by Tom Strachan 2021
6. Genomics and Personalized Medicine by Altman and Klein 2019

Annexure-VIII

Scheme of Studies PhD Medical Lab Technology (MLT)

PhD in Medical Laboratory Technology (MLT)

Eligibility Criteria:

- **Educational Qualification:** An 18-year education degree (MS/MPhil or equivalent) in Medical Laboratory Technology, Biomedical Sciences and equivalent.
- **Minimum CGPA:** At least a 3.0 out of 4.0.
- **Admission Test:** A minimum of 70% marks in a GAT-Subject test or University Entrance Exam.

1. Laboratory Facilities

- **Specialized Laboratories:** Institutions must have fully equipped laboratories relevant to MLT, including:
  - Clinical Biochemistry
  - Hematology
  - Microbiology
  - Molecular Biology
  - Histopathology

❖ **Equipment and Materials:**

Laboratories should be furnished with modern equipment, glassware, and reagents necessary for advanced research and diagnostics.

❖ **Support Staff:** Qualified laboratory personnel must be available to assist in practical sessions and research activities.

2. Faculty Requirements

- **Qualified Faculty:** A minimum of 3 full-time PhD faculty members is required for with expertise in relevant MLT disciplines.
- **Internet Connectivity:** High-speed internet access (minimum 256 Kbps per user) to support research and learning activities.

3. Administrative and Support Services

- **Administrative Offices:** Spaces for program coordinators and administrative staff to manage program logistics.

List of Compulsory Courses for PhD MLT

Course Code	Course Title	Credits
MLT-801	Advanced Clinical Biochemistry	3(3-0)
MLT-802	Advances in Molecular Diagnostics in Clinical Practice	3(3-0)
MLT-805	Medical Microbiology and Infectious Disease	3(3-0)
MLT-806	Advanced Immunology & Immunopathology	3(3-0)

List of Optional Courses for PhD MLT

Course Code	Course Title	Credits
MLT-810	Molecular Oncology and Cancer Biomarkers	3(3-0)
MLT-811	Transfusion Science and Blood Banking	3(3-0)
MLT-812	Advanced Virology and Vaccine Technology	3(3-0)
MLT-813	Forensic Laboratory Science	3(3-0)
MLT-814	Biosafety & Bioethics	3(3-0)

Courses PhD MLT (Semester Wise Distribution of Courses)

Semester	Course Code	Course Title	Credits
First	MLT-801	Advanced Clinical Biochemistry	3(3-0)
	MLT-802	Advances in Molecular Diagnostics in Clinical Practice	3(3-0)
	STAT-711	Advanced Experimental Design and Data Processing	3(3-0)
	BIOT-XXX		3(2-2)
	MLT-820 (I)	Seminar-I	1(1-0)
			10
Second	MLT-805	Medical Microbiology and Infectious Disease	3(3-0)
	MLT-806	Advanced Immunology & Immunopathology	3(3-0)
	ZOOL-751	Quality Control and Laboratory Management	3(3-0)
	BCH-751	Advances in Biotechnology	3(3-0)
	MLT-720 (II)	Seminar-II	1(1-0)
			10

MLT-801	Advanced Clinical Biochemistry	3(3-0)

THEORY

Recent research articles, In-depth study of biochemical processes and markers in health and disease. Covers metabolic pathways, diagnostic enzymology, and biochemical interpretation.

Recommended Books (Latest available editions):

9. Richard, A., Harvey, R.A., Ferrier, D.R. Lippincott's Illustrated Reviews: Biochemistry. Lippincott Williams & Wilkins
10. Murray, R.K., Grannar, D.K., Rodwell, V.W.. Harper's Illustrated Biochemistry, McGraw Hill.

11. Nelson, D.L., Cox, M.M. Lehninger Principles of Biochemistry. W. H. Freeman Publishers.
12. Voet, D. and Voet, J. Biochemistry. John Wiley and Sons.
13. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D., Darnell, J. E. Molecular Cell Biology. W. H. Freeman & Co
14. Berg, J.M., John, L.T., Stryer, L. Biochemistry. 6th Ed. W. H. Freeman and Co.
15. Boyer, R. F. Concepts in Biochemistry, J. Wiley & Sons Inc.
16. West, E. S, Willberd, R. T., Howard, S.M. and Johan. T.V.B. Text Book of Biochemistry. Macmillan.

MLT-802	Molecular Diagnostics in Clinical Practice	3(3-0)

THEORY

Recent research articles ,Principles and applications of PCR, RT-PCR, blotting techniques, microarrays, and CRISPR-based diagnostics.

Principles and applications of PCR, RT-PCR, blotting techniques, microarrays, and CRISPR-based diagnostics.

Recommended books:

5. Molecular Diagnostics by Buckingham & Flaws 2019
6. Diagnostic Molecular Biology by Chang-Hui 2018
7. Essentials of Molecular Biology by Brown 2020
8. PCR Technology by Henry Erlich 2022

MLT-803	Advanced Hematology & Coagulation Disorders	3(3-0)

THEORY

Recent research articles , Introduction to hematology Role of growth factors in hematopoiesis-erythropoiesis, granulopoiesis and megakariopoiesis. Morphology of red blood cells, white blood cells and platelets. Complete blood count and its importance. Introduction to hemoglobin structure, synthesis and function. Defects of RBCs. Introduction to anemia and classification Role of Vitamin B 12 and Folate deficiency

Recommended Books:

6. Essential of Hematology, A.V Hoff Brand, 6th edition 2006
7. Clinical Hematology, G.C Degrunchi, 5th edition 2002
8. Practical Hematology, Dacie J.V. 10th edition 2012
9. Hmeatology, Hoffman, 5th edition 2019
10. PCR Technology by Henry Erlich 2022.

Annexure-IX

Scheme of Studies BS Biochemistry
(4 Years Program)

II **A single major** (Minimum of 132 credit hours), that requires
i. General Education courses: 32 credit hours
ii. Major: minimum 73 credit hours
iii. Interdisciplinary/ Allied courses: minimum 21 credit hours
iv. Field experience/internship: 03 credit hours
v. Capstone project: 03 credit hours

The courses distribution along with their credit hours is given below:

S#	Division/Courses	Total Number	Credit hours
1.	Major	25	73
2.	General Education Courses	13	32
3.	Interdisciplinary/Allied Courses	07	21
4.	Field Experience/Internship	01	3
5.	Capstone Project	01	3
	Total Credits		**132**

List of Major Courses

S.#	Course Code	Course Title	Theory	Practical	Credits
1	BCH-301	Introductory Biochemistry	2	1	3(2-2)
2	BCH-302	Molecular Biology	2	1	3(2-2)
3	BCH-303	Cell Biology	2	1	3(2-2)
4	BCH-304	Principles of Genetics	3	0	3(3-0)
5	BCH-306	Fundamentals of Enzymology	2	1	3(2-2)
6	BCH-401	Nucleic Acids	2	0	2(2-0)
7	BCH-402	Carbohydrates	2	1	3(2-2)
8	BCH-403	Amino Acids and Proteins	2	1	3(2-2)
9	BCH-404	Lipids	2	1	3(2-2)
10	BCH-405	Bioinformatics	2	1	3(2-2)
11	BCH-406	Integrated Metabolism	3	0	3(3-0)
12	BCH-501	Genetic Engineering	2	1	3(2-2)
13	BCH-502	Cellular Signaling	3	0	3(3-0)
14	BCH-503	Protein Chemistry	**3**	**0**	**3(3-0)**
15	BCH-504	Biotechnology	2	1	3(2-2)
16	BCH-505	Biochemical Techniques	1	2	3(1-4)
17	BCH-506	Introduction to Bioenergetics	2	0	2(2-0)
18	BCH-507	Tissue and Cell Culture	2	1	3(2-2)
19	BCH-508	Plant Biochemistry	2	1	3(2-2)
20	BCH-601	Industrial Biochemistry	2	1	3(2-2)
21	BCH-603	Good Laboratory Practices and Quality Control	3	0	3(3-0)
22	BCH-605	Biomembranes	2	0	2(2-0)
23	BCH-607	Nutritional Biochemistry	2	1	3(2-2)
24	BCH-609	Immunology and Immunochemistry	3	0	3(3-0)
25	BCH-611	Current Trends in Biochemistry	3	0	3(3-0)
26	BCH-620	Seminar	1	0	1(1-0)
					73

List of General Education Courses (Mandatory)

S.#	Course Code	Course Title	Theory	Practical	Credits
1.	CHEM-401	Organic Chemistry	2	1	3(2-2)
2.	CSC-100	Applications of Information and Communication Technologies (ICT)	2	1	3(2-1)
3.	ENG-301	Functional English	3	0	3(3-0)
4.	ENG-302	Expository Writing	3	0	3(3-0)
5.	IS-302	Islamic Studies and Ethics	2	0	2(2-0)
6.	QR-401	Quantitative Reasoning-I	3	0	3(3-0)
7.	QR-402	Quantitative Reasoning-II	3	0	3(3-0)
8.	SOC-301	Introduction to Sociology	2	0	2(2-0)
9.	SOS-301	Moral Foundation of Education	2	0	2(2-0)
10.	SSH-301	Civic and Community Engagement	2	0	2(2-0)
11.	SSH-302	Ideology and Constitution of Pakistan	2	0	2(2-0)
12.	SSH-304	Entrepreneurship	2	0	2(2-0)
13.	???-???	Time Management & Organizing Skills	2	0	2(2-0)

List of Interdisciplinary/Allied Courses

S.#	Course Code	Course Title	Theory	Practical	Credits
5.	ZOOL-313	Human Physiology	2	1	3(2-2)
6.	CHEM-301	Inorganic Chemistry	2	1	3(2-2)
7.	CHEM-501	Physical Chemistry	2	1	3(2-2)
8.	MIC-311	General Microbiology	2	1	3(2-2)

Internship/Field Experience, Capstone Project

S.#	Course Code	Course Title	Theory	Practical	Credits
1.	BCH-299	Internship/Field Experience	0	3	3(0-6)
2.	BCH-399	Capstone Project	0	3	3(0-6)

List of Minor Courses

S.#	Course Code	Course Title	Theory	Practical	Credits
9.	BCH-301	Introductory Biochemistry	2	1	3(2-2)
10.	BCH-302	Molecular Biology	2	1	3(2-2)
11.	BCH-304	Principles of Genetics	2	1	3(2-2)
12.	BCH-306	Fundamentals of Enzymology	2	1	3(2-2)
13.	BCH-405	Bioinformatics	2	1	3(2-2)
14.	BCH-406	Integrated Metabolism	3	0	3(3-0)
15.	BCH-501	Genetic Engineering	2	1	3(2-2)
16.	BCH-505	Biochemical Techniques	1	2	3(1-4)

List of Audit Courses

S.#	Course Code	Course Title	Theory	Practical	Credits
1	TOQ-301	Translation of Quran (Audit Course)	1	0	1(1-0)
2	TOQ-401	Translation of Quran (Audit Course)	1	0	1(1-0)
3	TOQ-501	Translation of Quran (Audit Course)	1	0	1(1-0)
4	TOQ-601	Translation of Quran (Audit Course)	1	0	1(1-0)

Semester Wise Courses

Semester	Course Code	Course Title	Theory	Practical	Credits
First	BCH-301	Introductory Biochemistry	2	1	3(2-2)
	BCH-303	Cell Biology	2	1	3(2-2)
	CHEM-401	Organic Chemistry	2	1	3(2-2)
	ENG-301	Functional English	3	0	3(3-0)
	QR-401	Quantitative Reasoning-I	3	0	3(3-0)
	TOQ-301	Translation of Quran (Audit Course)	1	0	1(1-0)
	???-???	Time Management & Organizing Skills	2	0	2(2-0)
			14	**3**	**17**
Second	BCH-302	Molecular Biology	2	1	3(2-2)
	BCH-304	Principles of Genetics	3	0	3(3-0)
	BCH-306	Fundamentals of Enzymology	2	1	3(2-2)
	SSH-301	Civic and Community Engagement	2	0	2(2-0)
	CSC-100	Applications of Information and Communication Technologies (ICT)	2	1	3(2-1)
	IS-302	Islamic Studies and Ethics	2	0	2(2-0)
	TOQ-401	Translation of Quran (Audit Course)	1	0	1(1-0)
			13	**3**	**16**
Third	BCH-401	Nucleic Acids	2	0	2(2-0)
	BCH-403	Amino Acids and Proteins	2	1	3(2-2)
	BCH-405	Bioinformatics	2	1	3(2-2)
	QR-402	Quantitative Reasoning-II	3	0	3(3-0)
	SSH-302	Ideology and Constitution of Pakistan	2	0	2(2-0)
	SOS-301	Moral Foundation of Education	2	0	2(2-0)
	TOQ-501	Translation of Quran (Audit Course)	1	0	1(1-0)
			12	**3**	**15**
Fourth	BCH-402	Carbohydrates	2	1	3(2-2)
	BCH-404	Lipids	2	1	3(2-2)
	BCH-406	Integrated Metabolism	3	0	3(3-0)
	SOC-301	Introduction to Sociology	2	0	2(2-0)
	ENG-302	Expository Writing	3	0	3(3-0)
	SSH-304	Entrepreneurship	2	0	2(2-0)
	TOQ-601	Translation of Quran (Audit Course)	1	0	1(1-0)
			14	**2**	**16**
Fifth	BCH-501	Genetic Engineering	2	1	3(2-2)
	BCH-503	Protein Chemistry	3	0	3(3-0)
	BCH-505	Biochemical Techniques	1	2	3(1-4)
	BCH-507	Tissue and Cell Culture	2	1	3(2-2)
	MIC-311	General Microbiology	2	1	3(2-2)
	CHEM-301	Inorganic Chemistry	2	1	3(2-2)
			12	**6**	**18**

Sixth	BCH-502	Cellular Signaling	3	0	3(3-0)
	BCH-504	Biotechnology	2	1	3(2-2)
	BCH-506	Introduction to Bioenergetics	2	0	2(2-0)
	BCH-508	Plant Biochemistry	2	1	3(2-2)
	CHEM-501	Physical Chemistry	2	1	3(2-2)
	ZOOL-313	Human Physiology	2	1	3(2-2)
			13	**4**	**17**
Seventh	BCH-601	Industrial Biochemistry	2	1	3(2-2)
	BCH-603	Good Laboratory Practices and Quality Control	3	0	3(3-0)
	BCH-605	Biomembranes	2	0	2(2-0)
	BCH-607	Nutritional Biochemistry	2	1	3(2-2)
	BCH-609	Immunology and Immunochemistry	3	0	3(3-0)
	BCH-611	Current Trends in Biochemistry	3	0	3(3-0)
	BCH-620	Seminar	1	0	1(1-0)
			16	**2**	**18**
Eighth	BCH-299	Internship/Field Experience	0	3	3(0-6)
	BCH-399	Capstone Project	0	3	3(0-6)
			0	**6**	**6**

Scheme of Studies - BS Biochemistry

BCH-301	Introductory Biochemistry	3(2-2)

Theory

Introduction to Biochemistry. Importance and the scope of Biochemistry. Life; Evolution, forms, functions, and classification of living organisms. Review of the variety and ecology of the living world. Structure, physical properties, and importance of water; pH and buffer. Unique properties of carbon. Nature of organic matter. Isomerism. General reactions of different functional groups. Biologically important organic compounds/solvents. Overview of biomolecules and their structures (proteins, carbohydrates, lipids, and nucleic acids etc.). Prebiotic molecular evolution and rise of living systems. Use and significance of radioisotopes and fluorescent molecules in Biochemistry. Brief introduction of vitamins, hormones, and enzymes.

Practical

Safety measures in laboratory. Calculations and preparation of different types of solutions. Preparation of stock solution and their dilutions. Standardization of a given solution. Determination of pH of different samples and body fluids (pH meter, pH strip/paper and titrimetric method). Preparation of buffers; Phosphate buffer, acetate buffer, citrate buffer and tris buffer. Acid base titrations.

Books Recommended

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry: MacMillan International Higher Education; 9th Edition.
2. Boyer, R. (2011). Biochemistry Laboratory: Modern Theory and Techniques. Pearson, 2nd Edition
3. Nelson, D.L., Cox, M.M. Lehninger Principles of Biochemistry. W. H. Freeman; 9th Edition
4. Voet, D., Voet, J. G. Voet. And Pratt, C. W. (2016). Fundamentals of Biochemistry: Life at the Molecular Level. Wiley; 5th edition
5. Voet, D. and Voet, J. G. (2018). Biochemistry. Wiley; 4th Edition

BCH-302	Molecular Biology	3(2-2)

Theory

Introduction to molecular biology. Molecular evolution. Genes and genomes. DNA replication, repair and recombination, comparison between prokaryotes and eukaryotes. RNA synthesis, modifications and splicing, parallels and anti-parallels between prokaryotes and eukaryotes. Protein synthesis in prokaryotes and eukaryotes, post-translational modifications. Protein targeting and turnover. Regulation of gene expression in prokaryotes and eukaryotes. Chromatin and gene regulation.

Practical

Genomic DNA isolation using CTAB, agarose gel electrophoresis. Spectrophotometric quantification of nucleic acids. Melting kinetics of DNA. Extraction of proteins from various sources, estimation and separation by native PAGE/SDS-PAGE. RNA extraction, estimation and separation by denaturing agarose gel electrophoresis.

Recommended Books

1. Cox, M. M., Doudna, J. and O'Donnell, M. (2015). Molecular Biology: Principles and Practice. W. H. Freeman, 2nd Edition
2. Allison, L. A. (2021). Fundamental Molecular Biology. Wiley-Blackwell; 3rd Edition
3. Vologodskii, A. (2022). The Basics of Molecular Biology. Springer; 1st Edition
4. Craig, N. L., Green, R. R., Greider, C. C., Gisela G. Storz, G. G. and Cynthia Wolberger, C. (2020). Molecular Biology: Principles of Genome Function. Oxford University Press, 3rd Edition
5. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, Hidde, Amon, A. and Martin, K. C. (2021). Molecular Cell Biology. W. H. Freeman; 9th Edition
6. Nelson, D.L., Cox, M.M. (2021). Lehninger's Principles of Biochemistry. W. H. Freeman; 8th Edition

BCH-303	Cell Biology	3(2-2)

Theory

Introduction. Types, structure, and chemical composition of cell. Cell membrane; Molecular organization, concept of unit membrane, the fluid mosaic model, and function. Endocytosis and exocytosis. Cell organelles and their separation. Mitochondria; Structure, function, conservation of chemical energy. Chloroplast; Structure, function, mechanism of photosynthesis. Cytoskeleton; Structure and function, centriole, cilia and flagella, the mitotic apparatus. The nucleus; Structure and function. Cell cycle; Mitosis and meiosis. Asymmetric Cell Division, its mechanisms and role in development. Stem Cells and Cell death.Integrating Cells into Tissues.

