

Scheme of Studies

FOR

BS Biotechnology

Approved in 4th meeting of Departmental Council, held on 23rd July 2018

(Sessions 2018-22 & onwards)



**DEPARTMENT OF BIOTECHNOLOGY
MIRPUR UNIVERSITY OF SCIENCE AND TECHNOLOGY (MUST)
MIRPUR-10250, AJK.**

Curriculum of BS Program in Biotechnology

The Curriculum of BS 4-year Program in Biotechnology from Session 2013 is prepared in the light of guidelines of HEC, Pakistan. A total of 134 credit hours are required for BS in Biotechnology. A comprehensive oral examination on satisfactory and unsatisfactory basis are compulsory for the award of BS degree in Biotechnology. The details of the curriculum are as follows:

Content		Description						
1	Title of the Degree	Bachelor Studies in Biotechnology (BS in Biotechnology) or as per University Policy						
2	Entrance Requirement	F.Sc (Pre-Medical), Biology Chemistry and Physics or Computer Science.						
		No D-grade in academic career						
2	Entrance Requirement	Entry Test will be conducted by the University with the following breakup: Biology: 35 % English: 10% Physics: 20% Chemistry: 35% Merit will be determined on 20% of SSC, 50% of Intermediate and 30% of Entry Test marks.						
3	Duration of the Program	8-10 Semesters						
4	Credits (Credit Hours)	Course Work : 126 Credits						
		Project/ Special Papers: 06 Credits						
		Seminars: 02 Credits						
		Comprehensive Oral Examination: S/U						
		Total Credits: 134						
5	Evaluation Criteria (Examination)		Theo ry Cour ses	Theory + Practical Courses				
				(3+0)		(2+1)		(1+2)
		Sessional			Thr	Pra	Thr	Pra
			Quizzes	10 %	5 %	-	5 %	
			Assignments	10 %	5 %	8.2 5%	5.25 %	10 %
			Sessional Exam.	30 %	22%	8.2 5%	7.25 %	22 %
		Terminal Exam.	Practical	-	33%		-	
			Terminal Exam	50 %	35%	16. 5%	15.5 %	35 %
6	Requirement for the Award of Degree	As per University Policy						

Scheme of Studies (Structure)

Sr. No.	Category	No. of Courses	Credits
01	Compulsory Courses	09	24
02	General Courses	07	24
03	Foundation Courses	13	39
04	Major Courses	13	35
05	Electives Courses	04	12

Layout/Framework

Category	Course Title	Credits
Compulsory	English-I	3+0
	English-II	3+0
	English-III	3+0
	Pakistan Studies	2+0
	Islamic Studies	2+0
	Biosafety & Bioethics	2+0
	Mathematics-I (Pre-calculus)	3+0
	Biomathematics	3+0
	Introduction to Computer Science	2+1
	Total	24
General Courses	Physical Chemistry	3+0
	Inorganic Chemistry	2+1
	Organic Chemistry	2+1
	Ecology, Biodiversity & Evolution-I	3+0
	Ecology, Biodiversity & Evolution-II	2+1
	Bio-Physics	3+0
	Two social science courses from following list:	
	a. Sociology	3+0
	b. Mass Communication	3+0
	c. Economics	3+0
	d. Marketing	3+0
e. Environmental Policy	3+0	
f. Psychology	3+0	
g. Fine Arts	3+0	
h. Political Science	3+0	
i. International Affairs	3+0	
j. Public Administration	3+0	
k. Arabic (ARA-0001)	3+0	
Total	24	
Foundation Courses	Microbiology	2+1
	Biochemistry-I	2+1
	Biochemistry-II	2+1
	Cell Biology	2+1

	Principles of Genetics	3+0
	Probability & Biostatistics	3+0
	Analytical Chemistry & Instrumentation	2+1
	Molecular Biology	3+0
	Introduction to Biotechnology	3+0
	Introduction to Immunology	3+0
	Methods in Molecular Biology	1+2
	Genetic Resources & Conservation	3+0
	Microbial Biotechnology	2+1
	Total	39
Major Courses	Principles of Biochemical Engineering	2+1
	Agriculture Biotechnology	2+1
	Health Biotechnology	3+0
	Environmental Biotechnology	2+1
	Food Biotechnology	3+0
	Genomics & Proteomics	3+0
	Introduction to Bioinformatics	1+2
	Industrial Biotechnology	2+1
	Research Planning and Scientific Writing	3+0
	Seminar-I	1+0
	Seminar-II	1+0
	Research Project OR Internship OR Special Paper –I (M)	3+0
	Research Project OR Internship OR Special Paper –II(M)	3+0
Total	35	
Elective Courses	Elective – I	3
	Elective – II	3
	Elective – III	3
	Elective – IV	3
	<u>Note</u> These courses will be selected from the list of elective courses.	
	Total	12

Semester-Wise Breakup

YEAR ONE - SEMESTER ONE

Codes	Name of Subject	Credits
ENG-1107	English-I (C)	3+0
ISL-1112	Islamic Studies (C)	2+0
MAT-1115	Mathematics-I (pre-calculus) (C)	3+0
BIOT-1104	Ecology, Biodiversity & Evolution-I (G)	3+0
CHE-1104	Inorganic Chemistry (G)	2+1
BIOT-1106	Cell Biology (F)	2+1
	Total	17

YEAR ONE - SEMESTER TWO

Code	Name of Subject	Credits
ENG-1207	English-II	3+0
PS-1217	Pakistan Studies	2+0
BIOT-1203	Biochemistry-I	2+1
CHE-1204	Organic Chemistry	2+1
BIOT-1205	Ecology, Biodiversity & Evolution-II	2+1
BIOT-1206	Microbiology	2+1
	Total	17

YEAR TWO - SEMESTER THREE

Code	Name of Subject	Credits
ENG-2307	English-III	3+0
COM-2305	Introduction to Computer Science	2+1
BIOT-2303	Introduction to Biotechnology	3+0
PSY-2319	Psychology or Any subject from Social Sciences	3+0
BIOT-2305	Biochemistry-II	2+1
MAT-2315	Biomathematics	3+0
	Total	18

YEAR TWO - SEMESTER FOUR

Code	Name of Subject	Credits
BIOT-2401	Bio-Physics	3+0
STA-2420	Probability & Biostatistics	3+0
ARA-2401	Arabic or Any subject from Social Sciences	3+0
CHE-2404	Physical Chemistry	3+0
BIOT-2405	Principle of Genetics	3+0
BIOT-2406	Molecular Biology	3+0
	Total	18

YEAR THREE - SEMESTER FIVE

Code	Name of Subject	Credits
BIOT-3501	Analytical Chemistry and Instrumentation	2+1
BIOT-3502	Introduction to Immunology	3+0
BIOT-3503	Methods in Molecular Biology	1+2
BIOT-3504	Principles of Biochemical Engineering	2+1
BIOT-3505	Introduction of Bioinformatics	1+2
BIOT-3506	Genetic Resources & Conservation	3+0
	Total	18

YEAR THREE - SEMESTER SIX

Code	Name of Subject	Credits
BIOT-3601	Microbial Biotechnology	2+1
BIOT-3602	Agriculture Biotechnology	3+0
BIOT-3603	Food Biotechnology	3+0
	Elective-I (from list of elective courses)	3
BIOT-3605	Seminar-I	1+0
BIOT-3606	Research Planning and Scientific Writing	3+0
	Total	16

YEAR FOUR - SEMESTER SEVEN

Code	Name of Subject	Credits
BIOT-4701	Health Biotechnology	3+0
BIOT-4702	Environmental Biotechnology	2+1
BIOT-4703	Genomics and Proteomics	3+0
BIOT-4704	Research Project <u>OR</u>	0+6
BIOT-4708	Special Paper – I <u>OR</u>	3+0
BIOT- 4709	Internship	0+6
	Elective-II (from list of elective courses)	3
	Total	15

YEAR FOUR - SEMESTER EIGHT

Code	Name of Subject	Credits
BIOT- 4801	Seminar-II	1+0
BIOT- 4802	Industrial Biotechnology	2+1
BIOT- 4803	Biosafety & Bioethics	2+0
BIOT- 4704	Research Project (continue from 7 th semester) <u>OR</u>	
BIOT- 4709	Internship <u>OR</u>	
BIOT- 4811	Special Paper – II	3+0
	Elective-III (from list of elective courses)	3
	Elective-IV (from list of elective courses)	3
	Total	15

Special Paper-1 BIOT-4708 Molecular Diagnostics

Special Paper-2 BIOT-4811 Recent Trends in Biotechnology

List of Elective Courses

Code	Name of Subject	Credits
BIOT-3604	Introduction to Cell and Tissue Culture	2+1
BIOT-3607	Fungal Biotechnology	3+0
BIOT-3608	Biofuels and Biorefineries	3+0
BIOT-3609	Hospital Waste Management	2+1
BIOT-3610	Fundamentals of Enzymology	2+1
BIOT-4705	Animal Biotechnology	3+0
BIOT-4706	Water and Waste water Treatment	2+1
BIOT-4707	Introduction to Nanobiotechnology	3+0
BIOT-4708	Molecular Diagnostics	3+0
BIOT-4805	Marine Biotechnology	3+0
BIOT-4806	Radiobiology	3+0
BIOT-4807	Pharmaceutical Biotechnology	3+0
BIOT-4808	Biosensor	3+0
BIOT-4809	Fermentation Biotechnology	2+1
BIOT-4810	Introduction to Virology	3+0
BIOT-4811	Recent Trends in Biotechnology	3+0
BIOT-4812	Cellular Signaling	3+0

LIST OF COMPULSORY COURSES

MAT-2315	BIOMATHEMATICS	(3+0)
<p>OBJECTIVES: This course aims to provide students with the essential concepts of biomathematics and how these can be employed for analyzing real data.</p> <p>CONTENTS: <i>Preliminaries:</i> Real-number line, functions and their graphs, solution of equations involving absolute values, inequalities, binomial theorem and its use. <i>Limits and Continuity:</i> Limit of a function, left-hand and right-hand limits, continuity, continuous functions. <i>Derivatives and their Applications:</i> Differentiable functions, differentiation of polynomial, rational and transcendental functions, derivatives. <i>Integration and Definite Integrals:</i> Techniques of evaluating indefinite integrals, integration by substitution, integration by parts, change of variables in indefinite integrals. Application and importance of calculus for biotechnology; the exponential growth curve and growth equation.</p> <p>RECOMMENDED BOOKS:</p> <ol style="list-style-type: none"> 1. Helfgott, M., and D. Moore. 2011. Introductory Calculus for the Natural Sciences. Create Space Independent Publishing Platform, USA. 2. Neuhauser, C. 2010. Calculus for Biology and Medicine. Prentice Hall. 3. Anton, H., et al., 2005. Calculus: A New Horizon. John Wiley, New York. 4. Thomas, G. B. and A. R. Finney. 2005. Calculus. Addison-Wesley, Reading, USA. 5. Kumar, A. 2011. Mathematics for biologist. First Edition; Alpha science international. 		

BIOT- 4803	BIOSAFETY AND BIOETHICS	(2+0)
<p>OBJECTIVES: To acquaint students with principles of biosafety and ethical perspectives pertaining to biotechnology.</p> <p>CONTENTS: Introduction to Biosafety: definition, concept, uses and abuses of genetic information, and biohazards; good laboratory practices; risks related to genetically modified organisms (GMO); international rules and regulations for biosafety and GMOs; introduction to bioethics; ethical issues related to GMOs; euthanasia, reproductive and cloning technologies, transplants and eugenics; patenting, commercialization and benefit sharing; role of national bioethics committees; biosafety guidelines from a national perspective.</p> <p>RECOMMENDED BOOKS:</p> <ol style="list-style-type: none"> 1. Altman, A. and P. M. Hasegawa. 2012. Plant Biotechnology and Agriculture: Prospects for the 21st Century. First Edition; Academic Press. 2. Laboratory Biosafety Manual, WHO, 2006. Third Edition; AITBS Publishers and Distributors, India. (Available online free of cost). 3. Furr, A. K. 2000. CRC Handbook of Laboratory Safety. Fifth Edition; CRC Press. 4. Jose, M. A. 2003. Genes Technology and Policy. Available online at; http://www.apdip.net/publications/iespprimers/eprimer-genes.pdf 5. Krishna, V.S. 2007. Bioethics and Biosafety in Biotechnology. New Age International Publishers. 6. National Biosafety Guidelines. 2005. Pakistan Environmental protection Agency (Available online) 		

LIST OF GENERAL COURSES

BIOT-1104	ECOLOGY, BIODIVERSITY & EVOLUTION – I	(3+0)
<p>COURSE OBJECTIVES: This course aims to introduce students to the fundamentals of ecology, biological diversity and evolution – key areas that are pertinent to modern day biology. The ecology section will emphasize biotic interactions and communities and ecosystems while the evolutionary section will focus on the evidence for evolution and cover the major factors influencing evolutionary change. Where possible, principles of evolution and ecology will be integrated.</p> <p>COURSE LEARNING OUTCOMES: After successful completion of this course, the students gain an appreciation for the diversity of life and how organisms interact with each other and their environment. The student should have gained a basic understanding of how populations function, how communities are structured, and be aware of the central role that evolution plays in biology.</p> <p>CONTENTS: Introduction; ecosystem and ecological pyramids; role of environment on phenotype of organisms; food chain, webs and trophic levels; factors influencing environment; impact of urbanization and industry on environment; population: air, water, land, thermal, radiation and noise; community ecology; atmosphere – composition and cycles; pollution; climate change (greenhouse effect and global warming); ozone layer – composition and state across the globe; waste and sewerage processing and disposal; microbes, plants and animal species; comparative study of life forms; features and characteristics of bacteria, archaea and eukaryotes; 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.</p> <p>RECOMMENED BOOKS:</p> <ol style="list-style-type: none"> 1. Davet, P. 2004. Microbial ecology of soil and plant growth. Science Publishers. 2. Nico, <i>et al.</i>, 2006. An Introduction to Ecological Genomics. First Edition; Oxford University Press. 3. Aston, <i>et al.</i>, 2004. Ecological Genetics: Planning and Application. Blackwell Science (UK). 4. Costa, L.G. and D. L. Eaton. 2006. Gene-Environment Interactions: Fundamentals of Ecogenetics. First Edition; John-Wiley and Son. 5. Freeland, J. R. 2005. Molecular Ecology. First Edition; John-Wiley and Son. 6. Wenz, P. S. 2001. Environmental Ethics Today. Oxford University Press. 7. Louis, P and L. P. Pojman. 2007. Environmental Ethics: Readings in Theory and Application. Fifth Edition; Wadsworth Publishing. 8. Light, A. and H. Rolston. 2002. Environmental Ethics. First Edition; Wiley Blackwell Publishing. 9. Raven, P.H, and L.R. Berg. 2005. Environment. Fifth Edition; John-Wiley and Son. 		

