STRUCTURE AND SYLLABUS OF MSc COURSEWORK

TO BE DISCUSSED IN THE

BOARD OF STUDIES (CENTRE FOR COMPUTATIONAL SCIENCES)

FOR

MSc Life Science (Bioinformatics)

2017-19

Central University of Punjab
Bathinda-151001

Eligibility Criterion for MSc Life Science (Bioinformatics) approved by BOS

Bachelor's degree in any branch of Life Sciences/ Pharmaceutical Sciences/ Mathematical Sciences/ Computer Sciences (or applications)/ Physical Sciences/ Chemical Sciences/ Veterinary Sciences/ Agricultural Sciences / Medical Sciences or B.Tech in CSE/IT/BioTech with 55% marks from a recognized Indian or foreign university.

Certificate

The Board of Studies of Centre for Bioinformatics certifies that the syllabus of MSc Life Science (Bioinformatics) has been designed to ensure maximal overlap with the CSIR-NET and BINC syllabus.

Program Objectives or Expected Skill Development among Students of Bioinformatics

In line with the syllabus of MSc Life Science (Bioinformatics) it is expected that a student graduating after successful completion of the course shall be

1. Proficient in various aspects of Bioinformatics.
2. Competent to carry out understanding complex information from the concurrent scientific literature, identify the knowledge lacunae, shortlist attainable objectives, design comprehensive methodology and carry out the unsupervised research.
3. Shall have scientific temperament.

Multiple courses shall be opted by students from other (allied) departments, however, concerned teacher shall have to use examples from relevant discipline so as to gravitate the students more towards Bioinformatics.

Therefore graduated students of MSc Life Science (Bioinformatics) would be a valuable asset for nation by virtue of his/her scientific abilities. The student can expect gainful employment in academic / research / industry by undertaking this course. A special effort has been made to enable the student clear national level tests, especially, CSIR-NET and BINC.

M.Sc. Life Sciences (Bioinformatics)

Semester-1													
S.No.	Paper Code	Course Title	Course Type	L	T	P	Cr	% Weightage					
								a	b	c	d	Marks	
		Research Methodology	F	2	-	-	2	25	25	25	25	50	
1	LBI.501	Chemical Biology	F	2	-	-	2	25	25	25	25	50	
2	LBI.502	Cell and Molecular Biology	E	3	-	-	3	25	25	25	25	75	
3	LBI.503	Basics of Biochemistry	E	4	-	-	4	25	25	25	25	100	
4	LBI.504	Concepts of Genetics	C	3	-	-	3	25	25	25	25	75	
5	LBI.505	Mathematics for Biologists	F	4	-	-	4	25	25	25	25	100	
		Biostatistics (P)	F	-	-	2	1	-	-	-	-	25	
		Cell Biology (P)	E	-	-	2	1	-	-	-	-	25	
		Biochemistry (P)	C	-	-	2	1	-	-	-	-	25	
		Genetics (P)	E	-	-	2	1	-	-	-	-	25	
6	LBI.591	Credit Seminar	E			4	2	-	-	-	-	50	
7		Elective Course 1		4	-	-	4	25	25	25	25	100	
8		Interdisciplinary Course-1		2	-	-	2	25	25	25	25	50	
		Total Sem-1		21	0	6	24	-	-	-	-	600	
Elective -I (Opt any one course from the following Elective courses)													
9	LBI.507	Basic Sciences for Bioinformatics Biological Databases and management Systems	E	3	2	-	4	25	25	25	25	100	
10	CSC.452	Introduction to Computational Sciences	E	4	-	-	2	25	25	25	25	100	
Interdisciplinary courses for other departments													
11	LBI.301	Bioinformatics	E	2	-	-	2	25	25	25	25	50	

a. Continuous Assessment: Based on Objective Type Tests
b. Pre-Scheduled Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)
c. Pre-Scheduled Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)
d. End-Term Exam (Final): Based on Objective Type Tests
e. Total Marks

Please Note: The subject in Red font signifies that these subjects are proposed to be replaced with those in Greeen font.

Semester 2													
S.No.	Paper Code	Course Title	Course Type	L	T	P	Cr	% Weightage a	b	c	d	Marks
1	LBI.521	Essentials of Immunology	C	2	-	-	2	25	25	25	25	50
		Human Physiology	E	3	-	-	3	25	25	25	25	75
2	LBI.522	Sequence Analysis	C	3	-	-	3	25	25	25	25	75
3	LBI.523	Perl Primers for Data Analysis	E	3	-	-	3	25	25	25	25	75
4	LBI.524	Statistical Mechanics	C	4	-	-	4	25	25	25	25	100
		Molecular Modeling and Dynamics	C	4	-	-	4	25	25	25	25	100
5	LBI.525	Data Analysis with PERL	E	-	-	4	2	-	-	-	-	50
6	LBI.527	Biomolecular Structure Modelling (P)	C	-	-	4	2	-	-	-	-	50
		Molecular Modeling and Dynamics (P)	C	-	-	4	2	-	-	-	-	50
7	LBI.592	Credit Seminar	C	-	-	4	2	-	-	-	-	50
8		Elective Course-2	E	4	-	-	4	25	25	25	25	100
9		Interdisciplinary course-2	E	2	-	-	2	25	25	25	25	50
10		**Total Sem-2**		18	-	12	24					600
Elective -II (Opt any one course from the following Elective courses)													
11	LBI.526	Biomolecular Structure Modeling	E	4	-	-	4	25	25	25	25	100
12	LBI.528	Quantum Chemistry	E	4	1	-	4	25	25	25	25	100
Interdisciplinary course for other departments													
14	LBI.401	Molecular Phylogenetics	E	2	-	-	2	25	25	25	25	50

a. Continuous Assessment: Based on Objective Type Tests
b. Pre-Scheduled Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)
c. Pre-Scheduled Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)
d. End-Term Exam (Final): Based on Objective Type Tests
e. Total Marks

Please Note: The subject in red font signifies that these subjects are proposed to be replaced with those in greeen font. The subjects in blue font are proposed to be shifted to the third semester.

Semester-3												
S.No.	Paper Code	Course Title	Course Type	L	T	P	Cr	% Weightage				Marks
								a	b	c	d	
1	LBI.601	Ecology and Environment	E	4	-	-	4	25	25	25	25	100
2	LBI.602	Evolutionary and Developmental Biology	E	3	-	-	3	25	25	25	25	75
3	LBI.603	Microbiology	F	2	-	-	2	25	25	25	25	50
4	LBI.604	Complex Algorithms in Bioinformatics	C	3	-	-	3	25	25	25	25	75
5	LBI.605	Complex Algorithm in Bioinformatics (P)	C	-	-	4	2	-	-	-	-	50
6	LBI.606	Molecular Dynamics	C	4	-	-	4	25	25	25	25	100
7	LBI.607	Computational Genomics and Proteomics	E	2	-	-	2	25	25	25	25	50
8	LBI.608	Molecular Dynamics (P)	C	-	-	4	2	25	25	25	25	50
		Dissertation Research		-	-	24	12	-	-	-	-	300
9	LBI.691	Credit Seminar	C			4	2					50
		Total Sem-3		**16**	**-**	**10**	**24**					**550**

a. Continuous Assessment: Based on Objective Type Tests
b. Pre-Scheduled Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)
c. Pre-Scheduled Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)
d. End-Term Exam (Final): Based on Objective Type Tests

Please Note: The subject in red font signifies that these subjects are proposed to be replaced with those in greeen font. The subjects in blue font are proposed to be shifted from second semester.

Semester-4												
S.No.	**Paper Code**	**Course Title**	**Course Type**	**L**	**T**	**P**	**Cr**	**% Weightage**				
								a	**b**	**c**	**d**	**e**
33	LBI.621	Systems Biology	C	4	-	-	4	25	25	25	25	100
34	LBI.622	Molecular Evolution	C	4	-	-	4	25	25	25	25	100
35	LBI.623	Scientific Writing and Intellectual Property Rights	C	4	-	-	4	25	25	25	25	100
		Dissertation		-	-	32	16	-	-	-	-	400
37	LBI.699	M.Sc. Project Work	C	-	-	24	12	-	-	-	-	S/US
		Total Sem-4		12	0	24	23					300

a. Continuous Assessment: Based on Objective Type Tests
b. Pre-Scheduled Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)
c. Pre-Scheduled Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)
d. End-Term Exam (Final): Based on Objective Type Tests
e. Total Marks

Please Note: The subject in red font signifies that these subjects are proposed to be replaced with those in greeen font.

Course Title: Chemical Biology
Paper Code: LBI.501
Semester: I

L	T	P	Credits	Marks
2	0	0	2	50

Course Objective and Learning Outcomes: The objective of this subject is to ensure that a student learns basis of Chemical Biology.

Unit I **10 Hours**

Atomic structure and chemical bonding: Bohr model, spectrum of hydrogen atom, quantum numbers; Wave-particle duality, de Broglie hypothesis; Uncertainty principle; Qualitative quantum mechanical picture of hydrogen atom, shapes of s, p and d orbitals; Electronic configurations of elements (up to atomic number 36); Aufbau principle; Pauli's exclusion principle and Hund's rule; Orbital overlap and covalent bond; Hybridisation involving s and p orbitals only. Concept of atoms and molecules; Mole concept; Chemical formulae; Concentration in terms of mole fraction, molarity, molality and normality.