Practical

Study of cell structure using compound microscope and elucidation of ultra-structure from electron microphotographs. Microscopic study of prokaryotic and eukaryotic cells (plant and animalcell). Cellular reproduction; Mitosis. Smear/squash preparation of onion roots/cheek cells. Organelle separation by differential centrifugation

Books Recommended

1. Alberts, B., Hopkin, K., Johnson, A., Morgan, D., Raff, M., Roberts, K. and Walter, P. (2019). Essential Cell Biology. W. W. Norton & Company; 5th Edition
2. Pollard, T. D., Earnshaw, W. C., Lippincott-Schwartz, J. and Johnson, J. (2023). Cell Biology. Elsevier, 4th Edition
3. Plopper, G. and Ivankovic, D. B. (2020). Principles of Cell Biology. Jones & Bartlett Learning. 3rd Edition
4. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry: MacMillan International Higher Education; 9th Edition.
5. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, Hidde, Amon, A. and Martin, K. C. (2021). Molecular Cell Biology. W. H. Freeman; 9th Edition

BCH-304	Principles of Genetics	3(2-2)

Theory

Introduction. Foundation of genetics; Mendel's experiments and laws of inheritance. Genes and chromosomes. Alleles and their interactions. Gene interactions. Dominance and codominance. Recombination patterns and chromosome mapping. Sex determination and sex linkage; non-nuclear inheritance. Population genetics: Hardy Weinberg equilibrium. Human genetic analysis; karyotyping and constructing pedigrees. Human genetic disorders, changes in chromosomal number, categories and mechanisms of change. Turner syndrome, Klinefelter syndrome, XYY

condition. X Chromosome inactivation, mechanism and its effects on X-linked disorders.Changes in chromosome structure; Duplication, translocation, deletion.

Practical

Experiments involving monohybrid and dihybrid ratios, sex-linked inheritance, detection of linkage, gene frequencies in natural populations. Demonstration of Hardy-Weinberg equilibrium in a large population. Analysis of quantitative characters. Population genetics. Construction of chromosome linkage maps. Pedigree analysis. Karyotype analysis. Blood group analysis. Bacterial mating.

Books Recommended

1. Brooke, R.J. (2021). Genetics: Analysis of Principles, 7th Ed, McGraw-Hill Co.
2. Hartwell, L., Goldberg, M., Fischer,J. and Hood, L. (2021). Genetics: From Genes to Genomes. 7th Ed. McGraw-Hill Education.
3. Pierce B, A. (2019), Genetics, A conceptual approach, 7th Ed., MacMillan International.
4. Simmons, M.J., and Snustad, P.D. (2015) Principles of Genetics, 7th Ed, John Willey, and Sons.
5. Strachan, T and Read, A. (2019). Human Molecular Genetics. 5th Ed. Garland Science

BCH-306	Fundamentals of Enzymology	3(2-2)

Theory

Introduction. Classification and nomenclature. Theories of enzyme catalysis. General characteristics, substrate specificity, isozymes, coenzymes, cofactors. Quantative assays of enzyme activity. Chemical and enzyme kinetics; Michaelis-Menten equation and its application. Effect of various factors on rate of reactions. Regulation of enzyme activity. Inhibition: Types, mechanism-based inhibitors, covalent inhibitors, and transition state analogues compounds. Denaturation and renaturation of enzymes. Multienzyme system and bi-substrate reactions, catalytic mechanisms, regulatory enzymes, and immobilizedenzymes. Ribozymes. Clinical enzymology; Analytical, diagnostic, and therapeutic applications of enzymes.

Practical

Extraction and estimation of enzymes from plant source. Acid and enzymatic hydrolysis of glycogen and starch. Biosynthesis of enzymes by fungi and bacteria. Effect of Temperature on enzymes activity. Effect of Substrate concentration on enzyme activity. Effect of Enzyme concentration on enzyme activity. Effect of heat stability on enzyme activity.

Books Recommended

1. Murphy, M. (2022). Practical Enzymology. Murphy and Moore Publishing.
2. Smith, C. (2020). Essentials of Enzymology. Larsen and Keller Education.
3. Price, N. C. and Stevens, L. (1999). Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins. 3rd Ed. Oxford University Press.
4. Voet, D. and Voet, J. G. (2018). Biochemistry. Wiley; 4th Edition
5. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry. MacMillan International Higher Education; 9th Edition.
6. Bisswanger, H. (2019). Practical Enzymology. Wiley-VCH; 3rd edition

BCH-401	Nucleic Acids	2(2-0)

Theory

Introduction. DNA structure and types of DNA. Nucleosides and nucleotides; Structure, types, and biologically important nucleotides. RNA structure, types, and function. Techniques; Physical and structural properties of nucleic acids. Interactions of nucleic acids; Reversible interactions of small molecules and protein nucleic acid interactions. Central Dogma of Molecular; Replication, transcription, and translation. Nucleic acid degradation, repair, recombination, rearrangement, and modification. Chemical synthesis of oligonucleotides. Digestion and absorption of nucleotides. Metabolism of purines and pyrimidines. Metabolic disorders related to purines and pyrimidines. Applications of nucleic acids in biotechnology. Ribozymes.

Recommended Books

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry. MacMillan International Higher Education; 9th Edition.
2. McHughen, A. (2020). DNA Demystified: Unravelling the Double Helix. Oxford University Press
3. Cox, M. M., Doudna, J. and O'Donnell, M. (2015). Molecular Biology: Principles and Practice. W. H. Freeman, 2nd Edition
4. Allison, L. A. (2021). Fundamental Molecular Biology. Wiley-Blackwell; 3rd Edition Vologodskii, A. (2022). The Basics of Molecular Biology. Springer; 1st Edition
5. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, Hidde, Amon, A. and Martin, K. C. (2021). Molecular Cell Biology. W. H. Freeman; 9th Edition

BCH-402	Carbohydrates	3(2-2)

Theory

Introduction. Classification, structure, and functions of carbohydrates. Monosaccharides; Classification, structure, configuration, and chemical reactions. Isomerism; Asymmetric carbon, importance. Mutarotation. Di- and oligosaccharides; Classification, occurrence, structure, properties, function and importance of reducing and non-reducing sugars, invert sugars. Polysaccharides; Classification, structure, functions, importance, and distribution. Carbohydrates as Informational Molecules: The Sugar Code. Blood group polysaccharides and their role in blood grouping and immunity. Derived sugars; Chemistry and functions of sugar alcohols, sugar acids, deoxy sugar, and sugar phosphate. Structure, chemistry and functions of proteoglycans, glycoprotein, and glycolipids. Metabolic pathways; Glycogenolysis, glycolysis, citric acid cycle, gluconeogenesis, hexose monophosphate pathway. Digestion and absorption of carbohydrates. Disorders of carbohydrate metabolism. Glyco-informatics.

Practical

Qualitative analysis of carbohydrates (poly, di-, and monosaccharides, reducing and non-reducing sugars). Polarimetry. Extraction and determination of polysaccharides from plant sources. Extraction of glycogen from animal sources and its confirmatory tests.

Books Recommended

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry. MacMillan International Higher Education; 9th Edition.
2. Nelson, D.L., Cox, M.M. (2021). Lehninger Principles of Biochemistry. W. H. Freeman; 9th Edition
3. Stick, R.V., Williams, S.J. (2009) Carbohydrates: The Essential Molecules of Life, 2nd Ed, Elsviers limited.
4. Voet, D. and Voet, J. G. (2018). Biochemistry. Wiley; 4th Edition
5. Barker, K. (2004). At the Bench: A Laboratory Navigator 2 Spi Rev edition. Cold Spring Harbor Laboratory Press

BCH-403	Amino Acids and Proteins	3(2-2)

Theory

Introduction. Classification, properties, and reactions. pH dependent ionization of amino acids.Chemical and enzymatic reactions of amino acids.Identification of amino acids by different methods. Biological role of amino acids. Peptides and polypeptides.Proteins; Introduction, classification, properties, functions, and their biological functions. Overview of protein structure; Primary, secondary, tertiary, and quaternary. Protein Sequencing and Peptide Synthesis.Protein denaturation and folding. Functional diversity of proteins. Protein sequence and evolution. Protein digestion and amino acid absorption. Amino acid biosynthesis. Protein turnover and amino acid catabolism. Disorders of protein metabolism.Introduction to online databases of protein sequence and function.

Practical

Qualitative tests of proteins and amino acids. Amino acid separation by paper/thin layer chromatography (TLC). Extraction of proteins from animal and plant sources. Estimation of proteins by Biuret, Lowry and/or Bradford methods.Protein Sequence Analysis; Retrieval, homology searches, motifs searching.

Books Recommended

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry. MacMillan International Higher Education; 9th Edition.
2. Boyer, R. (2011). Biochemistry Laboratory: Modern Theory and Techniques. Pearson, 2nd Edition
3. Nelson, D.L., Cox, M.M. (2021). Lehninger's Principles of Biochemistry. W. H. Freeman; 8th Edition
4. Voet, D., Voet, J. G. Voet. And Pratt, C. W. (2016). Fundamentals of Biochemistry: Life at the Molecular Level. Wiley; 5th edition
5. Voet, D. and Voet, J. G. (2018). Biochemistry. Wiley; 4th Edition

BCH-404	Lipids	3(2-2)

Theory

Introduction. Structure, classification, and their biological role. Fatty acids; Structure, classification, nomenclature, and properties. Triacylglycerols; Nomenclature, physical and chemical properties including hydrolysis, saponification value, rancidity, acid value, iodine value and Reichert-Meissl number. Reactions of glycerol. Phospholipids; Glycerophospholipids, sphingolipids and glycolipids; Properties and functions. Steroids; Structure, classification, nomenclature, and their biological role. Miscellaneous lipids, prostaglandins, thromboxanes and leukotrienes. Digestion and absorption of lipids. Metabolism of fatty acids, cholesterol, lipoproteins. Disorders of lipid metabolism.

Practical

Qualitative tests for lipids; Litmus, solubility, unsaturation, acid value, per-oxide value, color value, saponification, and emulsification tests. Melting point determination of fats. Qualitative tests for fatty acids. Extraction of total lipids from plant seeds. Extraction of Lipids from animal sources.

Books Recommended

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry. MacMillan International Higher Education; 9th Edition.
2. Boyer, R. (2011). Biochemistry Laboratory: Modern Theory and Techniques. Pearson, 2nd Edition
3. Nelson, D.L., Cox, M.M. Lehninger Principles of Biochemistry. W. H. Freeman; 9th Edition
4. Voet, D., Voet, J. G. Voet. And Pratt, C. W. (2016). Fundamentals of Biochemistry: Life at the Molecular Level. Wiley; 5th edition
5. Voet, D. and Voet, J. G. (2018). Biochemistry. Wiley; 4th Edition

BCH-405	Bioinformatics	3(2-2)

Theory

Introduction. Biological Sequence Databases. DNA Sequence Analysis: Online tools, DNA databases, submission, retrieval and storage, homology searches, sequence alignment.Sequence Alignment; Local and global alignment. Codon Usage. Restriction analysis. Searching motifs; Palindromic, repetitive, and putative regulatory sequences. Primer design. Translation of DNA sequence into protein, finding ORF and gene prediction in eukaryotes. Protein Sequence Analysis; Retrieval, homology searches, motifs searching, hydropathy profile. Prediction of protein structure and function. Phylogenetic analysis; Molecular markers and macromolecular sequences. Using Programming Language (e.g., Python) to Facilitate Biological Analysis.

Practical

General Introduction; Computer hardware, file management, windows application in bioinformatics, codon usage analysis. DNA restriction; Restriction enzymes databases, single/ multiple enzyme digestions. DNA sequence manipulations; Generating reverse, complementary and reverse complementary sequence. DNA sequence manipulations; Translation in single/ multiple frames. Finding ORF/coding sequences. Primer/Probe designing and analysis. Global alignment tools; CLUSTAL, BLAST for DNA/proteins and phylogenetic analysis. Prot Param, Protein digestion and fragment analysis.

Recommended Books

1. Antao, T. (2022). Bioinformatics with Python Cookbook. 3rd Ed, Packt publishing.
2. Pevzner, P. and Shamir, R. (2011). Bioinformatics for Biologists. Cambridge University Press
3. Jin, X. (2006). Essential Bioinformatics. 1st Ed. Cambridge University Press.
4. Neelakanta, P. S. (2022). Textbook of Bioinformatics, A: Information-theoretic perspectives of bioengineering and biological complexes. WSPC.
5. Asotic, D. (2023). Mastering Bioinformatics and Computational Biology: Unraveling the complexities of life through data-driven discovery. Informatics Unleashed: Mastering the Digital World.

BCH-406	Integrated Metabolism	3(3-0)

Theory

Overview of metabolism. Major metabolic pathways; General features and regulation of carbohydrates and lipid metabolism. Hormonal regulation of carbohydrates metabolism; Insulin, glucagon, leptin, adiponectin etc. Organ specific metabolism: Liver, adipose tissue, kidneys, skeletal muscles, brain, and pancreas. Disorders related to metabolic imbalances; Obesity, metabolic syndrome, and type 2 diabetes. Metabolic adaptation and regulation of body mass; Feed/fast cycle, physical activity. Integration of proteins, amino acids, and nucleotides metabolism.

Books Recommended

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry. MacMillan International Higher Education; 9th Edition.
2. Nelson, D.L., Cox, M.M. (2021). Lehninger Principles of Biochemistry. W. H. Freeman; 9th Edition
3. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry: MacMillan International Higher Education; 9th Edition.
4. Boyer, R. (2011). Biochemistry Laboratory: Modern Theory and Techniques. Pearson, 2nd Edition
5. Nelson, D.L., Cox, M.M. Lehninger Principles of Biochemistry. W. H. Freeman; 9th Edition

BCH-501	Genetic Engineering	3(2-2)

Theory

Introduction. Working with nucleic acids; Isolation, quantification, labeling, hybridization, electrophoresis, amplification, and sequencing of DNA. Tools of trade; Restriction enzymes, DNA modifying enzymes, and DNA ligase. Biology of genetic engineering; Host cell types, vectors, and transformation techniques. Cloning strategies. Selection, screening and analysis of recombinants. Genetic engineering in action; Analysis of gene structure and function, making proteins. Spin-off techniques; Recombinant technology and medicine, food industry, disease diagnosis. Human genome project. Transgenic animals and transgenic plants.

Practical

Introduction to Culturing Techniques and Making of LB Agar and LB Broth. Mini preparation of plasmid from bacterial cells, running of agarose gel electrophoresis. Restriction of bacterial plasmid by restriction enzyme. Designing of Primers and Polymerase Chain Reaction (PCR). Elution of DNA fragments from agarose gel. Ligation of different DNA fragments. Preparation of competent cells and transformation. Expression of proteins using expression systems. Running of SDS- PAGE and Western Blotting.

Books Recommended

1. Nicoll, D.S.T. (2008). An introduction to Genetic Engineering. Cambridge University Press; 3rd Edition
2. Primrose, S.B. and Twyman, R.M. (2016) Principles of Gene Manipulation and Genomics, Wiley-Blackwell Publishing Company; 8th Edition
3. Brown, T.A. (2017). Genomes: Garland Science; 4th Edition
4. Green. M.R. and Sambrook, J.(2012). Molecular Cloning: a laboratory manual. Cold Spring Harbor Laboratory; 4th Edition
5. Glick, B. R. and Patten, L.C. (2022). Molecular Biotechnology: ASM Press; 6th Edition

BCH-502	Cellular Signaling	3(3-0)

Theory

Introduction. Classification of hormones. Biosynthesis and secretion of steroids, peptides, and other hormones. Receptors; Types, structure, function. Modes and mechanisms of hormone

action at the cellular and molecular levels. Cell Signaling; General principles of signaling, G-protein linked cell surface receptors, Enzyme linked cell surface receptors, target cell adaptation. Signal transduction pathways at nuclear level. Comparison of signaling mechanisms in normal and cancerous cells. Signaling in plants.Signaling during metabolic dysfunctions leading to obesity, diabetes, etc. Down regulation of signaling. Integration and controlling signals.

Books Recommended

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry. MacMillan International Higher Education; 9th Edition.
2. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, Hidde, Amon, A. and Martin, K. C. (2021). Molecular Cell Biology. W. H. Freeman; 9th Edition
3. Hancock, J. T. (2017). Cell Signalling. Oxford University Press; 4th Edition
4. Hancock, J. T. (2021). Cell Signalling. Oxford University Press
5. Felix Scholkmann, Stefan K Drexler. (2020). Biochemistry of Cell Signalling.

BCH-503	Protein Chemistry	3(3-0)

Theory

Introduction. Amino acids; Types, physical and chemical properties. Hierarchy of protein structure. Primary structure, structural implications of peptide bond and Ramachandran plot. Secondary structure; Types, chemical and structural properties. Super-secondary structures; Types, structural and functional properties. Domains; Types/classification and properties. 3-Dimmensional structure; Stabilizing forces, models of 3D-structures and diversity of proteins. Protein folding (*in vivo* and *in vitro*). Globular proteins; Types, structure, and function. Fibrous proteins; Types, structure, and function. Methods of determining protein structure. Protein structure designing and engineering.

Books Recommended

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry. MacMillan International Higher Education; 9th Edition.
2. Branden, C. and Tooze, E. J. (1999). Introduction to Protein Structure. 2nd Ed. Garland Publishing, Inc.
3. Kyte, J. (2012). Structure in Protein Chemistry 2nd Ed. Garland Science
4. Lesk, A. M. (2016). Introduction to Protein Science: Architecture, Function, and Genomics 3rd UK Ed. Oxford University Press.
5. Nelson, D.L., Cox, M.M. Lehninger Principles of Biochemistry. W. H. Freeman; 9th Edition
6. Voet, D. and Voet, J. G. (2018). Biochemistry. Wiley; 4th Edition

BCH-504	Biotechnology	3(2-2)

Theory

Introduction. Branches of biotechnology. Molecular diagnostic; Immunological diagnostics, monoclonal antibodies, DNA diagnostic system. Microbial production of therapeutic agents. Synthesis of commercial products by recombinant microorganisms; Antibiotics and biopolymers. Bioremediation and biomass utilization. Plant growth promoting bacteria; Nitrogen fixation by free-living bacteria. Microbial insecticides; Insecticidal toxins of *Bacillus thuringiensis* and baculovirus as bio-control agents. Large scale production of proteins from recombinant microorganisms. Fermentation and downstream processing. Human molecular genetics and gene editing includingCRISPR-Cas9. Stem cell research.

