CURRICULUM

OF

BIOINFORMATICS
BS
MS

(Revised 2011)

HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

Prof. Dr. Syed Sohail H. Naqvi	Executive Director
Prof. Dr. Altaf Ali G. Shaikh	Member (Acad)
Mr. Muhammad Javed Khan	Adviser (Academic)
Mr. Malik Arshad Mahmood	Director (Curri)
Dr. M. Tahir Ali Shah	Deputy Director (Curri)
Mr. Abdul Fatah Bhatti	Asstt. Director (Curri)

Composed by: Mr. Zulfiqar Ali, HEC, Islamabad

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PREFACE

The curriculum of subject is described as a throbbing pulse of a nation. By viewing curriculum one can judge the stage of development and its pace of socio-economic development of a nation. With the advent of new technology, the world has turned into a global village. In view of tremendous research taking place world over new ideas and information pours in like of a stream of fresh water, making it imperative to update the curricula after regular intervals, for introducing latest development and innovation in the relevant field of knowledge.

In exercise of the powers conferred under Section 3, Sub-Section 2 (ii) of Act of Parliament No. X of 1976 titled **"Supervision of Curricula and Textbooks and Maintenance of Standard of Education"** the erstwhile University Grants Commission was designated as competent authority to develop review and revise curricula beyond Class-XII. With the repeal of UGC Act, the same function was assigned to the Higher Education Commission under its Ordinance of 2002 Section 10 Sub-Section 1 (v).

In compliance with the above provisions, the HEC undertakes revamping and refurbishing of curricula after regular intervals in a democratic manner involving universities/DAIs, research and development institutions and local Chamber of Commerce and Industry. The intellectual inputs by expatriate Pakistanis working in universities and R&D institutions of technically advanced countries are also invited to contribute and their views are incorporated where considered appropriate by the National Curriculum Revision Committee (NCRC).

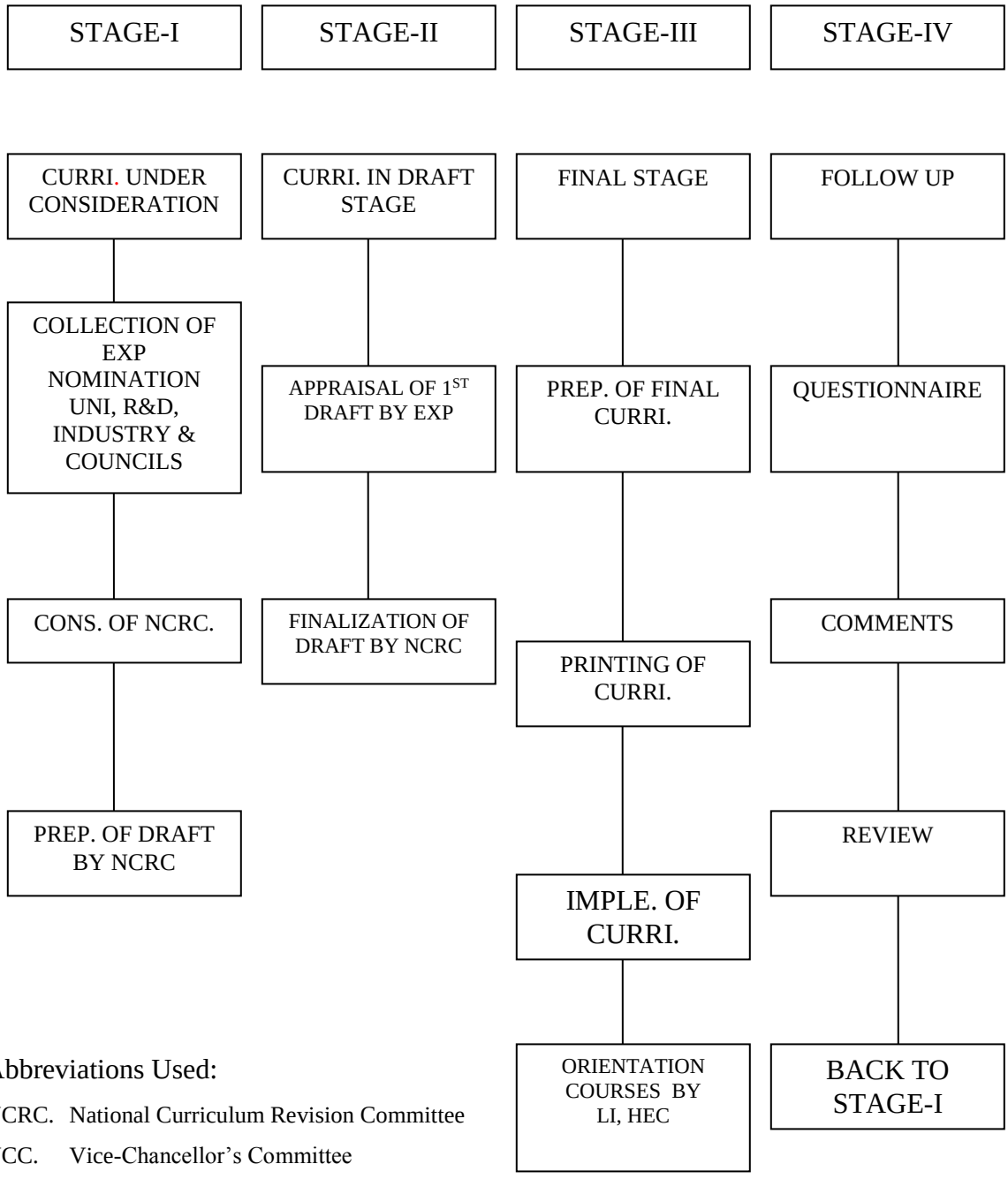
To bring international compatibility to qualifications held from Pakistani universities/DAIs for promotion of students mobility and job seekers around the globe, a Committee comprising of Conveners of the National Curriculum Revision Committee of HEC met in 2009 and developed a unified template for standardized 4-years/8-semesters BS degree programs. This unified template was aimed to inculcate broader base of knowledge in the subjects like English, Sociology, Philosophy, Economics etc. in addition to major discipline of study. The Bachelor (BS) degree course requires to be completed in 4-years/8-semesters, and shall require qualifying of 130-140 credit hours of which 77% of the curriculum will constitute discipline specific and remaining 23% will comprise compulsory and general courses.

In line with above, NCRC comprising senior university faculty and experts from various stakeholders and the respective accreditation councils has finalized the curriculum for B.S 4-years and M.S 2-years in Bioinformatics. The same is being recommended for adoption by the universities/DAIs channelizing through relevant statutory bodies of the universities.

MUHAMMAD JAVED KHAN
Adviser (Academics)

June, 2011

CURRICULUM DEVELOPMENT



Abbreviations Used:

NCRC. National Curriculum Revision Committee

VCC. Vice-Chancellor's Committee

EXP. Experts

COL. Colleges

UNI. Universities

PREP. Preparation

REC. Recommendations

LI Learning Innovation

R&D Research & Development Organization

HEC Higher Education Commission

INTRODUCTION

The final meeting of the National Curriculum Revision Committee in Bioinformatics was held on May 17-19, 2011 at HEC, Regional Centre, Karachi to review and finalize the curriculum for BS (4-years) and MS (2-years) degree programs in Bioinformatics. Following members and experts attended the meeting:

1.	Prof. Dr. Gulzar Ahmed Niazi HEC Foreign Professor, Centre of Excellence in Molecular Biology, 78 West Canal Bank Road, Thokar Niazbaig, Lahore	Convener
2.	Prof. Dr. Masroor Ellahi Babar Director, Institute of Biochemistry and Biotechnology University of Veterinary and Animal Sciences, Lahore.	Member
3.	Prof. Dr. Mohammad Inayatullah Khan Babar Professor, Electrical Engineering and Chairman, Computer Science and IT Department, University of Engineering and Technology, Peshawar.	Member
4.	Prof. Dr. Shamshad Zarina Director, National Center for Proteomics, University of Karachi, Karachi.	Member
5.	Prof. Dr. Ahmad Saeed Dean, Faculty of Biological Sciences, University of Science and Technology, Bannu.	Member
6.	Prof. Dr. Fida Mohammad Chairman, Department of Plant Breeding and Genetics, University of Agricultural, Peshawar, Khyber Pakhtunkhwa	Member

7.	Dr. Rani Faryal Associate Professor, Department of Biosciences, COMSATS Institute of Information Technology (CIIT), Islamabad.	Member
8.	Dr. Imran Sajid Assistant Professor, Department of Microbiology and Molecular Genetics, University of the Punjab, Lahore.	Member
9.	Dr. Nazeer Ahmed Assistant Professor, Faculty of Life Sciences & Informatics, Balochistan University of Information Technology, Engineering and Management Sciences, Quetta	Member
10.	Dr. Muhammad Asif Senior Scientist, National Institute for Biotechnology and Genetic Engineering, Faisalabad.	Member
11.	Mrs. Afshan Kaleem Lecturer, Department of Zoology, Lahore College for Women University (LCWU), Lahore.	Member
12.	Prof. Dr. Syed Afaq Hussain Faculty of Engineering and Applied Sciences, Ripah International University, Islamabad.	Member
13.	Prof. Dr. Zubair A. Shaikh Associate Dean, Faculty of Computer Science, National University of Computer and Emerging Sciences, Karachi.	Member
14.	Dr. Syed Sikander Azam Assistant Professor, Department of Biotechnology and Bioinformatics, Quaid-i-Azam University, Islamabad	Member

15. Dr. Muhammad Nauman Aftab — Secretary
Assistant Professor,
Institute of Industrial Biotechnology,
Government College University,
Lahore.