Unit II **10 Hours**

Chemical equilibrium: Law of mass action; Equilibrium constant, Le Chatelier's principle (effect of concentration, temperature and pressure); Significance of ΔG and ΔG_0 in chemical equilibrium; Solubility product, common ion effect, pH and buffer solutions; Acids and bases (Bronsted and Lewis concepts); Hydrolysis of salts.

Unit III **8 Hours**

Chemical kinetics: Rates of chemical reactions; Order of reactions; Rate constant; First order reactions; Temperature dependence of rate constant (Arrhenius equation).

Unit IV **8 Hours**

Solid state: Classification of solids, crystalline state, seven crystal systems (cell parameters a, b, c, α, β, γ), close packed structure of solids (cubic), packing in fcc, bcc and hcp lattices; Nearest neighbours, ionic radii, simple ionic compounds, point defects.

1. Physical Chemistry by A. J. Mee, James Clare Speakman, Heinemann Educational Publishers (1993)

2. Physical Chemistry by P.W. Atkins, Oxford University Press; (2014)

Course Title: Cell and Molecular Biology
Paper Code: LBI.502
Semester: I

L	T	P	Credits	Marks
3	0	0	3	75

Course Objective and Learning Outcomes: This objective of the subject is to ensure that a student understands the following

a. The structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.
b. The structural aspects organelles.
c. The process of mitotic cell division.
d. The influences of changes or losses in cell function; including the responses to environmental or physiological changes, or alterations of cell function brought about by mutation.
e. The procedure of cell signaling.

Unit 1 **15 Lectures**

Introduction to the Cell: prokaryotic and eukaryotic cells, Single cell to multicellular organisms.
Membrane Structure and Function: Models of membrane structure, membranes of intracellular organelles, Membrane transport.
Protein Secretion and Sorting: Structure and functions of intracellular organelles,
Intracellular traffic and secretory pathways, protein sorting, endocytosis and, exocytosis.

Unit 2 **12 Lectures**

The Cytoskeleton: cell cytoskeleton and its organization including extracellular matrix, adhesions and junctions.
Cell-cell communication and cell growth: Overview of cell signaling, cell surface receptors and second messengers, cell cycle and its regulation.

Unit 3 **15 Lectures**

Chemical structure and functions of Nucleic acids: Chemical structure of DNA and RNA
Watson-Crick model, Different forms of DNA and RNA, Organelle DNA, Refgulation of nucleosome asssembly Chromatin.
Gene and Genome organization: Split genes, Overlapping genes, Transposons & retrotransposons, Gene clusters, Mechanism of DNA replication, DNA damage and their repair

Unit 4 **15 Lectures**

Transcription and mRNA Processing: transcription and transcription factors, Transcriptional and posttranscriptional gene silencing, mRNA processing: Capping, Polyadenylation, Splicing, editing, mRNA stability.
Translation: Genetic code, the translation machinery, mechanisms of chain initiation, elongation and termination, regulation of translation, post-translational modifications of proteins.
Suggested Reading:

1. Alberts, B., Bray, D., Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). Molecular Biology of the cell. Garland publishers, Oxford.
2. Celis, J.E. (2006). Cell biology: A laboratory handbook, Vol 1, 2, 3. Academic Press, UK.
3. Gupta, P.K. (2008). Cytology, Genetics and Evolution. Rastogi publications, Meerut, India
4. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons. Inc. New Delhi, India.
5. Robertis, (2011). Cell and Molecular Biology. Lippincott Williams & Wilkins
6. Fasman, G.D. (1989). Practical Handbook of Biochemistry and Molecular Biology. CRC Press, Taylor and Francis Group, UK.
7. James, D.W., Baker, T.A., Bell, S.P., Gann, A. (2009). Molecular Biology of the Gene. Benjamin Cummings, USA.
8. Jocelyn, E.K., Elliott, S.G., Stephen, T.K. (2009). Lewin's Genes X. Jones & Bartlett Publishers, USA.

Course Title: Basics of Biochemistry
Paper Code: LBI.503
Semester: I

L	T	P	Credits	Marks
4	0	0	4	100

Course Objective and Learning Outcomes: This objective of the subject is to ensure that a student understands the following

a. The structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.

b. The energy metabolism by cellular components in cells.

c. The process of mitotic cell division.

d. Influences of changes or losses in cell function; including the responses to environmental or physiological changes, or alterations of cell function brought about by mutation.

Unit 1 **15 Lectures**

Principles of biophysical chemistry pH, Buffer, Reaction kinetics, Thermodynamics, Colligative properties, Structure of atoms, Molecules and chemical bonds. Stabilizing interactions: Van der Waals, Electrostatic, Hydrogen bonding, Hydrophobic interaction, etc.

Unit 2 **25 Lectures**

Composition, structure and function of Biomolecules: Carbohydrates, Lipids, Proteins, Nucleic acids and Vitamins. Bioenergetics and metabolism of Carbohydrates, Lipids, Amino Acids and Nucleotides.

Unit 3 **17 Lectures**

Enzymology: Classification, Principles of catalysis, Mechanism of enzyme catalysis, Enzyme kinetics, Enzyme regulation, Isozymes Clinically important enzymes.

Unit 4 **15 Lectures**

Protein Chemistry: Ramachandran plot, Secondary, Tertiary and Quaternary structure, Domains, Motif and Folds. Nucleic acids: A-, B-, Z-DNA, tRNA, micro-RNA, Stability of protein and Nucleic acid structures.

Suggested Reading:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2010). *Biochemistry.* W.H. Freeman & Company. USA.
2. Brown, T.A. (2006). *Gene Cloning and DNA analysis: In Introduction*. Blackwell Publishing Professional. USA.
3. Haynie, D.T. (2007). *Biological thermodynamics*. Cambridge University. UK.
4. Mathews, C.K., Van Holde, K.E. and Ahern, K.G. (2000). *Biochemistry*. Oxford University Press Inc. New York.
5. Nelson, D. and Cox, M.M. (2013). *Lehninger Principles of Biochemistry*. BI publications Pvt. Ltd. Chennai, India.
6. Ochiai, E. (2008). *Bioinorganic chemistry: A survey.* Academic Press. Elsevier, India.
7. Randall, D. J., Burggren, W. and French, K. (2001). *Eckert animal physiology*. W.H. Freeman & Company. USA.
8. Raven, P.H., Johnson, G.B. and Mason, K.A. (2007). *Biology*. Mcgraw-Hill. USA.
9. Shukla AN (2009). *Elements of enzymology.* Discovery Publishing. New Delhi, India.
10. Voet, D. and Voet, J.G. (2014). *Principles of biochemistry*. CBS Publishers & Distributors. New Delhi, India.

Course Title: Concepts of Genetics
Paper Code: LBI.504
Semester: I

L	T	P	Credits	Marks
3	0	0	3	75

Course Objective and Learning Outcomes: This objective of the subject is to ensure that a student understands the following

a. The structures and organisation of nucleic acids.
b. DNA replication.
c. Inheritance patterns

Unit 1 **20 Lectures**

Introduction and scope of genetics, DNA as genetic material: The vehicles of inheritance, Chemical structure and base composition of nucleic acids, Double helical structure, Structure of DNA and RNA, Different types of DNA molecules, forces stabilizing nucleic acid structure, super coiled DNA, properties of DNA, denaturation and renaturation of DNA and Cot curves. **DNA replication:** Messelson and Stahl Experiment, Carins Experiment, Okazaki Experiment, Basic mechanism of DNA replication.

Unit 2 **17 Lectures**

Cell division and Cell cycle: Mitosis, Meiosis, Chromosomal basis of inheritance. Basic principles of Mendelian inheritance: Segregation and independent assortment, Alleles and multiple alleles, Human pedigrees and inheritance. Linkage analysis and gene mapping: Coupling and repulsion phase linkage, Crossing over and recombination**.** Population genetics: Application of Mendel's laws to populations, Hardy-Weinberg principle, inbreeding depression and heterosis, inheritance of quantitative traits.

Unit 3 **17 Lectures**

Gene Interaction: Sex determination and Sex linked inheritance, Sex determination in humans, *Drosophila* and other animals, Sex determination in plants, Sex linked genes and dosage compensation. Human genetics: pedigree analysis. Gene concept: Fine structure of gene and gene concept, Fine structure analysis – Benzer's experiments, Complementation analysis and fine structure of gene, Complementation and recombination, Concept of gene.

Unit 4 **18 Lectures**

Extra-chromosomal inheritance: Chloroplast and Mitochondrial inheritance, Yeast, *Chlamydomonas/Neurospora* and higher plants Chromosomal aberrations: Types of changes– deletions, duplications, inversions, translocations,Change in chromosome number: trisomy and polyploidy. Evolutionary history of bread wheat, Aneuploids–nullisomics, monosomics, and trisomics, Somatic aneuploids, Changes in chromosome structure, Properties of chromosomes for detection of structural changes. Mutations: Spontaneous and induced mutations, Somatic vs germinal mutation.

