Annexure IIa

Scheme of curriculum approved by the Board of Studies

Semester – I		
Major	BIN 415 Basics of Biochemistry	2
	BIN 416 Cell and Molecular Biology	2
	BIN 417 Statistical Methods	4
	BIN 418 Linux and Shell Scripting Lab	2
Minor	BIN 419 Sequence Analysis	2
	BIN 420 Biomolecular Structure Analysis	2
Vocational	BIN 421 Python Programming Lab I	2
	BIN 422 Sequence and Structure Analysis Lab	2
IKS	University wide	2
Semester – II		
Major	BIN 465 Computer Aided Drug Discovery	4
	BIN 465 Computational Genomics and Proteomics	4
	BIN 467 Algorithms in Bioinformatics	4
Minor	BIN 468 Fundamentals of Machine Learning	2
	BIN 469 Fundamentals of Molecular Dynamics simulations	2
Vocational	BIN 470 Python Programming Lab II	2
IKS	BIN 471 History of Science in India	2
Semester – III		
Major (Any for credits equivalent to 4)	BIN 515 Biological Databases and Management System	2
	BIN 516 Systems Biology and Biological Networks	4
	BIN 517 Essentials of Immunology	2
Minor	BIN 518 Research Methodology	4
Vocational	BIN 519 Computer Aided Drug Design Lab	2
	BIN 520 Systems Biology Lab	2
Review	BIN 521 Review of Literature and research proposal	8
Semester – IV		
Major (Any for credits equivalent to 4)	BIN 565 Statistical Genetics	2
	BIN 566 Molecular Evolution	4
	BIN 567 Introduction of Synthetic Biology	2
Minor	BIN 568 Academic Writings	2
	BIN 569 Paper publication/ seminar/ conference	2
Vocational	BIN 570 Molecular Dynamics Simulation Lab	2
	BIN 571 Data Analysis Lab	2
Dissertation	BIN 595 Dissertation	8
Total		**80**

Selection Criteria / Exam Pattern for M.Sc. Bioinformatics approved by the Board of Studies

The students will be admitted on the basis of entrance examination which will have the two parts: Part I will have two section and student will have to opt for any one section in the following pattern:

Part I

Section A

80% questions will be from Biology / Life Sciences background (20% Genetics, 20% Cell and Molecular Biology, 20% Microbiology, 20% Biochemistry and 20% Biotechnology)

Section B

80% questions will be from Non-Medical sciences (more specifically as Physics 25%; Chemistry 25%, Computer Sciences 25%, Mathematics 25%)

Part II

20 % questions will be from general aptitude and reasoning.

Eligibility of the prospective students approved by the Board of Studies

A student with more than 55% marks or equivalent in Bachelor's degree from any University / institution (National or International) duly recognised by UGC, in any stream of biology / life sciences, physical sciences, chemical sciences, mathematical sciences, Comupter sciences, computer applications, IT, environmental sciences, technology, engineering, agricultural sciences or medicine or any allied field of sciences.

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Annexure II

Semester – I		
Major	BIN 415 Basics of Biochemistry	2
	BIN 416 Cell and Molecular Biology	2
	BIN 417 Statistical Methods	4
	BIN 418 Linux and Shell Scripting Lab	2
Minor	BIN 419 Sequence Analysis	2
	BIN 420 Biomolecular Structure Analysis	2
Vocational	BIN 421 Python Programming Lab I	2
	BIN 422 Sequence and Structure Analysis Lab	2
IKS	University wide	2
Semester – II		
Major	BIN 465 Computer Aided Drug Discovery	4
	BIN 465 Computational Genomics and Proteomics	4
	BIN 467 Algorithms in Bioinformatics	4
Minor	BIN 468 Fundamentals of Machine Learning	2
	BIN 469 Fundamentals of Molecular Dynamics simulations	2
Vocational	BIN 470 Python Programming Lab II	2
IKS	BIN 471 History of Science in India	2
Semester – III		
Major (Any for credits equivalent to 4)	BIN 515 Biological Databases and Management System	2
	BIN 516 Systems Biology and Biological Networks	4
	BIN 517 Essentials of Immunology	2
Minor	BIN 518 Research Methodology	4
Vocational	BIN 519 Computer Aided Drug Design Lab	2
	BIN 520 Systems Biology Lab	2
Review	BIN 521 Review of Literature and research proposal	8
Semester – IV		
Major (Any for credits equivalent to 4)	BIN 565 Statistical Genetics	2
	BIN 566 Molecular Evolution	4
	BIN 567 Introduction of Synthetic Biology	2
Minor	BIN 568 Academic Writings	2
	BIN 569 Paper publication/ seminar/ conference	2
Vocational	BIN 570 Molecular Dynamics Simulation Lab	2
	BIN 571 Data Analysis Lab	2
Dissertation	BIN 595 Dissertation	8
Total		**80**

Semester – I

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Course Title: Basics of Biochemistry
Course Code: BIN.415
Total Hours: 20

L	T	P	Cr
2	0	0	2

Learning Outcomes: The outcomes of the subject is to ensure that a student comprehends the following:

- The structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.
- The energy metabolism by cellular components in cells and the process of mitotic cell division.
- 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.

Course Content

Unit 1

Principles of biophysical chemistry Thermodynamics, Colligative properties, Stabilizing interactions: Van der Waals, Electrostatic, Hydrogen bonding, Hydrophobic interaction, etc.

Unit 2

Composition, structure, function and metabolism of Carbohydrates, Lipids.

Unit 3

Composition, structure, function and metabolism of Amino Acids and Nucleotides.

Unit 4

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

Unit 5

Bioenergetics and oxidative phosphorylation, Carbohydrates, metabolism and glycolysis, tricaboxylic acid cycle and pyruvate dehydrogenase complex, gluconeogenesis, glycogen metabolism, monosaccharide and disaccharide metabolism, pentose phosphate pathway

Transactional Modes: Lecture; Tutorial; Problem solving; Self-learning.

Suggested Readings

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.

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Course Title: Cell and Molecular Biology
Course Code: BIN 416
Total Hours: 20

L	T	P	Cr
2	0	0	2

Learning Outcomes:
On successful completion of the course the student will be able to:

- Conceptualization of basic cellular and molecular mechanisms.
- Understanding structures and functions of various cellular organelles.
- Understanding the molecular processes of DNA replication, transcription, and translation

Course Content

Unit – I

Membranes of intracellular organelles, Membrane transport, Structure and functions of intracellular organelles, Intracellular traffic and secretory pathways, endocytosis and exocytosis.

Unit – II

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.

Unit – III

Gene and Genome organization: Eukaryotic gene organization, transposition, Mechanism of DNA replication, DNA damage and their repair.

Unit – IV

Transcription: transcription and transcription factors, Transcriptional and post-transcriptional gene silencing, mRNA processing: Capping, Polyadenylation, Splicing, editing, mRNA stability.

Unit – V
Translation: Genetic code, the translation machinery, mechanisms of chain initiation, elongation and termination, regulation of translation, post-translational modifications of proteins.

Transactional Modes:
Lecture; Demonstration; Tutorial; Lecture cum demonstration; Problem solving; Self-learning.

Suggested Reading:

1. Sambrook, J., Fritsch, E. F., & Maniatis, T. (2015). Molecular cloning: a laboratory manual. Cold Spring Harbor Laboratory Pressn New York.
2. Lodish, H.,Berk, A. Chris, A.K. & Krieger, M. (2011). *Molecular Cell Biology*. W.H. Freeman, USA.
3. Robertis, (2011). *Cell and Molecular Biology*. Lippincott Williams & Wilkins.
4. Karp, G. (2010). *Cell and molecular biology: concepts and experiments*. John Wiley & Sons.
5. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2017). *Lewin's Genes XII*. Jones & Bartlett Learning.
6. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., & Levine, M. (2003). Molecular Biology of the Gene Benjamin Cummings.
7. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2007). Molecular biology of the cell. Garland Science. *New York*, *1392*.
8. Fasman, G.D. (1989). *Practical Handbook of Biochemistry and Molecular Biology*. CRC Press,Taylor and Francis Group, UK.