Practical

Production of monoclonal antibodies and its use in immunological diagnosis. DNA diagnosis using PCR. Study tours to various biotechnological laboratories and industries.

Books Recommended

1. Glick, B. R. and Patten, L.C. (2022). Molecular Biotechnology: ASM Press; 6th Edition
2. Primrose, S. B., Twyman, R. M and Old, R. W. (2016). Principles of Gene Manipulation. Blackwell Publishing Company; 8th Edition
3. Stephenson, F. H. (2016). Calculations for Molecular Biology and Biotechnology: A guide to mathematics in the laboratory. Academic Press; 3rd Edition
4. Rapley, R and Whitehouse, D. (2014). Molecular Biology and Biotechnology. Royal Society of Chemistry. 6th Edition
5. Recent review articles.

BCH-505	Biochemical Techniques	3(1-4)

Theory

Introduction to biochemical techniques. Homogenization, centrifugation, Ultra-centrifugation, paper, TLC, and column chromatography, Gel filtration, Ion exchange chromatography, Affinity chromatography, HPLC,LCMS/MS. GCMS, lyophilization, electrophoresis, Polymerase chain reaction, Flame photometry, atomic absorption, Spectrophotometry, Spectro-fluorimetry, UV/visible Spectrophotometry and use of radioisotopes. Amino acids analyzer,Electron microscopy,X – ray diffraction,Nuclear magnetic resonance

Practical

Mineral analysis of plant tissues using atomic absorption spectrophotometer. Separation of biomolecules by affinity chromatography. Identification of sugars, proteins, electrolytes etc. by UV/Vis spectrophotometer. Determination of sodium and potassium content in blood serum by flame photometer. Determination of molecular weight of a given protein by gel filtration. Separation of Hb and serum proteins by electrophoresis.

Books Recommended

1. R S Sengar. R. S. (2023). Laboratory Manual of Biochemistry: Methods and Techniques. Nipa
2. Reiner Westermeier, R. (2005). Electrophoresis in Practice: A Guide to Methods and Applications of DNA and Protein Separations. Wiley-Blackwell, 4th Edition
3. Hofmann, A and Clokie, S (2018). Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press; 8th Edition
4. Nießner, R and Bock, R. (2023). Separation Techniques in Analytical Chemistry: Distribution in Non-Miscible Phases or by Different Migration Rates in One Phase. De Gruyter
5. Cox, M. M., Doudna, J. and O'Donnell, M. (2015). Molecular Biology: Principles and Practice. W. H. Freeman, 2nd Edition

BCH-506	Introduction to Bioenergetics	2(2-0)

Theory

Introduction. Bioenergetics and thermodynamic principles. Gibbs concepts of energy; Free energy, enthalpy, entropy, and their relations. Biological oxidation and reduction; Endothermic and exothermic reactions. High energy compounds and their biological roles. Energy coupling

mechanisms; Substrate level phosphorylation, electron transport chain, oxidative and photophosphorylation. Self-regulation of energy production.

Books Recommended

1. Weller, M., Overton, T., Rourke, J. and Armstrong, F. (2018). Inorganic Chemistry. 7th Ed. Oxford University Press.
2. Rodewell, V., Bender, D., Botham, K., Kennelly, P. and Weil, P.A.(2018). Harper's Illustrated Biochemistry, 31st Ed. McGraw Hill.
3. Sibley, R.J., Alberty, R.A., and Bawendi, M.G. (2018) Physical Chemistry, 5th Ed, J. Wiley & Sons.
4. Voet, D. and Voet, J. (2018). Biochemistry. 4th Ed. John Wiley & Sons.

BCH-507	Tissue and Cell Culture	3(2-2)

Theory

Introduction. Level of potency and development. Sterilization; Concept and techniques. Biology of cultured cells. Timeline of plant tissue and cell culture. Plant tissue culture nutrients and growth regulators. Meristem culture, micropropagation, micro-tuberization, and embryo rescue. Callus, cell, protoplast, and haploid culture. Somatic embryogenesis. Soma-clonal variations. Industrial uses of plant cell culture;tissue culture in genetic engineering and biotechnology.Cryopreservation of cells/tissues. Introduction to animal cell culture. Animal cell culture media; Role of serum and other components. *In vitro* capacitation and fertilization. Normal, transformed, and malignant cell lines. Tissue engineering. Stem cells; Properties, types, and ethical concerns.Introduction of organoids culture.

Practical

Setting up a Tissue culture laboratory. Media Preparation. Explant surface sterilization and culture initiation. Screening of contamination and data recording. Regeneration from cultured tissues; Direct regeneration and through callus formation. Microscopic study of callus/regenerating cultures. Micropropagation of potato and/or tobacco. Agrobacterium andBiolistic mediated transformation, Analysis of transformed tissues.

Books Recommended

1. Helgason, C. D and Miller, C. L (2012). Basic Cell Culture Protocols (Methods in Molecular Biology, 946). Humana, 4th Edition (2013 Edition)
2. Kasper,C., Charwat, V. and Lavrentieva, A. (2018). Cell Culture Technology (Learning Materials in Biosciences. Springer, 1st Edition
3. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, Hidde, Amon, A. and Martin, K. C. (2021). Molecular Cell Biology. W. H. Freeman; 9th Edition

BCH-508	Plant Biochemistry	3(2-2)

Theory

Introduction. Chemical composition and biosynthesis; Cell wall, tonoplast, and vacuoles, Golgi apparatus, membrane origin and flow. Plant cell specific plastids; Microbodies and spherosomes. Photosynthesis; Brief discussion about C3, C4 and CAM. Importance of compartmentalization. Cyanide resistant respiration and respiration-like processes. Nitrogen metabolism; Nitrogen fixation, transport and storage, non-protein amino acids, cyanogenic glucosides, and plant proteins. Plant products; Classification, nature, distribution, and biological functions of terpenes and terpenoids, alkaloids, and phenolics. Plant growth regulators; history, classification,

biosynthesis and bioassays, in-vivo transport, role of natural and synthetic growth regulators in plant metabolism, importance in research/commercial applications.

Practical

Isolation of chloroplast. Extraction and qualitative analysis of chlorophyll, auxins, alkaloids, and flavonoids. Determination of photosynthesis in plants, determination of effects of phytohormones.

Books Recommended

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry. MacMillan International Higher Education; 9th Edition.
2. Buchanan, B.B., Wilhelm, G. and Jones, R.L. (2015). Biochemistry and Molecular Biology of Plants. Wiley; 2nd Ed.
3. Heldt, H. W. and Piechulla, B. (2021). Plant Biochemistry. Academic Press; 5th Edition.
4. Nelson, D.L. (2021). Lehninger: Principles of Biochemistry. W. H. Freeman, 8th Edition
5. Bowsher, C. and Tobin, A. (2021) Plants Biochemistry. Garland Science. 2nd Edition.

BCH-601	Industrial Biochemistry	3(2-2)

Theory

Introduction. Types of industries. Selection of industrially important organism for food, pharmaceutical, fertilizer, textile, tanneries, paper, and other related industries. Fermentation technology and its applications; Production of antibiotics, organic acid, enzymes, and biofuels. Brief introduction to microbial metabolites. Manipulation of fermentation for enhanced production of targeted metabolite. Plant extraction and purification of extracted components. Manufacturing of sugar (glucose, starch) from different sources and their industrial applications. Quality assurance and value addition. Industry and research institute(s) visits.

Practical

Determination of ethanol percentage in the fermentation broth. Estimation of total proteins in the given sample. Purification of proteins by column chromatography. Determination of citric acid by titration method in the fermentation medium. Extraction of plant seeds oil by using Soxhelt apparatus. Determination of acid value of oil extracted from plant seeds. Determination of Iodine value of fat/oil. Separation of phospholipids by Thin Layer Chromatography. Preservation of food by UV-radiation /chemical method. Estimation of glucose in the given sample.

Recommended Books

1. Austin, G.T. (1998) Shreve's chemical process industries, 5th Ed, McGraw-Hill
2. Benvenuto, M. A. (2019). Industrial Biotechnology. De Gruyter.
3. Kent, J.A. Bommaraj, T.V. and Barnicki, S.D. (2017). Kent and Riegel's Handbook of Industrial Chemistry and Biotechnology, 13th Ed. Springer.
4. Moo-Yong, M., Cooney, C.L. (2019) Comprehensive Biotechnology. 3rd Ed. Pergamon Press
5. Soetaert, W., Vandamme, E. J. (2010). Industrial Biotechnology: Sustainable Growth and Economic Success, John Wileyand Sons.

BCH-603	Good Laboratory Practices and Quality Control	3(3-0)

Theory

Introduction. Good laboratory practices (GLPs); Overview, international guidelines, regulation of laboratory activities and responsibilities. GLPs for chemicals, apparatus, material and reagents, computerized systems, test systems, test, and reference items. Standard operating procedures, study performance and reporting. Quality assurance programme; General guidelines, management, and practices. Good working laboratories; General biochemistry lab, clinical biochemistry lab, research labs etc. Certification and Accreditation. LJ-Charts. Application of Westgard Rules.

Books Recommended

1. Miller F. P., Vandome A. F., McBrewster, J. (2010) Good Laboratory Practice, VDM Publishing House Ltd.
2. WHO (2008) Good Laboratory Practice (GLP) Handbook, 2nd Ed, WHO.
3. Seiler, J. (2005) Good laboratory practice: the why and the how, 2nd Ed, Springer link.
4. Allport-Settle, M.J. (2010). Good Laboratory Practice: Nonclinical Laboratory Studies Concise Reference. Pharmalogika

BCH-605	Biomembranes	2(2-0)

Theory

Introduction. Structure and functions. Membrane lipids; Types, physical and chemical properties. Membrane proteins; Types, structure and function, and methods for studying membrane proteins. Oligomeric components of membranes; Structure and functions. Membrane associated carbohydrates: glycoproteins and glycolipids. Molecular models of cell membranes; Supra-molecular membrane structure. Membrane associated cellular components in eukaryotes: Cytoskeleton, types, interactions. Cytoskeletal-like components in prokaryotes. Putting membrane to work: Bioenergetics, transport across membranes, receptors, and responses. Membrane fusion, formation, and flow.

Books Recommended

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry. MacMillan International Higher Education; 9th Edition.
2. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, Hidde, Amon, A. and Martin, K. C. (2021). Molecular Cell Biology. W. H. Freeman; 9th Edition
3. Nelson, D.L., Cox, M.M. Lehninger Principles of Biochemistry. W. H. Freeman; 9th Edition
4. Voet, D. and Voet, J. G. (2018). Biochemistry. Wiley; 4th Edition

BCH-607	Nutritional Biochemistry	3(2-2)

Theory

Introduction.Nutrient types, structure& functional characteristics. Concepts of food; Food selection; Food lists, food pyramid, meal.Healthy diet: types and constituents. Recommended dietary allowances and planning in health and disease. Energy metabolism; Measurement of energy of different foods, energy expenditure,Basic metabolic rate (BMR), body mass index calculations (BMI).Estimation of dietary intake (FFQ, 24 hours dietary recall, questionnaires, etc). Assessment and Surveillance; Nutritional aspects and dietetic treatment of a few important primary nutritional and general diseases/disorders.

Practical

Sample collection, processing, and storage.Clinical surveys, Physical examination, Dietary Surveys through Questionnaire. Related calculations; BMI, energy value, dietary allowance (DA),

basal energy expenditure(BEE) and BMR. Quantitative tests; Vitamin C, Sodium Potassium, Phosphorus from plant and animal sources. Proximate analysis; Moisture content and ash content of plant leaves. Estimation of lactose from milk by titration method.Dietary analysis using Windiets© software.

Books Recommended

1. Joshi, S.A. (2015) Nutrition & Dietetics. Tata McGraw Hill Publishers; 4th Edition
2. Kathleen, L., Mahan, Sylvia, Escott-Stump (2017) Krause's Food, Nutrition and Diet Therapy, Saunders; 14th Edition
3. Webb, (2019). Nutrition: Maintaining and Improving Health. Oxford University Press; 5th Edition
4. Nix, S. (2022). Williams' basic nutrition and diet therapy. Elsevier
5. Whitney, E. N., Rolfes, S. R. (2022) Understanding Nutrition, Cengage Learning; 16th Edition

BCH-609	Immunology and Immunochemistry	3(2-2)

Theory

Introduction. Immune system: Components, elements of innate and acquired immunity. Immunogens and antigens. Antibodies; Types, genetic basis of antibody structure and functions. Antibody response cells: Biology of B and T lymphocytes, activation and function of T and B cells, hypersensitivity response, role of MHC in the immune system, complement system, cytokines. Molecular basis of antigen-antibody interactions. Control mechanisms in immune response. Autoimmune responses. Production and purification of polyclonal and monoclonal antibodies. Antibody labeling and analytical methods; Immunoassays, western blotting, affinity chromatography, immunohistochemistry. Immune responses against cancer and transplants. Immunodeficiencies.

Practical

Antibody precipitation reactions-basedassay, Agglutination. Antibody based assays; Enzyme-linked immunosorbent assay (ELISA), Enzyme linked Oligonucleotide sorbent assay (ELOSA), Fluorescent antibody technique, Immuno-fluorescence assay. Antibody based techniques; Immuno-enzymatic cytochemistry, Immunogold, Immuno-electron microscopy, Immuno-electrophoresis, Counter current electrophoresis, Radial immunodiffusion.

Books Recommended

1. Abbas, A. K., Lichtman A. H. and Pillai, S. (2021). Cellular and Molecular Immunology. 10th Ed. Elsevier.
2. Abbas, A. K., Lichtman A. H. and Pillai, S. (2019). Basic Immunology: Functions and Disorders of the Immune System. 6th Ed. Elsevier.
3. Martin, S. J., Burton D. R., Roitt, I. M. and Delves, P. J. (2017) Roitt's Essential Immunology, 13th Ed. Wiley-Blackwell.
4. Miller, C. D., and Stevens L. E. (2021). Clinical Immunology and Serology A Laboratory Perspective . 5th Ed. F.A. Davis Company.
5. Murphy, K. M., Weaver, C. and Berg, L. J. (2022). Janeway's Immunology. 10th Ed. W. W. Norton & Company.

BCH-611	Current Trends in Biochemistry	3(3-0)

Theory

Advanced level course will cover all recent advances in Biochemistry.

Books/Literature Recommended

4. Nature and Science series research articles
5. Current Topics, Critical Reviews and other research journals
6. Recent topics on Biochemistry Journals and web Sources

BCH-299	Internship/Field Experience	3(0-6)

The students will be attached individually or in groups.

BCH-399	Capstone Project	3(0-6)

The students, individually or in groups, will be assigned Supervisors to select research topics

INTER-DISCIPLINARY COURSES

BCH-311	Biochemistry-I	3(2-2)

Theory

An overview of biochemical structures and reactions that occur in living systems: cell, biomolecules and water. Protein structure and function: the building blocks of proteins; amino acids, peptides and polypeptides. The three dimensional structures of proteins, functional diversity of proteins. Enzymes. Nucleic acids: chemical structure and base composition, double helical structure, forces stabilizing nucleic acid structures, nucleic acid fractionation, super coiled DNA, RNA, mRNA, tRNA and rRNA. Diverse physiological functions of nucleotides. Nucleic acid synthesis and protein synthesis. Lipids and carbohydrates. Glycolysis, citric acid cycle, electron transport, chair, oxidative and photo phosphorylation and regulation of ATP production in brief. Vitamins and hormones.

Practical

Titration curves, pKa determination, buffer preparation, amino acid and proteins determination, protein precipitations, carbohydrate and lipid determination. Sugar identification using paper chromatography, amino acid separation by two dimensional paper chromatography, steroid separation by thin layer chromatography (TLC).

Books Recommended

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry: MacMillan International Higher Education; 9th Edition.
2. Boyer, R. (2011). Biochemistry Laboratory: Modern Theory and Techniques. Pearson, 2nd Edition
3. Nelson, D.L., Cox, M.M. Lehninger Principles of Biochemistry. W. H. Freeman; 9th Edition
4. Voet, D., Voet, J. G. Voet. And Pratt, C. W. (2016). Fundamentals of Biochemistry: Life at the Molecular Level. Wiley; 5th edition
5. Voet, D. and Voet, J. G. (2018). Biochemistry. Wiley; 4th Edition

BCH-312	Biochemistry-II	3(3-0)

Theory

Introduction to Metabolism Bioenergetics, Basic concepts of bioenergetics. Metabolism of carbohydrates, Glucose, Glycogen, starch and other sugars relevant to metabolic routes.

Metabolism of lipids, role of simple and compound lipids in production of energy, β oxidation and fatty acids biosynthesis, lipoprotein and their function in transporting cholesterol and phospholipid. Metabolism of proteins and amino acids: catabolism and anabolism of protein. Amino acids, essential and non essential amino acids, total nitrogen balance and formation of creatinine and urea. Nucleic acids Metabolism and uric acid synthesis. Over view of catabolic and anabolic process, Integration, regulation and organ specialization of metabolism with Phase I and Phase II reactions. Digestion of food and transport.