CHE-1204	ORGANIC CHEMISTRY	(2+1)
<p>COURSE OBJECTIVES: The objectives of the course are to develop understanding about basic concepts of organic chemistry and organic molecules. To understand structural and chemical properties of organic molecules. To get familiar with preparation, chemical transformation and reaction mechanism of major organic molecules.</p> <p>COURSE LEARNING OUTCOMES: This course will help students to learn about basic concept of resonance, hybridization and hyperconjugation. Students will able to learn about preparation, chemical reactions and their</p>		

mechanism of alkane, alkene, alcohols, phenols and ethers. Students will be able to understand about preparation and reactions of aldehydes, ketones and carboxylic acids.

CONTENTS:

Basic Concepts of Organic Chemistry: Bonding and hybridization, localized and delocalized bonding, dipole moment, resonance and its rules, hyperconjugation, classification and nomenclature of organic compounds including IUPAC system, types of organic reactions (an overview).

Chemistry of Hydrocarbons: Saturated and unsaturated hydrocarbons with emphasis on free radical, electrophilic addition and electrophilic substitution reactions.

Chemistry of Functional Groups: Preparation and properties of alcohols, phenols and ethers with focus on reaction mechanism. Preparations and reaction mechanism of aldehydes, ketones and carboxylic acids. Acidity of carboxylic acids and effect of substituents on their acidity. Preparation and reactions of esters and amides.

PRACTICALS:

- i- Lab safety and ethics
- ii- Determination of melting point of given organic solid
- iii- Determination of boiling point of given organic liquid
- iv- Study of purification of liquids by distillation from mixture
- v- Isolation of liquids by solvent extraction technique
- vi- Purification of compounds by crystallization
- vii- Qualitative analysis for the identification of carbohydrates
- viii- Qualitative analysis for the identification of alcohols
- ix- Qualitative analysis for the identification of hydrocarbons
- x- Qualitative analysis for the identification of lipids
- xi- Qualitative analysis for the identification of aldehydes
- xii- Qualitative analysis for the identification of ketones
- xiii- Preparation of iodoform in laboratory
- xiv- Preparation of aspirin in laboratory
- xv- Preparation of acetanilide in laboratory

RECOMMENDED BOOKS:

1. Bansal.R.K, "A Text book of Organic Chemistry" Wiley Eastern Ltd; Second Edition (1990).
2. Carrey.F.A, "Organic Chemistry" The McGraw-Hill Companies, Inc; Fourth Edition (2000).
3. March.J, "Advanced Organic Chemistry Reactions, Mechanisms and Structure" John Wiley & Sons (latest edition available).
4. McMurry.J, "Organic Chemistry" Thomson Asia Ltd; Singapore, Fifth Edition (2000).
5. Morrison.R.T, Boyd.R.N; "Organic Chemistry"Prentice-Hall, Inc; Sixth Edition (1992).
6. Pine.S.H, Hendrickson.J.B Hammond.G.S, "Organic Chemistry"McGraw-Hill, Inc; Fourth Sons.Inc; Fourth Edition (1992).
7. A Text Book of Organic Chemistry by Muhammad Younas, Ilmi Lhitab Khana, Urdu Bazar Lahore

CHE-1104

INORGANIC CHEMISTRY

(2+1)

COURSE OBJECTIVES:

This course is intended for students studying to develop an understanding about basic concepts and theories of acids and bases. To learn about pH of acids and bases with its significance. To make the students familiar with Theories of chemical bonding with applications. Learn about halogens and their derivatives and oxides of sulphur.

COURSE LEARNING OUTCOMES:

Students will be able to learn about acids, bases, concept of pH, P_{Ka} , P_{Kb} and common ion effect. Students will be able to study molecular structure of inorganic compounds as explained by VSEPR, VBT and MO Theory. Student will explain the preparation and uses of oxyacids of halogens and oxides of sulphur.

COURSE CONTENTS:

Acids and Bases: Concepts of acids and bases (Arrhenius, Lowry-Bronsted, Lewis and SHAB concept), relative strength of acids and bases. pH, pK_a , pK_b and buffer solutions and their significance. Concept of Solubility product, common ion effect and their applications.

Theories of Covalent Bonding (Structure of Molecules): A brief history of concept of chemical bond. Nature and types of chemical bonding, Lewis concepts, ionic, covalent bond. VSEPR model followed by VBT theory (Hybridization and Resonance concept) to explain the structure of molecules of various types. Molecular orbital (MOT) approach as applied to homodiatomic and heterodiatomic molecules. Bonding in electron deficient compounds. Theories of metal bonds, conductors, semi-conductors and insulators and their applications.

The Halogens: Gradation of the characteristic properties within the group, anomalous behaviour of fluorine. Preparation of oxyacids of halogens (HClO₃ and HClO₄) and their uses.

Oxides of Sulphur: Oxides of Sulphur, Preparations and Chemical reactions.

PRACTICALS:

1. Laboratory Ethics and safety measures

Awareness about the toxic nature of chemicals and their handling, cleaning of glassware, safe

2. Qualitative analysis (Six experiments)

Analysis of four ions (two anions and two cations) from mixture of salts

3. Quantitative analysis (Six experiments)

a. Acid-Base Titrations (minimum 02)

b. Redox Titrations (minimum 02)

c. Complexometric Titrations (minimum 02)

RECOMMENDED BOOKS:

1. Cotton, F.A. and Wilkinson G., "Advanced Inorganic Chemistry", 5th Ed, John Wiley & Sons, New

2. York, 1988. James Huheey, E., "Inorganic Chemistry, Principles of Structure and Reactivity", 3rd.

Ed., Cambridge, Harper International, London, 1983.

3. Basolo, F. and Johnson, R., "Coordination Chemistry", W.A. Benjamin, Inc., 1964.

4. Zafar Iqbal M., "Pi-Acceptor Ligands", UGC Islamabad, 1982.

5. Kent Murmann R., "Inorganic complex compounds", Reinhold publishing corporation, New York, 1964.

6. Kamlesh Bansal, "Coordination Chemistry", Campus Books International, New Dehli, 2003.

BIOT-1205

ECOLOGY, BIODIVERSITY & EVOLUTION – II

3(2+1)

OBJECTIVES:

This course is a continuation of Ecology, Biodiversity & Evolution – I and offers advanced concepts in these areas. We will focus on the interaction between humans, animals and plants and how domestication has given rise to the society we see today. An understanding of evolutionary processes, using domestication as a model system, will be investigated. This will be followed by looking at the importance of biodiversity for mediating ecosystem level processes and how this relationship may be impacted by environmental context. Finally, we will discuss how evolution affects the ecology of invasive species, and how invasions affect evolution.

COURSE LEARNING OUTCOME:

Having successfully completed this course student will be able to:

- appreciate the extent of overlap between ecology and evolution
- understand the importance of biodiversity for mediating ecosystem level processes and the relationship may be impacted by environmental context
- develop the interaction between humans, animals and plants and domestication has given rise to the society we see today
- explain how species co-evolve depending on the nature of their interactions
- explain how evolution affects the ecology of invasive species

CONTENTS:

Introduction to animal kingdom: features of protists, protozoa, annelids, arthropods, myriapods, echinoderms, chordates, amphibians, reptiles and birds. Plant biodiversity – history, importance, usefulness and evolution; importance of plants, their conservation and domestication; improvement

of crops; impact of environment on loss of genetic diversity and speciation; *in situ* and *ex situ* conservation; evolution of microbes, plants and animals; origin of life; methods of studying evolution; construction of phylogenetic trees on basis of morphology and molecular markers; environmental ethics.

PRACTICALS:

- i. Shape and structure of different classes of microbes, plants and animals by light microscopy
- ii. Study of Euglena, Amoeba, Entamoeba, Plasmodium and Paramecium (from slides);
- iii. Study of Sponges and their various body forms; cnidarian;
- iv. Study of Platyhelminthes; nematodes; molluscs;
- v. Annelids; Pisces; amphibians;
- vi. Study of reptilian; aves; Mammalia;
- vii. Pond freshwater ecosystem;
- viii. Terrestrial Plant Community Assessment and vegetation profile; grassland, rangeland and forest;
- ix. Biotic and abiotic factors of grassland, rangeland
- x. Sampling a Plant Community
- xi. Sampling Animal Communities
- xii. Aquatic ecosystem including methods of sampling;
- xiii. Analysis of plant communities by different methods
- xiv. Micro Community Assessment
- xv. Decomposition of leaf litter by organisms.

RECOMMENDED BOOKS:

1. Davet, P. 2004. Microbial ecology of soil and plant growth. Science Publishers.
2. Nico, *et al.*, 2006. An Introduction to Ecological Genomics. First Edition; Oxford University Press.
3. Aston, *et al.*, 2004. Ecological Genetics: Planning and Application. Blackwell Science (UK).
4. Costa, L.G. and Eaton, D. L. 2006. Gene-Environment Interactions: Fundamentals of Ecogenetics. First Edition; John-Wiley and Son.
5. Freeland, J.R. 2005. Molecular Ecology. First Edition; John-Wiley and Son.
6. Wenz, P. S. 2001. Environmental Ethics Today. Oxford University Press.
7. Louis, P., and Pojman, L. P. 2007. Environmental Ethics: Readings in Theory and Application. Fifth Edition; Wadsworth Publishing.
8. Light, A. and Rolston, H. 2002. Environmental Ethics. First Edition; Wiley Blackwell Publishing.
9. Raven, P.H., and Berg, L.R. 2005. Environment. Fifth Edition; John-Wiley and Son.

BIOT-2401	BIOPHYSICS	(3+0)
<p>COURSE OBJECTIVES: To acquaint students that how physical principles guide biological processes and the behavior of biological cells and organisms. To introduce students with biophysical methods.</p> <p>COURSE LEARNING OUTCOMES: At the end of this course student will be able to understand the guiding principles of physics in living organisms.</p> <p>CONTENTS: Introduction, scope and application of Biophysics; Essentials of thermodynamics, biological thermodynamics; concept of entropy, enthalpy and Gibb's free energy; order and disorder in biological systems; Validity of 1st and 2nd law of thermodynamics to living systems; diffusion, random walks and friction; methods of studying macromolecules; interactions of molecules in 3-D space – determining binding and dissociation constants; molecular motors; sedimentation; Reynold's number; physics of ion channels.</p> <p>RECOMMENDED BOOKS:</p>		

1. Nelson, P. 2004. Biological Physics, Energy, Information and Life. First Edition; WH Freeman & Company.
2. Kirsten, *et al.*, 2010. Introduction to Biological Physics for the Health and Life Sciences. Second Edition; John Wiley & Sons.
3. Davidovits, P. 2013. Physics for Biology & Medicine. Fourth Edition; Academic Press.
4. Newman. 2008. Physics of the Life Sciences. Springer.
5. Duncan. 1975. Physics for Biologist. Blackwell Science.

CHE-2404	PHYSICAL CHEMISTRY	(3+0)
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OBJECTIVES:

This course is intended for students studying to introduce the students to the laws of Thermodynamics,

CONTENTS:

Gases: Equation of states, ideal and real gases, the real gas equation and the van der Waals equation for real gases, critical phenomena and critical constants,

Chemical Thermodynamics: Introduction, thermodynamic terms like system, surrounding, boundary, state and state function, internal energy, enthalpy of a system, laws of thermodynamics and their applications, thermochemistry, calorimetry, heat capacities and their dependence on temperature, pressure and volume, reversible and nonreversible processes, spontaneous and non-spontaneous processes, relations of entropy and Gibbs free energy with equilibrium constant,

Chemical Equilibrium: General equilibrium expressions, reaction quotients, examples of equilibrium reactions in solid, liquid and gas phases, extent of reactions and equilibrium constants, Gibbs energies of formation and calculations of equilibrium constants, effect of temperature and pressure on the equilibrium constants/compositions, van't Hoff equation, Le-Chatelier's principle.