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Website: www.cuhimachal.ac.in

Course Title: Statistical Methods
Course Code: BIN.417
Total Hours: 40
Credits Equivalent: 4 Credits

L	T	P	Cr
4	0	0	4

(One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

This course will introduce the students to the concepts and methods of statistics, covering topics such as data organization and presentation, data analysis, probability, estimation and hypothesis testing and their application to the biological data. Students will be encouraged to use Python or R to gain computational hands-on learning about the topics covered. At the end of the course, students will be able to:

1. Develop an understanding of the fundamental theoretical aspects of methods of statistics and probability.
2. Develop the foundational skills in statistical analysis for Bioinformatics and Data Science.

Attendance Requirement:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 25%
2. End Term Examination: 50%
3. Continuous Internal Assessment : 25%
   a. Class test: 10%
   b. Class room participation: 10%
   c. Attendance: 5%

Course Contents:

Unit-I: Introductory concepts **(8 Hours)**

- Big Data in Biology: Need of statistical measures to analyze it.
- Statistical population and sample: Types of data, Relative and cumulative frequency.
- Descriptive measures:

1. Measures of Central tendency: Mean, Median, Mode: notation and formulae, grouped data, relative merits
2. Measures of Dispersion: Absolute and relative measures.

- Organization and presentation of data: Histogram, Stem and leaf, Polygon, Ogive, Box Plot etc.

Unit-II: Discrete probability distributions **(8 Hours)**

- Basic probability models: Combinatorics based computation
- Concepts of Conditional, Joint and Marginal probabilities. Bayes' rule
- Discrete random variables: Expected value, Variance, Covariance
- Discrete parametric distributions: (i) One Bernoulli Trail, (ii) Binomial distribution, (iii) Uniform distribution, (iv) Poisson distribution, (v) Power-law distribution

Unit-III: Continuous probability distributions **(8 Hours)**

- Continuous probability models: Cumulative distribution function, Density functions
- Continuous probability distributions:
  (i) Uniform distribution, (ii) Normal distribution: Standard deviation, Variance, Skewness and Kurtosis, z-score (iii) Exponential distribution.

Unit IV: Hypothesis testing **(8 Hours)**

- Statistical preliminaries: Sample mean, Sample variance, Standard error
- Family of normal distributions: Standard normal distribution, The central limit theorem, Chi-squared distribution
- Statistical inference: Confidence intervals, Student-t distribution, Significance tests, p-values, ANOVA

Unit V: Multivariate analysis **(8 Hours)**

- Discrete and continuous multivariate distributions
- Covariance and correlation: Pearson's, Spearman's correlation coefficients
- Clustering, Classification, Regression, Goodness of fit

Text Books:

1. Ewens and Grant (2005), Statistical Methods in Bioinformatics, Springer
2. Matloff (2020). Probability and Statistics for Data Science, CRC
3. Prem S. Mann (2018), Introductory Statistics, Wiley
4. Daniel and Cross (2019), Biostatistics, Wiley

Reference Books:

- Murray Spiegel et al. (2010), Probability and Statistics. McGraw Hill Education.
- Roger E. Kirk (2007), Statistics: An Introduction, Cengage Learning.
- Neil A. Weiss (2012), Introductory Statistics.
- Charles H. Brase and Corrinne P. Brase (2011), Understandable Statistics: Concepts and Methods.
- J. H. Zar (2019), Biostatistical Analysis, Pearson

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Course Title: Linux and Shell Scripting Lab
Course Code: BIN.418
Total Hours: 20

L	T	P	Cr
0	0	4	2

Learning Outcomes: The outcomes of the subject is to ensure that a student can apply the knowledge of the following

- Linux administration
- File / Data management
- Stream processing

Course Content

What is Linux, Linux architectures: root, files system, standard directories general commands for files and directories cd, ls, cp, rm, mkdir, rmdir, pwd, file, more, less
Creating and viewing files using cat file comparisons
Essential Linux commands: Processes in Linux, Process fundamentals, Connecting processes with pipes, Redirecting input, Redirecting output, Background processing

Managing multiple processes, Process scheduling – (at,batch), nohup command,, kill, ps, who find, sort, touch, file, file processing commands – wc, cut, paste etc,
Mathematical commands – expr, factor etc
Creating files with editors: vi, vim, kate. Kwrite, pico etc

System administration
Common administrative tasks
Identifying administrative files
Configuration and log files
Role of system administrator
Managing user accounts -adding users
Managing user accounts -deleting users
Changing permissions and ownerships
Creating and managing groups
Modifying group attributes

Simple filter commands & Understanding various Servers.
Filter Commands-pr, head, tail
Filter Commands -cut, sort.
Filter Commands- uniq, tr.
Filter using regular expression grep.
Filter using regular expression egrep, sed Basics, Variables, Substitution & Quoting
Flow Control, Loops and Documentation

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Course Title: Sequence Analysis
Course Code: BIN 419
Total Hours: 20

L	T	P	Cr
2	0	0	2

Learning Outcomes: The outcomes of the subject is to ensure that a student can apply the knowledge of the following

- Data storage formats
- Pairwise alignments
- Sequence patterns and profiling
- Multiple sequence alignment

Course Content

Unit 1
Basic concepts of sequence similarity, identity and homology, homologues, orthologues, paralogues and xenologues

Unit 2
Pairwise sequence alignments: basic concepts of sequence alignment, Needleman and Wunsch, Smith and Waterman algorithms for pairwise alignments, gap penalties

Unit 3
Scoring matrices: basic concept of a scoring matrix, PAM and BLOSUM series Tools such as BLAST (various versions of it) and FASTA

Unit 4
Multiple sequence alignments (MSA): basic concepts of various approaches for MSA (e.g. progressive, hierarchical etc.). Algorithm of CLUSTALW (including interpretation of results), concept of dendrogram and its interpretation.

Unit 5
Sequence patterns and profiles: Basic concept and definition of sequence patterns, motifs and profiles, profile-based database searches using PSI-BLAST, analysis and interpretation of profile-based searches.

Transactional Modes: Lecture; Problem solving; Self-learning.

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

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Course Title: Biomolecular Structure Analysis
Course Code: BIN 420
Total Hours: 20

L	T	P	Cr
2	0	0	2

LEARNING OUTCOMES

The overall goal of this course is to give students advanced knowledge of the relationship between the structure and function of biomolecules and to handle different tools used in structural bioinformatics.
On completion of the course, the student should be able to:
Explain the basis of biological macromolecules constitution and traits
Explain the basis of biological catalysis
Explain the constitution of molecular complexes like ribosomes and viruses and aggregates like filaments and tubules
Use databases with information of structure and function of macromolecules
Use and analyse results from methods used to predict secondary- and tertiary structure of macromolecules

COURSE CONTENT

Unit 1
Methods for the determination of macromolecules structure and interaction.
Basic macromolecular structure; DNA, RNA, protein, lipids.

Unit 2
The folding process and structural background to the dynamics of macromolecules.
Binding specificity, catalysis and cooperativity in enzymes and receptors.
Macromolecules function described by a few specific examples.

Unit 3
Biological structure databases.
Structure analysis and classification of proteins in structural families.
Relation between sequence, structure and function.