Mission Statement:

To train the next generation professionals to gain advanced knowledge in Bioinformatics that is required to design and implement novel methods which can be useful to define and solve problems with emphasis on acquisition, representation, retrieval, visualization and analysis of biological data.

Programme Objectives:

At the end of four years BS programme, the graduates should be able to understand:

1. Gene and protein sequence acquisition, storage, retrieval and analysis
2. Protein structure and function relationship using computational tools
3. Development of computational applications for processing of biological data
4. Modeling and simulation of biological systems.

Learning outcomes:

At the completion of this programme, students are expected to know the relationship between genes and proteins and use of computers in handling flood of biological data which started with the completion of Human Genome project. Bioinformatics is now an established discipline in the main stream of Biology and is a key to unlock the information coded in genome, transcriptome and proteome. Being a multidisciplinary field, it has diversified applications in domains like drug designing, agriculture biotechnology and system biology.

Admission Requirements

Eligibility:

Higher Secondary School certificate or equivalent (2nd division with at least 50% marks) in pre-engineering / pre-medical / Intermediate in computer sciences / relevant subjects.

Duration:

Four years programme spread over 8 semesters, two semesters per year.

Course and Credit Requirements:

A total of 124-136 credit hours are required to complete Bachelor of Science in Bioinformatics.

Evaluation:

For uniformity in the evaluation system, NCRC recommends that the minimum CGPA required for award of degree is 2.5 out of 4.0 at undergraduate level subject to meet all requirements of the university.

STANDARDIZED FORMAT / SCHEME OF STUDIES FOR FOUR-YEAR INTEGRATED CURRICULA FOR BACHELOR DEGREE IN BIOINFORMATICS

STRUCTURE

Sr.	Categories	No. of courses Min – Max	Credit Hours Min – Max
1.	Compulsory Requirement (No Choice)	9 – 9	25 – 25
2.	General Courses to be chosen from other departments	7 – 8	21 – 24
3.	Discipline Specific Foundation Courses	9 – 10	30 – 33
4.	Major Courses including research project / Internship	11 – 13	36 – 42
5.	Electives within the major	4 – 4	12 – 12
	Total	**40 – 44**	**124 – 136**

- Total numbers of Credit hours 124-136
- Duration 4 years
- Semester duration 16-18 weeks
- Semesters 8
- Course Load per Semester 15-18 credit hours
- Number of courses per semester 4-6 (not more than 3 lab / practical courses)

LAYOUT

Compulsory Requirements (the student has no choice)		General Courses to be chosen from other departments		Discipline Specific Foundation Courses	
9 courses		**7-8 courses**		**9-10 courses**	
25 Credit hours		**21-24 Credit hours**		**30-33 Credit hours**	
Subject	**Cr. hr.**	**Subject**	**Cr. hr.**	**Subject**	**Cr. hr.**
1. English Comprehension	3	1. Programming Fundamentals	4	1. Linear Algebra and Differential Equations	**3**
2. Islamic Studies and Pak Studies	4	2. Data Structure and Algorithms	4	2. Essentials of Genetics	**3**
3. Basic I (Biology/Mathematics)	4	3. Object oriented programming	4	3. Biostatistics	**3**
4. Basic II (Chemistry/ Computer fundamentals)	4	4. Ethical and legal issues in Bioinformatics	2	4. Bioinformatics I	**3**
5. Communication Skills	3	5. Discrete Structures	3	5. Bioinformatics II	**4**
6. Basic Cell Biology	4	6. Database System	4	6. Biochemistry I	**4**
7. Basic Calculus	3	7. Modeling and Simulation	3	7. Biochemistry II	**4**
		8. Technical Report Writing	3	8. Molecular Biology	**4**
				9. Research Methodology	**2**
	25		**27**		**30**

Major courses including research project/internship		Elective Courses within the major	
11-13 courses		**4 courses**	
36-42 Credit hours		**12 Credit Hours**	
Subject	**Cr. hr.**	**Subject**	**Cr. hr.**
1.Bioinformatics Computing I	4	**Elective I**	4
2.Genomics	3		
3.Proteomics	3	**Elective II**	3
4.Graphics and Visualization	4		
5.Bioinformatics Computing II	3	**Elective III**	3
6.Artificial Intelligence	3		
7.Bioinformatics software Engineering	3	**Elective IV**	4
8.Special topics in Bioinformatics	3		
Research Project	6		
	32		**14**

Scheme of Studies for BS (Bioinformatics)

Course Code	Semester 1	Credit hours	
	Courses	Lectures	Lab
Hum-101	English Comprehension	3	0
Hum-102	Islamic Studies and Pakistan Studies	2+2	0
Bio-101/MTH-101	Basic I (Biology/Mathematics)*	3	1
Bio-102/CS101	Basic II (Chemistry/ Computer fundamentals)*	3	1
	*Deficiency courses		
	Total Credit Hours	**13**	**2**

Course Code	Semester 2	Credit hours	
	Course	Lectures	Lab
Hum-103	Communication skills	3	0
Bio-103	Basic Cell Biology	3	1
CS-102	Programming Fundamentals	3	1
BSI-191	Basic Calculus	3	0
Bio-104	Biochemistry-I	3	1
	Total Credit Hours	**15**	**3**

Course Code	Semester 3	Credit hours	
	Courses	Lectures	Lab
Hum-201	Technical Report Writing	3	0
MTH-201	Linear Algebra and Differential Equations	3	0
Bio-201	Essentials of Genetics	2	1
Bio-202	Molecular Biology	3	1
CS-201	Data Structure and Algorithms	3	1
	Total Credit Hours	**14**	**3**

Course Code	Semester 4	Credit hours	
	Courses	Lectures	Lab
BI-201	Bioinformatics I	2	1
Bio-203	Biostatistics	3	0
Bio-204	Biochemistry II	3	1
BI-202	Ethical and Legal Issues in Bioinformatics	2	0
CS-202	Object Oriented Programming	3	1
	Total Credit Hours	**13**	**3**

Course Code	Semester 5	Credit hours	
	Courses	Lectures	Lab
CS-301	Discrete Structures	3	0
Bio-301	Research Methodology	2	0
CS-302	Database Management Systems	3	1
BI-301	Bioinformatics II	3	1
Bio-302	Genomics	3	0
	Total Credit Hours	**14**	**2**

Course Code	Semester 6	Credit hours	
	Courses	Lectures	Lab
BI-302	Bioinformatics Computing I	3	1
CS-303	Modeling and Simulation	2	1
Bio-303	Proteomics	3	0
CS-304	Graphics and Visualization	3	1
***	Elective I	3	0
	Total Credit Hours	**14**	**3**

Course Code	Semester 7	Credit hours	
	Courses	Lectures	Lab
BI-401	Bioinformatics Computing II	3	0
CS-401	Artificial Intelligence	3	0
***	Elective II	3	1
***	Elective III	3	1
	Research Project	0	3
	Total Credit Hours	**12**	**5**

Course Code	Semester 8	Credit hours	
	Courses	Lectures	Lab
BI-402	Bioinformatics Software Engineering	2	1
BI-403	Special Topics in Bioinformatics	3	0
***	Elective IV	3	1
	Research Project	0	3
	Total Credit Hours	**8**	**5**

Grand Total Credit Hours	**103**	**26**

DETAIL OF COURSES
Semester-I

Hum-101 English Comprehension 3+0

Annexure - A

Hum-102 Pakistan Studies 2+2

Annexure - B

Hum-102 Islamic Studies 2+2

Annexure - C

MTH-101 Basic Mathematics 3+0

Prerequisite: None

Specific objectives of the course:

This is a deficiency course for students who have not studied mathematics at the intermediate level. The basic concepts of trigonometry, linear algebra and vectors are introduced in this course.