Books Recommended

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry. MacMillan International Higher Education; 9th Edition.
2. Nelson, D.L., Cox, M.M. (2021). Lehninger Principles of Biochemistry. W. H. Freeman; 9th Edition
3. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry: MacMillan International Higher Education; 9th Edition.
4. Boyer, R. (2011). Biochemistry Laboratory: Modern Theory and Techniques. Pearson, 2nd Edition
5. Nelson, D.L., Cox, M.M. Lehninger Principles of Biochemistry. W. H. Freeman; 9th Edition

Annexure-X

Scheme of Studies BS Microbiology

(4 Years Program)

I **A single major** (Minimum of 134 credit hours)

i. Major: minimum 72 credit hours
ii. General education courses: 32 credit hours
iii. Interdisciplinary/allied courses: minimum 24 credit hours
iv. Field experience/internship: 03 credit hours
v. Capstone project: 03 credit hours

The courses distribution along with their credit hours is given below:

S#	Division/Courses	Total Number	Credit hours
1.	Major	25	72
2.	General	13	32
3.	Interdisciplinary	08	24
5.	Internship/Field Experience	01	3
6.	Capstone Project	01	3
	Total Credits		**134**

List of Major Courses

S.#	Course Code	Course Title	Theory	Practical	Credits
1.	MIC-301	General Microbiology-I	2	1	3(2-2)
2.	MIC-302	General Microbiology-II	2	1	3(2-2)
3.	MIC-303	Cell Biology	2	1	3(2-2)
4.	MIC-304	Molecular Biology	2	1	3(2-2)
5.	MIC-401	General Microbiology-III	2	1	3(2-2)
6.	MIC-402	Microbial Anatomy and Physiology	3	1	3(2-2)
7.	MIC-403	Computational Microbiology	2	1	3(2-2)
8.	MIC-404	Microbial Taxonomy	2	1	3(2-2)
9.	MIC-405	Mycology	2	1	3(2-2)
10.	MIC-406	Biological Safety and Risk Management	3	0	3(3-0)
11.	MIC-501	Metabolic Engineering	3	0	3(3-0)
12.	MIC-502	Biotechnology and Synthetic Biology	2	1	3(2-2)
13.	MIC-503	Virology	2	1	3(2-2)
14.	MIC-504	Soil Microbiology	2	1	3(2-2)
15.	MIC-505	Fresh Water Microbiology	2	1	3(2-2)
16.	MIC-506	Systems Microbiology	3	0	3(3-0)
17.	MIC-507	Food Preservation Technology	3	0	3(3-0)
18.	MIC-508	Microbiomes and Health	2	0	2(2-0)
19.	MIC-509	Microbial Genetics	2	1	3(2-2)
20.	MIC-510	Molecular Disease Diagnostics	3	0	3(3-0)
21.	MIC-512	Medical Microbiology	3	0	3(3-0)
22.	MIC-601	Epidemiology of Infectious Diseases	3	0	3(3-0)
23.	MIC-603	Environmental Microbiology	3	0	3(3-0)
24.	MIC-605	Current Trends in Microbiology	3	0	3(3-0)
25.	MIC-620	Seminar	1	0	1(1-0)

List of General Education Courses (Mandatory)

S.#	Course Code	Course Title	Theory	Practical	Credits
1.	CHEM-401	Organic Chemistry	2	1	3(2-2)

2.	CSC-100	Applications of Information and Communication Technologies (ICT)	2	1	3(2-1)
3.	ENG-301	Functional English	3	0	3(3-0)
4.	ENG-302	Expository Writing	3	0	3(3-0)
5.	IS-302	Islamic Studies and Ethics	2	0	2(2-0)
6.	QR-401	Quantitative Reasoning-I	3	0	3(3-0)
7.	QR-402	Quantitative Reasoning-II	3	0	3(3-0)
8.	SOC-301	Introduction to Sociology	2	0	2(2-0)
9.	SOS-301	Moral Foundation of Education	2	0	2(2-0)
10.	SSH-301	Civic and Community Engagement	2	0	2(2-0)
11.	SSH-302	Ideology and Constitution of Pakistan	2	0	2(2-0)
12.	SSH-304	Entrepreneurship	2	0	2(2-0)
13.	SSH-XXX	Time Management & Organizing Skills	2	0	2(2-0)

List of Interdisciplinary/Allied Courses

S.#	Course Code	Course Title	Theory	Practical	Credits
1.	BCH-311	Biochemistry-I	2	1	3(2-2)
2.	BCH-312	Biochemistry-II	2	1	3(2-2)
3.	BCH-603	Good Laboratory Practices and Quality Control	3	0	3(3-0)
4.	BCH-609	Immunology and Immunochemistry	3	0	3(3-0)
5.	BCH-504	Biotechnology	3	0	3 (3-0)
6.	ZOOL-313	Human Physiology	2	1	3(2-2)
7.	CHEM-301	Inorganic Chemistry	2	1	3(2-2)
8.	CHEM-501	Physical Chemistry	2	1	3(2-2)

Internship/Field Experience, Capstone Project

S.#	Course Code	Course Title	Theory	Practical	Credits

1.	MIC-299	Internship/Field Experience	0	3	3(0-6)
2.	MIC-399	Capstone Project	0	3	3(0-6)

List of Minor Courses

S.#	Course Code	Course Title	Theory	Practical	Credits
1.	MIC-301	General Microbiology-I	2	1	3(2-2)
2.	MIC-503	Virology	2	1	3(2-2)
3.	MIC-404	Microbial Taxonomy	2	1	3(2-2)
4.	MIC-402	Microbial Anatomy and Physiology	2	1	3(2-2)
5.	MIC-509	Microbial Genetics	2	1	3(2-2)
6.	MIC-601	Epidemiology of Infectious Diseases	3	0	3(3-0)

List of Audit Courses

S.#	Course Code	Course Title	Theory	Practical	Credits
1	TOQ-301	Translation of Quran (Audit Course)	1	0	1(1-0)
2	TOQ-401	Translation of Quran (Audit Course)	1	0	1(1-0)
3	TOQ-501	Translation of Quran (Audit Course)	1	0	1(1-0)
4	TOQ-601	Translation of Quran (Audit Course)	1	0	1(1-0)

Semester Wise Courses

Semester	Course Code	Course Title	Theory	Practical	Credits
First	MIC-301	General Microbiology-I	3	0	3(2-2)
	MIC-303	Cell Biology	2	1	3(2-2)
	CHEM-401	Organic Chemistry	2	1	3(2-2)
	ENG-301	Functional English	3	0	3(3-0)
	QR-401	Quantitative Reasoning-I	3	0	3(3-0)
	SSH-XXX	Time Management & Organizing Skills	2	0	2(2-0)
	TOQ-301	Translation of Quran (Audit Course)	1	0	1(1-0)
			15	**2**	**17**
Second	MIC-302	General Microbiology-II	2	1	3(2-2)
	MIC-304	Molecular Biology	2	1	3(2-2)
	BCH-311	Biochemistry-I	2	1	3(2-2)
	SSH-301	Civic and Community Engagement	2	0	2(2-0)
	CSC-100	Applications of Information and Communication Technologies (ICT)	2	1	3(2-1)
	IS-302	Islamic Studies and Ethics	2	0	2(2-0)
	TOQ-401	Translation of Quran (Audit Course)	1	0	1(1-0)
			12	**4**	**16**
Third	MIC-401	General Microbiology-III	2	1	3(2-2)
	MIC-403	Computational Microbiology	2	1	3(2-2)
	MIC-405	Mycology	2	1	3(2-2)
	QR-402	Quantitative Reasoning-II	3	0	3(3-0)
	SSH-302	Ideology and Constitution of Pakistan	2	0	2(2-0)
	SOS-301	Moral Foundation of Education	2	0	2(2-0)
	TOQ-501	Translation of Quran (Audit Course)	1	0	1(1-0)
			13	**3**	**16**
Fourth	MIC-402	Microbial Anatomy and Physiology	2	1	3(2-2)
	MIC-404	Microbial Taxonomy	2	1	3(2-2)
	MIC-406	Biological Safety and Risk Management	3	0	3(3-0)

	SOC-301	Introduction to Sociology	2	0	2(2-0)
	ENG-302	Expository Writing	3	0	3(3-0)
	SSH-304	Entrepreneurship	2	0	2(2-0)
	TOQ-601	Translation of Quran (Audit Course)	1	0	1(1-0)
			14	**2**	**16**
Fifth	MIC-501	Metabolic Engineering	3	0	3(3-0)
	MIC-503	Virology	2	1	3(2-2)
	CHEM-301	Inorganic Chemistry	2	1	3(2-2)
	MIC-505	Fresh Water Microbiology	2	1	3(2-2)
	MIC-507	Food Preservation Technology	3	0	3(3-0)
	MIC-509	Microbial Genetics	2	1	3(2-2)
			15	**3**	**18**
Sixth	MIC-502	Biotechnology and Synthetic Biology	2	1	3(2-2)
	MIC-506	Systems Microbiology	3	0	3(3-0)
	ZOOL-313	Human Physiology	2	0	3(2-2)
	MIC-510	Molecular Disease Diagnostics	3	0	3(3-0)
	MIC-512	Medical Microbiology	3	0	3(3-0)
	CHEM-501	Physical Chemistry	2	1	3(2-2)
			15	**2**	**18**
Seventh	MIC-601	Epidemiology of Infectious Diseases	3	0	3(3-0)
	BCH-603	Good Laboratory Practices and Quality Control	3	0	3(3-0)
	MIC-603	Environmental Microbiology	3	0	3(3-0)
	BCH-504	Biotechnology	2	1	3(2-2)
	BCH-609	Immunology and Immunochemistry	3	0	3(3-0)
	MIC-508	Microbiomes and Health	2	0	2(2-0)
	MIC-620	Seminar	1	0	1(1-0)
			15	**1**	**18**
Eighth	MIC-299	Internship/Field Experience	0	6	3(0-6)
	MIC-399	Capstone Project	0	6	3(0-6)

	MIC-605	Current Trends in Microbiology	3	0	3(3-0)
	BCH-312	Biochemistry-II	3	0	3(3-0)
	MIC-504	Soil Microbiology	2	1	3(2-2)
			0	**6**	**15**
TOTAL					**134**

Scheme of Studies - BS Microbiology

MIC-301	General Microbiology-I	3(2-2)

THEORY

Fundamentals of Microbiology. Differentiation between Prokaryotic and Eukaryotic Cells. Historical Development of Microbiology and its Scope. Microscopy: An Outline of The Principles and Applications. Morphology, Arrangement and Detailed Anatomy of Bacterial Cell. Bacterial Taxonomy and Nomenclature. Microbial Nutrition and Growth. Microbial Metabolism. Microbial Genetics. General Methods of Studying Microorganisms: Cultivation, Isolation, Purification and Characterization. Control of Microorganisms by Physical and Chemical Methods. Chemotherapeutic Agents and Antibiotics. Modes of Action of Antibiotics on Microorganisms. Innate and Adaptive Immunity. Basic Properties of Fungi, Protozoa and Algae. A Brief Introduction to Structure and Propagation of Viruses and Bacteriophages.

PRACTICAL

Laboratory safety: Containment and decontamination. An introduction to microscopy. Principles of Staining Procedures: Simple staining, Gram's staining, Acid-fast staining, cell-wall staining, flagellar staining, capsule staining, spore staining and spirochaete staining. Study of cell motility by hanging drop preparation. Preparation and sterilization of bacteriological media and glassware. Inoculation techniques. Study of colony characteristics of microorganisms. Enumeration of bacteria from milk, water, food and soil by standard plate count technique (SPC) and/or most probable number technique (MPN). Microbiological analysis of air. Microscopic study of fungi isolated from air.

Books Recommended (Latest Available Editions)

1. Prescott, L.M. 2022, Microbiology, McGraw-Hill, New York, 12th Edition
2. Michael T. Madigan, John M. Martinko, Kelly S. Bender, Daniel H. Buckley, David A. Stahl and Thomas Brock , Brock Biology of Microorganisms, 14th Edition
3. Gerard J. Tortora, Berdell R. Funke and Christine L. Case, Microbiology: An Introduction, 13th Edition
4. Talaro, K. P and Chess, B., (2017). Foundations in Microbiology: Basic Principles. Mcgraw Hill Education. Publisher. 10th Edition

MIC-302	General Microbiology-II	3(2-2)

Theory

Structure and chemical composition of nucleic acid. Role of RNA, DNA in protein synthesis. Cell division, mitosis and meiosis, bacterial mutation and variation. Transformation, transduction and conjugation. Microbial metabolism and role of phosphorus in energy transfer. Glycolysis and T.C.A. cycle. Microbiology of water and wastewaters. Water as a source of infection and methods of water purification. Methods of sewage disposal and treatment. Introduction to food and dairy microbiology.

Methods of food preservation. Microbiology of soil with particular reference to nitrogen cycle. Microbiology of air. Agriculture microbiology, Industrial microbiology.

Practicals

Isolation of Chromosomal DNA from E.coli, Electophoresis of Microbial DNA, Effect of UV light on phenotype and genotype of bacteria. Enumeration of bacteria in drinking water, Enumeration of bacteria in milk, Enumeration of bacteria in soil, Enumeration of bacteria in air, Pure culture study of (on the basis of morphological, cultural and biochemical characteristics): E. coli, Salmonella sp, Shigellasp, Staphyloccusaureus, S. epidermidis and S. fecalis, Corynebacterium Microscopic study of Leishmania, Entamoeba, Plasmodium and Giardia. Antibacterial activity of serum. Aggltination test (Widal test). Precipitation tests. Urine analysis (physical, chemical and microbiologica

Recommended Books:

1. Michael T. Madigan, John M. Martinko, Kelly S. Bender, Daniel H. Buckley, David A. Stahl and Thomas Brock , Brock Biology of Microorganisms, 14th Edition
2. Gerard J. Tortora, Berdell R. Funke and Christine L. Case, Microbiology: An Introduction, 13th Edition
3. TALARO, K. P and Chess, B., (2017). Foundations in Microbiology: Basic Principles. Mcgraw Hill Education. Publisher,10th Ed.
4. KATHLEEN P. T., and ARTHUR, T. (2011). Foundations in Microbiology: Basic Principles. McGraw-Hill Companies, USA. 8th Edition

MIC-303	**Cell Biology**	**3(2-2)**

Theory

Introduction to cell biology. Difference between prokaryotes and eukaryotes. Physico-chemical properties of protoplasm. Ultra-structure, chemical composition and functions of cell wall, cell membrane, cellular organelles (mitochondria, endoplasmic reticulum, golgi apparatus, lysosome, glyoxysome, nucleus, ribosomes, etc.) cytoskeleton. Chemical composition and molecular structure of chromosomes. Cell cycle and apoptosis. Cell reproduction. Signal transduction. Cell culture

Practicals

Study of different types of Prokaryotic and Eukaryotic cell, Study of Human Blood Cells, Cell Counting and viability. Plasmolysis and Displasmosis in Blood, Blood Preparation of culture plates, Study of different cell organelle by staining, Blood smear preparation, Study of t cell structure. Study of meiosis (pollen) and mitosis (onion root). Study and preparation of epithelial cells

Books Recommended

1. Pollard, T. D., Earnshaw, W. C., Lippincott-Schwartz, J. and Johnson, J. (2023). Cell Biology. Elsevier, 4th Edition
2. Plopper, G. and Ivankovic, D. B. (2020). Principles of Cell Biology. Jones & Bartlett Learning. 3rd Edition
3. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry: MacMillan International Higher Education; 9th Edition.
4. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, Hidde, Amon, A. and Martin, K. C. (2021). Molecular Cell Biology. W. H. Freeman; 9th Edition
5. Alberts, B., Hopkin, K., Johnson, A., Morgan, D., Raff, M., Roberts, K. and Walter, P. (2019). Essential Cell Biology. W. W. Norton & Company; 5th Edition

MIC-304	Molecular Biology	3(2-2)

Theory

Introduction to molecular biology. Molecular evolution. Genes and genomes. DNA replication, transcription, translation. Regulation of gene expression in prokaryotes and eukaryotes. Chromatin and gene regulation. Bacterial transcription and regulation of transcription; post-transcriptional regulatory mechanisms; genetic tools to study bacteria; effector proteins, toxins, and their secretion systems; adherence and invasion mechanisms.

Practical

Genomic DNA and Plasmid isolation, agarose gel electrophoresis. Spectrophotometric quantification of nucleic acids. Melting kinetics of DNA. Extraction of proteins from various sources, estimation and separation by native PAGE/SDS-PAGE. RNA extraction, estimation and separation by denaturing agarose gel electrophoresis.

Recommended Books

1. Vologodskii, A. (2022). The Basics of Molecular Biology. Springer; 1st Edition
2. Allison, L. A. (2021). Fundamental Molecular Biology. Wiley-Blackwell; 3rd Edition
3. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, Hidde, Amon, A. and Martin, K. C. (2021). Molecular Cell Biology. W. H. Freeman; 9th Edition
4. Craig, N. L., Green, R. R., Greider, C. C., Gisela G. Storz, G. G. and Cynthia Wolberger, C. (2020). Molecular Biology: Principles of Genome Function. Oxford University Press, 3rd Edition

MIC-401	General Microbiology - III	3(2-2)

Theory

Host-Parasite Interactions. Determination of Pathogenicity and Molecular Mechanisms of Pathogenesis. Chemotherapy and Drug Resistance. Study of Bacterial Infections with Emphasis on Mechanisms of Pathogenesis of The Following Groups: *Streptococcus, StaphylococcusNiesseria, Pseudomonas, Corynebacterium, Bordetella, Vibrio,* Enterobacteraceae, *Clostridium, Bacillus, Campylobacter, Aeromonas*and *Helicobacter, Legionella, Mycobacterium, Actinomycetes/ Nocardia,Chlamydia and Mycoplasma.*Zoonotic Infections. Study of

Viral and Rickettsial Diseases Including Epidemic and Endemic Typhus, AIDS, Hepatitis. Poxviruses, Coronaviruses and Herpes Viruses. Protozoal Infections with Emphasis on Leishmaniasisand Toxoplasmosis. Pathogenesis of Mycotic Infections with Particular Emphasis on Mycetoma. Classical and Newly Emerging Pathogens. Outbreak Investigations and Surveillance. Remote Sensing, The Geographical Information Systems (GIS) and Satellite Image, Molecular Epidemiology

Practicals

Collection and transportation of clinical samples. Infections of ear, nose, throat, eye, GIT, urogenital tract and bone. Isolation and identification of selected pathogens. Antibiotic assays by disc diffusion methods and dilution method. Determination of MIC, MBC and E-test.

Recommended Books:

1. Patrick R. Murray Ken S. Rosenthal Michael A. Pfaller ,Medical Microbiology: 9th Edition
2. Anthony A. Nash, ,Robert G. DalzielJ. Ross Fitzgerald, 2015. Mims' Pathogenesis of Infectious Disease. 5th Edition
3. Greenwood, D., Slack, C. B. R., Peutherer, J. F., 2012. Medical Microbiology: A Guide to Microbial Infections: Pathogensis, Immunity, Laboratory Diagnosis and Control. 18th Edition.
4. Flint, S. J., Racaniello, V. R., Enquist, L. W. Skalka, A. M., 2004. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses. 3rd Edition

MIC-402	Microbial Anatomy and Physiology	3(2-2)

Theory

Microbial Abundance & Diversity. Cell Composition of Bacteria and Molecular Inventory. Structure & Physiological Function of Prokaryotic Cell Architecture. Genomic organization of prokaryotes. Regulation of gene expression. Bacterial Membrane-Associated Physiology. Bioenergetics. Microbial biosynthesis and its Regulation.Cell and Population Growth. Physiological Adaptations of Prokaryotes to Environmental Stresses

Practical

Isolation of polysaccharides from bacteria, Isolation of lipids from bacteria, Estimation of total protein from bacterial cell, Isolation and purification of a bacterial enzyme

Recommended Books

1. Robert K. Poole, David J. Kelly, Advances in Microbial Physiology, (2022, April 21). Volume 80 - 1st Edition.
2. Willey, J. M., Sandman, K. M., & Wood, D. H. (2020). *Prescott's microbiology*. McGraw Hil
3. Madigan, m. T., bender, k. S., Buckley, d. H., Stahl, d. A., & Sattley, W. M. (2019). Brock biology of microorganisms. New York, Pearson.
4. Spector, M. P., Foster, J.W. and Audia, J.P., 2011. Moat's Microbial Physiology. John Wiley and Sons, 5th Edition

MIC-403	Computational Microbiology	3(2-2)

Theory

Introduction. Biological Sequence Databases. DNA Sequence Analysis: Online tools, DNA databases, submission, retrieval and storage, homology searches, sequence alignment. Sequence Alignment; Local and global alignment. Codon Usage. Restriction analysis. Searching motifs; Palindromic, repetitive and putative regulatory sequences. Primer design. Translation of DNA sequence into protein, finding ORF and gene prediction in eukaryotes. Protein Sequence Analysis; Retrieval, homology searches, motifs searching, hydropathy profile. Prediction of protein structure and function. Phylogenetic analysis; Molecular markers and macromolecular sequences. Using Programming Language (e.g. Python) to Facilitate Biological Analysis.