Unit 4
Computer modelling of secondary- and tertiary structure of proteins and nucleic acid based on sequence data. Enzyme/receptor-based drugs-rational drug design.

Unit 5
Applications of Structure Analysis in Life Sciences, Land mark studies and success stories

Transactional Mode
Lectures, seminars.

Suggested Reading
1. Liljas, Anders Textbook of structural biology New Jersey: World Scientific, cop. 2009

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Website: www.cuhimachal.ac.in

Course Title: Python Programming Lab-I
Course Code: BIN 421
Total Hours: 40

L	T	P	Cr
0	0	4	2

Learning Outcomes: Upon successfully completing this course, students will be able to "do something useful with Python".

- Identify/characterize/define a problem
- Design a program to solve the problem
- Create executable code
- Read most Python code
- Write basic unit tests

Course Content

Working with Data. A detailed tour of how to represent and work with data in Python. Covers tuples, lists, dictionaries, and sets. Students will also learn how to effectively use Python's very powerful list processing primitives such as list comprehensions. Finally, this section covers critical aspects of Python's underlying object model including variables, reference counting, copying, and type checking.

Program Organization, Functions, and Modules. More information about how to organize larger programs into functions and modules. A major focus of this section is on how to design functions that are reliable and can be easily reused across files. Also covers exception handling, script writing, and some useful standard library modules.

Classes and Objects. An introduction to object-oriented programming in Python. Describes how to create new objects, overload operators, and utilize Python special methods. Also covers basic principles of object oriented programming including inheritance and composition.

Inside the Python Object System. A detailed look at how objects are implemented in Python. Major topics include object representation, attribute binding, inheritance, memory management, and special properties of classes including properties, slots, and private attributes.

Transactional Modes: Laboratory based practicals; Problem solving; Self-learning.

Suggested Readings

- The Python Tutorial (https://docs.python.org/3/tutorial/): This is the official tutorial from the Python website. No more authoritative source is available.
- Code Academy Python Track (http://www.codecademy.com/tracks/python): Often cited as a great resource, this site offers an entertaining and engaging approach and in-browser work.

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Learn Python the Hard Way (http://learnpythonthehardway.org/book/): Solid and gradual. This course offers a great foundation for folks who have never programmed in any language before. [Python 2]

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Website: www.cuhimachal.ac.in

Course Title: Sequence and Structure Analysis Lab
Course Code: BIN 422
Total Hours: 40

L	T	P	Cr
0	0	4	2

Learning Outcomes: The outcomes of the subject is to ensure that a student can apply the knowledge of the following

- Data storage formats
- Pairwise alignments
- Sequence patterns and profiling
- Multiple sequence alignment

Introduction to Bioinformatics and Sequence Analysis. In addition to lecture material, skills needed for future problem set assignments will be covered. This will include taking screenshots, formatting of text and generation of reports.
Internet Resources focusing on text-based searches of literature, molecular, and medical databases. We will again work on the skills needed for generating reports.
Searching DNA databases with DNA queries: BLASTN. First problem set assignment focused on material from this lecture: 5 grade points maximum.
Searching protein databases with protein queries: BLASTP. Second problem set assignment focused on material from this lecture: 10 grade points maximum.
Cross-molecular searches: BLASTX and TBLASTN. Third problem set assignment focused on material from this lecture: 10 grade points maximum.
Advanced topics in BLAST
Protein Analysis Fourth problem set assignment focused on material from this lecture: 10 grade points maximum.
Analysis problems involving short sequences Fifth problem set assignment focused on material from this lecture: 5 grade points maximum.
MicroRNAs and Pathway Analysis Sixth problem set assignment focused on material from this lecture: 5 grade points maximum.
Multiple Sequence Alignments
Exploring the genome with Genome Browsers
Prediction of Protein-membrane, Protein-ligand, Protein-nucleic acid and Protein-protein interaction sites
Protein Ligand Docking using (i) Autodock (ii) Vina and (iii) Dock
Protein-protein docking by HADDOCK or other similar methods Modelling macromolecular structure 1. Homology modelling 2. *ab-initio* structure modeling

Transactional Modes: Laboratory based practicals; Problem solving; Self-learning.

Suggested Readings

1. *Grant, Guy H.; Richards, W. Graham* Computational chemistry Oxford: Oxford Univ. Press, 1995
2. Schneider, Gisbert; Baringhaus, Karl-Heinz; Kubinyi, Hugo Molecular design: concepts and applications Weinheim: Wiley-VCH, c2008
3. Practical Bioinformatics by Michael Agostino ISBN 978-0-8153-4456-8

Semester – II

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Course Title: Computer Aided Drug Discovery
Course Code: BIN 465
Total Hours: 40

L	T	P	Cr
4	0	0	4

Learning Outcomes:
At the end of the course, the students will be able to:

- demonstrate various force field for biomolecular modeling
- execute various molecular docking methods
- Identify the dynamics of structural transitions which will help them to develop the molecular docking techniques in their further potential careers in academia and industry.

Course Content

Unit 1

Introduction to Computer Aided Drug Design (CADD) History, different technique sand applications Quantitative Structure Activity Relationships: Basics History and development of QSAR: Physicochemical parameters and methods to calculate physicochemical parameters: Hammett equation and electronic parameters (sigma), lipophilicity effects and parameters (log P, pisubstituent constant), steric effects (Taft steric and MR parameters) Experimental and theoretical approaches for the determination of these physicochemical parameters

Unit 2

Quantitative Structure Activity Relationships: Applications Hansch analysis, Free Wilson analysis and relationship between them, Advantages and disadvantages; Deriving 2D-QSAR equations 3D-QSARapproaches and contour map analysis Statistical methods used in QSAR analysis and importance of statistical parameters

Unit 3

Molecular Modeling and Docking Molecular and Quantum Mechanics in drug design Energetics of bioactive conformation Molecular docking and drug receptor interactions: Rigid docking,flexible docking and extra-precision docking. Agents acting on enzymes such as DHFR, HMG-CoA reductase and HIV protease, choline esterase (AchE & BchE)

Unit 4

Molecular Properties and Drug Design: Prediction and analysis of ADMET properties of new molecules and its importance in drug design.

Unit 5

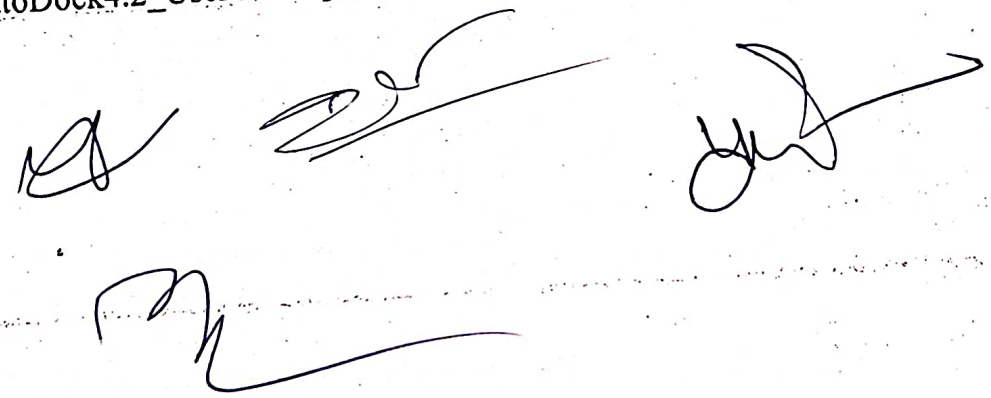
De novo drug design: Receptor/enzyme-interaction and its analysis, Receptor/enzyme cavity size prediction, predicting the functional components of cavities, Fragment based drug

design. Homology modeling and generation of 3D-structure of protein

Transactional Modes: Lectures; Tutorials; Problem solving; Self-learning.