Suggested Reading:

1. Anthony, J.F., Miller, J.A. ,Suzuki, D.T., Richard, R.C., Gilbert, W.M. (1998). *An introduction to Genetic Analysis*. W.H. Freeman publication, USA.
2. Atherly, A.G., Girton, J.R., Mcdonald, J.F. (1999). *The science of Genetics*. Saundern College publication.
3. Snusted, D.P., Simmons, M. J. (2010). *Principles of Genetics*. John Wiley & Sons, New York.
4. Gupta, P.K. (2009). *Genetics*. Rastogi publications, Meerut, India.
5. Gupta, P.K (2008). *Cytology, Genetics and Evolution.* Rastogi publications, Meerut, India.
6. Jocelyn, E.K., Elliott, S.G., Stephen, T.K. (2009). *Lewin's Genes X*. Jones & Bartlett Publishers, USA.
7. Schaum, W.D. (2000). *Theory & problems in Genetics by Stansfield, out line series* McGrahill, USA.
8. Tamarin, R.H. (1996). *Principles of Genetics, International edtn.* McGrawhill, USA.

Course Title: Mathematics for Biologists
Paper Code: LBI.505
Semester: I

L	T	P	Credits	Marks
4	0	0	4	100

Course Objective and Learning Outcomes: This objective of the subject is to ensure that a student understands the fundamentals of mathematics as applicable in various branchs of Bioinformatics.

Unit 1 **9 Hrs**

Cartesian Geometry:

Vectors, lines in two dimensions, circles, conics, transformation of coordinates, polar coordinates, parametric equations, and the solid analytic geometry of vectors, lines, planes, cylinders, spherical and cylindrical coordinate

Unit 2 **9 Hrs**

Differential Calculus and Matrix Algebra

Functions, limits, derivative, physical significance, basic rules of differentiation, maxima and minima, exact and inexact differentials, partial differentiation.

Addition and multiplication; inverse, adjoint and transpose of matrices, matrix equation, Introduction to vector spaces, matrix eigen values and eigen vectors, diagonalization, determinants (examples from Huckel theory).

Unit 3 **9 Hrs**

Integral Calculus

Basic rules for integration, integration by parts, partial fraction and substitution, definite integrals, evaluation of definite and some standard integrals related to chemistry

Unit 4 **9 Hrs**

Elementary Differential Equations

Variables-separable and exact, first-order differential equations, homogenous, exact and linear equations. Applications to chemical kinetics, quantum chemistry, etc. solutions of differential equations by the power series method, spherical harmonics, second order differential equations and their solutions.

SUGGESTED READINGS

1. Steiner, E. The Chemistry Mathematics, 2nd edition, 2008, Oxford University Press.
2. Doggett, G. and Sucliffe, B.T. Mathematics for Chemistry, 1st edition, 1995, Longman.
3. Daniels, F. Mathematical Preparation for Physical Chemistry, 2003, McGraw Hill.
4. Hirst, D.M. Chemical Mathematics, Longman.
5. Barrante, J. R. Applied Mathematics for Physical Chemistry, 3rd edition, 2008, Prentice Hall.
6. Tebbutt P. Basic Mathematics for Chemists, 1st edition, 1998, John Wiley

Course Title: Credit Seminar
Paper Code: LBI.591
Semester: I

L	T	P	Credits	Marks
0	0	4	2	50

Objective: The objective of Credit Seminar would be to ensure that the student learns the aspects of the seminar presentation. Herein, the student shall have to present a selective overview of a scientific problem with focus of literatural knowledge.

The evaluation criteria shall be as follows:

Maximum Marks: 50

S.No.	Criteria	Marks
1	Content	20
2	Presentation Skills	20
3	Handling of queries	10

Course Title: Biological Database and Management System
Paper Code: LBI.506
Semester: I

L	T	P	Credits	Marks
2	0	0	2	50

Course Objective and Learning Outcomes: The objective of this subject is to ensure that a student learns various aspects of database management.

Unit1 **14 Hours**

Biological Databases: Nucleotide Sequence Databases, GenBank, DDBJ, EMBL, Sequence Flatfile and submission process, Protein sequence databases, UniProt, Mapping databases, Genomic databases, PDBsum, PDB, SCOP, CATH, Pathway and molecular interaction databases.

Unit 2 **14 Hours**

Database planning and Design concepts General Database Planning and Design – Document or forms – preparation and architexture Entity-Relational ship Model- entities, Attributes, keys, tables design, relationships, roles and dependencies.

Unit 3 **14 Hours**

Relational DB Introduction to relational DB and transactions. SQL-statements-Data Definition-Manipulation-control-Objects, - Views, sequences and Synonyms. Working with code and forms- Front end development-query sublanguage-modifying relations in SQL.

Unit 4 **14 Hours**

Internals of RDBMS Physical data structures, query optimization. Join algorthim statisca and cost base optimization. Transaction processing.concurrency control and recovery management. Transaction model properities, state serizability, lock base protocols, two phase locking.

Tutorial Part should cover:
1. Introduction to NCBI Taxonomic Browser
2. DDL & DML: Creating and working with databases, creating tables, dropping tables, primary and secondary keys, data validation, simple queries using MySQL, cursors, stored procedures.
3. DTD and XML schema- simple DTD and creation of data in XML.
4. Design of database architecture - Design, planning, databases, UML Schema, Data models to physical tables.
5. Accessing molecular biology databases: Entrez, SRS, PIR
6. Databases: Retrieving, parsing and analysing sequences, structures etc

Suggested Readings:

1 Abraham Silberschatz, Henry F.Korth and S.Sudhashan (2005) Database system concepts. 5 Ed McGraw Hill Publications.
2 Elmasri Ramez and Novathe Shamkant, " Fundamentals of Database systems" (2007) Benjamin cummings Publishing Company. ISBN-10: 0321369572.
3 P. Ramakrishnan Rao: Database Management system, (2003) 3EdMcGraw Hill Publications. 9780071230575
4 Jim Gray and A.Reuter " Transaction processing : Concepts and Techniques" Morgan Kaufmann Press.(1997) ISBN-10: 1558601902
5 V.K .Jain. Database Management system (2002) Dreamtech Press ISBN 8177222279
6 Date C.J. " Introduction to database management" (2009) Vol1, Vol2, Vol3 addison Wesley.
7 Ullman, JD " Principles of Database systems" (1992) Galgottia publication
8 James Martin Principles of Database Management systems" (1985) PHI.

Course Title: Introduction to Computational Sciences
Paper Code: CCS.452
Semester: I

L	T	P	Credits	Marks
4	0	0	4	100

Course Objective and Learning Outcomes: This course has been designed to provide an introductory understanding of the broad filed of Computational Sciences. The course covers various aspects of the field and attempts to provide a bird's eye view of the scientific potential of this growing field.

Unit-I **(09)**

Introduction: Overview of Computational Sciences and its applications to Natural Sciences, Nobel Prize winners in Computational Natural Sciences and their contributions to the field, Modelling process and its types, Computational Toolbox- errors and their types, rate of change, fundamental concepts of integral calculus, Importance of Learning Computer Programming in Computational Natural Sciences.

Unit-II **(09)**

Applications of Computational Sciences in Chemistry

Computational Quantum Chemistry and its applications, Prediction of Molecular Properties using Computational Chemistry, Overview of Quantum Chemistry Theories and their level of accuracy and hierarchy of computational requirements, Overview of Computer aided drug design and QSAR, Promises of Computational Chemistry

Unit-III **(09)**

Applications of Computational Sciences in Physics

Computational Sciences in Molecular Physics, Computational Modeling of materials and prediction of material properties, Overview of Computational Fluid Dynamics and Computational Biophysics, Modeling force and motion, Overview of Cellular Automata Simulations, promises of Computational Physics

Unit IV **(09)**

Applications of Computational Sciences in Life Sciences

Overview of Computational Biology and bioinformatics, Structural Bioinformatics, Genomic data and its interpretation, Molecular Dynamics Simulations on Biological Systems, Hybrid Computational Methods for Studying Structure, Dynamics and Functions of Large Biological Systems, Promises of Computational Biology.

Recommended Books and References:

1. A. B. Shiflet and G. W. Shiflet. Introduction to Computational Sciences (Overseas Press (India) Pvt. Ltd., New Delhi, India), 2011.
2. F. Jensen. Introduction to Computational Chemistry (Second Edition, Wiley), 2007.
3. J. Hasbun, P. Devries. A First Course in Computational Physics. (Viva Books Pvt. Ltd., New Delhi), 2011.
4. D. W. Mount. Bioinformatics (2 nd Edition, Cold Spring harbour Press, New Jersey), 2004.
5. Some examples will be taken from Selected Articles from Standard /Reputed Journals.