Course Outline:

Basic concepts of Linear Algebra, introduction of Trigonometry, Using graphs, Graph transforms, Combination and Permutations, Introductory concepts in Integration and Derivatives, Exponentials, Logarithms, Basic concepts related to Complex Numbers, Basic probability, Introduction to Linear Equations and Algebraic Functions, Sequence and series, Introductory concepts of Vectors and various applications of Vector calculus.

Recommended Books:

Latest editions of following books

1. "Modular Math" by Heinemann.
2. "Core Mathematics" by Keith Pledger.

Bio-101 Basic Biology 3+1

Prerequisite: None

Specific objectives of the course:

To provide students with a biological foundation on which they can build a graduate degree in natural and physical science.

Course Outline:

Basic concepts of life science: origin of life; biological times scale, branches of biology, prokaryotic and eukaryotic cells, viruses, structure of viruses and

bacteriophages, bacteria, bacterial structure and classification; algae, fungi. Introduction to plant and animal biology, role of biology in medicine.

Lab Outline:

Study of plant and animal cell structure using compound microscope, culture and staining of microorganisms, study of mitosis and meiosis, study of flowers.

Recommended Books:

Latest editions of following books

1. Campbell and Mitchell, Biology. Concepts and connections. Wesley Longman Inc. New York.
2. Star C. Biology Concepts and Applications
3. Fogiel M. The Biology Problem Solver. Published by Research & Education Association.

Bio-102 **Chemistry** **3+1**

Prerequisite: None

Specific objectives of the course:

This is a deficiency course and will familiarize students with basic principles, concepts and theories in chemistry.

Course Outline:

Periodic table, nature of chemical bonding, state of matter, properties of solutions; properties of liquid vapor pressure, surface tension viscosity, optical activity, refractometry, liquid properties of water as solvent structure and interaction, chemical reactivity, acid, bases, oxidation-reduction reactions, chemical kinetics, First, second, and third order reactions, influence of temperature on reaction rates, polymers and colloids, introduction to organic chemistry.

Lab Outline:

Preparation of molar and normal solutions, use of pH meter to determine pH of various solutions, acid base titration, use of spectrophotometer to determine the absorbance, determination of melting point and boiling point.

Recommended Books:

Latest editions of following books

1. Brown *et al*. Chemistry the central Science Pearson Printing Hall.
2. Raymond Chang. Chemistry. McGraw Hill.
3. Christopher J. Crammer. Computational Chemistry Theories and Models. John Willey & Sons.
4. Philips / Mathews. Advanced Chemistry. Physical and Industrial, Cambridge University Press.

CS101 Computer Fundamentals 3+1

Prerequisite: None

Specific objectives of the course:

This course focuses on introducing computing environments, general application software, basic computing hardware, operating systems, desktop publishing, Internet, software applications and tools and computer usage concepts.

Course Outline:

History, classification, computer and society, overview of numbering system with various Boolean functions, flow chart techniques, storage, programs & software, system software, application software, operating systems, office automation tools: word processing, graphics packages, databases and spreadsheets, various operating systems, current trends and research prospects. Legal and moral aspects of computing.

Lab Outline:

Computation of Number system, Implementation of Boolean Functions, Basic machines organization including motherboard, memory, I/O cards, Networking devices, Use of flow charts, Introduction to office tools, overview of different browser including open source browsers, Introduction to various operating systems.

Recommended Books:

Latest editions of following books

1. "Introduction to Computer Science", P.K Sinha
2. "Computer Science- An Overview", Glenn Brooks.

Semester-II

Hum-103 Communication Skills 3+0

ANNEXURE - A

Bio-103 Basic Cell Biology 3+1

Prerequisite: None

Specific objectives of the course:

This course provides the basic concepts of life science, with emphasis on diversity of life, physical and chemical nature of living matter, the form and function of the cell and organisms.

Course Outline:

An introduction to cell biology, differences between prokaryotes and eukaryotes, physio-chemical properties of protoplasm, cell wall, cell

membrane, structure and transport properties, fluid mosaic model organelles, mitochondria, endoplasmic reticulum, golgi bodies, plastids, lysosmes, peroxisomes, cell internal structure, cytoskeleton, microtubules microfilaments, intermediate filaments, structure of chromosomes, cell cycle.

Lab Outline:

Study of cell structure using compound microscope and elucidation of ultra-structure from electron microphotographs, measurement of cell size, study of mitosis and meiosis by smear/squash method and from prepared slides, study of chromosome morphology and variation in chromosome number.

Recommended Books:

Latest editions of following books

1. David M. P. Academic Press London, Methods in Cell Biology Lowery Sekivetz. Cell Structure and Function. John Willey and Sons Publication.
2. Gerald Carp. Cell Biology.
3. Lodish H. Molecular Cell Biology. Media Connected
4. Lewin B. Genes VIII. Pearson/Prentice Hall.
5. Robertes, Cell and Molecular Biology.

CS-102 Programming Fundamentals 3+1

Prerequisite: Basic Math

Specific objectives of the course:

The course is designed to familiarize students with the basic programming skills. It emphasizes upon problem analysis, algorithm designing, program development and testing.

Course Outline:

Overview of computers and programming, overview of language for e.g. C language, basics of structured and modular programming, basic algorithms and problem solving, development of basic algorithms, analyzing problem, designing solution, testing designed solution, fundamental programming constructs, translation of algorithms to programs, data types, control structures, functions, arrays, records, files, testing programs.

Lab Outline:

Introduction to various programming paradigms, Coding, executing and debugging simple programs, Implementation of simple control structures, Implementation of functions, arrays, records, file input / output techniques.

Recommended Books:

Latest editions of following books

1. R. P. Halpern, “C for Yourself – Learning C Using Experiments”, Oxford University Press.
2. “Using Information Technology”, William.
3. “Computer Organization & Architecture”, William.

BS-191 Basic Calculus 3+0

Prerequisite: None

This course will familiarize students with the basic principles of calculus and their application to problem solving.

Course Outline:

Introduction to Functions: Mathematical and physical meaning of functions, graphs of various functions, Introduction to Limits: Theorems of limits and their applications to functions. Derivatives: Introduction to derivatives, Partial derivatives and their geometrical significance Application problems (rate of change, marginal analysis) Higher derivatives: Mean value theorem. Applications of derivatives: curvature and radius of curvature, maxima and minima of a function Applications of Partial Derivatives: Integral calculus: Methods of integration by substitutions and by parts, reduction formulae, Applications of integral calculus: Vector algebra: Introduction to vectors, Vector calculus: Vector differentiation, vector integration and their applications.

Recommended Books:

Latest editions of following books

1. Calculus by Thomas Finney.
2. Brief Calculus and its applications by Doniel D. Benice.
3. Applied Calculus by Raymond A. Barnett.
4. Calculus by Gerald L. Bradley.

Bio-104 Biochemistry-I 3+1

Prerequisite: None

Specific objectives of the course:

The course will provide fundamental knowledge about chemistry of biomolecules.

Course Outline:

Water, pH and buffer systems, molecules of life, nucleic acid as genetic material, lipids, bilayers and membranes, saccharide chemistry, mono, di and polysaccharides, amino acids the building block of proteins, levels of

protein structures, protein structure and folding, physiological role of proteins, role in catalysis and signaling.

Lab Outline:

Hydrolysis of a protein and qualitative tests for amino acids; paper chromatography of amino acids; estimation of proteins by Lowry's, dye-binding, titration curves of amino acids. Distinction between pentoses and hexoses, reducing and non-reducing sugars, acid value, saponification and iodine values of fat.

Recommended Books:

Latest editions of the following books

1. Nelson and Michel. LEHNINGER Principles of Biochemistry. Pub Freeman and Company.
2. Conn and Stumpf. Outlines of Biochemistry. John Willey and Sons Pub.
3. Devlin and Thomas. Text book of Biochemistry with Clinical Correlations.
4. Campbell M. and Shawn F. Biochemistry.
5. Voet and Voet Biochemistry John Wiley and Sons.

Semester-III

Hum-201 Technical Report Writing 3+0

ANNEXURE - A

MTH-201 Linear Algebra and Differential Equations 3+0

Prerequisite: None

Specific objectives of the course:

This course introduces matrices, determinants and differential equations for solving linear equations.