Solution Chemistry: Physical properties of liquids, surface tension, viscosity, refractive index, dipole moment etc. and their applications, brief account of interactions among the molecules in liquids, ideal and non-ideal solutions, Raoult's law and its applications, lowering of vapor pressure, elevation of boiling point, depression of freezing point, osmotic pressure, vapor pressure of non-ideal solutions and Henry's law, abnormal colligative properties, degrees of association and dissociation of solutes, osmotic pressure and its measurement, fractional distillation and concept of azeotropic mixtures.

Chemical Kinetics: The rates of reactions, zero, first, second and third order reactions with same and different initial concentrations, half-lives of reactions, experimental techniques for rate determination and methods for determination of order of reaction (integration, half-life, initial rate, and graphical methods), Arrhenius equation.

RECOMMENDED BOOKS:

1. Alberty, R.A and Silbey, R.J., "Physical Chemistry" John Wiley, New York, 1995

2. Atkins, P.W, "Physical Chemistry" 5th Ed., W.H. Freeman & Company, New York, 1994.
3. Barrow, G. M. "Physical chemistry" McGraw Hill, Singapore, 1988.
4. Klotz, I.M, "Chemical Thermodynamics" 3rd Ed., W.A. Benjamin Inc., California, 1972.
5. Pitzer, K.S, "Thermodynamics" 3rd Ed., McGraw-Hill, New York, 1995.
6. Latham, J.L. & Burgess, A.E, "Elementary Reaction Kinetics" 3rd Ed., Butterworths, London, 1977.

LIST OF DISCIPLINE-SPECIFIC FOUNDATION COURSES

BIOT-1106	CELL BIOLOGY	3(2+1)
<p>OBJECTIVES:</p> <p>To acquaint students with features of eukaryotic cells, composition and functions of different compartments at ultra-structural level as visualized by electron microscopy. Practically students will be able to observe cell structures using light microscope. Various staining techniques will be used to observe cell components. To perform and visualize the phenomenon of mitosis and meiosis in eukaryotic cells.</p>		
<p>COURSE LEARNING OUTCOMES:</p> <p>Upon completion of this course, the students will be able to:</p> <ol style="list-style-type: none"> i. Describe the fundamental principles of cellular biology ii. Apply these principals to current cell biological questions. iii. Develop a deeper understanding of cell structure and how it relates to cell functions. iv. Understand the phenomenon of cell movement. v. Understand the regulation of processes of cellular growth, division and death. vi. Understand cell signaling and its regulation of cellular functions. vii. Gain the knowledge and skills to interpret, analyze and present scientific data. viii. Develop and apply scientific thought to design experimental skills. 		
<p>CONTENTS:</p> <p>Introduction to cell theory including historical perspective. Techniques to study cell structure and function; microscopy and cell fractionation. Eukaryotic cell biology; membrane structure, composition, functions, membrane receptors and transport mechanisms. The structure of nucleus and its composition. Mitochondria; ultra-structure and mechanism of energy production. Types of plastids and their functions, Ultra-structure of Chloroplast and the mechanism of photosynthesis. Functions, isolation and molecular organization of Endoplasmic reticulum, Golgi apparatus, Lysosome, Microbodies, Ribosomes and Vacuoles. The cytoskeleton and cell movement. Structure and function of centriole, cilia and flagella. Composition and structure of extra cellular components; cell wall, plasmodesmata, cellular junctions. Cell cycle; cell divisions mitosis and meiosis.</p>		
<p>PRACTICALS:</p> <ol style="list-style-type: none"> i. Introduction to Biotechnology laboratory and orientation of biosafety measures. ii. Construction and maintenance of Light microscope. iii. Study of prokaryotic and eukaryotic cells (animal and plant) structures and electron micrographs of plant and animal cell organelles. iv. Preparation of stained mounts of animal (human cheek cells and blood smears) and plant cells. v. Cell fractionation and centrifugation in order to isolate cell components. vi. Observation of cytoplasmic streaming in <i>Tradescantia</i> filament and spinach leaf. vii. Cytochemical staining of biomolecules such as carbohydrates, proteins, lipids, nucleic acid and secondary products of plant cells. viii. Study of plasmolysis and de-plasmolysis of plant cell. 		

- ix. Isolation of plastids from spinach leaf (chloroplast), flower petal, tomato (chromoplast), potato tubers (amyloplast), cotyledons of bean (proteinoplasts) seeds.
- x. Identification of Barr body in the human cells
- xi. Isolation and observation of actin and myosin filaments
- xii. Micrometry of plant and animal cells.
- xiii. Cell counting by using hemocytometer.
- xiv. Mitosis and cell cycle in onion/ bean root tips.
- xv. Meiotic cell division in anthers of *Tradescantia*/ testis of grasshopper.

RECOMMENDED BOOKS:

1. Campbell, N. A. and Reece, J. B. 2007. Biology. 8th edition. Benjamin Cummings. New York.
2. Clark, D. P. and Pazdernik. 2016. Biotechnology. 2nd Ed. Elsevier Inc. London
3. Alberts B and Johnson A, 2006. Molecular Biology of the Cell. Fourth Edition; Garland Publishers, New York. (available at www.ncbi.nlm.nih.gov)
3. Alberts et al., 2009. Essential Cell Biology. Third Edition; Garland Publishers, New York.
4. Lodish et al., 2007. Molecular Cell Biology. Sixth Edition; Freeman and Company, New York. (available at www.ncbi.nlm.nih.gov)
5. Cooper GM and Hausman RE, 2009. The Cell, a molecular approach. Fifth Edition; Sinauer Associates, Inc.

BIOT-1203

BIOCHEMISTRY-I

(2+1)

COURSE OBJECTIVES:

This course aims to provide students with fundamental knowledge of the molecules of life, as well as their function in the context of a living cell.

COURSE LEARNING OUTCOMES:

Upon completion of the course, the student should achieve an understanding of the special properties of water; structure of fundamental monosaccharides and polysaccharides; structure of different classes of lipids and their roles in biological system; the structures and classification of amino acids, their chemical properties and their organization into polypeptides and proteins; the basic elements of protein structure; protein function and classification; enzymes and how they catalyze reactions as well as enzyme kinetics; structure and basic function of nucleotides and nucleic acid.

CONTENTS:

Introduction to biochemistry; water, pH, buffers, and biochemical composition of cells; carbohydrates – stereoisomers, structure and classification; lipids - structure, classification and biological significance; proteins - overview with emphasis on their composition and structure, classification and function, amino acids structure and classification, enzymes - properties, nomenclature, classification, and factors affecting enzyme activity including inhibitors and potentiators, basic kinetics, Michaelis and Menten Kinetics, derivation of K_m and V_{max} ; coenzymes and vitamins; nucleic acids – (DNA, RNA) structure and function.

PRACTICALS:

Preparation of laboratory solutions (Molar, Molal and Normal)

Measure pH of tap water and distilled water using pH paper and pH meter; Preparation of buffers of known pH, qualitative and quantitative tests for carbohydrates, proteins and lipids; enzyme extraction, enzyme assays and the effect of pH, temperature and substrate concentration on amylase enzyme activity.

RECOMMENDED BOOKS:

1. Nelson, D. L. and M. M. Cox. 2012. Lehninger Principles of Biochemistry. Sixth Edition; WH Freeman, New York. (available at www.ncbi.nlm.nih.gov)

2. Stryer, *et al.* 2006. Biochemistry. Sixth Edition; WH Freeman, New York. (available at www.ncbi.nlm.nih.gov)
3. Voet, D. and T. G. Voet. 2008. Biochemistry. Fourth Edition; John Wiley and Sons, New York.
4. Murray, *et al.*, 2012. Harper's Illustrated Biochemistry. 29th Edition; McGraw-Hill Medical Publishing.
5. Ferrier, D. R. 2013. Lippincott's Biochemistry. Sixth Edition; Lippincott Williams & Wilkin Publishing Company.
6. Schantz, J.T. 2007. A Manual for Biochemistry Protocols. World Scientific Publishing. (*available online*).
7. Nigam and Ayyagari. Lab Manual in Biochemistry, Immunology and Biotechnology. Tata McGraw Hill

BIOT-1206	MICROBIOLOGY	(2+1)
<p>OBJECTIVES: This course aims to familiarize students with fundamentals of prokaryotic and eukaryotic microbial life including viruses.</p> <p>CONTENTS: Overview and history of microbiology including microbial diversity (Archaea, bacteria, fungi, algae, protozoa), nutrition, growth, metabolism; cultivation; viruses; control of microorganisms: sterilization and disinfection, antimicrobial agents, antibiotics, antibiotic resistance and susceptibility, antifungal and antiviral agents; cell death; symbiosis, carbon, nitrogen, sulfur and phosphorus cycles; microbiology of soil, freshwater and seawater.</p> <p>PRACTICALS: Sterilization techniques; culturing of bacteria in liquid and on solid medium; Gram-staining of bacteria; colony and cell morphology; bacterial cell count and growth curves; biochemical tests.</p> <p>RECOMMENDED BOOKS:</p> <ol style="list-style-type: none"> 1. Alcamo, I. E. 2010. Fundamentals of Microbiology. Ninth Edition, Jones and Bartlett Publishers. 2. Madigan, M. T. and J. Martinko. 2010. Brock Biology of Microorganisms. 13th Edition; Pearson College Div. 3. Talaro, K. P. 2009. Foundations in Microbiology: Basic Principles. Seventh Edition; McGraw Hill Publisher. 4. Black, J. G. 2007. Microbiology: principles and explorations. Seventh Edition; John Wiley and Sons. 5. Baker <i>et al.</i>, 2006. Instant Notes in Microbiology. Third Edition; Taylor and Francis. 6. Prescott <i>et al.</i>, 2005. Microbiology. Sixth Edition; McGraw-Hill Medical Publishing. 7. Cappuccino, J. G. and N. Sherman. 2013. Microbiology: a laboratory manual. Tenth Edition; Pearson Education. 		

BIOT-2303	INTRODUCTION TO BIOTECHNOLOGY	(3+0)
<p>OBJECTIVES: To acquaint students with the basic concepts and significance of biotechnology as it stands today.</p> <p>CONTENTS: 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</p>		

biotechnology; public perception of biotechnology; biotechnology and ethics; biotechnology and the developing world

RECOMMENDED BOOKS:

1. Daugherty, E. 2012. Biotechnology: Science for the New Millennium. First Edition, Revised; Paradigm Publication.
2. Smith, J. E. 2009. Biotechnology. Fifth Edition; Cambridge University Press.
3. Nicholl, T. S. D. 2004. An Introduction to Genetic Engineering. Second Edition; Cambridge University Press, UK.
4. Purohit, S. S. 2005. Biotechnology Fundamentals & Application. Fourth Edition; Agro Bios, India.
5. Ratlegde, C. and B. Kristiansen. 2006. Basic Biotechnology. Second Edition; Cambridge University Press, UK.
6. Thomas, J. A. and R. L. Fuchs. 2002. Biotechnology and Safety Assessment. Third Edition; Academic Press, UK.

BIOT-2305

BIOCHEMISTRY-II

(2+1)

COURSE OBJECTIVES:

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

COURSE LEARNING OUTCOMES:

At successful completion of this course students will be able to understand basic energy metabolism of cells; students will have detail insight into various anabolic and catabolic pathways involved in the metabolism of carbohydrate, lipids, protein and nucleic acids.

CONTENTS:

Introduction to metabolism and basic aspects of bioenergetics and biochemical thermodynamics (endergonic and exergonic reactions); metabolism, oxidation-reduction; carbohydrate metabolism and regulation (glycolysis, **glycogenesis**, glycogenolysis; gluconeogenesis; pentose phosphate pathway); citric acid cycle (reactions, energetics and control), electron transport chain, oxidative and **substrate level** phosphorylation, shuttle mechanisms (**Malate shuttle**, glycerol-phosphate shunt), lipid metabolism (simple and compound lipids, Beta oxidation of fatty acids, ketogenesis, ketolysis, glycerol metabolism, cholesterol metabolism); photosynthesis; Calvin Cycle; metabolism of nitrogenous compounds (amino acid biosynthesis, **transamination catabolic end product of standard amino acids**), purine and pyrimidine synthesis); nucleic acid metabolism and control; urea cycle.

PRACTICALS:

1. Preparation of stock and working solutions
2. Extraction of starch from potatoes,
3. Iodine test for polysaccharides.
4. Hydrolysis of starch by salivary amylase
5. Fermentation of sugars by Baker's yeast and Fractional distillation
6. Extraction of glycogen from liver
7. Acidic and enzymatic hydrolysis of glycogen (DNS method);
8. Isolation of Caesin from Milk
9. Extraction and estimation of lipids from plant tissue/seed and
10. Extraction of lipid from egg yolk.
11. Fractionation by thin layer chromatography (TLC).