Course Title: Bioinformatics (for other departments)
Paper Code: LBI.301
Semester: I

L	T	P	Credits	Marks
2	0	0	2	50

Course Objective and Learning Outcomes: Bioinformatics course is being offered to the students as fundamental course to brush up the basics of the students in this important emerging area. Students will be composed to the concepts of data mining, computational and algorithmic tools for biological data analysis and are expected to get a good idea on using computational resources to understand and resolve biological problems.

Unit I **10hours**

Biological databases: Nucleotide Sequence Databases, GenBank, DDBJ, EMBL, Sequence Flatfile and submission process, Protein sequence databases

Unit II **15hours**

Sequence analysis: Gene Prediction methods and programs, Promoter analysis, RNA secondary structure thermodynamics

Analysis for protein sequences: Predicting features of individual residues, Predicting function, Neural networks, Protein structure prediction, Protein structure databases, PDB

Unit III **16hours**

Inferring relationships: Global Vs. local sequence alignments, Dotplots, Scoring matrices, Pairwise sequence alignment, BLAST, Position-Specific scoring and PSI-BLAST, MegaBLAST, BL2SEQ, BLAT, FASTA Vs BLAST, Protein multiple sequence alignments, Multiple structural alignments

Unit IV **15hours**

Modelling and structure: From protein sequence to structure, theoretical and practical aspects of protein sequence alignments, secondary, tertiary structure prediction, comparative modeling, Docking, protein-protein and protein-ligand docking.

Computational drug designing: Structure-based drug design, virtual screening, quantitative structure activity relations, Cheminformatics and pharmacophore mapping in therapeutic development.

Suggested reading

1. Baxevanis, A.D. and Ouellette, B.F.F. (2005). Bioinformatics: A Practical guide to the Analysis of Genes and Proteins. Wiley-Interscience, USA.
2. Hall, B.G. (2011). Phylogenetic Trees Made Easy: A How-To Manual. Sinauer Associates, Inc. USA.
3. Lesk, A.M. (2008). Introduction to Bioinformatics. Oxford University Press, UK.
4. Zvelebil, M. and Baum, J. (2007). Understanding Bioinformatics, Garland Science, New York, USA.
5. Ramsden, J. (2010). Bioinformatics: An Introduction (Computational Biology). Springer, India.
6. Ye, S.Q. (2008). Bioinformatics: A Practical approach. Chapman & Hall/CRC, UK.
7. Mount, D. (2012). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
8. Graur, D., Li, W. H. (2000). Fundamentals of Molecular Evolution. Sinauer Associates.
9. Tisdall, J. (2001). Beginning Perl for Bioinformatics. O'Really Publishers.
10. Orengo, C., Jones, D., Thornton, J. (2005). Bioinformatics: Genes, Proteins and Computers (Advanced Texts). Taylor and Francis Publishers.

Semester 2												
S.No.	Paper Code	Course Title	Course Type	L	T	P	Cr	% Weightage a	b	c	d	Marks
1	LBI.521	Essentials of Immunology	C	2	-	-	2	25	25	25	25	50
		Human Physiology	E	3	-	-	3	25	25	25	25	75
2	LBI.522	Sequence Analysis	C	3	-	-	3	25	25	25	25	75
3	LBI.523	Perl Primers for Data Analysis	E	3	-	-	3	25	25	25	25	75
4	LBI.524	Statistical Mechanics	C	4	-	-	4	25	25	25	25	100
		Molecular Modeling and Dynamics	C	4	-	-	4	25	25	25	25	100
5	LBI.525	Data Analysis with PERL	E	-	-	4	2	-	-	-	-	50
6	LBI.527	Biomolecular Structure Modelling (P)	C	-	-	4	2	-	-	-	-	50
		Molecular Modeling and Dynamics (P)	C	-	-	4	2	-	-	-	-	50
7	LBI.592	Credit Seminar	C	-	-	4	2	-	-	-	-	50
8		Elective Course-2	E	4	-	-	4	25	25	25	25	100
9		Interdisciplinary course-2	E	2	-	-	2	25	25	25	25	50
10		**Total Sem-2**		18	-	12	24					600
Elective -II (Opt any one course from the following Elective courses)												
11	LBI.526	Biomolecular Structure Modeling	E	4	-	-	4	25	25	25	25	100
12	LBI.528	Quantum Chemistry	E	4	1	-	4	25	25	25	25	100
Interdisciplinary course for other departments												
14	LBI.401	Molecular Phylogenetics	E	2	-	-	2	25	25	25	25	50

a. Continuous Assessment: Based on Objective Type Tests
b. Pre-Scheduled Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)
c. Pre-Scheduled Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)
d. End-Term Exam (Final): Based on Objective Type Tests
e. Total Marks

Please Note: The subject in red font signifies that these subjects are proposed to be replaced with those in greeen font. The subjects in blue font are proposed to be shifted to the third semester.

Course Title: Essentials of Immunology
Paper Code: LBI.521
Semester: II

L	T	P	Credits	Marks
2	0	0	2	50

Course Objective and Learning Outcomes: The objective of this course is to cover basic concepts of immune system and to understand the concept of immune-based diseases as either a deficiency of components or excess activity as hypersensitivity.

Unit: 1 **12 Lectures**

Immune system: The cells and organs of immune system. Recognition of self and nonself, Humoral immunity-immunoglogulins, basic structure, classes and subclasses, structural and functional relationships, nature of antigen, antigen-antibody reaction, estimation of affinity constants. Molecular mechanisms of antibody diversity and Cellular immunity: Organization of genes coding for constant and variable regions of heavy chains and light chains. Mechanisms of antibody diversity, class switching. Lymphocytes, cytokines, interferons, Interlukins, antigen recognition-membrane receptors for antigens.

Unit: 2 **10 Lectures**

Immune Effectors: Complement system, their structure, functions and mechanisms of activation by classical, alternative and lectin pathway. Th1 and Th2 response, cytokines, Chemokines. Antigen and antibody interactions

Unit: 3 **10 Lectures**

Mechanisms of Immune System Diversity: Organization and expression of immunoglobulin genes, Mechanisms of antibody diversity, class switching. Structure and functions of Major Histocompatibility Complex (MHC) and Human Leukocyte Antigen (HLA) system, polymorphism, distribution, variation and their functions. Organization and rearrangement of T-cell receptor genes (TCR).

Unit: 4 **12 Lectures**

Immune System in Health and Diseases: Inflammation, hypersensitivity and autoimmunity, Immunity to microbes, immunity to tumors, AIDS and immunodeficiencies, hybridoma technology and vaccine development associated challenges for chronic and infectious diseases. Production, characterization and applications of monoclonal antibodies in diagnosis, therapy and basic research, concept of making immunotoxins.

Suggested Reading:

1. Kindt, T.J., Osborne, B.A. and Goldsby, R.A. (2007). *Kuby Immunology*. 7th Edition. W.H. Freeman, USA.
2. Abbas. (2008). *Cellular and Molecular Immunology*. CBS Publishers & Distributors, India.
3. Charles, A. and Janeway, J.R. (1994). *Immunobiology: The immune system in health and disease.* Blackwell Publishing, USA.
4. Delves, P.J., Roitt, I.M. and Seamus, J.M. (2006). *Roitt's essential immunology (Series–Essentials).* Blackwell Publishers, USA.
5. Elgert, K.D. (2009). *Immunology: Understanding the immune system*. Wiley-Blackwell, USA.
6. Paul, W.E. (1993). *Fundamental immunology.* Raven Press, SD, USA.
7. Sawhney, S.K. and Randhir, S. (2005). *Introductory practical biochemistry*. Alpha Science International Ltd. New Delhi, India.
8. Tizard. (2008). *Immunology: An Introduction*. Cengage Learning, Thompson, USA.

Course Title: Sequence Analysis
Paper Code: LBI.522
Semester: II

L	T	P	Credits	Marks
3	0	0	3	75

Course Objective and Learning Outcomes: The objective of this subject is to ensure that a student learns various algorithms and softwares for the sequence analysis.

Unit 1 **14 Hours**

Various file formats for bio-molecular sequences: GenBank, FASTA, GCG, MSF etc. Basic concepts of sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues and xenologues **Scoring matrices:** basic concept of a scoring matrix, Matrices for nucleic acid and proteins sequences, PAM and BLOSUM series, principles based on which these matrices are derived Database Searches: Keyword - based Entrez and SRS; Sequence-based: BLAST & FASTA; Use of these methods for sequence analysis including the on-line use of the tools and interpretation of results from various sequence and structural as well as bibliographic databases.

Unit 2 **14 Hours**

Pairwise sequence alignments: basic concepts of sequence alignment, Needleman and Wunsch, Smith and Waterman algorithms for pairwise alignments, gap penalties, use of pairwise alignments for analysis of Nucleic acid and protein sequences and interpretation of results.

Unit 3 **14 Hours**

Multiple sequence alignments (MSA): the need for MSA, basic concepts of various approaches for MSA (e.g. progressive, hierarchical etc.). Algorithm of CLUSTALW and PileUp and their application for sequence analysis (including interpretation of results), concept of dandrogram and its interpretation.