Suggested Readings

1. Schneider, Gisbert; Baringhaus, Karl-Heinz; Kubinyi, Hugo Molecular design : concepts and applications Weinheim: Wiley-VCH, c2008
2. Andrew R.Leach Molecular Modelling Principles and applications . (2001) II ed . Prentice Hall.
3. Lednicer, D. "Strategies for Organic Drug Discovery Synthesis and Design"; (1998) Wiley International Publishers.
4.http://autodock.scripps.edu/faqs-help/manual/autodock-4-2-user-guide/AutoDock4.2_UserGuide.pdf



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L	T	P	Cr
4	0	0	4

Course Title: Computational Genomics and Proteomics
Course Code: BIN 466
Total Hours: 40

Learning Outcomes:
At the end of the course, the students will be able to:

- learn the importance of DNA-Protein Interactions During Transcription
- gain a deep knowledge about the role of bioinformatics-OMIM database, integrated genomic maps, gene expression profling
- apply probabilistic modeling techniques for the building of transcriptional regulatory networks which will help them to use the techniques of computational proteomics in their further potential careers in academia and industry.

Course Content

Unit 1
The Importance of DNA-Protein Interactions During Transcription. Initiation-Regulation of Transcription, Synthesis and Processing of the Proteome

Unit 2
The Role of tRNA in Protein Synthesis, The Role of the Ribosome in Protein Synthesis, Post-translational Processing of Proteins, Protein Degradation.

Unit 3
Role of bioinformatics-OMIM database, integrated genomic maps, gene expression profiling; identification of SNPs, SNP database (DbSNP)

Unit 4
Transcriptomics: database and basic tools, Gene Expression Omnibus (GEO), SAGE databases. detecting differential gene expression,

Unit 5
Only for yeasts: building predictive models of transcriptional regulatory networks using probabilistic modeling techniques.
Peptide Mass Finger-printing: database searches

Extra Reading Topics (Not in evaluatory content)
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

Transactional Modes: Lecture; Tutorial; Problem solving; Self-learning.

Suggested Readings

1. Sándor Suhai (2002). Genomics and Proteomics. Springer US
2. CAMPBELL (2007). Discovering Genomics, Proteomics and Bioinformatics. Pearson Education
3. Richard P. Grant (2004). Computational Genomics: Theory and Application. Horizon Bioscience

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L	T	P	Cr
4	0	0	4

Course Title: Algorithms in Bioinformatics
Course Code: BIN467
Total Hours: 40

Learning Outcomes: On completion of the course the student should be able to :

- Understand the issues involved in dealing with large amount of data
- Gain a deep knowledge about the principles of a number of optimization algorithms

Credits Equivalent: 4 Credits

(One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives: The course is designed to introduce students the algorithmic principles, central to the studies in Computational Biology and Bioinformatics. Concepts from computer science like dynamic programming and graph theory will enable students to understand a variety of concepts that are used in the theoretical studies of life sciences and expose them to the underlying mechanisms of widely used softwares. Students, who are familiar with at least one programming language, will be encouraged to write their own codes for various algorithms discussed in this course.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student will not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 25%
2. End Term Examination: 50%
3. Continuous Internal Assessment: 25%
   - Class Participation – 5%
   - Assignments – 10%
   - Course project – 10%

Course Contents:

Unit 1: Introduction to algorithms and complexity **8 Hours**

1. Basic Concepts: Algorithmic complexity (spatial and temporal), Biological vs. Computer algorithms, Genetic algorithm.
2. Standard Notations: Big-Oh, Omega, Theta notations; Hardness of an algorithm.
3. Linear and non-linear data structures, Stack, Queues, Linked list.
4. Algorithm design techniques: Exhaustive search, Greedy Algorithms, Divide and conquer etc.
5. Searching algorithms: Linear and Binary search; Sorting algorithms: Selection, Bubble, Insertion, Merge.

Unit 2: Sequence Analysis **10 Hours**

1. Models of DNA evolution: Jukes Cantor, Kimura and Tamura models
2. Derivation of protein evolution models: PAM and BLOSUM
3. Elements of dynamic programming: Edit distance, Longest common subsequence, Global and Local Sequence Alignment
4. Working of BLAST: Usage of Finite State Machine, E-value, etc. Basics of PHI-BLAST and PSI-BLAST
5. Markov Chains and Hidden Markov Models: CpG islands, Pairwise alignment using HMMs, Introduction to HMMer
6. Tandem and Interspersed repeats. Repeat finding: Motifs, consensus, position weight matrices

Unit 3: Phylogenetics **8 Hours**

1. Basics of Molecular Evolution, Tree - terminologies, Binary trees, AVL trees.
2. Tree traversal: Pre-order, In-order, post-order;
3. Ukkonen's linear time suffix tree algorithm
4. Evolutionary trees: (I) Distance based methods – UPGMA, NJ, Fitch Margoliash (FM); (II) Character based methods – MP, ML, Bayesian inference algorithm.
5. Tree Evaluation, Bootstrapping.

Unit 4: RNA and Protein Structure Prediction **8 Hours**

1. RNA secondary structure: Nussinov algorithm, Zuker's Algorithm, SCFG.
2. RNA tertiary structure: Basics of "minimum free energy" based methods.
3. Protein secondary structure: Chou-Fasman, GOR method.

4. Protein tertiary structure: Rosetta method, Contact potential method.

Unit 5: Graph Theory and Network Biology **8 Hours**

1. Basics of graph terminologies. Tree vs Graph. Hamiltonian path vs. Eulerian path, Degree distribution
2. Introduction to Biological Networks
3. Graph traversal algorithms: Breadth-first search, Depth-first search
4. Basics of network models: Random, Small-world, Scale-free

Text Books:

1. **Jones and Pevzner (2004)**, An Introduction to Bioinformatics Algorithms. MIT Press.
2. **Durbin *et al.* (1998)**,Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids. Cambridge University Press
3. **Mount (2004)**, Bioinformatics: Sequence and Genome Analysis. CBS Publishers
4. **Pevsner (2015)**, Bioinformatics and Functional Genomics. Wiley.

Additional Readings:

1. **Gusfield (2005)**,Algorithms on Strings, Trees and Sequences. Cambridge University Press.
2. **Cormen *et al.* (2009)**, Introduction to Algorithms. MIT Press.
3. **Sung (2009)**, Algorithms in Bioinformatics: A Practical Introduction. Chapman & Hall/CRC.
4. **Neapolitan and Naimipour (2011)**, Foundations of Algorithms. Jones & bartlett.
5. **Korf *et al.* (2003)**, BLAST. O'Reilly
6. **Junker and Schreiber (2008)**, Analysis of Biological Networks. Wiley-Interscience, New Jersy.
7. **Mitchell (1998)**, An Introduction to Genetic Algorithms. MIT Press.

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Course Title: Fundamentals Machine Learning
Course Code: BIN 468
Total Hours: 20

L	T	P	Cr
2	0	0	2

Learning Outcomes: At the end of the course, the students will be able to understand the fundamentals of Machine learning

Course Content

Unit 1

Class overview: Class organization, topics overview, software etc.
Introduction: what is ML; Problems, data, and tools; Visualization

Unit 2

Linear regression; SSE; gradient descent; closed form; normal equations; features

Unit 3

Overfitting and complexity; training, validation, test data, and introduction to Python Libraries

Unit 4

Classification problems; decision boundaries; nearest neighbor methods
Probability and classification

Unit 5

Naive Bayes and Gaussian class-conditional distribution, Linear classifiers, Bayes' Rule and Naive Bayes Model

Transactional Modes: Lecture; Tutorial; Problem solving; Self-learning.