Practical

General Introduction; Computer hardware, file management, windows application in bioinformatics, codon usage analysis. DNA restriction; Restriction enzymes databases, single/ multiple enzyme digestions. DNA sequence manipulations; Generating reverse, complementary and reverse complementary sequence. DNA sequence manipulations; Translation in single/ multiple frames. Finding ORF/coding sequences. Primer/Probe designing and analysis. Global alignment tools; CLUSTAL, BLAST for DNA/proteins and phylogentic analysis. Prot Param, Protein digestion and fragment analysis.

Recommended Books

1. Asotic, D. (2023). Mastering Bioinformatics and Computational Biology: Unraveling the complexities of life through data-driven discovery. Informatics Unleashed: Mastering the Digital World.
2. Antao, T. (2022). Bioinformatics with Python Cookbook,Packt publishing, 3rd Ed
3. Neelakanta, P. S. (2022). Textbook of Bioinformatics, A: Information-theoretic perspectives of bioengineering and biological complexes. WSPC.
4. Pevzner, P. and Shamir, R. (2011). Bioinformatics for Biologists. Cambridge University Press

MIC-404	Microbial Taxonomy	3(2-2)

Theory

Basic Concepts and Aims of Classification. Classical and Molecular Basis of Classification of Prokaryotes. Bacterial Nomenclature. Classification of Enterobacteriaceae, Spore Formers, Actinomycetes (*Mycobacterium &Nocardia*), Spirochaetes (*Treponema*&*Leptospira*). Detailed Classification of Viruses, Fungi, Protozoa and Algae. A Brief Introduction of Rickettsia, Chlamydia and Mycoplasma. Diversity of *Archaea,* An Introduction to Prions and Viroids.

Practical

Characterization of bacteria and fungi on the basis of different biochemical and cultural characteristics, Study of phylogenetic relationship using appropriate computer software.

Recommended Books

1. Willey, j. M., Sandman, k. M., & wood, d. H. (2020). *Prescott's microbiology*. McGraw Hill
2. Dimmock, N.J., Easton, A.J., Leppard, K.N., (2016). Introduction to Modern Virology. lackwell Science, Inc, 7th Edition
3. George, G, D. J., Brenner, N. R., Krieg, J. R., 2019. Bergey's Manual of Systematic Bacteriology: The Proteobacteria, Williams and Wilkins Co, Baltimore Ogunseitan, O., Microbial diversity. Vol. 3. 2nd Ed.

4. Madigan, m. T., bender, k. S., Buckley, d. H., Stahl, d. A., & Sattley, W. M. (2019). Brock biology of microorganisms. New York, Pearson.

MIC-405	Mycology	3(2-2)

Theory

History of Mycology. Fungal Classification. Structure and Physiology of Fungi. Physical and Nutritional Factors affecting the Growth of Fungi. Structural Development and Reproduction in Fungi Including Cell Cycle. Fungal Metabolism (With Reference to Food and Beverages). Fungal Plant Diseases and their Control. Fungi of Medical Importance. Mycotoxins. Biotechnological Importance of Fungi. Application of Fungi in Agriculture. Importance of Fungi in Food Industry.

Practicals

Basic mycological lab techniques, microscopic and macroscopic study of common fungi, study of fungi in natural habitat, collection of fungal infected samples, Isolation and identification of fungi from: a) Environment b) Rhizosphere c)Clinical samples., Effect of temperature on growth of fungi, Determination of antifungal activity of (nystatin, actidion, amphoteracin B etc.)

Recommended Books

1. Gioconda, S. B. and Richard, C. A., 2008. Pathogenic Fungi: Insights in Molecular Biology. Caister Academic Press.
2. Textbook of Medical Mycology by Jagdish Chander, 2017
3. Pandey, B.P., 2005. College Botany: 1: Algae Fungi and Bryophyta. S Chand & Co Ltd
4. Alexopoulos, C.J., 2004. Introductory Mycology. 4th Ed. John Wiley & Sons

MIC-406	Biological Safety and Risk Management	3(3-0)

Theory

Introduction. Lab safety, management, Detailed concept of Risk and Hazardous: Environment, Factors, Chemicals, Biological Radiations. Risk Management: Preventions, Surveillance, Monitoring Committee. Judicial Rights / Penalties. Concepts of Biosafe Environment: Terrestrial, Marim, Atmosphere. Designing of Labs based on Biosafety and Containment Parameters. Details of Biological Containment: Plants, Animals, Microbes.

Books Recommended

1) WHO Laboratory Biosafety Manual, 4th edition, 2020, Geneva.
2) Lindler, L. E., F. J. Lebeda., G. W. Korch, 2004. Biological Weapon Defence: Infectious diseases and counter bioterrorism. Humana Press.
3) Samuels, D.S., 2010. Biosafety and Biosecurity Issues in High-Containment Laboratories .Nova Publishers.ISBN1616687061
4) Richmond, JY., R.W. McKinney, 2010. Biosafety in Microbiological and Biomedical Laboratories, 5th edition

MIC-501	Metabolic Engineering	3(3-0)

Theory

Introduction to Metabolic Engineering, Basic concepts; Scopes and Applications; Metabolism overview; Cellular Transport processes, Fueling Reactions, Cellular Metabolism. Overview Biosynthetic reactions, Polymerization, Growth Energetics; Regulation of Metabolic Pathways, Reconstruction of Genome-scale metabolic network, Examples of pathway manipulations by metabolic engineering : Ethanol, Amino acids, antibiotics, vitamins, biopolymers; Metabolic Flux, Analysis: Flux Balance Analysis (FBA), Flux Variability Analysis, Flux Map, Application of metabolic Flux Analysis.

Books Recommended (Latest Available Editions)

1. G N Stephanopoulos, A A Aristidou, J Nielsen, March, 2022, Metabolic Engineering, Principles and Methodologies, 1st Edition
2. Jens Nielse, 2020, Advances in Biochemical Engineering/Biotechnology; Metabolic Engineering.
3. Sang Yup Lee and E Terry Papoutsakis, 2019, Metabolic Engineering (Biotechnology and Bioprocessing)"
4. Kazuyuki Shimizu 25 April 2017, Metabolic Regulation and Metabolic Engineering for Biofuel and Biochemical.

MIC-502	Biotechnology and Synthetic Biology	3(2-2)

Theory

Introduction to Biotechnology, Advances in vaccine development, Recombinant products expression bioreactor systems, Fermentation broth rheology, Product recovery, waste treatment and safety, Biosensors: principles of biosensors, applications of biosensors, Recombinant Protein Production, General aspects of heterologous protein expression, Bacterial expression systems - Escherichia coli and Bacillus subtilis., Saccharomyces cerevisiaeas a system for expression of heterologous proteins, Cloning, PCR & Sequencing. Enzymes, BACs and YACs. Sequencing strategies 2nd and 3rd Generation. Biobricks ; Approaches to Bacterial Genome engineering. Bacterial Genome Assembly,Elements of genetic circuits. Natural and synthetic promoters; attenuation and termination. Codon usage, Operons, RBSs and their relevance to biotechnology sRNA and ribolocks. Hybrid systems. Recombineering and Genome engineering. Recombineering for eukaryotes CRISPR-based engineering TetR regulation of genes.

Practical

Construction of aerobic and anaerobic bioreactor model, Field trip to an industry with a large scale fermenter. Field trip to vaccine production unit.

Recommended Books

1. David, B., T. R. Jewell, 1999. Biotechnology: demystifying the concept, Oxford University Press.1stEdition
2. Sedivy, J. M., A. L. Joyner, 2012. Gene targeting, Oxford University Press, 2nd Edition,
3. Goodsell, D.S., 2004. Bionanotechnology: Lessons from Nature, John Wiley & Sons Limited.
4. Firdos Alam Khan, 2020,Biotechnology Fundamentals 3rd Edition.

MIC-503	Virology	3(22)

Theory

General Properties of Viruses. Structure and Chemical Composition of Viruses. Classification of Viruses. Replication of Viruses. Cultivation and Assays of Viruses. Purification and Identification of Viruses. Nature of Animal and Plant Viruses. Genetics of Animal Viruses. Ecology and Modes of Transmission of Viruses. Pathogenesis and Control of Viral Diseases. Principles of Viral Diagnostic Procedures. Introduction to Bacterial Viruses, Receptors for Bacteriophages. Somatic, Non-Somatic Viruses and Sex Specific Viruses. Transducing Viruses of Eukaryotes and Cross-Phylogenetic Transfer, Prion and Viroid. Viruses and Host Immunity. Viral Ecology, The Antiviral System of Bacteria and Archaea: CRISPR, The Human Virome.

Practical

Detection and quantification of viruses. Hemagglutination Inhibition assay. Chick embryo inoculation. Plaque assay. Transmission electron microscopy (field trip). Sample preparation for electron microscopy. Isolation and identification of phages from various sources.

Recommended Books

1. Prof. Ed Rybicki, 13 March 2023.Cann's Principles of Molecular Virology, 7th Edition

2. Flint, S. J., Enquist, L. W., Racaniello, V. R., Rall, G. F., Skalka, A. M., 2015. Principle of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses (Vol. 2). Cambridge University Press, UK, 4th Ed
3. Zuckerman, A. J., Banatvala, J. E., Pattison, J. R., Griffiths, P., Schoub, B., 2009.
4. Wagner, E. K., Hewlett, M. J., 2009, Principles and Practice of Clinical Virology, John Wiley and Sons Limited. Blackwell Publishers. 6th Ed.

MIC-504	Soil Microbiology	3(2-2)

Theory

Elements of soil formation and conservation, Soil microbial population and methods of study with their advantages and disadvantages, Role of microorganisms in mineral transformations with special and detailed emphasis on Carbon and Nitrogen transformations, Brief introduction to Sulphur and Phosphorus, Introduction to soil ecology, Plant-microbe interactions and microbe-microbe interactions and their impact on soil fertility and formation of compost and humus, Biotechnological potentials of soil microorganisms, Importance of the subject in the agricultural development of Pakistan, Problems of salinity and water logging and the methods of land reclamations, Microbial remediation: salt, heavy metals, etc., Pesticides and their biodegradation, Mycorrhiza.

Practical

Role of microbes in soil formation. Reduction of metallic salts by microbial activity. Buried slide technique. Symbiotic and antagonistic relationship of soil microflora. Cellulolytic activity of soil microorganisms. Isolation of antibiotic producing and pesticide degrading microbes from soil.

Recommended Books

1. Robert L. Tate III, October 2020,Soil Microbiology, 3rd Edition.
2. Elass , V., J.K. Jansson and J.T. Trevors, 2021. Modern Soil Microbiology. 3rd edition
3. Diane Tice, D., 2021. Principles and Applications of Soil Microbiology. 3rd Edition
4. Varma, A and R.Oelmüller, 2007. Advanced Techniques in Soil Microbiology. Springer.

MIC-505	Fresh Water Microbiology	3(2-2)

Theory:

Introduction to fresh-water environment and its microbiology. Stratifications in lakes and ponds. Laws of ecology with particular reference to fresh-water ecosystem: environmental factors (biotic and abiotic) and their influence on the distribution of microorganisms. Enumeration of bacteria: sampling and samplers, processing and actual enumeration procedures. Fresh-water microorganisms: some important groups of fresh-water microorganisms. Detailed study of biogeochemical cycling of C, N, S & P. Advantages and disadvantages of fresh-water microorganisms including their importance in fresh-water biotechnology. An introduction to aqua-culture and some common microbiological problems. Some common diseases of fresh-water fauna.

Practical

Study of microbial population from fresh water. Study of Microbial counts. Biological oxygen demand of freshwater sample. Effect of physical factors on microbial freshwater flora.

Recommended Books

1. David, S., 2005. Freshwater Microbiology: Biodiversity and Dynamic Interactions of Microorganisms in the Aquatic Environment, Wiley Publisher.
2. Gjedrem, T., 2005. Selection and Breeding Programs in Aquaculture, Springer-Verlag New York, LLC
3. Greer, D. and B. Harvey, 2004. Blue Genes: Sharing and Conserving the World's Aquatic Biodiversity, Earthscan/James & James Publishers.
4. Paul Southgate, P. and J. Lucas, 2012. Aquaculture: Farming Aquatic Animals, Iowa State Press, 2nd ed.

MIC-506	Systems Microbiology	3(3-0)

Theory

Microbial Systems: The cell cycle in *E. coli* and other Bacteria exposed to antibiotics, Microbial communities, Microbial Genomes: Genome sequencing, Genome assembly, Genome visualization, Genome annotation. Microbial Functional Genomics: Microarrays, RNA-seq; Transcriptomics analysis of the cell cycle, Transcriptomics analysis of cells exposed to antibiotics. Genome-scale Mutagenesis, Random vs systematic mutagenesis, Knockout vs knockdown, Tn-seq and Bar-seq. CRISPR methods, Systems Microbiology approaches to microbial control: Chemogenomic applied to antimicrobial discoveries of Probiotics and microbiome.

Books Recommended (Latest Available Editions)

1. Ussery D., Wassenaar T and Borini S. Springer-Verlag London, 2009, Computing for Comparative Microbial Genomics.
2. Marjorie Kelly Cowan Microbiology: A Systems Approach, 5th Edition
3. Joanne Willey Linda Sherwood, Christopher J. Woolverton Prescott's Microbiology 10th Edition
4. Jun Sun, May 28, 2020,The Microbiome in Health and Disease,1st Edition

MIC-507	Food Preservation Technology	3(3-0)

Theory:

Scope of Food and Dairy Microbiology. World Food Demand and Issues. Microorganisms Important in Food Industry. Principles of Food Spoilage and their Preservation. Bacteriology of Preserved Foods. Food Preservation and Processing Techniques: Blanching, Thermal Processing, Canning, Extrusion, Dehydration, Chilling, Freezing, Microwave Heating Technology, Ultrasonic and UV Disinfection of Food. High-Pressure Process Design and Evaluation. Ohmic Heating. Preservative Agents for Improving the Quality, Shelf-Life and Organoleptic Properties of Foods. Neutralizers, Stabilizers, Firming Agents, Coating and Wrapping Agents. Packaging and Packaging Problems. Modified Atmosphere Packaging. Biosensors in Food Technology. Ozone Applications in Food Processing. Industry and research institute(s) visits.

Recommended Books:

1. Jay, J.M.M., 2008. Modern Food Microbiology. Aspen Publishers.
2. Steele Sr, J.L and E.H. Marth, 2001. Applied Dairy Microbiology. Marcel Dekker.
3. Molins, R.A., 2001. Food irradiations: Principles and applications. Wiley, John and Sons
4. Luck, E., M. Jager and S.F. laichen, 2000. Antimicrobial food additives: Characteristics, uses, effects. Springer-Verlag, NY, Inc.

MIC-508	Microbiomes and Health	2(2-0)

Theory

Microbiome and human adaptation/evolution; Ecological principles of microbiomes; approaches for working on human microbiome; Bioinformatics and statistics tool kits for human microbiome research; Research strategy and experimental/trial design in microbiome study; From correlation to causality of human microbiome in chronic diseases; Nutrition and gut microbiome; Food processing and gut microbiome; Microbiome in pharmacology; Intergenerational, vertical transmission of human microbiomes; Horizontal transfer of human microbiomes; Microbiome and human society; Microbiome and Human-Nature relationship.

Books Recommended (Latest Available Editions)

1. Alexandru Mihai Grumezescu, Alina Maria Holban, January 2, 2018 Diet Microbiome and Health, 1st Edition.
2. Douglas, A., Fundamentals of Microbiome Science: How Microbes Shape Animal Biology. 2018, 41 William Street, Princeton, New Jersey 08540: Princeton University Press.
3. Gunjan Goel, Teresa Requena, Saurabh Bansal, Human-Gut Microbiome, July 9, 2022,1st Edition

4. I, Microbiome: A Secret to a Healthy and Balanced Human Body by Jakovljevic, Vladimir and Co Authors ,2022

MIC-509	Microbial Genetics	3(2-2)

Theory

Why study Prokaryotic genetics, DNA and RNA, Bacterial chromosomes, Plasmids. Protection of DNA Mutations DNA Repair. Genetic recombination, Genetic transfer, Transformation, Conjugation Bacteriophage, Transposable elements. Gene Maps Operons Gene expression. Current Research Tools and protocols. World Wide Web Databases. Issues: Genetically modified organisms (GMOs) Technological advances, Controls and cautions.

Practicals

Plasmid extraction, DNA extraction, DNA Running Gel, RNA Extraction, RNA Running Gel, DNA running Gel, Transformation, Transduction, Conjugation, Catabolite repression through growth curve, Beta galactosidase assay.

1.

Books Recommended

1. Eya Chaudhari, September 30, 2015, Microbial Genetics.
2. Uldis, N., U. N. Streips, E. Ronald, R. E. Yasbin, 2002. Modern Microbial genetics. Wiley, John and Sons, Inc 2nded,
3. Synder, L., and W. Champness, 2020. Molecular Genetics of Bacteria. ASM Press, Washington D.C, 5hed
4. Gardner, E. J., 2008. Principles of Genetics, John Willey and Sons, New York, 5thed

MIC-510	Molecular Disease Diagnostics	3(3-0)

Theory:

Introduction. DNA based techniques: Molecular genetics for the diagnosis of inherited diseases (PCR in relation to mutation-specific and general mutation scanning assays. DNA sequencing).Chromosome analysis (microscopy and molecular cytogenetics).Methods for detection of disease markers – e.g. metabolites – in plasma and tissue (immune assays, chromatography and mass spectrometry, spectrophotometry and flow cytometry). Detection and characterization of disease causing microorganisms (DNA sequencing and Real-time PCR).Methods for characterization of gene expression (micro arrays and quantitative PCR). Quality control, validation, sources of variation, specificity and sensitivity in relation to molecular disease diagnostics. Automation and high throughput screening. Search in sequence, disease and syndrome databases. Ethics in relation to genetic counseling.