Unit 4 **14 Hours**

Sequence patterns and profiles: Basic concept and definition of sequence patterns, motifs and profiles, various types of pattern representations viz. consensus, regular expression (Prosite-type) and sequence profiles; profile-based database searches using PSI-BLAST, analysis and interpretation of profile-based searches.

Phylogenetic analysis: Taxonomy and phylogeny: Basic concepts in systematics, taxonomy and phylogeny; molecular evolution; nature of data used in Taxonomy and Phylogency, Definition and description of phylogenetic trees and various types of trees.

Suggested Reading:

1. A.D. Baxevanis *et. al.*, Current Protocols in Bioinformatics, (2005) Wiley Publishers
2. David W.Mount Bioinformatics (2001) Cold Spring Harbor Laboratory Press, ISBN 0-87969-608-7
3. Computational Molecular Biology by P. A. Pevzner, Prentice Hall of India Ltd, (2004) ISBN81-203-2550-8
4. D.E.Krane and M.L.Raymer Fundamental concepts of Bioinformatics (2003) Pearson Education ISBN 81-297-0044-1
5. N.Gautham Bioinformatics Narosa publications. (2006) ISBN-13: 9781842653005

Course Title: Perl Primers for Data Analysis
Paper Code: LBI.523
Semester: II

L	T	P	Credits	Marks
3	0	0	3	75

Course Objective and Learning Outcomes: The objective of this subject is to ensure that student learns basic Unix and PERL programming.

Unit: 1 **14 Lectures**

Scripting languages and introduction: Getting comfortable with the UNIX shell, Basic shell commands, Unix shell scripting programming languages, Origin of PERL as a scripting language, Installation on various OS, Integrated Development Environment, The Comprehensive PERL Archive Network, BioPerl, Getting started in PERL coding, Running PERL programs.

Unit: 2 **14 Lectures**

PERL Basics: Scalar variables, Syntax and semantics, Processing scalar variables, Iteration with while construct, Variable containers, Loops, Conditional statements, Introducing Patterns, Reading and writing files, Case study: Making Motif Search tool.

Unit: 3 **14 Lectures**

Advance data structure and programming in PERL: Arrays, Hashes, Sub-routines, Getting organized: Visibility and Scope of big programs, Modules, Case study: Parsing NCBI GenBank records.

Unit: 4 **10 Lectures**

Regular expression and Text mining: The Match Operator, Match Operator Modifiers, The Substitution Operator, Substitution Operator Modifiers, Translation, Translation Operator Modifiers, More complex regular expressions, Case study: UniProt database parsing.

Suggested Reading:

1. Moorhouse M, Barry P (2005): Bioinformatics Biocomputing and Perl: An Introduction to Bioinformatics Computing Skills and Practice, Book, John Wiley & Sons
2. Dwyer R. A. (2003): Genomic Perl: From Bioinformatics Basics to Working Code, Volume 1, Book, Cambridge University Press
3. Tisdall J (2003): Mastering Perl for Bioinformatics, Book, O'Reilly
4. Hietaniemi J, John Macdonald J, Orwant J (1999): Mastering Algorithms with Perl, Book, O'Reilly
5. Bradnam K & Korf I (2012): Unix and Perl Primer for Biologists, Web tutorial at http://korflab.ucdavis.edu/Unix_and_Perl/current.html
6. Robert's PERL tutorial http://www.physics.rutgers.edu/~kotliar/perltut.html
7. Collection of PERL tutorials at http://perl-tutorial.org/

L	T	P	Credits	Marks
4	0	0	4	100

Course Title: Statistical Mechanics I
Paper Code: CSC.504
Total Lectures: 72

Unit I: **(18)**

Mathematical Review of Classical Mechanics:
Lagrangian Formulation, Hamiltonian Formulation, Poisson Brackets and Canonical Transformations
Classical approach to Ensembles:
Ensembles and Phase Space, Liouville's Theorem, Equilibrium Statistical Mechanics and it's ensembles
Partition Function: Review of rotational, vibrational and translational partition functions. Application of partition functions to specific heat of solids and chemical equilibrium. Real gases.

Unit II: **(18)**

Elementary Probability Theory
Distributions and Averages, Cumulants and Fluctuations, The Central Limit Theorem
Distributions & Fluctuations:
Theory of Ensembles, Classical and Quantum, Equivalence of Ensembles, Fluctuations of Macroscopic Observable

Unit III: **(18)**

Basic Thermodynamics: Review of Concepts, The Laws of Thermodynamics, Legendre Transforms, The Maxwell Relations, The Gibbs-Duhem Equation and Extensive Functions, Intensive Function

Unit IV: **(18)**

Bose-Einstein distribution: Einstein condensation. Thermodynamic properties of ideal BE gas.
Fermi-Dirac distribution: Degenerate Fermi gas. Electron in metals. Magnetic susceptibility.

Books Recommended:

1. Statistical Mechanics, by Donald A McQuarrie
2. Introduction to Modern Statistical Mechanics, by David Chandler
3. Statistical Mechanics, by Kerson Haung
4. Statistical Mechanics, by Patria

Course Title: Data Analysis with PERL
Paper Code: LBI.525
Semester: II

L	T	P	Credits	Marks
0	0	4	2	50

Course Objective and Learning Outcome: The objective of this subject is to ensure that students able to write their own programs in PERL for data mining and analysis.

1. Unix Shell scripting, Grep, AWK and SED
2. Printing various number sequences
3. Reading and writing files
4. Searching patterns in files
5. Programming Motif Search tool
6. Sorting algorithm
7. Counting GC and amino acid contents in sequence files
8. Translating gene sequence into protein using Hashes
9. Creating and using modules
10. Parsing BLAST result files
11. Parsing NCBI GenBank records
12. UniProt records to annotation tables

Suggested Reading:

1. Moorhouse M, Barry P (2005): Bioinformatics Biocomputing and Perl: An Introduction to Bioinformatics Computing Skills and Practice, Book, John Wiley & Sons

2. Hietaniemi J, John Macdonald J, Orwant J (1999): Mastering Algorithms with Perl, Book, O'Reilly

Course Title: Credit Seminar
Paper Code: LBI.592
Semester: II

L	T	P	Credits	Marks
0	0	4	2	50

Objective: The objective of Credit Seminar would be to ensure that the student learns the aspects of the seminar presentation. Herein, the student shall have to present a selective overview of a scientific problem with focus of literatural knowledge.

The evaluation criteria shall be as follows:

Maximum Marks: 50

S.No.	Criteria	Marks
1	Content	20
2	Presentation Skills	20
3	Handling of queries	10

Course Title: Biomolecular Structure Modelling
Paper Code: LBI.526
Semester: II

L	T	P	Credits	Marks
4	0	0	4	100

Course Objective and Learning Outcomes: The objective of this subject is to ensure that a student learns modelling of biomolecular structures.

Unit 1 **14 Hours**

Introduction to Molecular Geometry, Coordinate Space for Optimization of Algorithm of Molecular Geometry, Z-Matrix, Molecular Vibrations, Electrostatic Charges, Electrostatic Charges, Multipole Moments,

Unit 2 **14 Hours**

Modelling and structure: From protein sequence to structure, theoretical and practical aspects of protein sequence alignments, secondary, tertiary structure prediction, comparative modeling, Docking, protein-protein and protein-ligand docking.

Unit 3 **14 Hours**

Computational drug designing: Structure-based drug design, virtual screening, quantitative structure activity relations, Cheminformatics, Historical Perspective and Viewpoint of Pharmacophore, Functional Groups Considered as Pharmacophores, Ehrlich's "Magic Bullet", Fischer's "Lock and Key", Two-dimensional Pharmacophores, Three-dimensional Approach of Pharmacophores, Criteria for Pharmacophore Model,

Unit 4 **14 Hours**

Pharmacophore Model Generation Software Tools, Molecular Alignments, Handling Flexibility, Alignment Techniques, Scoring and Optimization, Pharmacophores, Validation and Usage, Automated Pharmacophore Generation Methods, GRID-based Pharmacophore Models, Pharmacophores for Hit Identification, Pharmacophores for Human ADME/Tox-related Proteins.

Suggested Readings:

1. Molecular and Structural Database, Protein Data Bank, Bioactivity Databases, Gene and Protein Sequence Databases,Cambridge Crystallographic Database, Compound Storage and Management.
3. Lednicer, D. "Strategies for Organic Drug Discovery Synthesis and Design"; (1998) Wiley International Publishers.
3. Gordon, E.M. and Kerwin, J.F "Combinatorial chemistry and molecular diversity in drug discovery" (1998) Wiley-Liss Publishers.

Course Title: Biomolecular Structure Modelling
Paper Code: LBI.527
Semester: II

L	T	P	Credits	Marks
0	0	4	2	50

Course Objective and Learning Outcomes: The objective of this subject is to ensure that a student learns practical aspects of modelling of biomolecular structures.