RECOMMENDED BOOKS:

1. Nelson, D.L. and M.M. Cox. 2012. Lehninger Principles of Biochemistry. Sixth Edition; WH Freeman, New York. (available at www.ncbi.nlm.nih.gov)
2. Stryer, *et al.*, 2006. Biochemistry. Sixth Edition; WH Freeman, New York. (available at www.ncbi.nlm.nih.gov)
3. Voet, D. and T. G. Voet. 2008. Biochemistry. Fourth Edition; John Wiley and Sons, NY.
4. Murray, *et al.*, 2012. Harper's Illustrated Biochemistry. 29th Edition; McGraw-Hill Medical Publishing.
5. Ferrier, D. R. 2013. Lippincott's Biochemistry. Sixth Edition; Lippincott Williams & Wilkin Publishing Company.
6. Kumar *et al.*, 2015. Biochemical Tests Principles and protocols. Viva books

STA-2420**PROBABILITY AND BIostatISTICS****(3+0)****OBJECTIVES:**

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

CONTENTS:

Frequency distribution, exercise frequency distribution, measures of central tendency, measures of dispersion and measures of location. Second part of the study will cover the areas of statistical hypothesis and significance, null and alternative hypothesis, confidence interval, tests involving binomial distribution, tests involving normal distribution, F-distribution, student's t-distribution, chi-square test, tests of independence and contingency tables. In the third part lectures will cover the following topics: Analysis of Variance (ANOVA), LSD test, experimental designs, Completely Randomized Design (CRD), Randomized Complete Block Design (RCBD), Latin Square Design, Markov chains and Models and their applications in Bioinformatics such as gene predication, sequence analysis, profile HMMs, probabilistic approaches to phylogeny, etc.

RECOMMENDED BOOKS:

1. Mann, P.S. 2010. Introductory Statistics. Seventh Edition; John Wiley and Sons.
2. Freund, J. E. and M. B. Perles. 2005. Modern Elementary Statistics; 12th Edition. Pearson.
3. Chaudhry, S. M. 2005. Introduction to statistical theory. Sixth Edition; Markazi Kutub Khana, Lahore.
4. Chernick, M. R. and R. H. Friis. 2003. Introductory Biostatistics for the Health Sciences: Modern Applications Including Bootstrap. First Edition; Wiley Interscience.
5. Le, C. T. 2003. Introductory Biostatistics. First Edition; Wiley Interscience.

BIOT-2405**PRINCIPLES OF GENETICS****(3+0)****OBJECTIVES:**

To acquaint students with classical aspects of genetics.

CONTENTS:

Classical Mendelian genetics; monohybrid crosses, dominance, recessiveness, codominance, and semidominance; 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, D. P. and M. J. Simmons. 2008. Principals of Genetics. Fifth Edition; John Willy & Son, New York.
2. Klug, W. S. and M. R. Cumming. 2008. Concepts of Genetics. Ninth Edition; Prentice Hall, USA.
3. Pierce, B. 2004. Genetics: A Conceptual Approach. Second Edition; WH Freeman, New York.
4. Brooker, R. 2011. Genetics: Analysis and Principles. Fourth Edition; McGraw-Hill.
5. Pierce, B. A. 2011. Genetics: A conceptual approach. Fourth Edition. WH Freeman Publisher.

BIOT-2406	MOLECULAR BIOLOGY	(3+0)
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OBJECTIVES:

To acquaint students with the chemistry and biology of macromolecules.

CONTENTS:

Introduction to molecular biology and history; structure and function of DNA; chromatin and structure of chromosomes; protein structure and function; DNA replication in prokaryotes and eukaryotes; transcription in prokaryotes and eukaryotes; post transcriptional processing (e.g., RNA splicing, alternative splicing, editing); genetic code; translation, post-translational processing in prokaryotes and eukaryotes; protein folding, targeting and turnover; DNA damage and repair, recombination and transposable elements. Signaling and control of gene regulation in prokaryotes and eukaryotes.

RECOMMENDED BOOKS:

1. Nelson, D. and M. M. Cox. 2009. Lehninger Principles of Biochemistry. Fifth Edition; WH Freeman, New York.
2. Lodish, et al., 2012. Molecular Cell Biology. Seventh Edition; WH Freeman, New York
3. Berg, et al., 2006. Biochemistry. Sixth Edition; WH Freeman, New York.
4. Alberts et al., 2007. Molecular Biology of The Cell. Fifth Edition; Garland Science
5. Weaver, R. 2011. Molecular Biology. Fifth Edition; McGraw-Hill

BIOT-3501	ANALYTICAL CHEMISTRY AND INSTRUMENTATION	(2+1)
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OBJECTIVES:

To acquaint students with key analytical chemistry concepts involving identification and analysis at the molecular level by introducing a variety of analytical chemistry techniques and their applications at the molecular level; designing analytical chemistry methods to obtain analysis data with the high precision and accuracy from experiments; demonstrating biochemical laboratory techniques and explaining the theory and background behind these techniques.

CONTENTS:

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.

PRACTICALS:

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;

RECOMMENDED BOOKS:

1. Boyer, R. F. 2011. Biochemistry Laboratory: Modern Theory and Techniques. Second Edition; Prentice Hall
2. Wilson, K. 2010. Principles and Techniques of Biochemistry and Molecular Biology. Seventh Edition; Cambridge University Press.
3. Christian, G.D. 2003. Analytical Chemistry. Sixth Edition, John Wiley and Sons, New York.
4. Chung, *et al.*, 2005. Analytical Methods validation and Instrument Performance verification. First Edition; John Wiley and Sons, New York.
5. Sharma, B. K. 2005. Instrumental Method of Chemical analysis. First Edition; Meerut Goel Publishing House, India.
6. Harris, D. C. 2010. Quantitative Chemical analysis. Eighth Edition; WH Freeman, New York

BIOT-3502	INTRODUCTION TO IMMUNOLOGY	(3+0)
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OBJECTIVES:

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

CONTENTS:

Overview of the immune system as the body's main defense mechanism; elements of innate and acquired immunity; cells and organs of the immune system; properties of antibodies and antigens together with their structure, function and interactions; genetics of antibody structure and diversity; expression of immunoglobulin genes; VDJ recombination; antigen processing and presentation; major histocompatibility complex; monoclonal and polyclonal antibodies; T-cell receptors, maturation, activation, and differentiation; B-cell generation, activation, and differentiation; complement system, hypersensitivity, cytokines, resistance and immune response to infectious diseases, cell-mediated effector response, leukocyte migration and inflammation, vaccines, diseases of the immune system - autoimmunity, transplantation immunology.

RECOMMENDED BOOKS:

1. Kuby, J. 2007. Immunology. Sixth Edition; WH Freeman, New York.
2. Janeway, *et al.*, 2001. Immunobiology - The immune system in health and disease. Fifth Edition; Garland Science Publisher, New York.
3. Anderson, W. L. 1999. Immunology. First Edition; Wiley-Blackwell.
4. Delves, P. J., *et al.*, 2012. Roitt's Essential Immunology. 12th Edition. Wiley-Blackwell
5. Abbas, A.K. and A. H. Lichtman. 2010. Basic Immunology: Functions and Disorders of the Immune System. Third illustrated Edition; Saunders Publisher.
6. Harlow, E. and L. David. 1988. Antibodies, A laboratory Manual. First Edition; Cold Spring Harbor laboratory Press.

BIOT-3503	METHODS IN MOLECULAR BIOLOGY	(1+2)
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COURSE OBJECTIVES:

The main objective of the course is to teach the students about techniques and tools used in modern biotechnology/ genetic engineering. A sound background knowledge about the genetic/ enzymatic tools used in basic and applied biotechnology for manipulation and analysis of genetic material.

COURSE LEARNING OUTCOMES:

After completion of the course student will be able to prepare different stock and working solutions used in variety of experiments. Course will provide hands on training to prepare genomic DNA from variety of organisms. Student will also be able to perform polymerase chain reaction for amplification of gene of interest and its subsequent cloning into cloning/ expression vectors. After successful completion of the course student will also be able to use analytical techniques for quantification of micro and macro molecules, electrophoretic analysis of DNA and proteins.

CONTENTS:

Introduction to recombinant DNA technology; restriction and modifying enzymes; cloning and expression vectors and their types; expression of recombinant proteins and their purification by affinity chromatography; polymerase chain reaction (PCR) - types; (inverse, touch-down, nested, hemi-nested, pit stop, multiplex, reverse transcriptase, RACE, real-time) and its applications; detection of mutations and/or SNPs; DNA fingerprinting; analysis of nucleic acids by gel electrophoresis – horizontal, vertical, pulse field, denaturing gradient gel electrophoresis; analysis of proteins by native and SDS-PAGE; enzyme-linked immunosorbant assay; Southern, Western, Northern blotting.

PRACTICALS:

1. Preparation of stock and working solutions
2. Isolation of DNA from Bacteria
3. Isolation of DNA from human blood
4. Isolation of DNA from plant tissue
5. Quantitative analysis of DNA by spectrophotometer
6. Quantitative analysis of DNA by agarose gel electrophoresis
7. Isolation of plasmid DNA
8. Gene amplification by PCR
9. TA cloning by T4 DNA ligase

10. Competent cell preparation (*Escherichia coli* DH5 α / BL-21)
11. Bacterial transformation with plasmid
12. Blue/ white colony screening
13. Restriction enzyme digestion
14. Protein analysis by SDS-PAGE

RECOMMENDED BOOKS:

1. B. R. Glick, et al. Molecular Biotechnology: Principles & Applications of Recombinant DNA (ASM Press, ed. 4,2009).
2. Brown, T. A. 2013. Gene Cloning & DNA Analysis, an introduction. Sixth Edition; John Wiley & Sons.
3. Ausubel, F. M. 2005. Short Protocols in Molecular Biology (2 volume set). Fifth Edition; John Wiley and Son.
4. Green, M. R. and J. Sambrook. 2001. Molecular Cloning: A Laboratory Manual. Third Edition; Cold Spring Harbor Laboratory Press.
5. Primrose, S. B. and R. Twyman. 2006. Principles of Gene Manipulation and Genomics. Seventh Edition; Wiley- Blackwell.
6. Wilson, K. and J. Walker. 2010. Principles and Techniques of Biochemistry and Molecular Biology. Seventh Edition; Cambridge University Press.
7. Walker, J. M. and Rapley. 2008. Molecular Biomethods Handbook (Methods in Molecular Biology). Second Edition; Humana Press.

BIOT-3504	PRINCIPLES OF BIOCHEMICAL ENGINEERING	(2+1)
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COURSE OBJECTIVES:

To acquaint students with fundamentals of biological molecules and principles of enzymes catalysis. To get basics of methods of enzymes and cell immobilization, enzyme kinetics and bioreactors. To learn about genetic engineering of living organisms for industrial production.

COURSE LEARNING OUTCOMES:

After learning this course the students will be able to learn about the basics biological molecules, enzyme catalysis, enzyme kinetics and immobilization. Students will be able to know about different types of bioreactors and their functioning. Will also be able to learn the industrial applications f enzymes, gene cloning and biosensors. Students will also practically performs media preparation, its sterilization, microbial cell culturing and utilize microbes under controlled conditions for industrial enzymes production in bioreactor.

CONTENTS:

Introduction to microorganisms and biological molecules; Principles of enzyme catalysis; methods of enzyme and cell immobilization; Enzyme kinetics; Stoichiometry models of microbial growth; Bioreactors - continuous stirred tank bioreactors, plug-flow and packed bed bioreactors, fed batch bioreactors, Industrial applications of enzymes, Sterilization, Introduction to bioproduct recovery and biological product manufacturing, Genetic engineering; Cloning of gene, stability of recombinant microorganisms, Biosensors

PRACTICALS:

- i- Microbial growth with application of Monod model;
- ii- Study of nutrient uptake rate by microbes
- iii- Study of Methods of cells immobilization
- iv- Study of Methods of enzymes immobilization
- v- Design and analysis of batch bioreactor
- vi- Design and analysis of Stir Tank Bioreactor
- vii- Preparation and sterilization of media for microbial growth
- viii- Growth of microbes on media from environment
- ix- Preparation of microbial inoculum
- x- Solid state fermentation for the production of enzymes (cellulases, amylases)
- xi- Extraction of enzymes from fermentation mixture.

- xii- Enzyme assay
- xiii- Characterization of extracted enzyme
- xiv- Study of effect of different factors on enzyme production

RECOMMENDED BOOKS:

1. Douglas, S. C. and H. W. Blanch. 1997. Biochemical Engineering. Second Edition; CRC Publishers.
2. Bailey, *et al.* 1986. Biochemical Engineering Fundamentals. Second Edition; McGraw-Hill
3. Katoh, S. and F. Yoshida. 2009. Biochemical Engineering, a textbook for engineers, chemists and biologists. Wiley VCH
4. Rajiv Dutta. 2008. Fundamentals of Biochemical Engineering. Springer.
5. Katoh, S., Horiuchi, J. and Yoshida, F. 2015. Biochemical Engineering: A Textbook for Engineers, Chemists and Biologists. 2nd Ed. Wiley.
6. Najafpour, G. 2015. Biochemical Engineering and Biotechnology, Second Edition. Elsevier Science.

BIOT-3506	GENETIC RESOURCES AND CONSERVATION	(3+0)
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OBJECTIVES:

To acquaint students with importance of bio-resources and their conservation especially in relation to Pakistan.

CONTENTS:

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, R. B. 2012. A Primer of Conservational Biology. Fifth Edition; 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, L. S. 2012. Conservation of Wildlife Populations: Demography, Genetics, and Management. Second Edition; Wiley-Blackwell.
4. Kamau, E. C. and G. Winter. 2009. Genetic Resources, Traditional Knowledge and the Law: Solutions for Access and Benefit Sharing. First Edition; Earthscan.