Suggectged Readings:

- Ethem Alpaydin, Introduction to Machine Learning, Second Edition , http://mitpress.mit.edu/catalog/item/default.asp?ttype=2&tid=12012.
- Stephen Marsland, Machine Learning: An Algorithmic Perspective. http://www.amazon.com/Machine-Learning-Algorithmic-PerspectiveRecognition/dp/1420067184
- Christopher M. Bishop, Pattern Recognition and Machine Learning. http://research.microsoft.com/en-us/um/people/cmbishop/prml/. □
- Tom Mitchell, Machine Learning, http://www.cs.cmu.edu/~tom/mlbook.html.

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L	T
2	0

Course Title: Fundamentals of Molecular Dynamics simulations
Course Code: BIN 469
Total Hours: 20

Learning Outcomes: At the end of the course, the students will be able to:

- learn the modelling of small to large molecular environments
- understand various force field for biomoleculra simulation in details
- gain the knowledge about different molecular simulation techniques
- learn different methods for simulating large systems
- understand the dynamics of the structural transitions

Course Content

Unit 1

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

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

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

Simulation methods: algorithm for time dependence; leapfrog algorithm, Verlet algorithm, Boltzmann velocity, time steps, duration of the MD run,

Unit 5

Starting structure, analysis of MD job, uses in drug designing, ligand protein interactions. Various methods of MD, Monte Carlo, systematic and random search methods.

Transactional Modes: Lecture; Tutorial; Problem solving; Self-learning.

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.

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L	T	P	Cr
0	0	4	2

Course Title: Python Programming Lab-II
Course Code: BIN 470
Total Hours: 40

Learning Outcomes: Upon successfully completing this course, students will be able to "do something useful with Python".

- Identify/characterize/define a numerical problem
- Design a program to solve the data parsing problem
- Create Time series code
- Read most of the advanced Python code

Course Content

- Introduction to Numpy and Pandas
- Visualizations with Matplotlib and Seaborn
- Statistical analysis to understand our data
- Data cleaning and normalization.
- Advanced Pandas models
- Hierarchical indexing
- Data Wrangling and transformations
- Advanced visualizations
- Introduction to Machine Learning
- Intro to Regressions- Linear and logistic regression using Scikit Learn
- Intro to Classification- Classification with K nearest Neighbours- Decision Trees and Random Forest

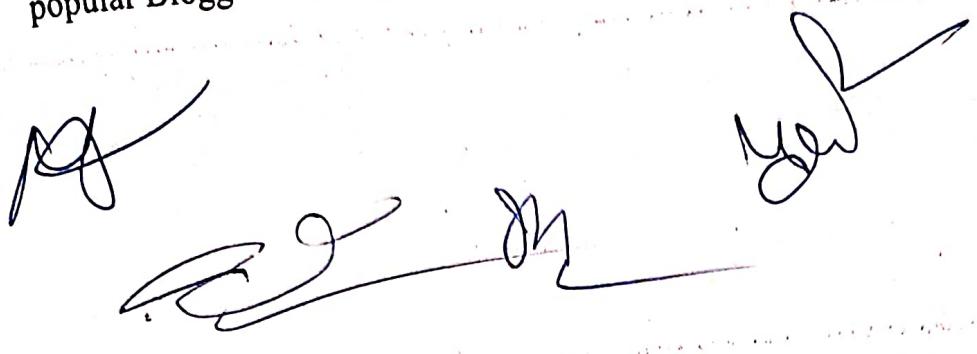
Transactional Modes:
Laboratory based practicals; Problem solving; Self-learning.

Suggested Readings

- Core Python Programming (http://corepython.com/): Only available as a dead trees version, but if you like to have book to hold in your hands anyway, this is the best textbook style introduction out there. It starts from the beginning, but gets into the full language. Published in 2009, but still in print, with updated appendixes available for new language features. In the third edition, "the contents have been cleaned up and retrofitted w/Python 3 examples paired w/their 2.x friends."
- Dive Into Python 3 (http://www.diveinto.org/python3/): This book offers an introduction to Python aimed at the student who has experience programming in another language.
- Python for You and Me (http://pymbook.readthedocs.org/en/latest/): Simple and clear. This is a great book for absolute newcomers, or to keep as a quick reference as you get used to the language.
- The latest version is Python 3.
- Think Python (http://greenteapress.com/thinkpython/): Methodical and complete. This book offers a very "computer science"-style introduction to Python. It is really

an intro to Python in the service of Computer Science, though, so while helpful for the absolute newcomer, it isn't quite as "pythonic" as it might be.

- Python 101 (http://www.blog.pythonlibrary.org/2014/06/03/python-101-book-published-today/) Available as a reasonably priced ebook. This is a new one from a popular Blogger about Python.



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L	T	P	C
2	0	0	2

Course Title: History of Science in India
Course Code: BIN 471
Total Lectures: 20

Course Objectives: This course is designed to introduce students about the rich scientific culture of India. The course attempts to develop a quest for search and research of scientific concepts embedded in the traditional Indian texts and rituals. For that, each topic covered in the course is taught by integrating two aspects: its modern scientific understanding and its discussion in the Indian literature. Prominent Indian Scientists, the Acharyas and the Rishis associated with a topic under discussion are duly introduced and acknowledged.

Course Contents

Unit 1: Introductory concepts

- Antiquity of Indian civilization
- The archaeological sources
- The literature sources: Vedas and Vedangas, Epics and Puranas, Sastras (Niti, Artha), etc.
- Needham's puzzle

Unit 2: Mathematics

- The Sulbasutras
- Concept of pi
- Zero, decimal number system, place value system, combinatorics
- Katapyadi system, binary number system
- Fibonacci series and golden ratio

Unit 3: Physics and Astronomy

- The Vaisheshika: Matter and Universe (Notions of Padarth, Dravya and Guna)
- Measurements of length and mass
- Kaal ganana, calendars and eclipses: Five siddhants
- Laws of motion, concept of gravity and relativity
- Sound, light and energy

Unit 4: Life Sciences and Medicine

- Plants and agriculture, the Vrikshayurveda
- Microbes, animals and humans
- Origin and evolution of Ayurveda

- Basic concepts; food, drinks and materia-medica; diseases; medicine; surgery; holistic view of life
- Brief discussions on Rasachikitsa, Nadi vijnana, Yoga, Siddha, Homeopathy, Sowa-Rigpa

UNIT 5: Engineering Sciences and Technology

- Architecture and Vastu Shastra
- Alchemy and metallurgy
- Marine science

Text Books:

- **Suresh Soni (2008).**India's Glorious Scientific Tradition. Ocean Books
- **Bose et al. (2009).** A Concise History of Science in India. Universities Press

Additional Readings:

- **BB Datta and AN Singh (1962).** History of Hindu Mathematics. Asia Publishing House
- **NG Dongre and SG Nene (2016).** Physics in Ancient India. National book Trust.
- **MS Valiathan.** The Legacy of Caraka/ Susruta/ Vagabhata. Universities Press.
- **P.C. Ray (1903).**A History of Hindu Chemistry. The Bengal chmeical and pharmaceutical works ltd.

Semester – III

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Course Title: Biological Databases and Management Systems
Course Code: BIN 515
Total Hours: 20

L	T	P	Cr
2	0	0	2

Learning Outcomes: Upon successfully completing this course, students will be able to apply principles of DBMS to create novel solution in bioinformatics.

- Identify/characterize/define and solve a data collection, sorting and management problem
- Design an approach to create a Relational DBMS
- Create non-redundant databases

Course Content

Unit1

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

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

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

Internals of RDBMS Physical data structures, query optimization. Join algorthim statisca and cost base optimization.