The following experiments should be conducted by the students:
A. Molecular Recognition
1. Prediction of Protein-ligand interaction sites
2. Prediction of Protein-protein interaction sites
3. Prediction of Protein-membrane interaction sites
4. Prediction of Protein-nucleic acid interaction sites

B. Docking
1. Protein Ligand Docking using
(i) Autodock
(ii) Vina
(iii) Dock
2. Protein-protein docking by HADDOCK or other similar methods

C. Modelling macromolecular structure
1. Homology modeling
2. *ab-initio* structure modeling

Course Title: Quantum Chemistry
Paper Code: LBI.528
Semester: II

L	T	P	Credits	Marks
4	0	0	4	100

Objective and Learning Outcomes: This is a fundamental course for students who specialize in Computational Chemistry. The objective of this course is that students learn the basic concepts of quantum chemistry and apply them to study simple problems that have analytical solutions. In addition, the course will introduce the students towards basic ideas on solving problems in molecular quantum mechanics, which will, in turn, prepare them to take the next advanced level course of Computational Chemistry.

Unit I **(20)**

Fundamental Background: Postulates of quantum mechanics, Eigen values and Eigen functions, operators, hermitian and unitary operators, some important theorems. Schrodinger equation-particle in a box (1D, 3D) and its application, potential energy barrier and tunneling effect, one-dimensional harmonic oscillator and rigid rotor. Angular momentum, eigenvalues of angular momentum operator, Particle in a Ring, Hydrogen Atom.

Unit II **(14)**

Approximate Methods: Perturbation theory for non-degenerate and degenerate states and its applications. The variation theorem and its application.

Unit III **(18)**

Symmetry Point Groups: Determination of point group of a molecule, representations, the great orthogonality theorem, character table, construction of character tables for c2v and c3v groups, symmetry adapted atomic basis sets, construction of molecular orbitals. The direct product representation.

Unit IV **(20)**

Atomic and Molecular Structure: many electron wave functions, Pauli exclusion principle, Helium atom, atomic term symbols. The self-consistent field method. Slater-type orbitals. Born-Oppenheimer approximation. Molecular orbital treatment for H2+.MO treatment of homo- and hetero nuclear diatomic molecules.Hückel mo treatment of simple and conjugated polyenes and alternate hydrocarbons.

Books Recommended:

1. Quantum Chemistry, I.N. Levine, 5th edition, Pearson Educ., Inc. New Delhi (2000).
2. Physical Chemistry: A Molecular Approach, D. A. McQuarrie, and J. D. Simon, Viva Books (2011).
3. Valence Theory, J.N. Murrell, S.F.A. Kettle and J. M. Tedder, 2nd edition, John Wiley (1965).
4. Introductory Quantum Chemistry, A.K. Chandra, 4th Edition, Tata Mcgraw Hill (1994).
5. Chemical Applications of Group Theory, F. A. Cotton, John Wiley & Sons (2008).
6. Molecular Symmetry and Group Theory, R. L. Carter, J. Wiley (1998).

Course Title: Molecular Phylogenetics

(Inter disciplinary for other departments)

L	T	P	Credits	Marks
2	0	0	2	50

Paper Code: LBI.401
Semester: II

Course Objective and Learning Outcomes: The objective of this subject is to ensure that a student learns about various approaches for understanding the molecular phylogenetics.

Unit 1 **14 Hours**
Mutational processes, evolution of mutation rates, evolution of DNA sequences,

Unit 2 **14 Hours**
The molecular clock, selection and genetic drift on the molecular level, nucleotide composition, polymorphism and SNPs.

Unit 3 **14Hours**
Phylogenetic trees and other models, optimality criteria for selecting phylogenetic hypothesis. Substitution models for DNA and other data types.

Unit 4 **14Hours**
Super trees, consensus trees, tree compatibility. Algorithms for evaluating the tree space; Markov Chain Monte Carlo, genetic algorithms. Evaluation of results from phylogentic analyses, phylogenetic dating.

Suggested Reading

1. A.D. Baxevanis *et. al.*, Current Protocols in Bioinformatics, (2005) Wiley Publishers
2. David W.Mount Bioinformatics (2001) Cold Spring Harbor Laboratory Press, ISBN 0-87969-608-7
3. Computational Molecular Biology by P. A. Pevzner, Prentice Hall of India Ltd, (2004) ISBN81-203-2550-8
4. D.E.Krane and M.L.Raymer Fundamental concepts of Bioinformatics (2003) Pearson Education ISBN 81-297-0044-1
5. N.Gautham Bioinformatics Narosa publications. (2006) ISBN-13: 978184265300

Semester-3													
S.No.	Paper Code	Course Title	Course Type	L	T	P	Cr	% Weightage					
								a	b	c	d	Marks	
1	LBI.601	Ecology and Environment	E	4	-	-	4	25	25	25	25	100	
2	LBI.602	Evolutionary and Developmental Biology	E	3	-	-	3	25	25	25	25	75	
3	LBI.603	Microbiology	F	2	-	-	2	25	25	25	25	50	
4	LBI.604	Complex Algorithms in Bioinformatics	C	3	-	-	3	25	25	25	25	75	
5	LBI.605	Complex Algorithm in Bioinformatics (P)	C	-	-	4	2	-	-	-	-	50	
6	LBI.606	Molecular Dynamics	C	4	-	-	4	25	25	25	25	100	
7	LBI.607	Computational Genomics and Proteomics	E	2	-	-	2	25	25	25	25	50	
8	LBI.608	Molecular Dynamics (P)	C	-	-	4	2	25	25	25	25	50	
		Dissertation Research		-	-	24	12	-	-	-	-	300	
9	LBI.691	Credit Seminar	C			4	2					50	
		Total Sem-3		**16**	**-**	**10**	**24**					**550**	

a. Continuous Assessment: Based on Objective Type Tests
b. Pre-Scheduled Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)
c. Pre-Scheduled Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)
d. End-Term Exam (Final): Based on Objective Type Tests

Course Title: Ecology and Environment
Paper Code: LBI.601
Semester: III

L	T	P	Credits	Marks
3	0	0	3	75

Course Objective and Learning Outcomes: The objective of this subject is to ensure that a student learns about various approaches for understanding of Scology and sensitivity towards Environment.

Unit: 1 **14 Lectures**

The Environment: Physical environment, biotic environment, biotic and abiotic interactions. Concept of habitat and niche, niche width and overlap, fundamental and realized niche, resource partitioning and character displacement.

Unit: 2 **14 Lectures**

Ecosystem: Structure and function, energy flow and mineral cycling (CNP), primary production and decomposition, structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine). Types, mechanisms, changes involved in succession, concept of climax. Nature of communities, community structure and attributes, levels of species diversity and its measurement, edges and ecotones.

Unit: 3 **18 Lectures**

Population ecology: Characteristics of a population, population growth curves, population regulation, life history strategies (*r* and *K* selection), concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations. Types of interactions, interspecific competition, herbivory, carnivory, pollination and symbiosis.

Unit: 4 **8 Lectures**

Environmental pollution: Global environmental change, ozone depletion, biodiversity-status, monitoring and documentation, major drivers of biodiversity change, biodiversity management approaches, Carbon credit.

Suggested Reading:

1. Odum, E. and Barrett, G.W. (2005). *Fundamentals of Ecology*. Brooks Cole, USA.
2. Prasanthrajan, M and Mahendran, P.P. (2008). *A Text Book on Ecology and Environmental Science*. Agrotech, India.
3. Sharma, P.D. (2005). Ecology and Environment. Rastogi Publications, Meerut, India.
4. Verma, P.S. Agarwal, V. K. (2000). *Environmental Biology: Principles of Ecology*. S. Chand, New Delhi, India.

Course Title: Evolutionary and Developmental Biology
Paper Code: LBI.602
Semester: III

L	T	P	Credits	Marks
3	0	0	3	75

Course Objective and Learning Outcomes: The objective of this subject is to ensure that a student understands Evolutionay and Develpment Biology.

Unit: 1 **20 Lectures**

Emergence of evolutionary thoughts & Origin of life: Lamarckism, Darwinism, Concepts of variation, adaptation, struggle, Mendelism, Spontaneity of mutations, Theories of phyletic gradualism vs. punctuated equilibria, Modern evolutionary synthesis. Origin of basic biological molecules, Abiotic synthesis of organic monomers and polymers, Concept of Oparin and Haldane, Experiment of Miller (1953), The first cell, Evolution of prokaryotes, Origin of eukaryotic cells, Evolution of unicellular eukaryotes, Anaerobic metabolism, Photosynthesis and aerobic metabolism.

Unit: 2 **16 Lectures**

Paleontology and molecular evolution: The evolutionary time scale, Eras, periods and epoch, Major events in the evolutionary time scale, Origins of unicellular and multicellular organisms, Stages in primate evolution including *Homo sapiens*. Concepts of neutral evolution, Molecular divergence and molecular clocks, Molecular tools in phylogeny, Classification and identification; Origin of new genes and proteins; Gene duplication and divergence.

Unit: 3 **18 Lectures**

Basic concepts of development: Totipotency, Commitment, Specification, Induction, Competence, Determination and Differentiation, Morphogenetic gradients, Cell fate and cell lineages, Stem cells, Genomic equivalence and the cytoplasmic determinants, Imprinting, Mutants and transgenics in analysis of development.