5. Primack, R. B. 2010. Essentials of Conservational Biology. Fifth Edition; Sinauer Associates Inc.
6. Frankham, R. 2010. Introduction to Conservation Genetics. Second Edition; Cambridge University Press.

BIOT-3601	MICROBIAL BIOTECHNOLOGY	(2+1)
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OBJECTIVES:

To acquaint students with how modern methods may be employed to enhance the characteristics of microbes that are commonly used in various industries including food, agriculture and pharmaceutical.

CONTENTS:

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.

PRACTICALS:

Isolation and screening of potential microbes from different environmental sources; lab scale production of bacterial enzymes; lab-scale production of alcohol by yeast; the use of microbes in bioleaching.

RECOMMENDED BOOKS:

1. Glick, B. R. *et al.*, 2009. Molecular Biotechnology: Principles and Applications of Recombinant DNA. Fourth Edition; ASM Press.
2. Mukhopadhyay, S. N. 2004. Process Biotechnology Fundamentals. Second Edition. Anshan Publisher.
3. Goodsell, D. S. 2004. Bio-nanotechnology: Lessons from Nature. John Wiley and Sons.
4. Ray, R. C. 2005. Microbial Biotechnology in Agriculture and Aquaculture. NBN International.
5. Kreuzer, H. and A. Massey. 2005. Biology and Biotechnology Science, Applications, and Issues. First Edition; ASM Press.
6. Harding, S. E. 2010. Biotechnology and Genetic Engineering Reviews. First Edition. Nottingham University Press.

LIST OF MAJOR COURSES

BIOT-3505	INTRODUCTION TO BIOINFORMATICS	(1+2)
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COURSE OBJECTIVES:

In this course students will learn fundamental concepts and methods in bioinformatics, a new discipline at the intersection of biology and computing.

COURSE LEARNING OUTCOMES:

At the end of this course student will be able to understand the basics of molecular biology, differentiate between different biological databases and can explain sequence analysis. This course will train students to computational sequence analysis, sequence homology searching and motif finding, gene finding and genome annotation, protein structure analysis and modeling, genomics and SNP analysis.

CONTENTS:

Introduction, history, timeline, databases, sequence storage, retrieval and analysis, similarity and homology, creating alignments, local and global alignment, pairwise and multiple sequence alignments, phylogenetic analysis, dot matrix plots, dynamic programming algorithm, word (k-tuple) methods, substitution matrices PAM and BLOSUM, significance of scoring, gap penalties, online tools BLAST, BLAT and FASTA.

LAB OUTLINES:

Accessing NCBI databases, sequence databases, Genbank, EMBL, SWISSPROT Accessing structure database PDB, SCOP and CATH, Expaty server, using online alignment tools for pair wise and multiple sequence alignment, phylogenetic analysis by ClustalW, using BLAST and FASTA.

RECOMMENDED BOOKS:

Latest editions of following books

1. Arthur M. Lesk, Introduction to Bioinformatics Oxford University Press.
2. Ignacimuthu SJ . Basic Bioinformatics Narosa Publishing House.
3. Yadav Neelam. A Hand Book of Bioinformatics. Anmal Publications Pvt.Ltd.
4. Krawetz. Stephen A. Introduction to Bioinformatics: A Theoretical and Practical Approach, Humana Press.
5. Jean-Michel Claverie and Cedric Notredame. Bioinformatics for Dummies. Wiley Publishing Inc

BIOT-3602	AGRICULTURE BIOTECHNOLOGY	(3+0)
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COURSE OBJECTIVES:

The objective of this course is to acquaint students with techniques and skills employed for producing transgenic crops with beneficial traits. Students will learn various plant transformation techniques and strategies to develop transgenic crops. As well as they will learn about biopesticides, bioplastics and Biofertilizers.

COURSE LEARNING OUTCOMES:

At the successful completion of this course students will be able to understand various methods to produce transgenic crops with special focus on agrobacterium mediated gene transformation. They will have a thorough knowledge of transgenic crops that have been developed and commercialized. Moreover they would be aware of the problems and possible effects of releasing GMO's into environment. They will have a sound knowledge about biopesticides, bioplastics and Biofertilizers.

CONTENTS:

Agriculture biotechnology and its applications in crop improvements; cell and plant tissue culture methodology; plant molecular biomarkers; direct and indirect methods of plant and animal transformation: gene gun method of transformation, *Agrobacterium* mediated transformation, chloroplast transformation, Microinjection, Electroporation, Liposome mediated gene transfer, Fiber mediated DNA delivery, and polyethylene glycol (PEG) mediated transformation; transgenic crops with herbicide (glyphosate and glufosinate resistant), biotic and abiotic stress resistance; Drought and salinity resistant crops, Disease resistant crops developed, Bt crops development, Transgenic crops with improved nutrient content (Golden rice), Delayed fruit ripening (Antisense technology), Plants disease diagnostics, Edible vaccines, problems related to transgenic plants; genetically modified organisms (GMOs); field evaluation and commercialization of GMOs; possible effects of releasing GMOs into the environment; biopesticides and their types, biofertilizers ; non-symbiotic nitrogen fixers; present and future prospects of biofertilizers, Bioplastic production in plants.

RECOMMENDED BOOKS:

1. Qaim, M. 2010. Agricultural Biotechnology in Developing Countries: Towards Optimizing Benefits for Poor. Springer
2. Kempken, F. 2010. Genetic Modification of Plants: Agriculture, Horticulture and Forestry (Biotechnology in Agriculture and Forestry). Springer.
3. Herren, R. V. 2012. Introduction to Agricultural Biotechnology. Second Edition; Delmar Cengage Learning.
4. Slater, A. 2008. Plant Biotechnology: The Genetic Manipulation of Plants. Second Edition; Oxford University Press, USA
5. Altman, A. 2011. Plant Biotechnology and Agriculture: Prospects for the 21st Century. First Edition; Academic Press.

BIOT-3603	FOOD BIOTECHNOLOGY	(3+0)
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COURSE OBJECTIVES:

To acquaint the students with the basic concepts of composition of food, probiotics and fermented food. To learn about the food additives and bacterial engineering for improving food quality. To make students familiar with food spoilage, food borne diseases and food preservation.

COURSE LEARNING OUTCOMES:

After learning this course students shall be able to know about composition of food, effect of food additives on health and engineering of bacteria to improving food quality. Students will also learn about food spoilage, food borne diseases and control of food borne diseases. Students shall learn about fermented food, microbes involve in fermentation and safety assessment of food.

CONTENTS:

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. Study of fermented products, microorganisms used for fermentation biotechnology

RECOMMENDED BOOKS:

1. Joshi, V.K. 2012. Food Biotechnology. First Edition; I K International Publishing House.
2. Campbell, P. G. 2009. Food Science and Technology. First Edition; Wiley-Blackwell.
3. Singh, R. P. 2008. Introduction to Food Engineering. Fourth Edition; Academic Press
4. Belitz, H. D. 2009. Food Chemistry. Fourth Edition; Springer.
5. Nielsen, S. S. 2010. Food Analysis. Fourth Edition; Springer

BIOT-3606	Research Planning and Scientific Writing	(3+0)
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OBJECTIVES:

- To familiarize students with various methods used for conducting research and latest trends in the field of biotechnology through reading and understanding scientific literature, preparing scientific manuscripts, designing research projects and presenting them.
- To develop critical thinking and improve analytical capability of students for research planning
- To develop capacity and skills of students for developing research idea and synopsis, project designing, scientific writing skills and data handling

CONTENTS:

Introduction; Overview of scientific research, unethical academic practices (plagiarism); How to develop a scientific idea and synopsis for research; identification of problem, formulating a hypothesis, project selection and development: Writing a research grant application, extraction and review of literature; identifying a research problem and formulating a hypothesis; designing a study; Data processing; Analysis of results and interpretation; Primary and secondary sources; Scientific record keeping; Scientific writing: Compilation of thesis and research reports; Publication of a research paper; selection of suitable journal, instructions to authors, preparation and submission of manuscript, review process, referee’s comments and suggestions and responses to reviewers comments; Publication of review articles, making scientific presentations; intellectual property.

RECOMMENDED BOOKS:

1. Bryman, A. 2001. Social research methods. Second Edition; Oxford University Press.
2. Awan, J. A. 2003. Scientific Presentation. Unitech Communication, Faisalabad, Pakistan.
3. Kumar R, Kindersley D, 2010. Research Methodology: a step by step guide for beginners. Third Edition; SAGE Publications.
4. Kothari, C. R. 2004. Research Methodology: Methods and Techniques. Second Revised Edition; New Age International Publishers, New Delhi.
5. Durrani, S. A. 2004. Technical Writing. Higher Education Commission, Islamabad.
6. Rao, P.S.S. S. And J. Richard. 2012. Introduction to Biostatistics and Research Methods. 5th Ed. PHI Learning, New Delhi, India.
7. Sharma, M. 2004. Research Methodology. Anmol Publications, New Delhi, India

BIOT- 4701	HEALTH BIOTECHNOLOGY	(3+0)
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COURSE OBJECTIVES:

To acquaint students with biotechnology in healthcare including genetic disorders and their diagnostic tools. To make students aware about the immunization, vaccine and its types. To learn about the techniques of drug delivery, grafting and gene therapy.

COURSE LEARNING OUTCOMES:

Students will be able learn about basics of health biotechnology and genetic disorders. Techniques of detection of genetic disease and pathogens. Students will also learn about the immunization and different types of vaccines. Students will be able to know about organ transplantation, drug delivery methods for enhanced therapeutic effect. Learn about the pharmacogenetics and stem cell technology as modern therapeutic tool.

CONTENTS:

Introduction to health biotechnology; Social acceptance of medical biotechnology; Molecular and genetic disorders, Molecular and genetic markers for 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; Drug delivery systems; Blood transfusion and grafting techniques; Pharmacogenetics; Gene therapy; Stem cell technology.

RECOMMENDED BOOKS:

1. Pongracz, J. and M. Keen. 2009. Medical Biotechnology. First Edition; Elsevier Health Sciences.
2. Schacter, B. Z. 2005. Biotechnology and Your Health: Pharmaceutical Applications. Chelsea House Publishers,
3. Chetan, D. M. and K. P. Dinesh. 2006. Health and Pharmaceutical Biotechnology. Firewall Media.
4. Bustillo, L. G. T. and I. G. Pena. 2012. Biotechnology: Health, Food, Energy and Environment Applications (Biotechnology in Agriculture, Industry and Medicine). Nova Science Publication.
5. Dogramatzis. 2010. Health care Biotechnology. First Edition; CRC Press.
6. Glick, B. R., Patten, C. L. and Delovitch, T. L. 2013. Medical Biotechnology. 1st Ed. ASM Press

BIOT- 4702	ENVIRONMENTAL BIOTECHNOLOGY	(2+1)
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OBJECTIVES:

To acquaint students with conservation and reclamation of environment through biotechnology

CONTENTS:

Introduction to environmental biotechnology; fundamentals of biological interventions; genetic manipulation strategies in environmental biotechnology; pollution indicators and pollution control strategies; bioreactors; domestic waste water 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.

PRACTICALS:

Biodegradation of environmental pollutants by microorganisms; bacteriology of drinking water; microscopic studies of water specimens collected from various locations; field survey of polluted areas and field study for pollution indicators (e.g., plants, microorganisms and air).

RECOMMENDED BOOKS:

1. Fluker, M. H. 2010. Environmental Biotechnology. CRC Press.
2. Faster, C. F. and J. Wase. 2004. Environmental Biotechnology. John Willey & Sons.
3. Evans, G. M. and J. C. Furlong. 2010. Environmental Biotechnology Theory and Application. Second Edition; Wiley-Blackwell Publishers.
4. Srinivas, T. 2008. Environmental Biotechnology. First Edition; New Age International Publishers.
5. Spencer, J. F. T. and A. L. R. Spencer. 2004. Environmental Microbiology: Methods and Protocols (Methods in Biotechnology). 1st Edition; Humana Press.
6. Hurst, *et al.*, 2007. Manual of Environmental Microbiology. Third Edition; ASM Publishers.

BIOT-4703	GENOMICS AND PROTEOMICS	(3+0)
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COURSE OBJECTIVES:

The overarching goal of this course is to provide students with a thorough overview of both the theoretical and experimental aspects of structural and functional genomics as well as proteomics. The course will cover recent developments in genetics, epigenetics, small RNAs, proteomics, gene expression, mutagenesis and mapping genes, techniques commonly employed in studies of genomics and transcriptomics and applications. Techniques and methods of Proteomics, Interactomics and Proteogenomics.

COURSE LEARNING OUTCOME:

- Develop critical reasoning within the subject area and in relation to the scientific context.
- Describe recent advances in genomics, and proteomics.
- Explain some of the current genomics technologies and illustrate how these can be used to study gene function.
- Practical and theoretical knowledge in proteomics. Understanding how to identify proteins from mass spectrometry data.
- Able to evaluate MS/MS data including de novo sequencing.
- Insight into the analysis of post-translational modifications and protein-protein interactions.
- Hand out knowledge MALDI mass spectrometry and protein identification.