Recommended Books:

1. Wiley E-Text, 2012, Human Genetics and Genomics, 4th Edition.
2. Bruce R. Korf, Mira B. Irons Blau, N., D. Marinus., G. Michael,.D.V. Carlo, 2014. Physician's Guide to the Diagnosis, Treatment, and Follow-Up of Inherited Metabolic Diseases. Springer
3. Rosenthal, M. D., H.G Robert, 2009. Medical Biochemistry: Human Metabolism in Health and Disease, 1stEd.WileyLatest research findings, papers/ reviews articles
4. Synder, L., and W. Champness, 2013. Molecular Genetics of Bacteria. ASM Press, Washington

D.C, 4th Edition

MIC-512	Medical Microbiology	3(3-0)

Theory

Basic Principles of Medical Microbiology. Bacterial Classification (Aerobic Gram Positive Cocci, Aerobic Gram Positive Bacilli, Fastidious Gram Negative Bacilli and Gram Negative Diplococci, Enterobacteriacea, Non-Fermenters and Misc Gram Negative Bacilli, Anaerobic Bacteria). Bacterial Metabolism and Genetics. Viral Classification, Structure and Replication. Fungal Classification, Structure and Replication. Parasitic Classification, Structure and Replication. Cellular Sequence of Events in Immune Response. Humoral Immune Responses, Cellular Immune Response. Antimicrobial Vaccines. General Principles of Laboratory Diagnosis: Microscopic Principles and Applications, In Vitro Culture Principles and Applications, Molecular Diagnosis, Serologic Diagnosis. Microbial Diseases: Concepts of Microbial Diseases, Epidemiology and Cycle of Microbial Disease, Bacterial Diseases, Viral and Prion Diseases, Protozoans Helminthic and Fungal Diseases, Control of Microbial Diseases. Microbial Virulence Factors, Infectious Disease Concepts, Antimicrobial Agents and Susceptibility Testing, Bioterrorism Agents, Outbreak Investigations and Surveillance.

Recommended Books

5. Mahon, Connie R, Donald C. Lehman, and George Manulselis 2018, Textbook of Diagnostic Microbiology, 6th ed
6. Murray, P.R.,K.S. Rosenthal and M. Pfaller, 2016. Medical Microbiology. Elsevier, 8th ed
7. Krasner, R.I. and Shors, T., 2013. The Microbial Challenge: A Public Health Perspective. Jones & Bartlett Learning. 3rd ed.
8. Barer, M., W. L. Irving, Swann, A. Perera, N., 2019. Medical Microbiology: A Guide to Microbial Infections: Pathogenesis, immunity, laboratory investigation and control. 19th Ed. Amsterdam, Netherlands Elsevier.

MIC-601	Epidemiology of Infectious Diseases	3(3-0)

Theory

Types of Epidemiology. Epidemiological Methods. Types of Studies. Epidemiologic Consideration in Disease Process. Sampling Methodology. Screening Tests. Hypothesis Testing. Epidemiological Polarization. Disease Pattern in Community &Social Diversity. The Molecular Epidemiology of Infectious Disease. Modeling of Infectious Disease Cyclicity of Diseases: Chicken Pox, Measles, Rota Virus Infections, Mumps, Flu, Common Cold and Prevailing Pandemics and Epidemics. Surveillance Prevention. Control and Eradication of Disease. Status of Health Services in Pakistan: Comparison with other Counties. Detailed Study of Predisposing Factors in Developed Countries and a Comparison with the Existing Factors in Pakistan. Remote Sensing, The Geographical Information Systems (GIS) and Satellite Image

Recommended Books

1. Adami, H.o., Hunter, D., Lagiou, P. And Mucci, L., 2018. Textbook of Cancer Epidemiology, Oxford Press. 3rdEd
2. Salazar, L.F., Crosby, R.A., and Diclemente, R.J., 2015. Research Methods in Health Promotion. John Wiley and Sons Limited. 2ndEd

3. Dinardi, S.R. And Anna., 2011. Occupational Environment: Its Evaluation, Control, And Management. American Industrial Hygiene Association.
4. Salyers, A. A., 2006. Microbiology Diversity, Disease, And the Environment with Immunology: A Short Course. John-Wiley And Son Limited. 5thEd

MIC-603	Environmental Microbiology	3(3-0)

Theory

Microbial diversity in various ecosystems. Methods in environmental microbiology. Metabolism. Biosynthesis. Flow of organic matter in nature: the carbon cycle. Microbial Communications, interactions with environment and nutrient cycling. Autotrophy. Phototrophy. Lithotrophy. Chemolithotrophic Organisms and Biogeochemical Cycles. Microbial Ecology. Bioremediation; wastewater treatment, Remediation of organic and metal Pollutants. Microbial Population Interactions. Predation and Microbial Community Structure. Indicator Organisms. Future frontiers in environmental microbiology.

Books/Literature

1. Pepper, I.L., C. P. Gerba and T. J. Gentry, 2015. Environmental Microbiology. Academia press. Elsevier. 3rd Ed.
2. Madsen, E.L., 2015. Environmental Microbiology: From Genomes to Biogeochemistry. Blackwell Publishing.
3. Mitchell,R and Ji-D.Gu, 2015. Environmental Microbiology, Wiley-Blackwell. 3rdEd.
4. Mohapatra, P.K., 2013. Textbook of Environmental microbiology. International publishing House.

MIC-611	Current Trends in Microbiology	3(3-0)

Theory

Advanced level course will cover all recent advances in Microbiology.

Recommended Books

7. Nature and Science series research articles
8. Current Topics, Critical Reviews and other research journals
9. Recent topics on Microbiology Journals and web Sources

MIC-620	Seminar	1(1-0)

The students will learn skills of scientific communication and presentation and will be graded accordingly.

BCH-504	Biotechnology	3(2-2)

Theory

Introduction. Branches of biotechnology. Molecular diagnostic; Immunological diagnostics, monoclonal antibodies, DNA diagnostic system. Microbial production of therapeutic agents. Synthesis of commercial products by recombinant microorganisms; Antibiotics and biopolymers. Bioremediation and biomass utilization. Plant growth promoting bacteria; Nitrogen fixation by free-living bacteria. Microbial insecticides; Insecticidal toxins of *Bacillus thuringiensis* and baculovirus as bio-control agents. Large scale production of proteins from recombinant microorganisms. Fermentation and downstream processing. Human molecular genetics and gene editing includingCRISPR-Cas9. Stem cell research.

Practical

Production of monoclonal antibodies and its use in immunological diagnosis. DNA diagnosis using PCR. Study tours to various biotechnological laboratories and industries.

Books Recommended

6. Glick, B. R. and Patten, L.C. (2022). Molecular Biotechnology: ASM Press; 6th Edition
7. Primrose, S. B., Twyman, R. M and Old, R. W. (2016). Principles of Gene Manipulation. Blackwell Publishing Company; 8th Edition
8. Stephenson, F. H. (2016). Calculations for Molecular Biology and Biotechnology: A guide to mathematics in the laboratory. Academic Press; 3rd Edition
9. Rapley, R and Whitehouse, D. (2014). Molecular Biology and Biotechnology. Royal Society of Chemistry. 6th Edition
10. Recent review articles.

MIC-299	Internship/Field Experience	3(0-6)

The students will be attached individually or in groups with relevant industrial/commercial sectors including, but not limited to, hospitals, diagnostic laboratories, pharmaceutical industry, food and beverage industry, cosmetic /nutraceutical industry, forensic laboratory setups. Moreover, the students may also join various research centers and institutes.

The internship/field experience duration would not be less than 9 weeks, and the internees would be facilitated, monitored and evaluated as per HEC guidelines.

MIC-399	Capstone Project	3(0-6)

The students, individually or in groups, will be assigned research topics by their relevant notified supervisors. The research topics would be selected from within the field of Microbiology with special emphasis on topics of current interest with the potential of catering to the academic progress of students.

Annexure-XI

Scheme of Studies BS Biotechnology
(4 Years Program)

I **A single major** (Minimum of 135 credit hours), that requires
i. General education courses: 32 credit hours
ii. Major: minimum 85 credit hours
iii. Interdisciplinary/allied courses: minimum 12 credit hours
iv. Field experience/internship: 03 credit hours
v. Capstone project: 03 credit hours

The courses distribution along with their credit hours is given below:

S#	Division/Courses	Total Number	Credit hours
1.	Major	29	85
2.	General Education Courses	13	32
3.	Interdisciplinary/Allied courses	04	12
4.	Field Experience/Internship	01	3
5.	Capstone Project	01	3
	Total Credits		**135**

List of Major Courses

S. #	Course Code	Course Title	Theory	Practical	Credits
1.	BIOT-301	Introduction to Biotechnology	2	1	3(2-2)
2.	BIOT-302	Molecular Biology	2	1	3(2-2)
3.	BIOT-303	Cell Biology	2	1	3(2-2)
4.	BIOT-304	Classical Genetics	3	0	3(3-0)
5.	BIOT-306	Biochemistry-I	2	1	3(2-2)
6.	BIOT-308	General Microbiology	2	1	3(2-2)
7.	BIOT-401	Biodiversity and Conservation Biology	3	0	3(3-0)
8.	BIOT-402	Molecular Ecology and Evolution	3	0	3(3-0)
9.	BIOT-403	Genetic Engineering	2	1	3(2-2)
10.	BIOT-404	Analytical Chemistry and Instrumentation	2	1	3(2-2)
11.	BIOT-405	Biochemistry-II	3	0	3(3-0)
12.	BIOT-406	Principles of Biochemical Engineering	2	1	3(2-2)
13.	BIOT-501	Cell and Tissue Culture	2	1	3(2-2)
14.	BIOT-502	Health Biotechnology	2	1	3(2-2)
15.	BIOT-503	Genetic Resources and Conservation	3	0	3(3-0)
16.	BIOT-504	Industrial Biotechnology	2	1	3(2-2)
17.	BIOT-505	Genomics and Proteomics	3	0	3(3-0)
18.	BIOT-506	Agriculture Biotechnology	2	1	3(2-2)
19.	BIOT-507	Bioinformatics	1	2	3(1-4)
20.	BIOT-508	Environmental Biotechnology	2	1	3(2-2)
21.	BIOT-510	Food Biotechnology	2	1	3(2-2)
22.	BIOT-512	Nanobiotechnology	2	1	3(2-2)
23.	BIOT-601	Biorisk Management and Bioethics	2	1	3(2-2)
24.	BIOT-603	Pharmaceutical Biotechnology	3	0	3(3-0)
25.	BIOT-605	Animal Biotechnology	3	0	3(3-0)
26.	BIOT-607	Virology and Immunology	3	0	3(3-0)
27.	BIOT-609	Microbial Biotechnology	2	1	3(2-2)
28.	BIOT-611	Current Trends in Biotechnology	3	0	3(3-0)
29.	BIOT-620	Seminar	1	0	1(1-0)

List of General Education Courses (Mandatory)

S.#	Course Code	Course Title	Theory	Practical	Credits
1.	CHEM-401	Organic Chemistry	2	1	3(2-2)
2.	CSC-100	Applications of Information and Communication Technologies (ICT)	2	1	3(2-1)
3.	ENG-301	Functional English	3	0	3(3-0)
4.	ENG-302	Expository Writing	3	0	3(3-0)
5.	IS-302	Islamic Studies and Ethics	2	0	2(2-0)
6.	QR-401	Quantitative Reasoning-I	3	0	3(3-0)
7.	QR-402	Quantitative Reasoning-II	3	0	3(3-0)
8.	SOC-301	Introduction to Sociology	2	0	2(2-0)
9.	SOS-301	Moral Foundation of Education	2	0	2(2-0)
10.	SSH-301	Civic and Community Engagement	2	0	2(2-0)
11.	SSH-302	Ideology and Constitution of Pakistan	2	0	2(2-0)
12.	SSH-304	Entrepreneurship	2	0	2(2-0)
13.	???-???	Time Management & Organizing Skills	2	0	2(2-0)

List of Interdisciplinary/Allied Courses

S.#	Course Code	Course Title	Theory	Practical	Credits
1.	CHEM-301	Inorganic Chemistry	2	1	3(2-2)
2.	CHEM-501	Physical Chemistry	2	1	3(2-2)
3.	MIC-509	Microbial Genetics	2	1	3(2-2)
4.	STAT-202	Biostatistics	2	1	3(2-2)

Internship/Field Experience, Capstone Project

S.#	Course Code	Course Title	Theory	Practical	Credits
1.	BIOT-299	Internship/Field Experience	0	3	3(0-6)
2.	BIOT-399	Capstone Project	0	3	3(0-6)

List of Minor Courses

S.#	Course Code	Course Title	Theory	Practical	Credits
1.	BIOT-301	Introduction to Biotechnology	3	0	3(3-0)
2.	BIOT-302	Molecular Biology	2	1	3(2-2)
3.	BIOT-304	Classical Genetics	3	0	3(3-0)
4.	BIOT-401	Bioinformatics	1	2	3(1-4)
5.	BIOT-405	Genetic Engineering	2	1	3(2-2)
6.	BIOT-406	Principles of Biochemical Engineering	2	1	3(2-2)
7.	BIOT-503	Genetic Resources and Conservation	3	0	3(3-0)
8.	BIOT-505	Genomics and Proteomics	3	0	3(3-0)

List of Audit Courses

S.#	Course Code	Course Title	Theory	Practical	Credits
1	TOQ-301	Translation of Quran (Audit Course)	1	0	1(1-0)
2	TOQ-401	Translation of Quran (Audit Course)	1	0	1(1-0)
3	TOQ-501	Translation of Quran (Audit Course)	1	0	1(1-0)

4	TOQ-601	Translation of Quran (Audit Course)	1	0	1(1-0)

Semester Wise Courses

Semester	Course Code	Course Title	Theory	Practical	Credits
First	BIOT-301	Introduction to Biotechnology	2	1	3(2-2)
	BIOT-303	Cell Biology	2	1	3(2-2)
	CHEM-401	Organic Chemistry	2	1	3(2-2)
	ENG-301	Functional English	3	0	3(3-0)
	???-???	Time Management & Organizing Skills	2	0	2(2-0)
	QR-401	Quantitative Reasoning-I	3	0	3(3-0)
	TOQ-301	Translation of Quran (Audit Course)	1	0	1(1-0)
			14	**3**	**17**
Second	BIOT-302	Molecular Biology	2	1	3(2-2)
	BIOT-304	Classical Genetics	3	0	3(3-0)
	BIOT-306	Biochemistry-I	2	1	3(2-2)
	BIOT-308	General Microbiology	2	1	3(2-2)
	SSH-301	Civic and Community Engagement	2	0	2(2-0)
	CSC-100	Applications of Information and Communication Technologies (ICT)	2	1	3(2-1)
	IS-302	Islamic Studies and Ethics	2	0	2(2-0)
	TOQ-401	Translation of Quran (Audit Course)	1	0	1(1-0)
			15	**4**	**19**
Third	BIOT-401	Biodiversity and Conservation Biology	3	0	3(3-0)
	BIOT-403	Genetic Engineering	2	1	3(2-2)
	BIOT-405	Biochemistry-II	3	0	3(3-0)
	CHEM-301	Inorganic Chemistry	2	1	3(2-2)
	QR-402	Quantitative Reasoning-II	3	0	3(3-0)
	SSH-302	Ideology and Constitution of Pakistan	2	0	2(2-0)
	SOS-301	Moral Foundation of Education	2	0	2(2-0)
	TOQ-501	Translation of Quran (Audit Course)	1	0	1(1-0)
			17	**2**	**19**
Fourth	BIOT-402	Molecular Ecology and Evolution	3	0	3(3-0)
	BIOT-404	Analytical Chemistry and Instrumentation	2	1	3(2-2)
	BIOT-406	Principles of Biochemical Engineering	2	1	3(2-2)
	MIC-509	Microbial Genetics	2	1	3(2-2)
	SOC-301	Introduction to Sociology	2	0	2(2-0)
	ENG-302	Expository Writing	3	0	3(3-0)
	SSH-304	Entrepreneurship	2	0	2(2-0)
	TOQ-601	Translation of Quran (Audit Course)	1	0	1(1-0)
			16	**3**	**19**

Fifth	BIOT-501	Cell and Tissue Culture	2	1	3(2-2)
	BIOT-503	Genetic Resources and Conservation	3	0	3(3-0)
	BIOT-505	Genomics and Proteomics	3	0	3(3-0)
	BIOT-507	Bioinformatics	1	2	3(1-4)
	CHEM-501	Physical Chemistry	2	1	3(2-2)
	STAT-202	Biostatistics	2	1	3(2-2)
			13	**5**	**18**
Sixth	BIOT-502	Health Biotechnology	2	1	3(2-2)
	BIOT-504	Industrial Biotechnology	2	1	3(2-2)
	BIOT-506	Agriculture Biotechnology	2	1	3(2-2)
	BIOT-508	Environmental Biotechnology	2	1	3(2-2)
	BIOT-510	Food Biotechnology	2	1	3(2-2)
	BIOT-512	Nanobiotechnology	2	1	3(2-2)
			12	**6**	**18**
Seventh	BIOT-601	Biorisk Management and Bioethics	2	1	3(2-2)
	BIOT-603	Pharmaceutical Biotechnology	3	0	3(3-0)
	BIOT-605	Animal Biotechnology	3	0	3(3-0)
	BIOT-607	Virology and Immunology	3	0	3(3-0)
	BIOT-609	Microbial Biotechnology	2	1	3(2-2)
	BIOT-611	Current Trends in Biotechnology	3	0	3(3-0)
	BIOT-620	Seminar	1	0	1(1-0)
			17	**2**	**19**
Eighth	BIOT-299	Internship/Field Experience	0	3	3(0-6)
	BIOT-399	Capstone Project	0	3	3(0-6)
			0	**6**	**6**

Scheme of Studies - BS Biotechnology

BIOT-301	Introduction to Biotechnology	3(2-2)

Theory

Biotechnology- definition and history; foundations of biotechnology and interdisciplinary pursuit; branches and/or applications of biotechnology in medicine, agriculture (food, livestock, fisheries, algae, fungi, etc.); protection of biotechnological products; safety in biotechnology; public perception of biotechnology; biotechnology and ethics; biotechnology and the developing world.