Course Outline:

Introduction to matrices, elementary row operations and vector spaces: Brief introduction to matrices, system of linear equations, system of non-homogeneous and homogeneous linear equation, determinants, introduction to determinants, properties of determinants of order, axiomatic definition of a determinant, multiple integrals, double integrals, differential equations of first order, initial and boundary conditions, methods of solution of differential equation of first order and first-degree, separable equations, homogeneous equations, equations linear equations, Bernoulli equations, applications of first order differential equations, Higher order linear differential equations, homogeneous linear equations, solution of higher order differential equation.

Recommended Books:

Latest editions of following books

1. Linear Algebra, David C. Lay, Pearson Addison Wesley.
2. Advanced Engineering Mathematics, Michael Greenberg.
3. Advanced Engineering Mathematics,7/e, Erwin Kreyszig. John Wiley & Sons.

Bio-201 Essentials of Genetics 2+1

Prerequisite: Biochemistry 1

Specific objectives of the course:

This course provides the basic principles of inheritance and students will gain experience in variety of molecular techniques used in gene analysis.

Course Outline:

Genetics introduction, heredity and variations, Mendelian and non-Mendelian inheritance, chromosomal structure, chromosomal theory of heredity, multiple allelic, linkage and gene mapping, polygenic inheritance, epitasis, epigenetics, penetrance and expressivity, chromosomal aberrations, gene mutation, genetic disorders; DNA polymorphism.

Lab Contents:

Chromosome staining, Problems solving related to Mendelian inheritance – DNA extraction; PCR, Southern blotting techniques etc.

Recommended Books:

Latest editions of following books

1. Strickburger, Principles of Genetics.
2. Gardner, Principles of Genetics, UHR.
3. Griffith et al., An Introduction to Genetics analysis, W. H. Freeman.
4. William S. Klug, Michael Cummings. Essentials of Genetics 5th 2005. Pearson/Prentice Hall.
5. Ricky Lewis: Human Genetics. McGraw Hill Sixth ed 2005.

Bio-202 Molecular Biology 3+1

Prerequisite: Biochemistry 1

Specific objectives of the course:

This course is to teach the students about organization of genetic material, and its role in gene expression.

Course Outline:

Basic concepts about DNA, RNA and proteins with special emphasis on nature of genetic material and its organization in viruses, prokaryotes and eukaryotes, DNA replication, recombination, mutations and repair, transcription, regulatory elements, regulation of gene expression. RNA

processing, splicing and editing, translation and post-translational modifications, control of gene expression in prokaryotes and eukaryotes. Introduction about plasmids and vectors.

Lab Outline:

Isolation of plasmid and chromosomal DNA from bacteria and yeast. PCR, gel electrophoresis, comparing plasmids of different molecular weights using molecular weight markers, transformation in *E. coli.*

Recommended Books:

Latest editions of following books

1. Robert Weaver. Molecular Biology. McGraw Hill.
2. Benjamin Lewin. Genes VIII. Pearson/Prentice Hall.
3. Gerald Carp. Cell and Molecular Biology concepts and Experiments, John Willey and Sons Publications.
4. Brown T. A. Molecular Biology Lab .FEX. Academic Press Publication.

CS-201 Data Structure and Algorithms 3+1

Prerequisite: Programming Fundamentals

Specific objectives of the course:

It describes data structures and explains some common data structures and their implementation.

Course Outline:

Introduction to data structures and algorithms, definitions, overview of algorithms, basics of array data structure, basic data structure functions, store, retrieve and search, idea of big O notation, uses of arrays, concept of binary search and linear search, simple sorting techniques. Stacks and queues, overview of stacks, queues, sorting techniques, selection sort, insertion sort and bubble sort. Comparison of sorting techniques and their applications, priority queues, store, retrieve and search functionalities in stacks and queues, linked list, double ended links, linked list efficiency, sorted list. Recursion application, Triangular Numbers, Factorials. Merge Sort.

Lab Outline:

Implementation of Basic Arrays, storing and Searching data in Arrays, İmplementation of Linear Search, implementation of Binary Search in Arrays, Using Bubble Sort, Selection Sort and Insertion on sample data, Comparison study of simple sorting techniques, implementing Stacks and Queues, using priority queues for special cases, İmplementation of different types of Linked Lists for various applications.

Recommended Books:

Latest editions of following books

1. Data Structures and Algorithms By Robert Lafore,
2. An introduction to Bioinformatics Algorithms. Neil C. Jones, Pavel Persner
3. Gary Benson and Rodric Page. Algorithms in Bioinformatics Singapore, New York.

Semester-IV

BI-201 Bioinformatics-I 2+1

Prerequisite: Computer science 101

Specific objectives of the course:

This course presents the basic principles and concepts in exploring sequence storage, retrieval and analysis.

Course Outline:

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 Outline:

Accessing ncbi databases, sequence databases, Genbank, EMBL, SWISS-PROT Accessing structure database PDB, SCOP and CATH, Expasy 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.

Bio-203 Bio-statistics 2+1

Prerequisite: None

Specific objectives of the course:

This course introduces the concepts of statistical methods used in analyzing biological data.

Course Outline:

Frequency distribution and probabilities, measure of central tendencies and dispersion, standard distributions and tests of significance. Test of independence or association, method related to one and two means, variance and covariance, heritability and its uses, Bayesian statistics, analysis of variance (ANOVA), and regression analysis, use of basic software.

Lab Outline:

Collection of data, acquisition of random samples, graphical/tabular representation of data, MS-Excel, SPSS, problems related to combining probabilities, central tendencies and dispersion, problems related to chi-square, problems of goodness of fit and independent events, verification of genetic ratios and test of association.

Recommended Books:

Latest editions of following books

1. Gravetter Frederick J. Statistics for Behavioral Sciences.
2. Mead R Curnow R. N. Statistical Methods in Agriculture and Experimental Biology. Chairman and Hall.
3. Mathews and Farewell: Using and understanding Medical Statistics, Krager New York.

Bio-204 Biochemistry II 3+1

Prerequisite: Biochemistry I

Specific objectives of the course:

This course focuses on macromolecules and their metabolisms with emphasis on various cellular pathways.

Course Outline:

Study of bioenergetics, introduction to metabolic pathways, metabolism of carbohydrates, Glycolysis, Citric acid cycle, Pentose pathway, electron transport chain, and oxidative phosphorylation, lipid metabolism, β-oxidation, ketone bodies formation and biosynthesis of triglyceride, protein metabolism, oxidative deamination and decarboxylation, transamination,

urea cycle and amino acids metabolism, nucleic acid metabolism, break down and synthesis of pure and pyramidine bases.

Lab Outline:

Estimation of normal and abnormal constituents in urine including glucose, albumin, uric acid, chloride and phosphate, Kidney Function test, Liver function test.

Recommended Books:

Latest editions of following books

1. Nelson and Michel. LEHINGER Principles of Biochemistry. Pub Freedman and Company.
2. Conn and Stumpf. Outlines of Biochemistry. John Willey and Sons Pub.
3. Devlin and Thomas. Text book of Biochemistry with Clinical Correlations.
4. Campbell M and Shawn F. Biochemistry. Thomas Book Pub.

BI-202 Ethical & Legal Issues in Bioinformatics 3+0

Prerequisite (s): None

Specific objectives of the course:

This course introduces the ethical and legal aspects related to bioinformatics practices and products.

Course Outline:

Social context of computing and biology, Intellectual property, Privacy and civil liberties, Economic issues in bioinformatics, monopolies and their economic implications, effect of skilled labor supply and demand on the quality of bioinformatics products, pricing strategies in the bioinformatics domain, differences in access to bioinformatics resources and the possible effects thereof. Health, psychological and legal issues in GMOs. Biosafety and Bio-security issues.

Recommended Book:

Latest editions of following books

1. Legal and Ethical Issues in Acquisitions. Edited by Katina Strauch. A Bruce Strauch.
2. Computer Ethics: Cautionary Tales and Ethical Dilemmas in Computing By Tom Forester, Perry Morrison.
3. Public Management Information Systems**.** By Bruce A Rocheleau.
4. Security in Computing**.** By Willis H. Ware, Charles P. Pfleeger, Shari Lawrence Pfleeger.
5. Computer Ethics: Cautionary Tales and Ethical Dilemmas in Computing By Tom Forester, Perry Morrison.

CS-202 Object Oriented Programming 3+1

Prerequisite (s): Programming Fundamentals

Specific objectives of the course:

The course focuses on object-oriented concepts, analysis and software development.