Unit 5

Transaction processing.concurrency control and recovery management. Transaction model properities, state serizability, lock base protocols, two phase locking.

Transactional Modes: Lecture; Tutorial; Problem solving; Self-learning.

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.

6. Introduction to NCBI Taxonomic Browser
7. DDL & DML: Creating and working with databases, creating tables, dropping tables, primary and secondary keys, data validation, simple queries using MySQL, cursors, stored procedures.
8. DTD and XML schema- simple DTD and creation of data in XML.

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L	T	P	Cr
4	0	0	4

Course Title: Systems Biology and Biological Networks
Course Code: BIN 516
Total Lecture: 40

(One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Learning Outcomes: This course will be centered on (i) the theoretical and practical aspects of modelling in systems biology – both deterministic and stochastic and (ii) the study of biological networks. After completion of this course students will become acquainted with the key concepts and approaches of both these fields including mathematical and computational concepts of Synthetic Biology.

Course Objectives: This course will be centered on (i) the theoretical and practical aspects of modelling in systems biology – both deterministic and stochastic and (ii) the study of biological networks. Students will become acquainted with the key concepts and computational approaches to both of these fields.
"Systems Biology" finds its major application in the research field known as "Synthetic Biology" (aiming to design and realize modified or new biological parts). Students will also become familiar with necessary mathematical and computational concepts of Synthetic Biology.
Students having prior knowledge of any programming language will be encouraged to write their own codes for simulating and analysing model biological systems.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student will not be permitted to appear in examination.

Evaluation Criteria:
1. Mid Term Examination: 25%
2. End Term Examination: 50%
3. Continuous Internal Assessment: 25%
   - Attendance: 5%
   - Class-room participation: 5%
   - Class test: 5%
   - Presentation and assignment: 10%

Course Contents

Unit 1: Introductory interdisciplinary concepts **(8 hours)**

- Definition and scope of systems and synthetic biology. Introduction to biological complexity -- Self organization, Emergence, Chaos, Robustness.
- First-order systems: Fixed points and stability, Population growth.
- Bifurcations (with examples) in first order systems: Saddle node, Pitch fork, Transcritical.
- Basic notion of bifurcations in second order systems: Period doubling, Hopf.

Unit 2: Deterministic modelling in systems biology **(8 hours)**

- Chemical kinetics, Michaelis-Menten kinetics, Hill equations
- Feedback in gene regulation: positive, negative, mutual inhibition
- Deterministic methods of systems modelling (Euler and RK4), with numerical applications on
    - Simple examples of autocatalysis, linear degradation etc.
    - Examples from natural systems: Predator-Prey, p53-mdm2.
    - Examples from synthetic systems: Brusselator, Repressilator.

Unit 3: Stochastic modelling in systems biology **(8 hours)**

- Introduction to noise in biological systems. Intrinsic vs. extrinsic noise. System behaviour and role of noise.
- Stochastic Methods for modelling biological systems (Master equation, Gillespie's stochastic simulation algorithm)
- Application of Gillepsie's SSA on Brusselator, Predator-Prey and other simple examples.

Unit 4: Design principles of biological networks **(8 hours)**

- Introduction to networks: Hamiltonian path vs. Eulerian path; Basic terminology; Topology of Genetic, Metabolic and Ecological networks.
- Network models: Erdös-Renyi, Small-world, Scale-free.
- Global Properties: Average path length, Network diameter, Centrality measures, Clustering coefficients etc. Modular and hierarchical networks.
- Local Properties: Regulatory motifs and graphlets in networks. Motifs in TRNs: discussion on FFL, SIM and other motifs.

UNIT 5: Analysis of biological networks **(8 Hours)**

- Elementary graph algorithms: Breadth-first search, Depth-first search, Topological sort, Strongly connected components. Growing a minimum spanning tree.
- Finding shortest path: Single source shortest path, All pairs shortest paths
- Network clustering: Clique based clustering, Center based clustering

- Basics of flux balance analysis.

Text Books:

1. **Steven II. Strogatz (1994),** Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering. Perseus Books, Massachusetts.
2. **Szallasi *et al.* (2010),**System Modelling in Cellular Biology. MIT Press.
3. **Junker and Schreiber (2008),** Analysis of Biological Networks. Wiley-Interscience, New Jersy.

Additional Readings:

4. **Uri Alon (2006),** An Introduction to the Systems Biology. Chapman and Hall.
5. **Mark Newman (2010),** Networks: An Introduction. Oxford University Press.
6. **Klipp *et al.* (2009),**Systems Biology in Practice.Wiley-VCH.
7. **BO Palsson (2006),** Systems Biology. Cambridge University Press.
8. **Press *et al.* (2007),**Numerical Recipies in C. Cambridge University Press.
9. **Singh and Dhar (2015),** Systems and Synthetic Biology, Springer

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Course Title: Essentials of Immunology

L	T	P	Cr
2	0	0	2

Course Code: BIN 517
Total Lectures: 20

Learning Outcomes:
On successful completion of the course the student will be able to:

- Evaluate basic concepts of immune system.
- Gain knowledge about various key processes related to development of immune system.
- Understand the concept of immune-based diseases as either a deficiency of components or excess activity as hypersensitivity.
- Apply the knowledge how immune system is involved in diseases caused by internal or external factors.

Unit: I

Immune System: The cells and organs of immune system, humoral immunity-immunoglobulin, basic structure, classes and subclasses, structural and functional relationships,

Unit: II

Antigen and Antibody: Nature of antigen, antigen-antibody reaction, antibody diversity, class switching, B and T cell development.

Unit: III

Immune Effectors: Complement system, their structure, functions and mechanisms of activation by classical, alternative and lectin pathway. Th1 and Th2 response, various effector cells of immune system: DC, NK, Monocytes etc.

Unit: IV

Mechanisms of Immune System Diversity: Structure and functions of Major Histocompatibility Complex (MHC) and Human Leukocyte Antigen (HLA) system, polymorphism, distribution, variation and their functions.

Unit: V

Immune System in Health and Diseases: Inflammation, hypersensitivity and autoimmunity, AIDS and immunodeficiencies, vaccine development.

Transactional Modes: Lecture; Demonstration; Tutorial; Lecture cum demonstration; Problem solving; Self-learning.

Suggested Reading:

- Kindt, T.J., Osborne, B.A. and Goldsby, R.A. (2018). *Kuby Immunology*. W.H. Freeman, USA.
- Abbas. (2018). *Cellular and Molecular Immunology*.CBS Publishers & Distributors, India.
- Charles, A. and Janeway, J.R. (2001). *Immunobiology: The immune system in health and disease*. Blackwell Publishing, USA.
- Delves, P.J., Roitt, I.M. and Seamus, J.M. (2016). *Roitt's Essential Immunology (Series–Essentials)*.Blackwell Publishers, USA.
- Elgert, K.D. (2015). *Immunology: Understanding the immune system*. Wiley-Blackwell, USA.

Course Code: BIN 518
Total Hours: 40

Course Objectives: The objective of this subject is to ensure that a student learns the fundamentals of research methodologies

Learning Outcomes:
At the end of the course, the students will be able to:

- Prepare a research plan, reading and gain knowledge from scientific papers
- Develop skills for scientific writing, research proposal writing,
- Analyze the data using R

Course Content:

UNIT –I: Introduction to research design:
Definition of the Problem: Identifying and formulating the problem. Developing a research plan: Research objective: information required for solving the problem: defining each major concept in operational terms: an overall description of approach, clearly stating any assumptions.

UNIT –II: Scientific literature review - 1
Reading and critical analysis of scientific literature/ research paper/case reports etc. Drafting and communicating research results in peer-reviewed journals.