Unit: 4 **18 Lectures**

Gametogenesis, fertilization and cell death: Production of gametes, Cell surface molecules in sperm-egg recognition in animals; Embryo-sac development and double fertilization in plants, Zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals, Embryogenesis and establishment of symmetry in plants, Seed formation.Hypersensitive response, functions, relevance with diseases, apoptosis, Caspases, Importance of PCD in plant development, role of PCD, model of PCD.

Suggested Reading:

1. Darwin, C.R. (1911). *On the origin of species by means of natural Selection, or preservation of favoured races in the struggle for life*. Hurst Publishers, UK.
2. Dawkins, R. (1996). *The Blind Watchmaker*, W.W. Norton & Company Jones and Bartlett Publishers.
3. Futuyma, D.J. (2009). *Evolution*. Sinauer Associates Inc. USA.
4. Hake, S. and Wilt, F. (2003). *Principles of Developmental Biology*. W.W. Norton & Company, New York, USA.
5. Hall, B.K. and Hallgrimsson, B. (2007). *Strickberger's Evolution.* Jones and Bartlett Publishers, India.
6. Lewin, R. (2004). *Human Evolution - An Illustrated Introduction*. Wiley-Blackwell, USA.
7. Scott, F. and Gilbert, S.F. (2010). *Developmental Biology*. Sinauer Associates, Inc. USA.
8. Slack, J.M.W. (2005). *Essential Developmental Biology*, Wiley-Blackwell, USA.

Course Title: Microbiology
Paper Code: 603
Semester: III

L	T	P	Credits	Marks
2	0	0	2	50

Course Objective and Learning Outcomes: The objective of this subject is to ensure that a student understands Microbiology

Unit: 1 **16 Lectures**

Prokaryotic, Eukaryotic structure and function: Cell structure and function, Classifications. Bacteria, Fungi, Protozoa, Algae, and viruses, Structure of major viruses, and Viral replication.

Unit: 2 **16 Lectures**

Growth, nutrition & control: Phases in bacterial growth, Growth Curve, Calculation of G-time, Physical and environmental requirements of growth, Microbial nutritional requirements, Types of culture media. Physical and Chemical methods, Antimicrobial drugs, Antibiotic assays, Drug resistance in bacteria.

Unit: 3 **6 Lectures**

Microbial Genetics: DNA replication, Transcription and translation, Operon, Horizontal Gene Transfer.

Unit: 4 **16 Lectures**

Applied Microbiology: Environmental microbiology, Microbial ecology, Aquatic Microbiology, Food, Dairy and Agricultural Microbiology, Industrial Microbiology. Major bacterial diseases of animals and plants, Airborne, Food-borne, Soil-borne, Nosocomial and Sexually Transmitted/Contagious Diseases, Principles of disease and epidemiology, Host-Microbe relationship, Viral pathogenesis, Major viral diseases of plants and animals.Avian Influenza A/H5N1, A/H1N1 Swine Influenza, SARS, AIDS, Japanese encephalitis, Malaria and Tuberculosis, West Nile, Mechanisms of emergence and reemergence.

Suggested Reading:

1. Bauman, R.W. (2011). *Microbiology with Diseases by Body System*. Benjamin Cummings, USA.
2. Capuccino, J.G. and Sherman, N. (2004). *Microbiology-A Laboratory Manual*. Benjamin Cummings, USA.
3. Pelczar, M. J., Chan, E.C.S. and Krieg, N.R. (1993). *Microbiology: Concepts and Applications*. McGraw-Hill Inc. USA.
4. Pommerville, J.C. (2010). *Alcamo's Fundamentals of Microbiology*. Jones & Bartlett Publishers, USA.
5. Prescott, L.M., Harley, J.P. and Klein, D.A. (2004). *Microbiology*. McGraw-Hill Science, USA.
6. Strelkauskas, A., Strelkauskas, J. and Moszyk-Strelkauskas, D. (2009). *Microbiology: A Clinical Approach.* Garland Science, New York, USA.
7. Tortora, G.J., Funke, B.R. and Case, C.L. (2009). *Microbiology: An Introduction.* Benjamin Cummings, USA.

Course Title: Complex Algorithms in Bioinformatics
Paper Code: LBI.604
Semester: III

L	T	P	Credits	Marks
3	0	0	3	75

Course Objective and Learning Outcomes: The objective of this subject is to inculcate the understanding about complex algorithms currently in use in Bioinformatics.

Unit 1 **14Hours**
TSP; Weight matrices: Sequence weighting, pseudo count correction for low counts, Gibbs sampling, and Psi-Blast

Unit 2 **14Hours**
Dynamic programming: Needleman-Wunsch, Smith-Waterman, and alignment heuristics; Data redundancy and homology reduction: Hobohm and other clustering algorithms

Unit 3 **14Hours**
Hidden Markov Models: Model construction, Viterbi decoding, and posterior decoding, and Baum Welsh HMM learning

Unit 4 **14Hours**
Artificial neural networks: Architectures and sequence encoding, feed-forward algorithm, and back propagation; BCO; ACO; Genetic Algorithm

Suggested Reading

1. Mastering Algorithms with Perl; Oreilly
2. Algorithms by Robert Sedgewick
3. Art of Computer Programming, Volume 1: Fundamental Algorithms by Donald Ervin Knuth

Course Title: Complex Algorithm Lab
Paper Code: LBI.605
Semester: III

L	T	P	Credits	Marks
0	0	2	1	25

Making computer programs based on the following approaches for solving Travelling sales man problem

- Bee Colony Optimization
- Ant Colony Optimization
- Genetic Algorithm

Training Artificial neural networks for pattern predictions (different types feed-forward algorithm, and back propagation)

Suggested Reading

1. Mastering Algorithms with Perl; Oreilly
2. Algorithms by Robert Sedgewick
3. Art of Computer Programming, Volume 1: Fundamental Algorithms by Donald Ervin Knuth

Course Title: Molecular Dynamics
Paper Code: LBI.606
Semester: III

L	T	P	Credits	Marks
4	0	0	4	100

Course Objective and Learning Outcomes: The objective of this subject is to ensure that a student learns modelling of biomolecular structures and understanding the dynamics of the structural transitions.

Unit 1 **14 Hours**

Biomolecular Modeling and Structure - molecular modeling today: overview of problems, tools, and solution analysis, minitutorials in protein and nucleic acid structure. Techniques for Conformational Sampling- Monte Carlo, global optimization, etc.

Unit 2 **14 Hours**

Molecular Mechanics: general features, bond stretching, angle bending, improper torsions, out of plane bending, cross terms, non-bonded interactions, Ramachandran diagram point charges, calculation of atomic charges, polarization, van der waals interactions, hydrogen bond interactions, Water models, Force field, all atoms force field and united atom force field.

Unit 3 **14 Hours**

Energy minimization: Steepest descent, conjugate gradient – Derivatives, First order steepest decent and conjugate gradients. Second order derivatives Newton-Raphson, Minima, maxima saddle points and convergence criteria.-non derivatives minimization methods, the simplex, sequential univariative, Newton's equation of motion, equilibrium point, radial distribution function, pair correlation functions, MD methodology, periodic box, Solvent access, Equilibration, cut-offs.

Unit 4 **14 Hours**

Simulation methods : algorithm for time dependence; leapfrog algorithm, Verlet algorithm, Boltzmann velocity, time steps, duration of the MD run, Starting structure, analysis of MD job, uses in drug designing, ligand protein interactions. Various methods of MD, Monte Carlo, systematic and random search methods. Differences between MD and MC, Energy, Pressure, Temperature, Temperature dynamics, simulation softwares. Various methods of MD, Monte Carlo, systematic and random search methods.

Suggested Readings:

1. Andrew R.Leach Molecular Modelling Principles and applications . (2001) II ed . Prentice Hall.
2. Fenniri, H. "Combinatorial Chemistry – A practical approach",(2000) Oxford University Press, UK.
3. Lednicer, D. "Strategies for Organic Drug Discovery Synthesis and Design"; (1998) Wiley International Publishers.
4. Gordon, E.M. and Kerwin, J.F "Combinatorial chemistry and molecular diversity in drug discovery" (1998) Wiley-Liss Publishers.

Course Title: Computational Genomics and Proteomics
Paper Code: LBI.607
Semester: III

L	T	P	Credits	Marks
2	0	0	2	50

Unit 1 **7 Hrs**

The Importance of DNA-Protein Interactions During Transcription. Initiation-Regulation of Transcription, Synthesis and Processing of the Proteome, The Role of tRNA in Protein Synthesis, The Role of the Ribosome in Protein Synthesis, Post-translational Processing of Proteins, Protein Degradation.