CONTENTS:

Organization and structure of genomes; genetic mapping (RFLP, microsatellite, SNP); high-resolution physical mapping (STS, EST); flow cytometry; somatic cell and radiation hybrids; artificial chromosomes in bacteria and yeast; hierarchical and whole genome shotgun sequencing; DNA sequencing strategies – manual and automated sequencing, pyrosequencing, Solexa, Helicos, Roche 454, real-time and nanopore sequencing; sequence assembly, obstacles and solutions; estimating gene number – over-prediction and under-prediction, homology searches, exon prediction programs, integrated gene-finding software packages; structural variation in the genome and its applications; microarray and RNA interference; proteomics; cellular communication/signalling pathways; protein-protein interactions and validation – yeast two hybrid system, affinity purification-mass spectrometry (AP-MS), tandem affinity purification (TAP) tagging, fluorescence resonance energy transfer (FRET) and co-immunoprecipitation.

RECOMMENDED BOOKS:

1. Strachan, T. and A. P. Read. 2010. Human Molecular Genetics. Fourth Edition; Garland Science.
2. Saccone, C. and G. Pesole. 2003. Handbook of Comparative Genomics: Principles and Methodology. First Edition; Wiley-Liss.
3. Town, C. 2002. Functional Genomics. First Edition; Springer.
4. Krebs, *et al.*, 2010. Lewin Genes X. Tenth Edition; Jones and Bartlett Publishers.
5. Al-Rubeai, M. and M. Fussenegger. 2010. Systems Biology (Cell Engineering). First Edition; Springer
6. Primrose, S. B., and R. M. Twyman . 2006. Principles of gene manipulation and Genomics, Blackwell Publishing MA. USA

BIOT- 4802	INDUSTRIAL BIOTECHNOLOGY	(2+1)
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COURSE OBJECTIVES:

To provide students with a broad-based introduction to the field of industrial biotechnology and to broaden their knowledge about industrial scale production of various enzymes, amino acids, organic acids and fermented food products.

COURSE LEARNING OUTCOMES:

At the completion of this course students will know about various micro-organisms used in industry their isolation, screening and improvement process. They will have a sound knowledge of fermentation processes used in industries for production of fermented food products as well as they will study the industrial scale production of organic acid, amino acids, enzymes, vaccine and antibiotic production. In the practical portion students will isolate microbes from dairy products and fruit juices and will isolate and identify amylase producing microbes from rotten potatoes and extract the crude enzyme. They will study the effect of pH, temperature and substrate concentration on the enzyme activity. Study the process of fermentation of sugars by Bakers yeast.

CONTENTS:

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; extraction of fermented products; production of beer, wines, spirits and vinegar; use of single cell proteins as food products; biocatalysts; microbial insecticides; production of metabolites: organic acids and amino acids; vaccines and antibiotic production.

PRACTICALS:

Isolation of microbes from dairy products, fruit juices, etc.; fermentation of different sugars by bacteria (or other microorganisms); identification of proteases/ amylases producing microbes; extraction of hydrolytic crude enzymes from microbes; effect of environmental factors (e.g., pH, temperature, salt, etc.) on activity of crude enzymes.

RECOMMENDED BOOKS:

1. Okafor, N. 2007. Modern Industrial Microbiology and Biotechnology. First Edition; Science Publishers, USA.
2. Waites, *et al.* 2001. Industrial Microbiology: An Introduction. Blackwell Science Ltd.
3. Shara, *et al.* 2009. Industrial Biotechnology. First Edition; Nova Science Publishers
4. Abhilasha, M. S. 2009. Industrial Biotechnology. ANE Books.
5. Singh, R. and S. Ghosh. 2004. Industrial Biotechnology. Global Vision Publishing House

LIST OF ELECTIVE COURSES

BIOT-4705	ANIMAL BIOTECHNOLOGY	(3+0)
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OBJECTIVES:

To acquaint students with techniques for engineering transgenic animals and embryonic micromanipulations

CONTENTS:

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. Freshney, I. R. 2010. Culture of animal cells: A manual of basic techniques and specialized application. Sixth Edition; Wiley-Blackwell
2. Masters, J. R. 2000. Animal cell culture. Third Edition; Oxford University Press.
3. Lanza, *et al.* 2001. Methods of tissue engineering Academic Press Inc.
4. Doyle, *et al.* 1998. Cells and tissue culture: Laboratory. procedures in biotechnology. Wiley, John and Sons.
5. Barnum, S. 2004. Biotechnology: An Introduction (with Infotrac) Brooks /Cole.
6. Tourte, Y. and T. C. Catherine. 2005. Genetic Engineering and Biotechnology: Concepts, Methods, and Agronomic Applications. Science Publishers.
7. Houdebine, L. M. 2003. Animal Transgenesis and Cloning. First Edition; John Wiley and Sons.

BIOT-4706	WATER AND WASTE WATER TREATMENT	(2+1)
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OBJECTIVES:

To acquaint students with the principles and applications of treatment systems for water, waste water and hazardous wastes.

CONTENTS:

Water and wastewater sources and characteristics; drinking water treatment process; industrial effluent treatment process; novel treatment processes and recycling technology; theory and application of commonly used processes; sedimentation, coagulation, filtration, disinfection, gas transfer, activated sludge, trickling filters, oxidation ponds, sorption, and sludge stabilization and disposal; process combinations to produce treatment systems; role of microorganisms in waste treatment; utilization and management of waste; microbial characterization.

PRACTICALS:

Designing individual aerobic and anaerobic unit processes; physicochemical characteristics of drinking water and waste water; analytical analysis of drinking and waste water for detecting heavy metals and minerals.

RECOMMENDED BOOKS:

1. Metcalf and Eddy, 2003. Waste water Engineering: Treatment, Disposal, and Reuse. Fourth Edition; McGraw-Hill.
2. Clark, N. and A. Crull. 1997. Bioremediation of Hazardous Wastes, Waste Water and Municipal Waste. Business Communication
3. Maier, *et al.*, 1999. Environmental Microbiology. Academic Press Inc.
4. Bitton, G. 2011. Wastewater Microbiology. Fourth Edition; Wiley-Blackwell.
5. Csuros, M. and C. Csuros. 1999. Microbiological Examination of Water And Wastewater. First Edition; CRC Press.

BIOT-3608	BIOFUELS AND BIOREFINERIES	(3+0)
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OBJECTIVES:

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

CONTENTS:

Biofuels - introduction, types and sources; agroindustrial byproducts and biodegradable materials; genomics of biofuels; metabolic engineering; biorefineries; biobased industrial products; basics of green biorefineries; agriculture, forestry and primary refinery raw material; lingo-cellulosic feedstock biorefinery; whole-crop biorefinery based on wet/dry milling and products from whole-crop biorefinery; fundamental sugar platform and syngas platform.

RECOMMENDED BOOKS:

1. Kamm, *et al.* 2006. Biorefinery-Industrial Processes and Products Status Quo and Future Directions. Wiley-VCH.
2. Meroehr. 2001. Biotechnology of Ethanol. Wiley-VCH
3. Verts, *et al.* 2010. Biomass to Biofuels: Strategies for Global Industries. First Edition; Wiley.
4. Lee, S. and Y.T. Shah. 2012. Biofuels and Bioenergy: Processes and Technologies (Green Chemistry and Chemical Engineering). First Edition; CRC Press.

BIOT-3609	HOSPITAL WASTE MANAGEMENT	(2+1)
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OBJECTIVES:

To acquaint students with the principles and applications of clinical waste management.

CONTENTS:

An introduction to the management of infectious materials/waste; various types of infectious material and methods of their handling and disposal; laboratory and hospital acquired infections - possible sources and causes; hazardous microorganisms; basic containment rules and laboratory contamination levels, control measures; guidelines for workers in microbiology and pathology labs, and post-mortem rooms; rules for safe conduct during field work and outdoor activities; risk assessment including recognition of hazards; competence and elimination of hazards; collection of data, etc.; risk group personnel and their education, training and monitoring; radiation hazards and disposal of radioactive waste.

PRACTICALS:

Techniques for waste minimization; waste sorting; anaerobic and aerobic composting; industrial and hospital waste treatment processes.

RECOMMENDED BOOKS:

1. LaGrega, *et al.* 2001. Hazardous Waste Management. Second Edition; McGraw- Hills.
2. McDougall, *et al.*, 2001. Integrated Solid Waste Management: A Life Cycle Inventory. Second Edition; Blackwell Publishers.
3. WHO Biosafety Manual, World Health Organization, 2001. WHO, Geneva.
4. Garvin, M. L. 1995. Infectious Waste Management: A Practical Guide. Lewis Publishers, Inc.
5. Wayne, L. T. 1995. Biohazardous Waste: Risk Assessment, Policy, and Management. Lewis Publishers, Inc.
6. Hickman, H. L. and W. C. Anderson. Principles of Integrated Solid Waste Management. MSW Management

BIOT-4707	INTRODUCTION TO NANOBIO TECHNOLOGY	(3+0)
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OBJECTIVES:

To acquaint students with key integrative technologies and use of nanoparticles in biological systems.

CONTENTS:

Introduction; interface between nanotechnology and bionanotechnology; manipulating molecules; carbon fullerenes and nanotubes; non-carbon nanotubes and fullerene-like materials; quantum dots; nanowires, nanorods and other nanomaterials; 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 nanobiotechnology; future prospects of nanobiotechnology; use of nanotechnology for diagnosing and curing disease.

RECOMMENDED BOOKS:

1. Gazit, E. 2007. Plenty of Room for Biology at the Bottom: An Introduction to Bionanotechnology. First Edition; Imperial College Press.
2. Renugopalakrishnan, V. and R. V. Lewis. 2006. Bionanotechnology: Proteins to Nanodevices. Springer.
3. Greco, *et al.* 2004. Nanoscale Technology In Biological Systems. CRC Press.
4. Mirkin, C. A. and C. M. Niemeyer. 2007. Nanobiotechnology II: More Concepts and Applications. John Wiley & Sons.
5. Niemeyer, C. M. and C. A. Mirkin. 2004. Nanobiotechnology. First Edition; Wiley VCH.

BIOT- 3604	INTRODUCTION TO CELL AND TISSUE CULTURE	(2+1)
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OBJECTIVES:

The aim of this course is to provide students with a thorough understanding of the importance of cell, tissue and organ culture and its application in life sciences.

CONTENTS:

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 micropropagation; 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.

PRACTICALS:

Preparation of Murashige and Skoog medium and stocks of macronutrients, micronutrients, and hormones; selection of ex-plant, medium preparation and callus induction; shoot induction, root induction

RECOMMENDED BOOKS:

1. Setlow, J. K. 2000. Genetic Engineering: Principles and Methods. Kluwer Academic Publishers.
2. Nicholl, D. S. T. 2002. An Introduction to Genetic Engineering. Second Edition; Cambridge University Press.
3. Gale, Y. L. 2002. Genetic Engineering.
4. Razdan MK, 2003. Introduction to Plant Tissue Culture. Second Edition; Intercept, New York, USA.
5. Lanza, *et al.* 2000. Principles of Tissue Engineering. Second Edition; Academic Press, California.
6. Ignacimutu, S. 1997. Plant Biotechnology. Oxford IBH Publisher.
7. Punia, M. S. 1999. Plant Biotechnology and Molecular Biology: A Laboratory Manual. Scientific Publishers.

BIOT-4805	MARINE BIOTECHNOLOGY	(3+0)
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OBJECTIVES:

To acquaint students with recent advancements in the field of marine biotechnology and how molecular techniques may be applied for studying marine organisms.

CONTENTS:

Introduction to marine microorganisms and marine biotechnology; marine flora/phytoplankton; aquaculture techniques; marine microbes of biotechnological importance; primary and secondary metabolites (e.g., antibiotics, organic acids, toxins, etc); role of marine microbes in global carbon cycling; genomics of marine organisms; recent progress in discovery of drugs and enzymes from marine sources.

RECOMMENDED BOOKS:

1. Gal, Y. L. 2010. Marine Biotechnology I (Advances in Biochemical Engineering Biotechnology). Springer.
2. Gal, Y. L. 2010. Marine Biotechnology II (Advances in Biochemical Engineering Biotechnology). Springer.
3. Kim, S. K. 2011. Handbook of Marine Microalgae: Biotechnology and Applied Physiology. First Edition; Wiley.
4. Johansen, M. N. 2011. Microalgae: Biotechnology, Microbiology and Energy. Nova Science Pub Inc.
5. Buchholz, R. 2012. Microalgae Biotechnology. Walter De Gruyter Inc.
6. Gal, Y. L. 2010. New Developments in Marine Biotechnology. Springer

BIOT-4806	RADIOBIOLOGY	(2+1)
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OBJECTIVES:

To acquaint students with use of radiation and radioactive materials in agriculture, health and basic research

CONTENTS:

Introduction to radiobiology, radioisotopes and types and sources of radiation; physics of radioactive substances; effects of radiation on living cells; exposure and radiation dose-effect; molecular basis of cellular effects and cell radiation sensitivity; radiation therapy, radiation protection, safety measures and treatment of radiation injuries; fundamental aspects and relationship of imaging physics and radiobiology including current regulation and recommendations in radiation biology, radiological technologies and labeling techniques; use of radioisotopes as diagnostic and therapeutic tools.

PRACTICALS:

To enhance awareness of radiation use, visits to different medical centers/hospitals will be arranged for students for studying different types of radiation in use for treating various

conditions; visit to different stations/offices where any type of radio waves, electromagnetic waves etc. are in continuous use and collecting data about any harmful effects.