Course Outline:

Concept of object oriented programming (OOP), characteristics of OOP, polymorphism, encapsulation, data hiding. Java introduction, byte code, architectural neutral language, simple programs, compiling and execution, dynamic initializing, scope and lifetime of variables, type conversion and casting, the type promotion rules, arrays, string data type, arithmetic operators, Bit wise operators, relational operators, boolean logical operators. Introducing classes, declaring objects, object reference, control access, specified, public, private, static, data member and methods. Creating packages, constructors, function overloading, constructor overloading, reference, members, inheritance, polymorphism, dynamic method binding, inner class definitions, concatenating strings, string constructors, string comparing, string methods, string concatenating, string classes, string methods, Friend function, virtual functions, inline functions, Abstract classes, Interfaces.

Lab Outline:

Programs formulation according to the Course outlines.

Recommended Book:

Latest editions of following books

1. Complete Reference Java by “Herbert Schildt”.
2. Object Oriented Programming by “Robert Lafore”, JAVA How To Program Third edition by Deitel & Deitel.

Semester-V

CS-301 Discrete Structures 3+0

Prerequisite: Basic Calculus

Specific objectives of the course:
Introduces the fundamentals of discrete mathematics as they apply to Computer Science, focusing on providing a solid theoretical foundation.

Course Outline:
Logic and proofs, direct proofs, proof by contradiction. Sets, combinatorics, sequences, formal logic, prepositional and predicate calculus, methods of proof, mathematical induction and recursion, loop invariants, relations and functions, Pigeonhole principle, trees and graphs, elementary number theory, optimization and matching. Fundamental structures, functions, relations (more specifically recursions), cardinality and countability, probabilistic methods.

Recommended Books:
1. Kenneth H. Rosen, *Discrete Mathematics and Its Applications*, 6th edition, 2006, McGraw Hill Book Co.
2. Richard Johnsonbaugh, *Discrete Mathematics,* 7th edition, 2008, Prentice Hall Publishers.
3. Kolman, Busby & Ross, *Discrete Mathematical Structures*, 4th edition, 2000, Prentice-Hall Publishers.
4. Ralph P. Grimaldi, *Discrete and Combinatorial Mathematics: An Applied Introduction*, Addison-Wesley Pub. Co., 1985.

Bio-301 Research Methodology 2+0

Prerequisite: Biochemistry 101

Specific Objectives of course:
The basic concept of this course is to provide knowledge about how to design a research project and present it a professional manner.

Course Outline:
The main objectives of this course are: to understand the concepts of basic and applied research and their usefulness, formulation of research objectives, literature search, study designing, collection & compilation of research data, biostatistical methods used in data analysis, development of writing skills, use of reference manager software (Endnote).

Recommended Books:
Latest texts related to research methodology.

CS-302 Database Management Systems 3+1

Prerequisite: None

Specific objectives of the course:
The course aims to introduce basic database concepts, different data models, storage and retrieval techniques, database design techniques.

Course Outline:
Basic database concepts, conceptual modeling, hierarchical, network and relational data models, relational theory and languages, databases design, database security and integrity, query languages, relational calculus, relational algebra, SQL, introduction to query processing and optimization, introduction to concurrency and recovery, front-end and back-end databases.

Lab Outline:
Structures Query Language commands, creating and populating tables, design of simple databases, database normalization techniques, query optimization, indexing techniques, partial and full recovery techniques, developing GUI techniques, implementation of database security mechanisms.

Recommended Books:
Latest editions of following books

1. Data Structures and Algorithms By Robert Lafore,
2. An introduction to Bioinformatics Algorithms. Neil C. Jones, Pavel A.Persner
3. Gary Benson and Rodric Page, Algorithms in Bioinformatics Singapore, New York.

BI-301 Bioinformatics-II 3+1

Prerequisite: Bioinformatics I

Specific objectives of the course:
This course is designed to develop understanding of gene and protein at structural level using computational tools.

Course Outline:
Introduction to genome, gene prediction in prokaryotes and eukaryotes, ORF, TFBS, codon usage table, EST and SNP databases, primer designing, restriction enzyme databases, RNA structure prediction, computational secondary and tertiary protein structure prediction methods, hydrogen bonding, PTMs of proteins, Chou Fasman, PHD and PSIPred, neural network, X-ray crystallography, NMR, *ab initio*, threading and homology modeling, structure prediction evaluation, protein fold identification using Pfam (A & B) and other tools.

Lab Contents:
Online tools: Gene finder, ORF finder, EST database, SNP data, Primer 3, protein structure prediction using online server, protein structure visualizing using visualization programs, Secondary structure prediction, using pfam database.

Recommended Books:
Latest editions of following books
1. David Mount Bioinformatics: Sequence and Genome analysis Cold Spring Harbour Laboratories.
2. Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery.PHI Learning Pvt. Ltd.
3. Bioinformatics and drug discovery Humana Press.

Bio-302 Genomics 3+0

Prerequisite: Biochemistry I/Molecular Biology

Specific objectives of the course:
Students will be trained to grasp knowledge about structural and functional genomics and their applications.

Course Outline:
Introduction to genomics, genome anatomy, gene expression, genome evolution, genome mapping, DNA markers, linkage analysis. QTL, mutations, Human Genome Project, Microarray, Genevestigator, Non-coding RNAs and their regulation, siRNA.

Recommended Books:
Latest editions of following books
1. David Mount Bioinformatics Sequences and Genome Analysis. CSB publishers and distributors.
2. Bioinfomatics: Sequence and Genome: Analysis, CBS publisher & distributors New Delhi Bangalore by Spring Harbour laboratory press.

Semester-VI

BI-302 Bioinformatics Computing-I 3+1

Prerequisite: Programming Fundamentals

Specific objectives of the course:
This course aims to introduce the concepts of data representation, searching, security and ownership. Develop techniques for pattern matching, recognition and their applications in bioinformatics.

Course Outline:
Databases: Data management, networks, geographical scope, communications models, transmissions technology, protocols, bandwidth, topology, hardware, contents, security, ownership, implementation, Search engines. Search process, search engine technology, searching and information theory, computational methods, knowledge management, data, sequence and structure visualization, data mining methods and technology, pattern recognition and discovery, pattern matching, dot matrix analysis, substitution matrices, dynamic programming, Scripting.

Lab Outline:
Simulation of various bioinformatics entities, application of various bioinformatics methods, scripting languages python, perl and PHP, and their applications in Bioinformatics.

Recommended Books:
Latest editions of following books
1. "Bioinformatics Computing" Bryan Borgeron, Pearson Education.
2. "Methods in Biotechnology and Bioengineering", Vyas S.P. and Kohli D.V.

CS-303 Modeling & Simulation 2+1

Prerequisite: Programming Fundamentals

Specific objectives of the course:
This course emphasizes the development of modeling and simulation concepts and analysis skills necessary to design, program, implement, and use computers.

Course Outline:
Performance modeling and evaluation, bench marking, performance evaluation of high parallel systems architecture, application of performance evaluation, measurement techniques, hardware monitoring, software monitoring, hybrid monitoring, fundamentals of queuing models, structure and performance parameters, operational analysis of queuing models, general features of queuing models, birth and death processes, m/m/i and m/g/1 systems, dependability modeling, analysis of reliable, available and

high assurance systems, fault-tolerant techniques, software reliability modeling, adaptive modeling, agent based modeling.

Lab Outline:

Introduction to modeling techniques using simulation tools like MATLAB toolbox for various performance modeling and evaluation of high parallel systems. Using toolbox for analysis and study various faulty tolerant techniques, study queuing techniques.

Recommended Books:

Latest editions of following books

1. Complete Reference Java 2 by “Herbert Schildt”.
2. Object Oriented Programming by “Robert Lafore”, JAVA How to Program by Deitel & Deitel.
3. Computer Graphics *(C Version)*, by Donald Hearn and M. Pauline Baker (Prentice Hall).
4. Flash Professional *8,* by M. Waqar Aziz.

Bio-303 Proteomics 3+0

Prerequisite: Biochemistry I /Molecular Biology

Specific objectives of the course:

This course intends to provide basic concepts regarding proteome and protein chemistry with special focus on protein identification techniques.

Course Outline:

Introduction to proteomics and protein chemistry, techniques in proteomics, iso-electric focusing, one dimensional and two dimensional electrophoresis and analysis, Mass spectrometry, bioinformatics tools for analysis of proteomics data, proteomics databases, MS data analysis, peptide mass and fragment fingerprinting, protein identification, post-translational modification, protein-protein interaction, applications of proteomics.