Practical

Laboratory safety, Laboratory record keeping, micropipetting, bacterial culture techniques, basics of plant tissue culture techniques.

Recommended Books

1. Daugherty E. (2017). Biotechnology: Science for the New Millennium, 2nd Ed. EMC Paradigm, US.
2. Smith JE. (2012). Biotechnology, 5th Ed. Cambridge University Press.
3. Nicholl TSD. (2023). An Introduction to Genetic Engineering, 4th Ed. Cambridge University Press, UK.
4. Purohit SS. (2005). Biotechnology Fundamentals & Application, 4th Ed. Agro Bios, India.
5. Ratlegde C and Kristiansen B. (2006). Basic Biotechnology, 3rd Ed. Cambridge University Press, UK.

BIOT-302	Molecular Biology	3(2-2)

Theory

Introduction to molecular biology and macromolecules. Molecular evolution. Chemistry and structure of DNA and RNA. Genes & genomes. DNA replication, repair & recombination, comparison between prokaryotes & eukaryotes. RNA synthesis, modifications & splicing, parallels and anti-parallels between prokaryotes & eukaryotes. Protein synthesis in prokaryotes and eukaryotes, Post-translational modifications, Protein targeting and turnover. Regulation of gene expression in prokaryotes, eukaryotic chromatin & gene regulation.

Practical

Laboratory ethics. Spectrophotometery; Quantification of nucleic acids, Melting kinetics of DNA. Protein estimation by Lowry and Bradford methods. Protein separation by SDS-PAGE. Centrifugation; Density gradient centrifugation. Column and thin layer chromatography.

Recommended Books

1. Alberts B, Heald R, Johnson A, Morgan D, Raff M, Roberts K and Walter P. (2022). Molecular Biology of the Cell, 7th Ed. W. W. Norton & Company.
2. Berg JM, Tymoczko JL, Gatto Jr. GJ and Stryer L. (2019). Biochemistry, 9th ED. MACMILLAN.
3. Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Martin KC, Yaffe M, and Amon A. (2021). Molecular Cell Biology, 9th ED. W. H. Freeman.
4. Voet D and Voet JG. (2010). Biochemistry, 4th Ed. John Wiley & Sons, Inc.

BIOT-303	Cell Biology	3(2-2)

Theory

Introduction to cell theory including historical perspective; overview of membrane structure and chemical constituents of the cell; function, isolation and molecular organization of cellular organelles specifically the endoplasmic reticulum, lysosome, micro-bodies, mitochondrial ultra-structure and function, chloroplast ultra-structure and the mechanism of photosynthesis; composition and structure of membranes; membrane receptors and transport mechanisms; cell movement- structure and function of cytoskeleton, centriole, cilia and flagella; nucleus; structure and function of chromosomes; cell cycle, mitosis and meiosis.

Practical

Microscopy and staining techniques; study of prokaryotic, eukaryotic, plant and animal cells; cell structure in the staminal hair of *Tradescantia*; study of different types of plastids; cellular reproduction; Mitosis: smear/squash preparation of onion roots.

Recommended Books:

1. Alberts B, Heald R, Johnson A, Morgan D, Raff M, Roberts K and Walter P. (2022). Molecular Biology of the Cell, 7th Ed. W. W. Norton & Company.
2. Karp G, Iwasa J and Marshall W. (2019). Cell and Molecular Biology, 9th Ed. John Wiley and Sons, New York.
3. Alberts B, Hopkin K, Johnson A, Morgan D, Roberts K, Walter P and Heald R. (2023). Essential Cell Biology, 6th Ed. W. W. Norton & Company.
4. Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Martin KC, Yaffe M, and Amon A. (2021). Molecular Cell Biology, 9th ED. W. H. Freeman.
5. Cooper GM and Adams KW. (2022). The Cell: A molecular approach, 9th ED. Sinauer Associates, Inc.

BIOT-304	Classical Genetics	3(3-0)

Theory

Classical Mendelian genetics; monohybrid crosses, dominance, recessiveness, 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.

Recommended Books

1. Snustad DP and Simmons MJ. (2015). Principals of Genetics, 7th Ed. John Willy & Sons, New York.
2. Klug WS, Cummings M, Spencer CA, Palladino MA and Killian D. (2019). Concepts of Genetics, 12th Ed. Pearson.
3. Pierce BA. (2019). Genetics: A Conceptual Approach, 7th Ed.. W.H. Freeman, New York.
4. Brooker RJ. (2020). Genetics: Analysis and Principles, 7th Ed. McGraw-Hill.

BIOT-306	Biochemistry-I	3(2-2)

Theory

An overview of biochemical structures and reactions that occur in living systems: cell, biomolecules and water. Protein structure and function: the building blocks of proteins; amino acids, peptides and polypeptides. The three-dimensional structures of proteins, functional diversity of proteins. Enzymes. Nucleic acids: chemical structure and base composition, double helical structure, forces stabilizing nucleic acid structures, nucleic acid fractionation, super coiled DNA, RNA, mRNA, tRNA and rRNA. Diverse physiological functions of nucleotides. Nucleic acid synthesis and protein synthesis. Lipids and carbohydrates. Glycolysis, citric acid cycle, electron transport, chair, oxidative and photo phosphorylation and regulation of ATP production in brief. Vitamins and hormones.

Practical

Titration curves, pKa determination, buffer preparation, amino acid and proteins determination, protein precipitations, carbohydrate and lipid determination. Sugar identification using paper chromatography, amino acid separation by two-dimensional paper chromatography, steroid separation by thin layer chromatography (TLC).

Recommended Books

6. Berg JM, Tymoczko JL and Stryer L. (2019). Biochemistry: MacMillan International Higher Education; 9th Edition.
7. Boyer R. (2011). Biochemistry Laboratory: Modern Theory and Techniques. Pearson, 2nd Edition
8. Nelson DL and Cox MM. Lehninger Principles of Biochemistry. W. H. Freeman; 9th Edition
9. Voet D, Voet, JG and Pratt CW. (2016). Fundamentals of Biochemistry: Life at the Molecular Level. Wiley; 5th edition
10. Voet D and Voet JG. (2018). Biochemistry. Wiley; 4th Edition

BIOT-308	General Microbiology	3(2-2)

Theory

Introduction: History, Classification of microbial life, Characteristics of prokaryotes, Characteristics of eukaryotes, Characteristics of viruses. Microbial physiology: Microbial respiration and fermentation, Microbial energetics and enzymes, Physical growth requirements, Chemical growth requirements, Culture media. Microbial reproduction and growth kinetics. Microbial control: Physical control, Chemical control, Antimicrobial drugs. Pathogenicity and epidemiology: Resident and normal flora, Mechanism of pathogenesis, Basic factors of epidemiology.

Practical

Sterilization techniques, culturing, staining (Gram, simple, negative, capsule and spore), colony and cell morphology, bacterial cell count and growth curve, biochemical tests Oxidation, Fermentation, urease, oxidase and catalase tests of bacteria.

Recommended Books

1. Prescott LM. (2022). Microbiology. McGraw-Hill, New York, 12th Edition
2. Madigan M, Aiyer J, Buckley D, Sattley W and Stahl D. (2021). Brock Biology of Microorganisms, 16th Ed. Pearson.
3. Gerard T, Funke B and Case c. (2018). Microbiology: An Introduction, 13th Ed. Pearson.

4. Talaro KP and Chess B. (2017). Foundations in Microbiology: Basic Principles. 10th Ed. McGraw Hill Education.

BIOT-401	Biodiversity and Conservation Biology	3(3-0)

Theory

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. Common methods to conserve the environment and the biological diversity. Central aspects of biodiversity through history, the value of biodiversity, human effects on biodiversity, and the theoretical foundations for and empirical examples of conservation biology. *In situ* and *ex situ* conservation.

Recommended Books

1. Thangadurai D, Ching GH, Sangeetha J and Islam S. (2021). Biodiversity and Conservation: Characterization and Utilization of Plants, Microbes and Natural Resources for Sustainable Development and Ecosystem Management. Apple Academic Press Inc.
2. Mahanty S and Srivastava A. (2016). Biodiversity and its Conservation. Disha International Publishing House.
3. Krishnamurthy KV. (2018). An Advanced Textbook on Biodiversity: Principles and Practice. Oxford & IBH Publishing Co Pvt. Ltd.
4. William MN. (2016). Biodiversity. CBS Publishers and Distributors Pvt. Ltd.
5. Boylan M. (2022). Environmental Ethics, 3rd Ed. John Wiley & Sons, Inc.

BIOT-402	Molecular Ecology and Evolution	3(3-0)

Theory

Fundamental concepts and principles in population and quantitative genetics, meta-genomics, and landscape ecology for a better understanding of the forces operating in natural systems. Use of common molecular methods, their strengths and limitations for ecological coupling. Detection of genetic variation within and among populations, speciation, selection and local adaptation, environmental DNA (eDNA) assays, and biological conservation. Phylogenetic relationships between the three kingdoms; evolution of different members belonging to each of the three domains of life (with specific examples); models of speciation; causes and consequences of extinction.

Recommended Books

1. Van Straalen NM and Roelofs D. (2011). An Introduction to Ecological Genomics. Oxford University Press.
2. Costa LG and Eaton DL. (2006). Gene-Environment Interactions: Fundamentals of Ecogenetics. Wiley-Liss.
3. Freeland JR. (2020). Molecular Ecology, 3rd Ed. John Wiley and Sons.
4. Bromham L. (2016). An Introduction to Molecular Evolution and Phylogenetics, 2nd Ed. Oxford University Press.
5. Lewis M and Smith C. (2015). Molecular Evolution: Reference Source & Guide. CreateSpace Independent Publishing Platform.

BIOT-403	Genetic Engineering	3(2-2)

Theory

Introduction. Working with nucleic acids; Isolation, quantification, labeling, hybridization, electrophoresis, amplification and sequencing of DNA. Tools of trade; Restriction enzymes, DNA modifying enzymes, and DNA ligase. Biology of genetic engineering; Host cell types, vectors and transformation techniques. Cloning strategies. Selection, screening and analysis of recombinants. Genetic engineering in action; Analysis of gene structure and function, making proteins. Spin-off techniques; Recombinant technology and medicine, food industry, disease diagnosis. Human genome project. Transgenic animals and transgenic plants.

Practical

Introduction to Culturing Techniques and Making of LB Agar and LB Broth. Mini preparation of plasmid from bacterial cells, running of agarose gel electrophoresis. Restriction of bacterial plasmid by restriction enzyme. Designing of Primers and Polymerase Chain Reaction (PCR). Elution of DNA fragments from agarose gel. Ligation of different DNA fragments. Preparation of competent cells and transformation. Expression of proteins using expression systems. Running of SDS- PAGE and Western Blotting.

Recommended Books

1. Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Martin KC, Yaffe M, and Amon A. (2021). Molecular Cell Biology, 9th ED. W. H. Freeman.
2. Nicoll DST. (2023). An introduction to Genetic Engineering, 4th Ed. Cambridge University Press.
3. Primrose SB, Twyman RM and Old RW. (2006). Principles of Gene Manipulation, 6th Ed. Wiley-Blackwell.
4. Brown TA. (2023). Genomes, 5th Ed. CRC Press.
5. Clark DP and Pazdernik NJ. (2015). Biotechnology: Applying the Genetic Revolution, 2nd ED. Elsevier Inc.

BIOT-404	Analytical Chemistry and Instrumentation	3(2-2)

Theory

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, emission and inductively coupled plasma emission spectroscopy (ICPMS);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, lyophilisation, ultracentrifuge and amino acid analyzer.

Practical

Separation of biomolecules by paper, column and thin layer chromatography; determination of molecular weight of proteins by gel filtration; identification of sugars, proteins, electrolytes etc. by UV/Visible spectrophotometer; determination of sodium and potassium content in blood

serum by flamephotometer and mineral analysis of plant tissues using atomic absorption spectrophotometer.

Recommended Books:

1. Boyer RF. (2011) Biochemistry Laboratory: Modern Theory and Techniques. Prentice Hall
2. Wilson K. (2018) Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
3. Christian GD. (2004) Analytical Chemistry. John Wiley and Sons, New York.
4. Chung et al. (2004) Analytical Methods validation and Instrument Performance verification. John Wiley and Sons, New York.
5. Harris DC. (2015) Quantitative Chemical analysis. WHFreeman, 9th ed. New York.

BIOT-405	Biochemistry-II	3(3-0)

Theory

Introduction to Metabolism Bioenergetics, Basic concepts of bioenergetics. Metabolism of carbohydrates, Glucose, Glycogen, starch and other sugars relevant to metabolic routes. Metabolism of lipids, role of simple and compound lipids in production of energy, β oxidation and fatty acids biosynthesis, lipoprotein and their function in transporting cholesterol and phospholipid. Metabolism of proteins and amino acids: catabolism and anabolism of protein. Amino acids, essential and non-essential amino acids, total nitrogen balance and formation of creatinine and urea. Nucleic acids Metabolism and uric acid synthesis. Over view of catabolic and anabolic process, Integration, regulation and organ specialization of metabolism with Phase I and Phase II reactions. Digestion of food and transport.

Books Recommended

6. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry. MacMillan International Higher Education; 9th Edition.
7. Nelson, D.L., Cox, M.M. (2021). Lehninger Principles of Biochemistry. W. H. Freeman; 9th Edition
8. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry: MacMillan International Higher Education; 9th Edition.
9. Boyer, R. (2011). Biochemistry Laboratory: Modern Theory and Techniques. Pearson, 2nd Edition
10. Nelson, D.L., Cox, M.M. Lehninger Principles of Biochemistry. W. H. Freeman; 9th Edition

BIOT-406	Principles of Biochemical Engineering	3(2-2)

Theory

Introduction to microorganisms and biological molecules; principles of enzyme catalysis; methods of enzyme and cell immobilization; enzyme kinetics; internal mass transfer effect on immobilized growth; stoichiometry models of microbial growth; structured model, of microbial growth; bioreactors - continuous stirred tank bioreactors, plug-flow and packed bed bioreactors, imperfect mixing, fed batch bioreactors, gas liquid mass transfer in bioreactors, power requirement for bioreactor, sterilization and heat transfer in bioreactors; introduction to bioproduct recovery; biological product manufacturing; economic analysis of bioprocesses; case study: penicillin.

Practical

Unstructured microbial growth with application of Monod model; inhibition kinetics and nutrient uptake rate; methods of immobilization via binding and physical retention; yield coefficient and stoichiometry; production of enzymes by structured and segregated models; bioreactor design and analysis (batch, fed batch and continuous); enzyme catalysis in the CSTR; packed bed and plug flow bioreactor; rheology of fermentation broth; mixing and gas-liquid mass transfer, heat transfer, media and bioreactor sterilization techniques; techno-economic analysis of a typical bioprocess.

Recommended Books

1. Shuler M, Kargi F and DeLisa M. (2017). Bioprocess Engineering: Basic Concepts, 3rd Ed. Pearson.
2. Bailey JE and Ollis DF. (2017). Biochemical Engineering Fundamentals, 2nd Ed. McGraw-Hill.
3. Das D and Das D. (2019). Biochemical Engineering: An Introductory Textbook. Jenny Stanford Publishing.
4. Katoh S, Horiuchi J and Yoshida F. (2015). Biochemical Engineering: A Textbook for Engineers, Chemists and Biologists, 2nd Ed. Wiley-VCH.

BIOT-501	Cell and Tissue Culture	3(2-2)

Theory

Plant cell and tissue culture: 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 micro-propagation; somaclonal variation; industrial uses of plant cell culture; tissue culture in genetic engineering and biotechnology. **Mammalian cell culture**: origin and principles of cell culture; qualitative characteristics of cell cultures; cell counting and analysis; cryopreservation; cell banking and subculture (variety of different systems); primary cell culture techniques; development of immortalized cell line; detection of microbial contaminants; animal cells for bioassays and bioproducts; design and operation of animal cell culture bioreactors for therapeutic protein production; growth environment; Stem cell culture

Practical

Setting up a Tissue culture laboratory. Media Preparation. Explant surface sterilization and culture initiation. Screening of contamination and data recording. Regeneration from cultured tissues; Direct regeneration and through callus formation. Microscopic study of callus/regenerating cultures. Micropropagation of potato and/or tobacco. Agrobacterium and Biolistic mediated transformation, Analysis of transformed tissues.

Recommended Books:

1. Setlow JK. (2005). Genetic Engineering: Principles and Methods, Volume 27, 2006th Ed. Springer.
2. Nicoll DST. (2023). An introduction to Genetic Engineering, 4th Ed. Cambridge University Press.
3. Gale YL. (2015). Genetics and Genetic Engineering, 2015 Ed. Information Plus.
4. Razdan MK. (2019). Introduction to Plant Tissue Culture, 3rd Ed. Oxford and IBH Publishing.

5. Lanza R, Langer R, Vacanti JP and Atala A. (2020). Principles of Tissue Engineering, 5th Ed. Academic Press, California.

BIOT-502	Health Biotechnology	3(2-2)

Theory

Introduction to health biotechnology; social acceptance of medical biotechnology; molecular basis of disease; molecular and genetic markers; detection of mutations and infectious agents; active and passive immunization; vaccines (live, killed, recombinant DNA vaccines, subunit vaccines, DNA vaccines, edible vaccines); organ transplantation; applications of transgenic animals (animal models of diseases, farming and enhancement of farm animals);drug delivery systems; blood transfusion and grafting techniques; pharmacogenetics; gene therapy; biopharmaceuticals from plants; stem cell technology.

Practical

Proper handling of biological materials. Isolation and identification of microbes from samples. Sterilization techniques and media preparation. Detection of antigens/antibodies in biological samples. Use of software tools for sequence alignment (e.g., BLAST, Clustal Omega). Analysis of gene sequences related to disease-causing mutations. Extraction of DNA/RNA from human samples (e.g., blood, saliva).

Recommended Books:

1. Pongracz J. and Keen M. (2018). Medical Biotechnology. Elsevier Health Sciences.
2. Schacter B. Z. Biotechnology and Your Health: Pharmaceutical Applications (2006). Chelsea House Publishers.
3. Chetan DM and Dinesh KP. Health and Pharmaceutical Biotechnology. (2006) Firewall Media.
4. Bustillo LGT and Pena IG. Biotechnology: Health, Food, Energy and Environment Applications (Biotechnology in Agriculture, Industry and Medicine) (2012). Nova Science Publication.
5. Dogramatzis. Health care Biotechnology. CRC Press

BIOT-503	Genetic Resources and Conservation	3(3-0)

Theory

Introduction to genetic resources and their significance; plant genetic resources -utilization, opportunities and constraints; strategic role of plant genetic resources in achieving global food security and sustainable agriculture; overview of wild and domesticated genetic resources of Pakistan; genetic diversity in endangered species; genotype-environment interactions; gene pools and genetic boundaries; genetic drift, inbreeding, migration and gene flow; introduction to extinction and its causes; threatened animal and plant species; conservation of genetic resources through mapping of existing biological diversity; assessing conservation status; management strategies; laws and treaties of conservation; quarantine regulations; future prospects of genetic conservation.