UNIT –III: Scientific literature review - 2
Acknowledgement of contributions, authorship issues; Intellectual Property Rights (IPR), scientific ethics, rules of plagiarism.

UNIT –IV: Writing and presentation skills
Communication skills of research work through Poster and oral presentation Writing review paper on a relevant research topic and presentation of the same in a seminar /conferences / workshop / symposium etc.

UNIT –V: Data Analysis with R
Define sensitivity, accuracy, precision and specificity, miss rate, fall-out, false omission rate, prevalance threshold, critical success index, F1 Score, Balanced accuracy, MCC, FM Index, informedness, markedness. Confusion Matrix

Transactional Modes: Lecture; Tutorial; Problem solving; Self-learning

Suggested Readings

1. Blum, Deborah and Mary Knudson, eds. A field guide for science writers: the official guide of the National Association of Science Writers, New York: Oxford University Press, 1997.
2. Booth, Wayne, Gregory G Colomb, Joseph M. Williams. The craft of Research Chicago University of Chicago Press, 1995.
3. Davis, Martha. Scientific Papers and Presentations. San Diego: Academic Press, 1997.
4. Fuscaldo, AA, Erlick, BI, Hindman, B. Laboratory Safety: Theory and Practice. New York: Academic Press, 1980.

5. Bajpai, PK. Biological Instrumentation and Methodology. New Delhi: S. Chand & Co. Ltd. 2006:,
6. Kothari, C. R. (2014). 2/e, Research Methodology- Methods and Technique.(New Age International, New Delhi)
7. Montgomery, Douglas C. and Runger, George C. (2007), 3/e. applied statistics and probability for Engineers. (Willey, India)

L	T	P	C
0	0	2	2

Course Title: Computer Aided Drug Design Lab
Course Code: BIN 519
Total Hours: 40

Course Content –
Introduction to Structure based Drug Design and process layout of Docking
-Data mining, literature study and acquisition of target structure
-Comparative modelling of protein (Homology modelling) *target structure not available
-Server based –PHYRE, RaptorX, SWISSMODEL, I-TASSER, etc.
-Protein structure validation(ProSA)
-Ramachandran plot assessment(RAMPAGE,Pdbsum,Procheck)
-Active site/ Pocket identification
–MetaPocket,CastP,Active site identification using PyMol
-Molecular Docking *using AutoDock vina/AutoDock Tools/PyRx (For docking of multiple ligands)
-Protein and ligand preparation -Setting grid parameters and Docking parameters
-Docking analysis (based on binding energy, Hydrogen bond interactions, electrostatic interactions, hydrophobic interactions, etc.)
-BINANA (BINding ANAlyser)
-Pdbsum for visualising protein-ligand interactions -Building protein-ligand complex and visualization(publication standard)
-Report construction

L	T	P	Cr
4	0	0	2

Course Title: Systems Biology Lab
Course Code: BIN 520
Total Hours: 40

Course Objectives: The course is designed to give students an opportunity for learning the computational techniques to understand biological complexity at systems level. They will be introduced to the softwares implementing deterministic and stochastic modeling algorithms. At the same time they will also be acquainted with the network visualization and analysis softwares.

Students having working knowledge of any programming language will be encouraged to write their own codes for simulating and analysing model biological systems. Students will be required to learn the following modeling and analysis suites.

- CellDesigner, MCell
- Cytoscape
- XPPAut

Contents:

Standards in Systems Biology -- SBML, SBGN, BioPAX
Deterministic simulation of a natural biological system.
Deterministic simulation of a synthetic biological system.
Implementation of Gillespie's stochastic simulation algorithm to model the given chemical reaction system.
Introduction to biological network databases –
KEGG, STRING, STITCH, DIP, BIND, HPRD, EMP, EcoCyc, MetaCyc, AraCyc etc.
To construct and visualize simple biological network.
To analyze a given biological network by calculating the following characteristics
Diameter, density
Average path length
Clustering coefficient
Centrality measures (Degree, Closeness, Eccentricity, Betweenness)
Degree distribution
Community detection Etc.
To identify motifs and graphlets in a given network.
Stability analysis of a given 1-dimensional dynamical system.
Stability analysis of a given 2-dimensional biological system.
Systems Biology Capstone

L	T	P	C
0	0	16	8

Course Title: Review of Literature and Research Proposal
Course Code: BIN 521
Total Hours: 160

Course objectives

In this course a student will learn about the

- Basic techniques of literature review
- Various sources for literature review
- Writing the research proposal

Student must perform following task in the supervision of allotted supervisor

- Hands on browsing various literature retrieval databases such as PUBMED, Google Scholar, Shodhgangotri / Shodhganga.
- Student must submit the detailed research proposal/ synopsis along with a literature review in the Department / Centre.

Semester IV

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L	T	P	Cr
2	0	0	2

Course Title: Statistical genetics
Course Code: BIN 565
Total Hours: 20

Learning Outcomes: The course is designed to ensure that the students understand the fundamentals, theoretical and practical aspects of statistics which could be applied in wide fields of life sciences.

Course Contents

UNIT I Fundamentals of statistics -I

- Introduction to statistics
- Describing datasets
- Probability
- Random variables

UNIT II Fundamentals of statistics -II

- Testing statistical hypothesis
- Analysis of variance
- Linear regression
- Chi-square tests
- Non parametric hypothesis tests & quality control

UNIT III Genetic linkage maps

- Mendel's law, Hardy-Weinberg equilibrium and overview of linkage and association
- Map function & recombination fraction
- Genetic map construction
- Multipoint analysis of mendalian loci

UNIT IV Analysis of Quantitative traits

- Introduction to quantitative genetics
- Major gene detection and segregation analysis
- Interval mapping & CIM
- QTL mapping & GWAS

UNIT V Applications in life sciences

- Statistics for population genetics
- Statistics for genetic epidemiology and biomedical sciences
- Statistics for evolutionary genetics and epigenetic research
- Statistical genetics for animal and plant breeding
- Application of R in statistical genetics

Text Books:

a) D.J. Balding, M Bishop and C. Cannings. Handbook of Statistical Genetics Vol 1 & 2. *Wiley*
b) Murray R Spielgel and Larry J Stephens: Schaum's outline of statistics. *Tata McGraw Hill*
c) Sheldon M. Ross. Introductory Statistics. *Academic Press*
Shizhong Xu. Principles of Statistical Genomics. *Springer*

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L	T	P	Cr
4	0	0	4

Course Title: Molecular Evolution
Course Code: BIN 566
Total Hours: 40

Learning Outcomes: After completing the course the student should be able to

- describe evolutionary processes that give rise to variation in sequences and genomes and how these influence the architecture of the genome, contents and variation in base composition
- explain and justify different models for sequence and genome evolution
- choose, apply and evaluate bioinformatics methods for studying genetic variation in and between species.

Course Content

Unit 1
Comparison of DNA sequences to calculate gene distance; Convergent and divergent evolution; Mutation Vs. Substitution-Rate of Molecular Evolution.

Unit 2
Jukes Cantor Correction and evolutionary distance. Hardy-Weinberg equilibrium – Heterozygosity, gene frequency and heterozygosity; Loss of heterozygosity-mutant alleles-theta as the measure

Unit 3
Molecular clock- Concepts and significance-molecular mechanisms of molecular clock-Neutral theory -gene family organization.

Unit 4
Paralogy and Orthology- coordination expression in evolution-genome: content, structure and evolution.

Unit 5
Molecular evolution of recently diverged species - Databases of Molecular evolution.

Transactional Modes: Lectures; Tutorials; Problem solving; Self-learning

Suggested Readings

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. Bromham, L. (2016). An Introduction to Molecular Evolution and phylogenetics. OUP Oxford.