Recommended Books:

Latest editions of following books

1. Richerd Simpson J. Purifying Proteins for Proteomics (a laboratory manual) Cord Spring Harbor Laboratory Press.
2. Rastogi *et al.* Bioinformatics methods and applications. Genomics, Proteomics and Drug discovery.

CS-304 Graphics and Visualization 3+1

Prerequisite: Programming Fundamentals

Specific objectives of the course:

This course introduces algorithms and tools for data visualization and its applications to data manipulation.

Course Outline:

Graphics hardware, fundamental algorithms, applications of graphics, interactive graphics programming, graph plotting, windows, clipping and segmentation, programming raster display systems, panning and zooming, Raster algorithms and software, scan-converting lines, characters and circles, region filling, two and three dimensional imaging geometry and transformations, curve and surface design, rendering, shading, colour, and animation.

Lab Outline:

Line drawing techniques, clipping effects, 2D and 3D representations and transformations using open GL, development of graphical user interface with various blocks and modules, elliptical and curve creation exercises.

Recommended Books:

Latest editions of following books

1. “Computer Graphics”, by Donald Hearn and M. Pauline Baker, Prentice Hall.

Elective-I 3+0

Prerequisite: None

Course Outline:

To be chosen from the list of electives.

Semester-VII

BI-401 Bioinformatics Computing-II 3+1

Prerequisite: Bioinformatics Computing- I

Specific objectives of the course:
This course introduces advanced concepts of artificial intelligence, neural networks and pattern recognition for solving bioinformatics problems.

Course Outline:
This course emphasized on cellular, tissue, organ and system modeling, simulation, analysis using an object oriented programming languages, Bio-inspired computation, evolutionary algorithms, Swarm Intelligence, neural networks, application of neural networks to Bioinformatics, neural computation, approximate matching algorithm and their applications for DNA Matching.

Lab Outline:
Simulation and application of neural network related techniques for bioinformatics, implementation of approximate matching algorithms, DNA matching algorithms and applications.

Recommended Books:
Latest editions of following books

1. "Bioinformatics Concepts, Skills and Applications" Namita M, CSB Publishers.
2. "Bioinformatics Managing Scientific Data", Lacroix Zor, Morgan Kauffmann Publishers.

CS402 Artificial Intelligence 3+0

Prerequisite: Programming Fundamentals

Specific objectives of the course:
This course introduces the techniques of artificial intelligence for solving advanced problems using computers.

Course Outline:
Introduction to artificial intelligence, applications, problem solving, classical approach, generate and test, problem presentation, searching, tree and graph terminology, searching, branch and bound, improvements in branch and bound, common lisp. AI classical systems: general problem solver, rules, simple search, means-ends analysis. ELIZA, pattern matching, rule based translators, Knowledge Representation: natural language, rules, productions, predicate logic, semantic networks, frames, objects, scripts, hill climbing, min-max search, A* search, symbolic mathematics, solving

algebra problems, Logic Programming: Resolution, unification, horn-clause logic, prolog.

Recommended Books:

1. "Artificial Intelligence" by Ela Kumar, IK International.
2. "Artificial Intelligence: A Modern Approach", Stuart Russell and Peter Norvig.

Elective-II 3+1

Prerequisite: None

Course Outline:
To be chosen from the list of electives

Elective-III 3+1

Prerequisite: None

Course Outline:
To be chosen from the list of electives

Research Project 0+3

Prerequisite: None

Course Outline:
An independent research project and directed by the student and directed by a full time faculty member of the department.

Semester-VIII

Bio-406 Bioinformatics Software Engineering 2+1

Prerequisite:

Specific objectives of the course:
This course introduces the software engineering principles and methodologies with the goal of developing bioinformatics applications.

Course Outline:
Software development methodology, waterfall model, iterative model, rapid application development, prototyping, software life cycle. Development of software projects for bioinformatics problems, overview of software architecture, web based applications architecture, developing front end applications.

Lab Outline:
Introduction to software development techniques, implementation of various software models using simple case studies, introduction to HTML, XML, use of front end application tool.

BI-407 Special Topics in Bioinformatics 3+0

Prerequisite: Bioinformatics-I

Specific objectives of the course:
This course intends to introduce recent advances in bioinformatics.

Course Outline:
The course will review the major advances in Bioinformatics. Students are required to make presentation of the selected topics as determined by the faculty members / Coordinator conducting Bioinformatics Programme.

Recommended Books:
Latest editions of following books

1. Namita M. Bioinformatics concepts, skills and applications, CSB publishers and distributors.
2. Lacroix Zor. Bioinformatics managing scientific data, Morgan Kaufmann publishers.
3. Higgs Paul. G. Bioinformatics and Molecular evolution, Black well Publishing.
4. Schulze. S. Kremer. Advances in molecular Bioinformatics, Netherland Printing.

Elective-IV 3+1

Prerequisite: None

Course Outline:
To be chosen from the list of electives.

Research Project 0+3

Prerequisite: None

Course Outline:
An independent research project and directed by a full time faculty member of the department.

List of Electives

1. Enzyme Kinetics
2. Microarray Data Analysis
3. Human Computer Interaction
4. Nanotechnology
5. Environmental Biotechnology
6. Special Topics in Biochemistry
7. Immuno-Informatics
8. Microbial genomics and proteomics
9. Protein-protein interaction
10. Digital Image Processing
11. Gene Mining
12. Pattern recognition and matching
13. Biophysics
14. Modern programming languages
15. Medical Image processing

Note:

In addition to the above, the universities can offer any elective which they feel necessary subject to the availability of resources.

RECOMMENDED BOOKS:

The latest editions of:

Cell and Molecular Biology: Concepts and Experiments
Gerald Karp
John Wiley and Sons

Introduction to Computational Molecular Biology
Setubal, Meidanis
Brooks/Cole

Principles and Techniques of Biochemistry and Molecular Biology
Keith Wilson, John Walker
Cambridge University Press

Instant Notes: Biochemistry
B D Hames
Viva Books Pvt. Ltd.

Basics of Theoretical and Computational Chemistry
BM Rode
John Willey and Sons

Instant Notes: Genetics
P C Winter
Viva Books Pvt. Ltd.

Instant Notes: Molecular Biology
P C Turner
Viva Books Pvt. Ltd.

Molecular Cloning: A laboratory manual
Sambrook
Cold Dpring Harbor, Laboratory Press.

Instant Notes: Bioinformatics
David R. Westhead, J. Howard Parish and Richard M. Twyman
Viva Books Pvt. Ltd.

Bioinformatics for Dummies
Jean-Michel Claverie,Cedric Notredame
Wiley Publishing, Inc.

Essential Bioinformatics
Jin Xiong
Cambridge University Press.

Bioinformatics
Bal
Tata McGraw-Hill.

Bioinformatics
Andrzej Polański, Marek Kimmel
Springer.

Bioinformatics: An Introduction
Jeremy Ramsden
Springer.

Bioinformatics: A Concept-based Introduction
Venkatarajan Subramanian Mathura, Pandjassarame Kangueane
Springer.

Bioinformatics: Tools and Applications
David Edwards, Jason Eric Stajich, David Hansen Springer.

Bioinformatics: Principles and Basic Internet Applications
Hassan A. Sadek
Trafford Publishing, Canada.

Bioinformatics: Applications in Life and Environmental Sciences
M. H. Fulekar
Springer.

Bioinformatics: A Practical Approach
Shui Qing Ye
Chapman & Hall / CRC.

Applied Bioinformatics: An Introduction
Paul M. Selzer, Richard J. Marhöfer, Andreas Rohwer
Springer.

Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins
Andreas D. Baxevanis, B. F. Francis Ouellette
John Wiley and Sons, USA.

Bioinformatics: a Swiss perspective
Ron D. Appel, Ernest Feytmans
World Scientific, Singapore.

Bioinformatics: Genomics and Post-genomics
Frédéric Dardel, François Képès, Translated by Noah Hardy
John Wiley and Sons, France.

Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery
S. C. Rastogi, Namita Mendiratta, Parag Rastogi
PHI Learning Pvt. Ltd.

Bioinformatics and drug discovery
Richard S. Larson
Humana Press.

Computational molecular biology: an algorithmic approach
Pavel Pevzner
MIT Press.

Bioinformatics algorithms: techniques and applications
Ion Măndoiu, Alexander Zelikovsky
Wiley-Interscience.

Bioinformatics: problem solving paradigms
Volker Sperschneider, Jana Sperschneider, Lena Scheubert
Springer.

Parallel computing for bioinformatics and computational biology
Zomaya A. Y.
John Wiley & Sons, Inc.

Research and trends in data mining technologies and applications
David Taniar
Idea Group Inc (IGI).