Recommended Books

1. Primack RB. (1995) A Primer of Conservational Biology. Sinauer Associates Inc.
2. Virchow D. (1999) Conservation of Genetic Resources: Costs and Implications for a Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. Springer.

3. Mills LS. Conservation of Wildlife Populations: Demography, Genetics, and Management. Wiley-Blackwell.
4. Kamau EC and Winter G. (2014) Genetic Resources, Traditional Knowledge and the Law: Solutions for Access and Benefit Sharing. Earthscan.
5. Frankham R. (2010) Introduction to Conservation Genetics. Cambridge University Press.

BIOT-504	Industrial Biotechnology	3(2-2)

Theory

Industrial biotechnology–introduction and scope; microorganisms commonly used in industry; media and nutritional requirements of industrial organisms; screening for productive strains and strain improvement; culture collections; fermentation and fermenters; production and extraction of fermented products; use of single cell proteins as food products; biocatalysts; microbial insecticides; production of metabolites: organic acids and amino acids; vaccines and antibiotic production. Industry and research institute(s) visits.

Practical

Isolation and maintenance of industrially important microbes (e.g., Bacillus, Aspergillus, Saccharomyces). Sterilization methods and aseptic techniques. Scale-up from shake flask to bioreactor (small-scale). Use of bioreactors/fermenters (demo or small pilot units). Extraction and purification of enzymes (e.g., amylase, protease). Algae cultivation for bioenergy. Spectrophotometric analysis of product purity.

Recommended Books

1. Okafor N. (2007). Modern Industrial Microbiology and Biotechnology. 1st ed. Science Publishers, USA.
2. Waites et al. (2001). Industrial Microbiology: An Introduction. 1st ed, Blackwell Science Ltd.
3. Shara et al. (2009) Industrial Biotechnology. Nova Science Publishers.
4. Abhilasha MS. Industrial Biotechnology. ANE Books
5. Singh R and Ghosh S. Industrial Biotechnology. Global Vision Publishing House.

BIOT-505	Genomics and Proteomics	3(3-0)

Theory

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, pyro-sequencing, Solexa, Helicos, Roche 454, Realtime and nano-pore 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/signaling 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

1. Strachan T and Read AP (2019). Human Molecular Genetics.5th Garland Science.

2. Saccone C and Pesole G (2008). Handbook of Comparative Genomics: Principles and Methodology.1st Ed. Wiley-Liss.
3. Town C. Functional Genomics. Springer.
4. Krebs et al. Lewin Genes X. Jones and Bartlett Publishers.
5. Al-Rubeai M and Fussenegger M. Systems Biology (Cell Engineering). Springer.

BIOT-506	Agriculture Biotechnology	3(2-2)

Theory

Agriculture biotechnology and its applications in crop improvements; cell and plant tissue culture methodology; improvement of plants via plant cell culture; plant molecular biomarkers; direct and indirect methods of plant and animal transformation: gene gun method of transformation, *Agrobacterium* mediated transformation, chloroplast transformation and polyethylene glycol (PEG) mediated transformation; transgenic crops with herbicide, biotic and abiotic stress resistance; problems related to transgenic plants; genetically modified organisms (GMOs); field evaluation and commercialization of GMOs; possible effects of releasing GMOs into the environment; bio-fertilizers, bio-pesticides and their types; non-symbiotic nitrogen fixers; present and future prospects of biofertilizers.

Practical

Selection of ex-plant, Medium Preparation and Callus Induction, Culturing Agrobacterium and Infection to plant callus, Selection of Transformants, Regeneration of Plantlets and acclimatization, Plant DNA extraction and PCR for Transgene.

Recommended Books

1. Qaim M. Agricultural Biotechnology in Developing Countries: Towards Optimizing Benefits for Poor. Springer
2. Kemp Ken F. Genetic Modification of Plants: Agriculture, Horticulture and Forestry (Biotechnology in Agriculture and Forestry). Springer.
3. Herren RV. Introduction to Agricultural Biotechnology. Delmar Cengage Learning.
4. Slater A. Plant Biotechnology: The Genetic Manipulation of Plants. Oxford University Press, USA
5. Altman A. Plant Biotechnology and Agriculture: Prospects for the 21stCentury. Academic Press.

BIOT-507	Bioinformatics	3(1-4)

Theory

Introduction; bio-computing; biological databases - types and retrieval of nucleic acid (or genomic) or protein sequence information; sequence alignment -pairwise, multiple; phylogenetics; *in silico* identification of protein motifs and domains; structural bioinformatics of proteins and RNAs including protein modeling and prediction of their interactions with other proteins and small molecules; identification of genes and promoter regions within genomes; networks; strategies for whole genome sequencing and assembly.

Practical

General Introduction; Computer hardware, file management, windows application in bioinformatics, codon usage analysis. DNA restriction; Restriction enzymes databases, single/ multiple enzyme digestions. DNA sequence manipulations; Generating reverse, complementary

and reverse complementary sequence. DNA sequence manipulations; Translation in single/ multiple frames. Finding ORF/coding sequences. Primer/Probe designing and analysis. Global alignment tools; CLUSTAL, BLAST for DNA/proteins and phylogenetic analysis. Prot Param, Protein digestion and fragment analysis.

Recommended Databases and Tools

1. NCBI, PDB, EcoCyc, DDBJ, SWISS-PROT, TIGR, KEGG etc.
2. Bioedit, Repeatmasker, PHRED, PHRAP, BLAST, Prosite/BLOCKS/PFAM, CLUSTALW, Emotif, RasMol, Oligo, Primer3, Molscript, Treeview, Alscript, Genetic Analysis Software, Phylip, MEGA4.0 etc.

Recommended Books:

1. Claverie J-M and Notredame C. (2006). Bioinformatics for Dummies, 2nd Ed. Wiley Publishing.
2. Xiong J. (2006). Essential Bioinformatics. Cambridge University Press.
3. Xia X. (2018). Bioinformatics and the Cell: Modern Computational Approaches in Genomics, Proteomics and Transcriptomics, 2nd Ed. Springer
4. Mathura VS and Kangueane P. (2009). Bioinformatics: A Concept-Based Introduction. Springer
5. Sperschneider V. (2008). Bioinformatics: Problem Solving Paradigms. Springer.

BIOT-508	Environmental Biotechnology	3(2-2)

Theory

Introduction to environmental biotechnology; fundamentals of biological interventions; genetic manipulation strategies in environmental biotechnology; pollution indicators and pollution control strategies; bioreactors; domestic wastewater treatment; industrial effluent treatment; sludge treatment; contaminated land and bioremediation; phytoremediation; landfills and composts; concept of integrated environmental biotechnology; biodegradation and biotransformation of hazardous chemicals; products of environmental biotechnology.

Practical

Isolation and screening of microorganisms capable of degrading pollutants (e.g., oil spills, heavy metals, pesticides). Laboratory-based bioremediation experiments (e.g., using soil or water samples contaminated with hydrocarbons or heavy metals). Design and operation of laboratory-scale activated sludge and biofilm reactors. Microbial analysis and biomass growth in wastewater treatment. Monitoring of COD (Chemical Oxygen Demand), BOD (Biochemical Oxygen Demand), and nutrient levels before and after treatment.

Recommended Books

1. Fluker MH. Environmental Biotechnology. CRC Press.
2. Faster CF and Wase J. Environmental Biotechnology. John Willey &Sons.
3. Evans GM and Furlong JC. Environmental Biotechnology Theory and Application. Wiley-Blackwell Publishers.
4. Srinivas T. Environmental Biotechnology. New Age International Publishers.
5. Spencer JFT and Spencer ALR. Environmental Microbiology: Methods and Protocols (Methods in Biotechnology). Humana Press.
6. Hurst et al. Manual of Environmental Microbiology. ASM Publishers.

BIOT-510	Food Biotechnology	3(2-2)

Theory

Food composition, probiotics, fermented foods, food enzymes, colors and additives; overview of metabolic engineering of bacteria for food ingredients; techniques used for production of food ingredients by microbes; genetic modification of plant starches for food applications; biotechnological approaches to improve nutritional quality and shelf life of fruits and vegetables; microbial food spoilage and food borne diseases; detection and control of food borne bacterial pathogens; food safety and quality control; international aspects of quality and safety assessment of food derived by modern biotechnology.

Practical

Industry and research institute(s) visits. Isolation and identification of foodborne microorganisms (bacteria, yeasts, molds). Preparation of fermented foods (e.g., yogurt, sauerkraut, pickles, kefir). Fermentation of milk using *Lactobacillus* spp. Vinegar production using acetic acid bacteria. Detection of food adulterants (e.g., starch in milk, synthetic color in spices).

Recommended Books

1. Bhatia SC, Foster GN and Bhatia SC. (2020). Food Biotechnology. CBS Publishers & Distributors Pvt. Ltd.
2. Nash D. (2018). Food Biotechnology. Callisto Reference.
3. Campbell-Platt G. (2017). Food Science and Technology, 2nd Ed. Wiley-Blackwell.
4. Singh RP, Heldman DR and Erdogdu F. (2024). Introduction to Food Engineering, 6th Ed. Academic Press.
5. Damodaran S and Parkin KL. (2017). Fennema's Food Chemistry, 5th Ed. CRC Press.
6. Nielsen SS. (2017). Food Analysis, 5th Ed. Springer

BIOT-512	Nanobiotechnology	3(2-2)

Theory

Introduction; interface between nanotechnology and bio-nanotechnology; manipulating molecules; carbon fullerenes and nanotubes; non-carbon nanotubes and fullerene-like materials; quantum dots; nanowires, nanorods and other nanomaterial's; magnetic nanoparticles; natural biological assembly at the nanoscale and nanometric biological assemblies (complexes); nanobionics and bio-inspired nanotechnology; applications of biological assemblies in nanotechnology; medical, cosmetics, agriculture, water and other applications of nano-biotechnology; future prospects of nano-biotechnology; use of nanotechnology for diagnosing and curing disease.

Practical

Synthesis of metallic nanoparticles (e.g., silver, gold) using biological methods (plant extracts, microbial synthesis). Characterization of nanoparticles: colorimetric and basic spectral analysis. Disc diffusion method to evaluate antibacterial/antifungal activity of synthesized nanoparticles.

Recommended Books

1. Gazit E. (2013). Plenty of Room for Biology at the Bottom: An Introduction to Bionanotechnology, 2nd Ed. Imperial College Press.
2. Fruk L and Kerbs A. (2021). Bionanotechnology: Concepts and Applications. Cambridge University Press.
3. Jarvis C. (2018). Nanobiotechnology: An Introduction. Larsen and Keller Education.

4. Salati G. (2016). Principles and Practices of Nanobiotechnology. Syrawood Publishing House.

BIOT-601	Biorisk Management and Bioethics	3(2-2)

Theory

Introduction to the Biorisk management and the concepts of biosafety and biosecurity; Biorisk assessment: agent and practice associated hazards; Biosafety levels and specific safety measures; Biosecurity concepts; Biosafety cabinets; Transport of hazardous substances. Ethical considerations; Modern Biotechnology and its social implications; Biomedical research and bioethics; Ethics of animal research; Genetic testing and concerns.

Practical

Hands-on training on laboratory safety protocols (e.g., PPE, emergency response). Simulated laboratory accident response: Spillage management and decontamination procedures. Risk assessment exercises for laboratory practices (identifying potential hazards). Role-playing of an internal safety audit: Identification of non-compliance and corrective actions. Simulation of ethical review board meetings: Review of biotechnology research proposals and ethical concerns.

Recommended Books

1. Altman A and Hasegawa PM. (2011). Plant Biotechnology and Agriculture: Prospects for the 21st Century. Academic Press.
2. WHO. (2020). Laboratory Biosafety Manual, 4th Ed. AITBS Publishers and Distributors, India.
3. Furr AK. (2000). CRC Handbook of Laboratory Safety, 5th Ed. CRC Press.
4. Krishna VS. (2007). Bioethics and Biosafety in Biotechnology. New Age International Publishers.
5. PEPA. (2005). National Biosafety Guidelines. Pakistan Environmental protection Agency.

BIOT-603	Pharmaceutical Biotechnology	3(3-0)

Theory

Introduction and basic concepts of pharmaceutical biotechnology; properties of an effective drug; drug development process; selection of a lead molecule from available pool, lab scale studies, pilot scale studies and clinical trials (Phase I, II and III); drug toxicity; impact of genomics and other related technologies on drug discovery; use of DNA and protein microarrays in identification of disease targets and for monitoring effectiveness of drugs; pharmacogenomics; plants and microorganisms as sources of drugs; polymers: classification, polymerization and characterization; controlled drug release system and its advantages and disadvantages over conventional release methods; legal and regulatory issues.

Recommended Books

1. Kayser O and Warzecha H. (2012). Pharmaceutical Biotechnology: Drug Discovery and Clinical Application. Wiley-Blackwell.
2. Kokate C. (2022). Textbook of Pharmaceutical Biotechnology. CBS Publishers & Distributors Pvt. Ltd.
3. Crommelin DJA, Sindelar RD and Meibohm B. (2023). Pharmaceutical Biotechnology: Fundamentals and Applications, 6th Ed. 2024 Edition. Springer.

4. am Ende DJ. (2010). Chemical Engineering in the Pharmaceutical Industry: R&D to Manufacturing. Wiley.
5. Subramanian G. (2012). Biopharmaceutical Production Technology. Wiley-VCH.

BIOT-605	Animal Biotechnology	3(3-0)

Theory

Introduction and history of transgenic animals; role of synthetic peptides/proteins in animal health; use of monoclonal antibodies as a diagnostic/therapeutic agents; cytokines and their potential therapeutic value as applicable to the diagnosis of microbial infections; micromanipulations of farm animal embryos; use of biotechnological techniques in animal breeding strategies; gene transfer through embryo microinjection; ethical and social issues in animal biotechnology.

Recommended Books

1. Capes-Davis A and Freshney RI. (2021). Freshney's Culture of animal cells: A manual of basic technique sand specialized application, 8th Ed. Wiley-Blackwell
2. Freshney RI. (2016). Culture of animal cells: A manual of basic technique and specialized applications, 7th Ed. Wiley-Blackwell.
3. Lanza R, Langer R, Vacanti JP and Atala A. (2020). Principles of tissue engineering, 5th Ed. Academic Press.
4. Tourte Y. (2005). Genetic Engineering and Biotechnology: Concepts, Methods, and Agronomic Applications. CRC Press.
5. Frazier K. (2021). Animal Transgenesis and cloning. ED-Tech Press.

BIOT-607	Virology and Immunology	3(3-0)

Theory

Topics covered in the Immunology section comprise innate and adaptive immunity, including T and B cell development, cell mediated and humoral immunity; receptors and cytokines; inflammatory responses; tolerance and autoimmunity; immunity to intra- and extra-cellular organisms such as bacteria, viruses and macroparasites. Topics covered in the Virology section include: information on structure, replication and classification of eukaryotic viruses; virus-host interactions; epidemiology of virus infections; virus vaccines, antiviral drugs and viral diagnostics.

Recommended Books:

1. Punt J, Stranford S, Jones P and Owen J. (2018). Kuby Immunology, 8th Ed. W. H. Freeman
2. Leslie C, Oxford J and Kellam, P. (2016). Human Virology, 5th Ed. Oxford University Press
3. Hull R. (2013). Plant Virology, 5th Ed. Academic Press.
4. Martin SJ, Burton DR, Roitt IM and Delves PJ. (2017). Roitt's Essential Immunology, 13th Ed. Wiley-Blackwell.
5. Howley PM, Knipe DM and Enquist LW. (2023). Fields Virology: Fundamentals, 7th Ed. LWW.

BIOT-609	Microbial Biotechnology	3(2-2)

Theory
Issues and scope of microbial biotechnology; genetically modified microorganisms; microbes as tools for microbiological research; biotechnological potential of microbes; significance of microorganisms in food production, fermentation, pharmaceutical and other industries; vaccine development and production; microbiological mining, biofuels and use of microbes in petroleum industry; plant-microbe interactions; bio-fertilizers, biopesticides, composting; antimicrobials; significance of microbial biotechnology in the economic development of Pakistan.

Practical
Isolation of microorganisms capable of degrading environmental pollutants (e.g., oil, pesticides, heavy metals). Biodegradation assays: Monitoring growth on contaminated substrates. Isolation of microorganisms capable of producing industrial enzymes (e.g., amylase, cellulase, protease). Enzyme activity assays (colorimetric methods, substrate conversion assays).

Recommended Books

1. Glick BR and Patten CL. (2022). Molecular Biotechnology: Principles and Applications of Recombinant DNA, 6th Ed. ASM Press.
2. Mukhopadhyay SN. (2019). Process Biotechnology Fundamentals, 4th Ed. MV Learning.
3. Yeoman K, Fahnert B, Lea-Smith D and Clarke T. (2021). Microbial Biotechnology. Oxford University Press.
4. Saikia R. (2023). Microbial Biotechnology. Nipa.
5. Długoński J. (2023). Microbial biotechnology in the laboratory and practice: Theory, exercises, and specialist laboratories. Jagiellonian University Press.

BIOT-611	Current Trends in Biotechnology	3(3-0)

Theory
Advanced level course will cover all recent advances in Biotechnology.

Recommended Books

1. Nature and Science series research articles
2. Current Topics, Critical Reviews and other research journals
3. Recent topics on Microbiology Journals and web Sources

BIOT-620	Seminar	1(1-0)

The students will learn skills of scientific communication and presentation and will be graded accordingly.

BIOT-299	Internship/Field Experience	3(0-6)

The students will be attached individually or in groups with relevant industrial/commercial sectors including, but not limited to, hospitals, diagnostic laboratories, pharmaceutical industry, food and beverage industry, cosmetic and nutraceutical industry, forensic laboratory setups etc. Moreover, the students may also join various research centers and institutes.

The internship/field experience duration would not be less than 9 weeks, and the internees would be facilitated, monitored and evaluated as per HEC guidelines.

BIOT-399	Capstone Project	3(0-6)

The students, individually or in groups, will be assigned research topics by their relevant notified supervisors. The research topics would be selected from within the field of biotechnology with special emphasis on topics of current interest with the potential of catering to the academic progress of students.