Unit 2 **8 Hrs**

Basic concepts on identification of disease genes, role of bioinformatics-OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling; identification of SNPs, SNP database (DbSNP). Role of SNP in Pharmacogenomics, SNP arrays

Unit 3 **16 Hrs**

DNA microarray: database and basic tools, Gene Expression Omnibus (GEO), ArrayExpress, SAGE databases

DNA microarray: understanding of microarray data, normalizing microarray data, detecting differential gene expression, correlation of gene expression data to biological process and computational analysis tools (especially clustering approaches)

Unit 4 **6 Hrs**

Only for yeasts: building predictive models of transcriptional regulatory networks using probabilistic modeling techniques. Use of graphical models for understanding regulatory mechanisms, and use of both direct (molecular interaction data) and functional data (expression, phenotype) to constrain the models.

Extra Reading Topics (Not in evaluatory syllabus)

Genomes, Transcriptomes and Proteomes, The Human Genome and its Importance, Structure of the Eukaryotic and Prokaryotic Genome, the Repetitive DNA Content of Genomes. Mechanism of Genetic Action, Gene-protein relations, Genetic fine structure, Mutational sites Complementation

How Genomes Function, Accessing the Genome, Inside the Nucleus, Chromatin Modifications and Genome Expression, Assembly of the Transcription Initiation Complex , Metagenomics

Course Title: Molecular Modeling and Dynamics
Paper Code: LBI.608
Semester: III

L	T	P	Credits	Marks
0	0	4	2	50

1. Advanced Visualization Software and 3D representations with VMD and Rasmol.
2. Coordinate generations and inter-conversions.
3. Secondary Structure Prediction.
4. Fold Recognition, ***ab initio method.***
5. Homology based comparative protein modeling.
6. Energy minimizations and optimization.
7. Validation of models.
    a. WHATIF
    b. PROSA
    c. PROCHECK
    d. VERIFY 3D
8. Protein Structure Alignment.
9. Modeller
10. Structure based Drug Design
    a. Molecular Docking
    b. De Novo Ligand Design
    c. Virtual Screening
11. Ligand based Drug Design
    a. Pharmacophore Identification
    b. QSAR
12. Molecular Dynamics with Gromacs
13. Binding Site Identification

Suggested Reading

1. Andrew R.Leach Molecular Modelling Principles and applications . (2001) II ed . Prentice Hall.
2. Fenniri, H. “Combinatorial Chemistry – A practical approach”,(2000) Oxford University Press, UK.
3. Lednicer, D. “Strategies for Organic Drug Discovery Synthesis and Design”; (1998) Wiley International Publishers.
4. Gordon, E.M. and Kerwin, J.F “Combinatorial chemistry and molecular diversity in drug discovery” (1998) Wiley-Liss Publishers.

Course Title: Credit Seminar
Paper Code: LBI.691
Semester: I

L	T	P	Credits	Marks
0	0	4	2	50

Objective: The objective of Credit Seminar would be to ensure that the student learns the aspects of the seminar presentation. Herein, the student shall have to present a selective overview of a scientific problem with focus of literatural knowledge.

The evaluation criteria shall be as follows:

Maximum Marks: 50

S.No.	Criteria	Marks
1	Content	20
2	Presentation Skills	20
3	Handling of queries	10

Semester-4												
S.No.	**Paper Code**	**Course Title**	**Course Type**	**L**	**T**	**P**	**Cr**	**% Weightage**				
								a	**b**	**c**	**d**	**e**
33	LBI.621	Systems Biology	C	4	-	-	4	25	25	25	25	100
34	LBI.622	Molecular Evolution	C	4	-	-	4	25	25	25	25	100
35	LBI.623	Scientific Writing and Intellectual Property Rights	C	4	-	-	4	25	25	25	25	100
		Dissertation		-	-	32	16	-	-	-	-	400
37	LBI.699	Project Work	C	-	-	24	12	-	-	-	-	S/US
		Total Sem-4		12	0	24	23					300

a. Continuous Assessment: Based on Objective Type Tests
b. Pre-Scheduled Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)
c. Pre-Scheduled Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)
d. End-Term Exam (Final): Based on Objective Type Tests
e. Total Marks

Course Title: Systems Biology
Paper Code: LBI.621
Semester: IV

L	T	P	Credits	Marks
4	0	0	4	100

Course Objective and Learning Outcomes: The objective of this subject is to ensure that a student learns about various aspects of systems biology and molecular evolution.

Unit 1 **14 Hours**

Transcription networks, basic concepts, Auto-regulation, a network motif, the feed forward loop network motif

Unit 2 **14 Hours**

Temporal programs and the global structure of transcription networks, Network motifs in developmental, signal-transduction and neuronal networks

Unit 3 **14 Hours**

Robustness of protein circuits, the example of bacterial chemotaxis, Robust patterning in development

Unit 4 **14 Hours**

Kinetic proofreading, optimal gene circuit design; Rules for gene regulation based on error minimization, Simplicity in biology

Suggested Reading

1. An Introduction to Systems Biology: Design Principles of Biological Circuits by Uri Alon, Chapman & Hall, ISBN 1-58488-642-0.
2. Hake, S. and Wilt, F. (2003). Principles of Developmental Biology. W.W. Norton and Company, New York, USA.
3. Hall, B.K. and Hallgrimsson, B. (2007). Strickberger's Evolution. Jones and Bartlett Publishers, India.
4. Lewin, R. (2004). Human Evolution - An Illustrated Introduction. Wiley-Blackwell, USA.

Course Title: Molecular Evolution
Paper Code: LBI.622
Semester: IV

L	T	P	Credits	Marks
4	0	0	4	100

Course Objective and Learning Outcomes: The objective of Molecular Evolution would be to ensure that the student learns the nuances of Molecular Evolution.

Unit 1 **14 Hours**

Comparison of DNA sequences to calculate gene distance; Convergent and divergent evolution; Mutation Vs. Substitution-Rate of Molecular Evolution. Jukes Cantor Correction and evolutionary distance

Unit 2 **14 Hours**

Hardy-weinberg equilibrium – Heterozygosity, gene frequency and heterozygosity; Loss of heterozygosity-mutant alleles-theta as the measure

Unit 3 **14 Hours**

Molecular clock- Concepts and significance-molecular mechanisms of molecular clock- Neutral theory -gene family organization.

Unit 4 **14 Hours**

Paralogy and Orthology- coordination expression in evolution-genome : content, structure and evolution. Molecular evolution of recently diverged species - Databases of Molecular evolution.

Suggested Reading

1. Darwin, C.R. (1911). On the origin of species by means of natural Selection, or preservation of favoured races in the struggle for life. Hurst Publishers, UK.
2. Dawkins, R. (1996). The Blind Watchmaker, W.W. Norton & Company Jones and Bartlett Publishers.
3. Futuyma, D.J. (2009). Evolution. Sinauer Associates Inc. USA

Course Title: Scientific Writing and Intellectual Property Rights
Paper Code: LBI.623
Semester: IV

L	T	P	Credits	Marks
3	2	0	4	100

Unit I: 9 classes

Introduction; principles of effective writing (cutting unnecessary clutter); Principles of effective writing (verbs); Crafting better sentences and paragraphs; Organization; and streamlining the writing process; The format of an original manuscript

Unit 2: 9 classes

Reviews, commentaries, and opinion pieces; and the publication process; Issues in scientific writing (plagiarism, authorship, ghostwriting, reproducible research); How to do a peer review; and how to communicate with the lay public

Unit 3: Patents 9 classes

Introduction to Patents – Patentability criteria - Novelty, Non-Obviousness and industrial applicability - The Patent Act, 1970 – Inventions not patentable – Patent Specifications: Provisional and complete - Types of patent applications – compulsory licensing – Patent application Forms and fees – Types of Patent search – Prior-art search – Freedom to operate search – Patent validity/Invalidity search – state of art search - International Patent Classifications (IPC) – European patent classification (ECLA) – Cooperative patent classification (CPC) – patent claim analysis – IP landscaping.

Unit 4: IPR in Life Sciences and Computer related inventions 9 classes

Patentability of Biotechnology Inventions - Protection of Genetic Resources - Patenting of seeds Moral Issues in Patenting Biotechnological Inventions – case studies on biotechnology patents -protection for Software and Computer related inventions - Protecting Trademark and Copyright in the Social media - Copyright Issues in the Digital Environment – case studies on computer related Inventions.

Tutorials on:
1. Patent search and Analytics
2. Patent strategy game shall be organized based on a real time situation for the students

Course Title: M.Sc. Project Work
Paper Code: LBI.699
Semester: IV

L	T	P	Credits	Marks
0	0	24	12	S/US

Course Objective and Learning Outcomes: The objective of dissertation part II would be to ensure that the student learns the nuances of the scientific research. Herein the student shall have to carry out the experiments to achieve the objectives as mentioned in the synopsis. The data collected as a result of experiments must be meticulously analyzed in light of established scientific knowledge to arrive at cogent conclusions.

The Evaluation criteria shall be multifaceted as detailed below:

S.No.	Criteria	Marks allotted
1.	Report Writing	S/US
2.	Presentation and defense of research work	S/US
3.	Continuous evaluation of student by Guide	S/US
	Total	S/US

S/US = Satisfactory / Unsatisfactory

The final presentation shall be evaluated by a three membered committee consisting of

a. COC / OIC of the department
b. Another teacher from allied department
c. Supervisor (and Co-supervisor if applicable)