RECOMMENDED BOOKS:

1. Wambersie, A. 2007. Introduction to Radiobiology. Tylor and Francis.
2. Nias, A. H. W. 2007. Introduction to Radiobiology. Academic Press.
3. Forshier, C. M. 2008. Essentials of Radiation, Biology and Protection. Second Edition. Cengage Learning Press
4. Washington, C. M. 2009. Principles and Practice of Radiation Therapy. Elsevier Health Sciences
5. der Kogel, A.V. and M. Joiner. 2009. Basic Clinical Radiobiology. Fourth Edition; A Hodder Arnold Publication

BIOT-3607	FUNGAL BIOTECHNOLOGY	(2+1)
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OBJECTIVES:

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

CONTENTS:

Introduction to mycology; production techniques used in fungal biotechnology; metabolites produced by fungi; utilization of fungi in medical and agricultural biotechnology; industrial uses of fungi including food manufacturing; bio-deterioration and biodegradation; biotechnology and the control of pathogenic fungi; current applications of fungal biotechnology and screening of fungal metabolites; mycotoxins.

PRACTICALS:

Isolation of fungi from different sources, Fungal morphology; identification of fungi; sexual and asexual reproductive structures of fungi; DNA extraction from hyphae and zoospores, Production of different enzymes from fungal culture

RECOMMENDED BOOKS:

1. Tkacz, J. S. and L. Lange. 2004. Advances in fungal Biotechnology for Industry, Agriculture and Medicine. First Edition; Springer.
2. Arora, *et al.* 2003. Fungal Biotechnology in Agricultural, Food and Environmental Applications. First Edition; CRC Press.
3. An, Z. 2004. Handbook of Industrial Mycology. First Edition; CRC Press
4. Sati, S. C. 2007. Recent Mycological Research: Fungal Biotechnology. IK International Publishing House.
5. Rai, M. 2009. Advances in Fungal Biotechnology. IK International Publishing House
6. Carlile, *et al.*, 2001. The Fungi. Second Edition; Academic Press
7. Arora, *et al.*, 2003. Handbook of Fungal Biotechnology. Second Edition; CRC Press.
8. Oliver, R. P. and M. Schweizer. 1999. Molecular Fungal Biology. First Edition; Cambridge University Press.
9. Frisvad, *et al.* 1998. Chemical Fungal Taxonomy. First Edition; CRC Press.

BIOT-4807	PHARMACEUTICAL BIOTECHNOLOGY	(3+0)
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COURSE OBJECTIVES:

Pharmaceutical biotechnology is a relatively new and growing field in which the principles of biotechnology are applied to the development of drugs. A majority of therapeutic drugs in the current market are bio formulations. This course is developed to familiarize the students with several stages involved in drug development that include: understanding the principles underlying health and disease; the fundamental molecular mechanisms governing the function of related biomolecules; synthesis and purification of the molecules; determining the product shelf life, stability, toxicity and immunogenicity; drug delivery systems; patenting; and clinical trials.

COURSE LEARNING OUTCOMES:

At the end of this course student will be able to describe the process of bio-formulations, the up and downstream processing and approval process from regulatory bodies and important biotechnological products.

CONTENTS:

Introduction and history of Pharmaceuticals, biologicals and Biopharmaceuticals; Recombinant DNA technology and Pharma biotech; Cell culture systems; Protein structure, interactions, folding and stability and analytical methods; Production of Biopharmaceutical – Upstream and Downstream processing; Formulation and regulatory considerations of Biotech products; The biochemistry, production and medical uses of selected biotechnological products such as therapeutic proteins, Cell based therapies, RNA Technologies, and Aptamers.

RECOMMENDED BOOKS:

1. Gary Walsh. Pharmaceutical Biotechnology: Concepts and Applications. Wiley
 2. Cromein. Pharmaceutical Biotechnology. Springer
 3. Kayser, O. 2012. Pharmaceutical Biotechnology: Drug Discovery and Clinical Application. Second Edition; Wiley-Blackwell.
 4. Kokate, C. 2012. Textbook of Pharmaceutical Biotechnology. ELSEVIER
 5. Crommelin, *et al.* 2007. Pharmaceutical Biotechnology: Fundamentals and Applications. Third Edition. Informa Healthcare.
 6. Ende, D. J. 2010. Chemical Engineering in the Pharmaceutical Industry: R&D to Manufacturing. First Edition; Wiley
- Subramanian, G. 2012. Biopharmaceutical Production Technology. First Edition. Wiley-VCH

BIOT- 4808	BIOSENSORS	(3+0)
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OBJECTIVES:

To acquaint students with fundamentals of sensors that are capable of specifically detecting minute quantities of various individual biomolecules or those displayed on cellular or viral surfaces.

CONTENTS:

Introduction; miniaturization and microsystems including sensing by optical techniques, field-effect transistors, ion-selective and enzyme-sensitive electrodes; biological signals and their types; amperometric biosensors based on redox enzymes, potentiometric biosensors and enzyme field effect transistors (ENFET); thermal biosensors; optical biosensors based on

redox enzymes; indirect affinity sensors; optical and electrical antibody-based biosensor; direct affinity detection using surface plasmon resonance and piezoelectric biosensors.

RECOMMENDED BOOKS:

1. Nielson, *et al.* 2003. Bioreaction Engineering Principles. Second Edition; Kluwer Academic / plenum publisher, New York.
2. Monsi, *et al.* 2011. Fermentation Microbiology and Biotechnology. Third Edition; CRC Press.
3. Bone, S. and B. Zaba. 1992. Bioelectronics. First Edition; Wiley.
4. Hall, E. A. H. 1991. Biosensors. John Wiley & Sons.
5. Koryta, J. 1993. Ions, Electrodes and Membranes. Second Edition; John Wiley & Sons.

BIOT- 4708	Special Paper-I: MOLECULAR DIAGNOSTICS	(3+0)
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COURSE OBJECTIVES:

To acquaint students with modern techniques used in molecular diagnostics.

COURSE LEARNING OUTCOMES:

Upon completion of this course students will be able to understand different types of PCR, detection of mutations based on RFLP, DNA sequencing methods and blotting techniques. Moreover they will learn different immunological testing techniques and will be equipped with the knowledge to diagnose various inherited disorders.

CONTENTS:

Introduction and applications of molecular diagnostics techniques in agriculture and forensic sciences (DNA finger printing; polymerase chain reaction (PCR) and types; detection of mutations and single nucleotide polymorphisms (SNPs) by restriction fragment length polymorphisms (RFLPs); DNA sequencing(Maxam and gilbert, Sanger and next generation sequencing; blotting techniques (e.g., Southern, Northern and Western); enzyme-linked immunosorbant assays (ELISA); immunofluorescence staining and immunohistochemistry; DNA micro-arrays; *in situ* hybridization; molecular cytogenetics (Karyotyping, Comparative genome hybridization, Spectral Karyotyping) ; Molecular Diagnostics of inherited disorders, Amniocentesis, Prenatal and postnatal testing; Genetic counseling.

RECOMMENDED BOOKS:

1. Debnath, *et al.* 2010. Molecular Diagnostics: Promises and Possibilities. Springer
2. Wilson, D. D. 2008. Manual of Laboratory and diagnostic tests. McGraw-Hills publisher.
3. Brown, T. A. 2010. Gene Cloning and DNA analysis. Sixth Edition. Wiley-Blackwell Publishing.
4. Buckingham, *et al.* 2007. Molecular Diagnostics Fundamentals, Methods, and Clinical Applications. First Edition. FA Davis Publisher.
5. Walker, J. M. and R. Rapley. 2005. Medical Biomethods Handbook. Humana Press

BIOT-4810	INTRODUCTION TO VIROLOGY	(3+0)
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COURSE OBJECTIVES

Introduction of Virology course aimed at basic to advanced understanding of viruses. What is their structural and genomic composition, how they infect and replicate in host organisms, how they spread and cause diseases what are possible strategies of prevention. Primary focus of the course is on human

viruses, plant and bacterial (Bacteriophages) will also be taught. Some of the selected diseases (Influenza, AIDS, HCV, HBV, Polio) will be taught at molecular level. This course will also cover the anti-viral drugs and vaccines. Course will describe major virus diagnosis techniques

COURSE LEARNING OUTCOMES:

After successful completion of the course student will be able to understand the virus biology, its replication cycle, pathogenesis and disease control. Student will be able to apply basic concepts to the problems in the field of virology and how viral diseases can be controlled by vaccines and antiviral drugs. Student will be able to understand the techniques used in virus diagnosis.

CONTENTS:

The importance of studying viruses; the discovery of viruses (Historical perspective); common characteristics and structure of viruses; Classification and replication cycle of viruses; Pathogenesis and immune response to viruses; Detection and diagnosis of viral infections; Vaccines, anti-viral drugs and beneficial uses of viruses; Oncogenic viruses; Viral vectors and gene therapy; Bacteriophages; Plant viruses; Specific aspects of selected human viral diseases (Influenza viruses, Human immunodeficiency viruses, Hepatitis viruses, Polio viruses)

RECOMMENDED BOOKS:

1. Jennifer Louten, 2016. Essential Human Virology, Academic press, Elsevier, UK.
2. Flint, S. J. 2009. Principles of Virology, Vol. 2: Pathogenesis and Control. Third Edition; AMS Press
3. Flint, et al. 2009. Principles of Virology. ASM Press, USA.
4. Lal, S. 2007. The Biology of Emerging Viruses. Wiley-Blackwell, USA.
5. Carter, J. and V. Saunders. Virology: Principles and Applications. First Edition; Wiley.
6. Wagner, et al. 2007. Basic Virology. Third Edition; Wiley-Blackwell

BIOT- 4809	FERMENTATION BIOTECHNOLOGY	(2+1)
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OBJECTIVES:

To acquaint students with theoretical and experimental techniques used for fermentation.

CONTENTS:

Overview of fermentation technology: definition, economics, applications; strain development and improvement: isolation of microorganisms - plating, criteria for selection and improvement through genetic engineering; growth requirement of various organisms and media preparation; stoichiometry of microbial growth; preparation of inoculum; microbial growth kinetics in batch culture; continuous culture; sterilization: modes & kinetics of sterilization, design of batch and continuous sterilization process, air sterilization & theory of fibrous filters; fluid rheology: classification, Newtonian & non-Newtonian factors effecting $K_L a$ in fermentation vessel; design of bioreactors and configuration for free and immobilized cells; waste treatment; tissue engineering for plant and animal cell cultures; aeration and agitation; product recovery; scaling-up of fermentation process.

PRACTICALS:

Initiation of a bacterial/plant or animal cell/tissue culture in a simple conical flask or in a fermenter depending on availability and its handling according to the techniques introduced in theory as sterilization, media formulation, growth kinetics, product recovery etc.

RECOMMENDED BOOKS:

- 1- Doran, P. M. 2012. Bioprocess Engineering Principles. Second Edition; Academic Press.
- 2- McNeil, B. 2008. Practical Fermentation Technology. John Willey & Sons
- 3- El-Mansi, *et al.* 2007. Fermentation Microbiology and Biotechnology. CRC Press.

4- Shuler, M. L. and F. Kargi. 2002. Bioprocess Engineering: Basic concept. Prentice Hall.

BIOT-4811	RECENT TRENDS IN BIOTECHNOLOGY	(3+0)
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COURSE OBJECTIVES

The main objective of the course is to orient indigenous students with global recent trends in biotechnology. The course will provide a good exposure to students and motivate them to take up the relevant and advanced research.

COURSE LEARNING OUTCOMES

After completion of the course student will be familiar about latest trends and techniques being used in biotechnology. Course will include advanced knowledge of DNA and chromosomes, proteins, genome editing techniques, therapeutic proteins from plants, vaccines, biofuel and mass spectrometry.

CONTENTS:

Introduction to DNA and chromosomes, protein structure, folding, sorting, transport, degradation and functions, leucine zipper, zinc finger, RNAi, CRISPER-Cas (introduction, mechanism, applications, future prospects), modern vaccines, Edible Vaccines, Therapeutics from Transgenic Plants, gene therapy, personalized medicines, bio-energy, biofuel, biodegradable plastics, bioremediation and biosafety. Latest analytical techniques like GC-MS, LC-MS, FTIR etc will also be taught.

RECOMMENDED BOOKS:

1. Atul Bhargava, Shilpi Srivastava. (2017). Biotechnology: Recent Trends and Emerging Dimensions. CRC Press.
2. B. R. Glick, et al. (2009). Molecular Biotechnology: Principles & Applications of Recombinant DNA. ed. 4, ASM Press.
3. Doudna J, Mali P. (2016). *CRISPR-Cas: A Laboratory Manual*. New York: Cold Spring Harbor Laboratory Press.
4. Hakoshima, T. (2005). "Leucine Zippers". *Encyclopedia of Life Sciences*. doi:10.1038/npg.els.0005049. ISBN 0470016175.
5. M. P. Singh, Anju Agrawal, Bechan Sharma. (2010) Recent Trends in Biotechnology: v. 1. Nova Science Publishers Inc.
6. Primrose, S. B. and R. Twyman. (2006). Principles of Gene Manipulation and Genomics. Seventh Edition; Wiley- Blackwell.
7. Shahid, M., Shahzad, A., Malik, A., Sahai, A. (2013). Recent Trends in Biotechnology and Therapeutic Applications of Medicinal Plants. Springer publishers.

BIOT-3610	Fundamentals of Enzymology	3(2+1)
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COURSE OBJECTIVES:

To learn about the fundamental concepts of enzymes, coenzymes and their characteristics. To learn about the factors effecting enzyme activity, enzyme denaturation and inhibition. Learn about the enzyme immobilization and therapeutic applications.