Machine learning in bioinformatics
Yan-Qing Zhang, Jagath Chandana Rajapakse
John Wiley and Sons.

Computational Intelligence in Bioinformatics
Árpád Kelemen, Ajith Abraham, Yuehui Chen
Springer.

Bioinformatics and the Cell: Modern Computational Approaches in Genomics, Proteomics and Transcriptomics
Xuhua Xia
Springer.

Bioinformatics for Dummies 2nd Edition
Jean-Michel Claverie and Cerdric Notredame

Bioinformatics-Sequence and Genome Analysis
David W. Mount.

Introduction to Bioinformatics
T K Attwood and D J Parry-Smith.

Bioinformatics-Gene, Proteins and Computers
C. A. Orengo, D. T. Jones and J. M. Thornton.

MASTER OF SCIENCE (MS) IN BIOINFORMATICS

Introduction:

The purpose of MS degree programme in bioinformatics is to provide the students with an advanced knowledge and practices that will train them to decipher the biological processes with the help of computational tools. Exponential growth and complexity of biological data can be translated effectively into knowledge by the use of computer based approaches.

General objectives

The enormous influx of biological data can only be handled with better and faster computational approaches together with advanced knowledge in functional genomics and proteomics. Advanced concepts, structures, algorithms and tools are required for effective processing and analysis. Specialized courses in molecular biology, bioinformatics and computation are needed to achieve these objectives.

Learning Outcomes

After completion of MS program in bioinformatics, the graduates will be able to

- answer fundamental questions about molecular evolution, biological functions and control of biological systems.
- use bioinformatics skills predicting functions from structures, networks, complexes, transcriptome and proteome data.
- design novel genes/proteins and small molecules with specific functions.
- develop advanced computational applications related to bioinformatics

Admission Requirements:

Eligibility:

1. BS in Bioinformatics/Biological Sciences/Computer sciences/ Biotechnology or equivalent in relevant disciplines (deficiency courses to be completed if needed).
2. 2nd Division or GPA 2.50 or above.
3. Subject GRE/NTS or in-house written test.
4. Interview.

Duration:

2 years (course work may be completed in two semesters and one year for research work).

Total Credit Hrs:

30 (24 credit hours course work + 6 credit hours thesis).

Scheme of Studies
for MS Programme in Bioinformatics

Course Code	Semester 1 (Credit hours)		Course Code	Semester 2 (Credit hours)	
	Courses	**Credit hours**		**Course**	**Lectures Lab**
BI-601	Advanced Bioinformatics	3		Elective I	3
Bio-601	Advanced Molecular Biology	3		Elective II	3
CS-601	Information Processing	3		Elective III	3
BI-602	Advanced Computing Approaches	3		Elective IV	3
Total Credit Hours		12	**Total Credit Hours**		12
Semester 3 & 4 (Credit hours)					
Research/Thesis			**6**		
Grand Total Credit Hours			**30**		

DETAIL OF COURSES
SEMESTER-I

BI-601 Advanced Bioinformatics 3

Prerequisite: None

Specific objectives of the course:
The objective of this course is to train students to develop methods and understanding for integration and analysis of biological data**.**

Course Outline:
Functional genomics, comparative genomics, DNA microarray, computer aided drug designing (ligand and receptor based), molecular docking, protein-protein interaction network and databases, molecular dynamics simulation, biological networks, transcriptome, metabolomics

Recommended Books:
Latest editions of following books
1. Schulze S. Kremer. Latest Ed. Advances in Molecular Bioinformatics. Netherland Printing.
2. S. C. Rastogi, Namita Mendiratta, Parag Rastogi Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery, PHI Learning Pvt. Ltd.

Bio-601 Advanced Molecular Biology 3

Prerequisite: None

Specific objectives of the course:
The students will learn most recent advances in molecular biology and molecular cloning techniques.

Course outline: Molecular nature of gene' methods of molecular biology; transcription in prokaryotes and eukaryotes; post transcriptional events; translation; DNA replication, recombination and transposition; homologous; homologous recombination. Genomics and proteomics etc.

Recommended Books:
Latest editions of following books
1. Wisden and Richered. Advanced Molecular Biology. Viva Book Private Ltd.
2. Benjamin Lewin: GENES. Pearson/Prentice Hall.
3. Robert Weaver. Molecular Biology, McGraw Hill.

CS-601 Information Processing 3

Prerequisite: None

Specific objectives of the course:

To introduce the principles of data analysis, association, classification, matching and their applications to bioinformatics.

Course Outline:

Classification, Bayesian networks, nearest neighbour and k-means clustering, decision tree learning, clustering and data/dimensionality reduction, sampling, feature selection and feature transformation approaches, machine learning for user modeling, data warehousing, advanced query processing, data mining, association analysis, sequence mining, introduction to web mining, content, structure and usage mining.

Recommended Books:

Latest editions of following books

1. Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze.
2. "Introduction to Information Retrieval", Cambridge University Press.
3. Ricardo Baeza-Yates and Berthier Ribeiro-Neto, "Modern Information Retrieval" ACM Press.
4. David A. Grossman and Ophir Frieder, "Information Retrieval: Algorithms and Heuristics", Springer.

BI-602 Advanced Computing Approaches 3

Prerequisite: None

Specific objectives of the course:

This course provides knowledge on advanced principles and applications of biological data analysis and processing.

Course Outline:

Introduction to microarray experiments: principles and experimental design, biomedical image analysis (2D gel, DNA and protein chips), advanced analysis of microarray data, exploratory data analysis and visualization, cluster analysis: hierarchical clustering, k-means, gene shaving, correspondence analysis, multi-dimensional scaling, neural networks, unsupervised and supervised learning: discriminant analysis, error-rate concepts, tree-based methods, genetic algorithms, applications to genetic networks, genetic modeling.

Recommended Books:

Latest editions of following books

1. Image processing using Matlab, RC Gonzales.
2. Pattern classification by Huda & Hart.

SEMESTER-II

In Semester-II, four subjects will be selected from the following list of elective subjects:

LIST OF ELECTIVES

1. Computer aided drug designing
2. Advanced biotechnology
3. System biology
4. Programming for Bioinformatics
5. Data warehousing and data mining
6. Molecular dynamics simulation
7. Intelligent systems
8. DNA microarrays and integrative genetics
9. Functional genomics
10. Epidemiology
11. Advance topics in information systems
12. Neural Computing
13. Research Method in Biological Sciences
14. Advanced Algorithms
15. Current trends in bioinformatics
16. Gene regulation and expression
17. Principles and application of proteomics
18. Medical genetics
19. Epigenetics

Note: *In addition to the above the universities can offer any elective course subject to the availability of resources*

SEMESTER-III and IV

Research Thesis (6 Credit Hours):

Research Project:

1. Duration of the research project will be at least one full year. An independent research topic chosen by the student and supervised by a full-time faculty member of the department is required for all students in M.S Bioinformatics.
2. The research work of each student will be reviewed periodically by the supervisor/head of department to ensure the objectives laid down for study are being met.
3. All students must present and defend their research work before the panel of examiners as per the rules of the university.

Recommended Text Books For
MS Bioinformatics Programme

1. Bioinformatics: sequence and Genome Analysis, David W. Mount.
2. Bioinformatics: A practice Guide to Analysis of Gene and Proteins Andreas Baxevnis, B. F. Francis Ouellet.
3. Developing Bioinformatics Computer Skills, Cynthia Gibbs, Per Jambeck.
4. Discovering Genomics, Proteins and Bioinformatics, A. Makom Cambell, Laurie J. Heyer.
5. Microarray Bioinformatics, Dov Stekel, Ed Southern.
6. Introduction to Bioinformatics, Arthur M. Lesk.
7. Bioinformatics Computing, Bryan P. Bergeron.
8. A Primer of Genome Sequencing, Greg Gibson.
9. Instant Notes on Bioinformatics, Howard J. Parish.
10. Bioinformatics and functional Genomics, Donis Marshall, Jonathan Persner.
11. Bioinformatics: The Machine learning approach, Pierre Baldi, Sren Brunak, Soren Brunak.
12. An introduction to Bioinformatics, Algorithims Neil C. Jones, Pavel A. Persner.
13. Essentials of Genomics and Bioinformatics, C.W Sensen.
14. Bioinformatics, Biocomputing and Perl. An introduction to Bioinformatics Computing Skills and Practice Michael Moorhouse, Paul Berry.
15. Statistical Methods in Bioinformatics Warren Ewens, Gregory Grant.
16. Microarray for An Integrative Genomics S. Isaac, J-Atul, Alvin Khd
17. Bioinformatics; Sequence and Databanks: A Practical Approach Des Higgins, Willie Taylor.
18. Genomic Perl: From Basic To Workinf Code Rex A.Dwyer
19. Bioinformatics: From Genome To Drugs, Vol 1: Basic Technologies Vol 2: Application Thomas Lengauer.
20. Biotechnology, Genomics and Bioinformatics Teresa Atwood, David Perry-Smith
21. Introduction To Bioinformatics Teresa Atwood, David Perry-Smith
22. Structured Bioinformatics Philip Bourne, Helge Weissig
23. Bioinformatics Methods and Protocols Stephen Misener, Stephen Krawetz.
24. New Biology for Engineers and scientists, Aydin Tozeren, Stephen W.Byers.
25. Computational Molecular Biology: An Introduction, Peter Clote, RlfBackofen.
26. Bioinformatics in Post-Genomic Era: Genomic Transcription, Proteome and Information Based Medicine Jeffery Augen.
27. Bioinformatics: Using Computational Intelligence Paradims U. Seiffert, L.C.Jain, Pschwetzer