COURSE LEARNING OUTCOMES:

Students will be able to know about enzymes, coenzymes, their classification and catalysis. After study of course students will know about enzyme kinetics and regulation. Student will be able to

learn enzyme inhibition, denaturation, renaturation and immobilization. Student will also know the clinical applications of enzymes.

CONTENTS:

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 bisubstrate reactions, catalytic mechanisms, regulatory enzymes and immobilised enzyme. 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.

Recommended Books

1. Daniel, L., Purich. (2010). Enzyme Kinetics Catalysis & Control: A Reference of Theory and Best-Practice Methods, 1st Ed. Elsevier.
2. Yon-Kahn, J., Herve, G. (2010). Molecular and Cellular Enzymology. Springer-Verlag Berlin and Heidelberg GmbH & Co.
3. Kirby, A.J., Hollfelder, F. (2009). From Enzyme Models to Model Enzymes. Royal Society of Chemistry
4. Voet, D., Voet, J.G. and Pratt, C.W. (2008). Fundamentals of Biochemistry: Life at the Molecular Level, 3rd Ed. John Wiley & Sons
5. Hiromi, S. (2007). The Enzyme Factor, 1st Ed. Council Oak Books.
6. Gowenlock., A.H., and Bell, M. (1991). Varley's Pratical Clinical Biochemistry, 5th Ed. CBS Publishers & Distributors.

BIOT-4812	Cellular Signalling	3(3+0)
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COURSE OBJECTIVES:

The objectives of the course are to learn about hormones and their synthesis. To learn about the receptors and their mechanism with respect to hormonal signaling. To learn about the signaling pathways in normal, cancer and cultured cells.

COURSE LEARNING OUTCOMES:

After studying this course students will be able to learn about synthesis of different types of hormone and their receptor mediated signaling. Students will be able to know about the different strategies of cellular signaling adopted by the organisms. Students will also able to learn about the signaling mechanism in cancerous, cultured and plant cells.

CONTENTS:

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.

Recommended Books:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., Walter, P. (2008) Molecular Biology of the Cell, 5th Ed. Garland Sciences, Taylor and Francis.
2. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Scott, M.P., Bretscher, A. Ploegh, H. and Matsudaira, P. (2008). Molecular Cell Biology. 6th Ed. W.H. Freeman and Co.
3. Berg, J.M., Tymoczko, J.L., Stryer, L. (2007) Biochemistry 6th Ed. W.H. Freeman & Co. Recent review articles.

LIST OF COMPULSORY COURSES

COMPULSORY COURSES IN ENGLISH FOR BS

(4 YEAR) IN BASIC & SOCIAL SCIENCES

ENG-1107	English-I (Functional English)	(3+0)
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OBJECTIVES:

Enhance language skills and develop critical thinking.

CONTENTS:

Basics of Grammar

Parts of speech and use of articles

Sentence structure, active and passive voice

Practice in unified sentence

Analysis of phrase, clause and sentence structure

Transitive and intransitive verbs

Punctuation and spelling

Comprehension: Answers to questions on a given text

Discussion: General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

Listening: To be improved by showing documentaries/films carefully selected by subject teachers

Translation skills: Urdu to English

Paragraph writing: Topics to be chosen at the discretion of the teacher

Presentation skills: Introduction

Note: Extensive reading is required for vocabulary building

RECOMMENDED BOOKS:

1. Functional English

- a) Grammar
 - 1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492
 - 2. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506
- b) Writing
 - 1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Françoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-4
- c) Reading/Comprehension
 - 1. Reading. Upper Intermediate. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.
- d) Speaking

ENG-1207	English-II (Communication Skills)	(3+0)
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OBJECTIVES:

Enable the students to meet their real life communication needs.

CONTENTS:

Paragraph writing

Practice in writing a good, unified and coherent paragraph

Essay writing

Introduction

CV and job application

Translation skills

Urdu to English

Study skills

Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension

Academic skills

Letter/memo writing, minutes of meetings, use of library and internet

Presentation skills

Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

RECOMMENDED BOOKS:

Communication Skills

- a) Grammar
 - 1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.
- b) Writing
 - 1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Françoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).

2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).
- c) Reading
1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
 2. Reading and Study Skills by John Langan
 3. Study Skills by Riachard Yorky.

ENG-2107	English III (Technical Writing and Presentation Skills)	(3+0)
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OBJECTIVES:

Enhance language skills and develop critical thinking.

CONTENTS:

Presentation skills

Essay writing

Descriptive, narrative, discursive, argumentative

Academic writing

How to write a proposal for research paper/term paper

How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency)

Technical Report writing

Progress report writing

Note: Extensive reading is required for vocabulary building

RECOMMENDED BOOKS:

Technical Writing and Presentation Skills

a) Essay Writing and Academic Writing

1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).
2. College Writing Skills by John Langan. Mc=Graw-Hill Higher Education. 2004.
3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.

b) Presentation Skill

c) Reading: The Mercury Reader. A Custom Publication. Compiled by norther Illinois University. General Editors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharon. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

PS-1217	Pakistan Studies (Compulsory)	(2+0)
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OBJECTIVES:

- Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
- Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

CONTENTS:

1. *Historical Perspective:*
 - a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-i-Azam Muhammad Ali Jinnah.
 - b. Factors leading to Muslim separatism
 - c. People and Land
 - i. Indus Civilization
 - ii. Muslim advent
 - iii. Location and geo-physical features.
2. *Government and Politics in Pakistan:*

Political and constitutional phases:

 - a. 1947-58
 - b. 1958-71
 - c. 1971-77
 - d. 1977-88
 - e. 1988-99
 - f. 1999 onward
3. *Contemporary Pakistan:*
 - a. Economic institutions and issues
 - b. Society and social structure
 - c. Ethnicity
 - d. Foreign policy of Pakistan and challenges
 - e. Futuristic outlook of Pakistan

RECOMMENDED BOOKS:

1. Burki, J. Shahid. 1980. *State & Society in Pakistan*, The Macmillan Press Ltd.
2. Zaidi, A. S. 2000. *Issue in Pakistan's Economy*. Karachi: Oxford University Press.
3. Burke, S.M. and L. Ziring. 1993. *Pakistan's Foreign policy: An Historical analysis*. Karachi: Oxford University Press.
4. Mehmood, S. 1994. *Pakistan Political Roots & Development*. Lahore.
5. Wilcox, W. 1972. *The Emergence of Banglades.*, Washington: American Enterprise, Institute of Public Policy Research.
6. Mehmood, S. *Pakistan Kayyun Toota*, Lahore: Idara-e-Saqafat-e-Islamia, Club Road.
7. Amin, T. *Ethno - National Movement in Pakistan*, Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, L. 1980. *Enigma of Political Development*. Kent England: WmDawson & sons Ltd.
9. Zahid, A. 1980. *History & Culture of Sindh*. Karachi: Royal Book Company.
10. Rafique, A. M. 1998. *Political Parties in Pakistan*, Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research.
11. Sayeed, K. B. 1967. *The Political System of Pakistan*. Boston: Houghton Mifflin.
12. Aziz, K.K. 1976. *Party, Politics in Pakistan*, Islamabad: National Commission on Historical and Cultural Research.
13. Muhammad W. 1987. *Pakistan Under Martial Law*, Lahore: Vanguard.
14. Haq, N. 1993. *Making of Pakistan: The Military Perspective*. Islamabad: National Commission on Historical and Cultural Research.

ISL-1112	ISLAMIC STUDIES (Compulsory)	(2+0)
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OBJECTIVES:

This course is aimed at:

- 1 To provide Basic information about Islamic Studies
- 2 To enhance understanding of the students regarding Islamic Civilization
- 3 To improve Students skill to perform prayers and other worships
- 4 To enhance the skill of the students for understanding of issues related to faith and religious life.

CONTENTS:

Introduction to Quranic Studies

- 1) Basic Concepts of Quran
- 2) History of Quran
- 3) Uloom-ul -Quran

Study of Selected Text of Holly Quran

- 1) Verses of Surah Al-Baqra Related to Faith (Verse No-284-286)
- 2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
- 3) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
- 4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
- 5) Verses of Surah Al-Inam Related to Ihkam (Verse No-152-154)

Study of Selected Text of Holly Quran

- 1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.)
- 2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
- 3) Verses of Surah Al-Saf Related to Tafakar, Tadabar (Verse No-1,14)

Seerat of Holy Prophet (S.A.W) I

- 1) Life of Muhammad Bin Abdullah (Before Prophet Hood)
- 2) Life of Holy Prophet (S.A.W) in Makkah
- 3) Important Lessons Derived from the life of Holy Prophet in Makkah

Seerat of Holy Prophet (S.A.W) II

- 1) Life of Holy Prophet (S.A.W) in Madina
- 2) Important Events of Life Holy Prophet in Madina
- 3) Important Lessons Derived from the life of Holy Prophet in Madina

Introduction To Sunnah

- 1) Basic Concepts of Hadith
- 2) History of Hadith
- 3) Kinds of Hadith
- 4) Uloom –ul-Hadith
- 5) Sunnah & Hadith
- 6) Legal Position of Sunnah

Selected Study from Text of Hadith

Introduction To Islamic Law & Jurisprudence

- 1) Basic Concepts of Islamic Law & Jurisprudence
- 2) History & Importance of Islamic Law & Jurisprudence
- 3) Sources of Islamic Law & Jurisprudence
- 4) Nature of Differences in Islamic Law
- 5) Islam and Sectarianism

Islamic Culture & Civilization

- 1) Basic Concepts of Islamic Culture & Civilization
- 2) Historical Development of Islamic Culture & Civilization

- 3) Characteristics of Islamic Culture & Civilization
- 4) Islamic Culture & Civilization and Contemporary Issues

Islam & Science

- 1) Basic Concepts of Islam & Science
- 2) Contributions of Muslims in the Development of Science
- 3) Quranic & Science

Islamic Economic System

- 1) Basic Concepts of Islamic Economic System
- 2) Means of Distribution of wealth in Islamic Economics
- 3) Islamic Concept of Riba
- 4) Islamic Ways of Trade & Commerce

Political System of Islam

- 1) Basic Concepts of Islamic Political System
- 2) Islamic Concept of Sovereignty
- 3) Basic Institutions of Govt. in Islam

Islamic History

- 1) Period of Khlaft-E-Rashida
- 2) Period of Ummayyads
- 3) Period of Abbasids

Social System of Islam

- 1) Basic Concepts Of Social System Of Islam
- 2) Elements Of Family
- 3) Ethical Values Of Islam

RECOMMENDED BOOKS:

- 1) Muhammmad, H. “Emergence of Islam” , IRI, Islamabad.
- 2) Muhammmad, H. “Muslim Conduct of State”
- 3) Muhammmad, H. ‘Introduction to Islam
- 5) Hussan, H. H. “An Introduction to the Study of Islamic Law” leaf Publication Islamabad, Pakistan.
- 6) Hasan, A. “Principles of Islamic Jurisprudence” Islamic Research Institute, International Islamic University, Islamabad (1993)
- 7) Mir, W. 1982. “Muslim Jrisprudence and the Quranic Law of Crimes” Islamic Book Service.
- 8) Bhatia, H.S. 1989. “Studies in Islamic Law, Religion and Society” Deep & Deep Publications New Delhi.
- 9) Muhammad, Zia-ul-Haq.2001. “Introduction to Al Sharia Al Islamia” Allama Iqbal Open University, Islamabad.

MAT-1115	MATHEMATICS -I (Pre-calculus)	(3+0)
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OBJECTIVES:

To prepare the students, not majoring in mathematics, with the essential tools of algebra to apply the concepts and the techniques in their respective disciplines.

CONTENTS:

Preliminaries: Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions.

Matrices: Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer’s rule. *Quadratic Equations:* Solution of quadratic equations, qualitative analysis of roots of a quadratic equations, equations reducible to quadratic equations, cube roots of unity, relation between roots and coefficients of quadratic equations. *Sequences and Series:* Arithmetic progression, geometric progression, harmonic progression. *Binomial Theorem:* Introduction to mathematical induction, binomial theorem with rational and irrational indices.

Trigonometry: Fundamentals of trigonometry, trigonometric identities.

RECOMMENDED BOOKS:

Dolciani, M. P., W. Wooton, E. F. Beckenback, S, Sharron. 1978. *Algebra 2 and Trigonometry*, Houghton & Mifflin, Boston (suggested text)
 Kaufmann, J. E. 1987. *College Algebra and Trigonometry*, PWS-Kent Company, Boston
 Swokowski, E. W. 1986. *Fundamentals of Algebra and Trigonometry* (6th edition), PWS-Kent Company, Boston

COM-2305	Introduction to Computer Science (C)	2+1
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OBJECTIVES:

To familiarized students with the basics of computer.

CONTENTS:

Introduction and History of Computers, Computer Characteristics, Major components of computer, Introduction to operating system, Hardware and software concepts, Computer applications in modern ages, Categories of computers, Introduction to networks, Introduction to Internet and usage of web browsers, Introduction to e-mail and web documents searching, Presentation skills, Introduction to formatting documents, Introduction to information systems, Software development life cycle.

PRACTICALS:

Word processing, Windows operating systems, Graphics software, Network introduction LANs, WANs, MANs, Presentation software practice, Excel software practice, Formatting documents