28. Introduction To Bioinformatics: a theoretical and Practical Approach Stephen Krawetz, David D.Womble.
29. Bioinformatics for Geneticsts, Michaeal R.Barens, Ian C.Gray.
30. Immunological Bioinformatics, Lund Ole Nielsen.
31. Bioinformatics Basics Hooman Rashidi, Lukas Buehler.
32. Bioinformatics: Genes, Proteins and Computers C.Orengo, D.Jones, J.Thornton.
33. Bioinformatics and Molecular Evolution Paul G. Higgs.
34. The Application of Bioinformatics in Cancer Detection Asad Umar
35. Bioinformatics, Ralf Hofestadt.
36. Bioinformatics, Genomics and Proteomics: Getting the Bio PictureAnn Batiza, Bernice Schacter
37. Knowledge Discovery in Proteomics Igor Jerisca, Dennis Wigle
38. Proteomics and Protein-Protein Introductions:
Biology, Chemistry, Bioinformatics and Drug Design, Gabreil Waksman
39. An introduction to Bioinformatics Jermy Ramsden.
40. Bioinformatics Basics: Application in Biological Science and Medicine Hookman Rashidi, Lukas Buehler.
41. Medical Genetics Lynn B.Jorde, Jhon C.Carey, Micheal .Bamshad, Raymound L. White
42. Essential of Genetics, William S.Klug, Michel R.Cummings.
43. Thompson & Thompson Genetics in Mediccine Robert I.Nussbaum, Rodreick R.Mclnnes. Huntington F. Willard.
44. Medical Molecular Genetics, Patrick A.Hoffe.
45. Genomics, Sandy Primose, Richard Twyman
46. Essential of Medical Genetics Alan Emery, Robert Mueller.
47. Gene VIII Benjamin Lewin.
48. Understanding Biotechnology,George Acquaah.
49. Concept of Genetics, William Klug, Michael Cumming
Charlotte Spencer
50. Essential Genes, Benjamin Lewin.
51. Cell and Molecular Gerald Karp
52. Microbiology; A Human Perspective Eugene Nester, Denise Anderson, C. Evans Robert Jr.
53. Genetics, Benjamin A. Pierce.
54. Ethics from a Faith Perspective, Jack Hanford.
55. A companion to Genetics Justine Burrley, John Harris
56. Understanding Medical Statistics David Mathews, Vernon Farewell
57. Molecular Biology, Robert Weaver.
58. Lipincot's Biochemistry Champe; Harvey; Ferrier.
59. Harper's; Biochemistry, Murray. Grammer, Mayes, Rodwell
60 Lehninger; Principles of Biochemistry Nelson , Cox.
61 Biochemistry Donlad Voet
62 Pattern Recognition, Statistical, Structural & Neural Approached Robert Schalkoff
63 Pattern Recognition with neural networks in C++ Pandya/Macy
64 Pattern Classification Duda, Hart and Stork.

65 Fundamentals of Pattern Recognition, Monique Pavel.
66 Texture Analysis in Machine Vision, M.K. Pietikainen.
67 Genetic Algorithms for Pattern Recognition, Pal/Wang.
68 Digital Image Processing R.C. Gonzales
69 Digital Image Processing using Matlab R.C. Gonzales
70 Hand Book of Image Processing John C.Russ
71 Algorithms for Image Processing & Computer Vision, J.R. Parker.

Annexure "A"

COMPULSORY COURSES IN ENGLISH FOR BS (4-YEAR) IN BASIC & SOCIAL SCIENCES

English I (Functional English)

Objectives: Enhance language skills and develop critical thinking.

Course Contents

Basics of Grammar
Parts of speech and use of articles
Sentence structure, active and passive voice
Practice in unified sentence
Analysis of phrase, clause and sentence structure
Transitive and intransitive verbs
Punctuation and spelling

Comprehension

Answers to questions on a given text

Discussion

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 Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.

c) Reading/Comprehension

1. Reading. Upper Intermediate. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.

d) Speaking.

English II (Communication Skills)

Objectives: Enable the students to meet their real life communication needs.

Course 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-Chrisitine Boutin, Suzanne Brinand and Francoise 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 York.

English III (Technical Writing and Presentation Skills)

Objectives: Enhance language skills and develop critical thinking

Course 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 Skills

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

Annexure "B"

Pakistan Studies (Compulsory)

Introduction/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.

Course Outline

1. **Historical Perspective**
   a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-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, Shahid Javed. *State & Society in Pakistan,* The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000.
3. S. M. Burke and Lawrence Ziring. Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots & Development.* Lahore, 1994.

5. Wilcox, Wayne. *The Emergence of Bangladesh.,* Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. *Pakistan Kayyun Toota,* Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
7. Amin, Tahir. *Ethno - National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development.* Kent England: WmDawson & sons Ltd, 1980.
9. Zahid, Ansar. *History & Culture of Sindh.* Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan,* Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan.* Boston: Houghton Mifflin, 1967.
12. Aziz, K. K. *Party, Politics in Pakistan,* Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective.* Islamabad: National Commission on Historical and Cultural Research, 1993.

Annexure "C"

ISLAMIC STUDIES
(Compulsory)

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.

Detail of Courses

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 of 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

Reference Books:

1) Hameed ullah Muhammad, “Emergence of Islam” , IRI, Islamabad.
2) Hameed ullah Muhammad, “Muslim Conduct of State”
3) Hameed ullah Muhammad, ‘Introduction to Islam.
4) Mulana Muhammad Yousaf Islahi,”
5) Hussain Hamid Hassan, “An Introduction to the Study of Islamic Law” leaf Publication Islamabad, Pakistan.
6) Ahmad Hasan, “Principles of Islamic Jurisprudence” Islamic Research

Institute, International Islamic University, Islamabad (1993).
7) Mir Waliullah, “Muslim Jurisprudence and the Quranic Law of Crimes” Islamic Book Service (1982).
8) H. S. Bhatia, “Studies in Islamic Law, Religion and Society” Deep & Deep Publications New Delhi (1989).
9) Dr. Muhammad Zia-ul-Haq, “Introduction to Al Sharia Al Islamia” Allama Iqbal Open University, Islamabad (2001)

RECOMMENDATIONS

1. Only limited numbers of universities are offering under- and post graduate courses in bioinformatics. There is a need to encourage other public and private universities/institutes to develop expertise in bioinformatics at their respective campuses.
2. HEC should allocate sufficient funds and grants on priority basis for faculty development in this newly emerging field, especially for universities/institutes, located in developing areas of Pakistan by sending their faculty members for the short and long-term training courses. This will help in elimination of shortage of specialized manpower in bioinformatics especially at the university level.
3. HEC should facilitate and provide funds for infrastructure and equipments for strengthening the existing program and initiating new programs in bioinformatics.
4. HEC should implement a strict policy of monitoring and evaluation of universities/institutes (both in public and private sectors) offering degree courses in bioinformatics and enroll students giving them false/deceptive information about the faculty, programs and facilities.
   In this regard a special committee should be constituted comprising of five members (02 biological sciences, 02 computational sciences, 01 HEC, taking at least one member preferably from a developing province).
5. Both under- and post graduate courses in bioinformatics should be included in teaching curriculum of the public and private sector of the universities and degree awarding institutes.
6. A comprehensive course in bioinformatics should be developed for students of other relevant disciplines.
7. To promote public awareness series of seminars and workshops should be organized on regular basis.
8. There should be a strong link between academia and industry for the absorption of bioinformatics graduates. This will encourage other students to take programs in bioinformatics.