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Course Title: Introduction of Synthetic Biology
Course Code: BIN 567
Total Lectures: 20

L	T	P	Cr
2	0	0	2

Course Objectives:
The course is designed to introduce students the concepts of synthetic biology – a field of study at the interface of (i) complexity of biological systems and (ii) techniques of traditional engineering. This course is designed to acquaint students about the following basic questions:

- Can we study and understand biology as an engineering discipline?
- Why is it necessary to consider stochasticity while modeling biological processes?
- What are the basic parts and devices that have been successfully bioengineered?
- What are the implications of Synthetic Biology on the society?

Course Contents

UNIT I: Introductory Interdisciplinary Concepts
- Definition and scope of systems biology and synthetic biology.
- Engineering concepts: parts, devices, circuits -- digital vs. analog, logic gates.
- Biological complexity: Self organization, Emergence, Robustness.

UNIT II: Modeling methods for Biological Systems
- Review of kinetic chemistry, Aspects of noise in designing biological systems.
- Brief overview of deterministic modeling, master equation and Gillespie's Stochastic
- Simulation Algorithm. Lambda switch and Chemotactic module in E coli.
- Open source programs: CellDesigner, etc

UNIT III: Standards and parts in Synthetic Biology
- Standards: SBML, SBGN, BioPAX
- MIT Registry of standard biological parts
- Bio-brick and non-biobrick initiatives, iGEM events
- Lac operon, Promoter designing, Quorum sensing
- ZFNs, TALENs, CRISPR/Cas

UNIT IV: Bio-engineered Synthetic Circuits
- Gates: AND gate, Counters: Pulse generators, Switches: Toggle switch¬
- Oscillators: Repressilator, mammalian oscillator¬
- Brief overview of cascades, time delayed circuits, spatial patterning, biosensors, and other

- Logical formula driven circuits.
- Riboswitches and riboregulators

- Four and Six-letter genetic code

UNIT V: From Modules to Systems

Integrating gene circuits

- DNA Origami,
- Genome Synthesis, Minimal synthetic cell, Multicellular synthetic systems
- Protocell construction
- Bio-energetics and Bio-fuels
- Safety and Legal issues: Bio-security, Bio-safety

Text Books:

Chris Myers (2009). Engineering Genetic Circuits. Chapman & Hall.
Edda Klipp et al. (2009). Systems Biology: A Textbook. Wiley-VCH.
Huimin Zhao (2013). Synthetic Biology: Tools and Applications. Academic Press.

Additional Readings:

- Freemont and Kitney (2012). Synthetic Biology: A Primer. World Scientific
- Fu and Panke (2009). Systems Biology and Synthetic Biology. Wiley, New Jersy.
- Presidential Commission for the Study of Bioethical Issues (2010). NEW DIRECTIONS:
- Ethics of Synthetic Biology and Emerging Technologies. (http://bioethics.gov)
- Singh V., and Dhar, P. K. (2015). Systems and Synthetic Biology, Springer Science, 385. ISBN: 978-94- 017-9513- 5.

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L	T	P	Cr
4	0	0	2

Course Title: Academic Writing
Course Code: BIN 568
Total Hours: 40

Course objectives

- To understand the importance of academic writing
- To understand and avoid the plagiarism
- To understand the basic skills of literature review
- To understand the basic skills of research paper, review paper and thesis writing.
- To target the research work to suitable journal and communicate for publication
- To understand Time and team management
- To understand digital writing or OER development
- To understand research proposal writing, conference abstract and book writing

Course content

Unit 1:

Introduction of academic and research writing, importance of academic writing and basics of academic writing. English in academic writing and styles of research writing.

Unit 2:

UGC guidelines on Plagiarism, tools of detection of plagiarism and avoiding plagiarism. Journal metrices, author metrices

Unit 3:

Literature review, process of literature review, online literature databases. Literature management tools. Referencing and citation, submission, and post submission.

Unit 4:

Introduction and tips for writing the Popular article, research proposal, Research article, review articles, book and thesis. Empirical study.

Unit 5

Challenges in Indian research and writing, team management, time management, Open education resources, Ethics in academic writing.

Reading material

- https://onlinecourses.swayam2.ac.in/ugc19_ge03/preview
- Stephen B. Heard. The Scientist's Guide to Writing: How to Write More Easily and Effectively throughout Your Scientific Career, Princeton University Press (2016)
- John M. Swales, Christine B. Feak. Academic Writing for Graduate Students: Essential Tasks and Skills, University of Michigan Press (2012)

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Course Title: Paper Public/Seminar/Conference
Course Code: BIN 569
Total Hours: 40

L	T	P	Cr
0	0	4	2

Paper publication/ seminar/ conferences

Course objective

The main objective of this course is to give students real world exposure of publishing papers/ seminar/ conferences etc. In this course student must fulfill at least one of the objectives with the due permission of respective supervisor/ Director of the Centre.

1. Publish at least one research article in UGC approved research journal/Journal of Himalayan Life Sciences.
2. Publish at least one review article in UGC approved research journal/ Journal of Himalayan Life Sciences.
3. Participate in an oral presentation/ talk in refereed conference/ Seminar. Additionally, student must submit a writeup at CUHP before the end of this course.
4. Participate in poster presentation in a referred conference / Seminar. Additionally, student must submit a writeup at CUHP before the end of this course.
5. Participate in a seminar/ conference/ training event etc and make a detailed report.

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Course Title: Molecular Dynamics Simulation Lab
Course Code: BIN 570
Total Hours: 40

L	T	P	Cr
0	0	4	2

Learning Outcomes: At the end of the course, the students will be able to:

- learn the modelling of small to large molecular environments
- understand various force field for biomoleculra simulation in details
- learn different methods for simulating large systems
- gain the knowledge about different molecular simulation techniques understand the dynamics of the structural transitions

Course Content

1. Visualization Software and 3D representations with VMD and PYMOL
2. Coordinate generations and inter-conversions.
3. Energy minimizations and optimization.
4. Molecular Dynamics with Gromacs:
   - Protein in water
   - Membrane protein
   - Umbrella Sampling
   - Free Energy of Solvation
   - Protein ligand interaction
   - Free Energy of Solvation

Transactional Modes: Laboratory based practicals; Problem solving; Self-learning.

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.

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Course Title: Data Analysis Lab
Course Code: BIN 571
Total Hours: 40

L	T	P	Cr
0	0	4	2

Learning Outcomes: At the end of the course, the students will be able to:

- The techniques used to perform statistical inference on high-throughput and high-dimensional data.
- Several techniques widely used in the analysis of high-dimensional data.

Course Content

Mathematical Distance

Dimension Reduction

Singular Value Decomposition and Principal Component Analysis

Multiple Dimensional Scaling Plots

Factor Analysis

Dealing with Batch Effects

Clustering

Heatmaps

Basic Machine Learning Concepts

Suggested readings:

Statistical Analysis for High-Dimensional Data; Editors: Frigessi, A., Bühlmann, P., Glad, I.K., Langaas, M., Richardson, S., Vannucci, M. (Eds.) Hardcover ISBN 978-3-319-27097-5 Softcover ISBN 978-3-319-80073-8

Python for Data Analysis Year: 2017 Edition: 2 Publisher: O'Reilly Media Language: english Pages: 544 / 541 ISBN 10: 1491957662 ISBN 13: 9781491957660

Change of Nomenclature of PhD programto be considered by the Board of Studies

The nomenclature of PhD (Computational Biology and Bioinformatics) is to be modified to PhD (Bioinformatics) for the students enrolled in the said course, from Sep 2021 onwards. This is submitted for the approval of Board of Studies.

Annexure – IV

Pre Ph.D. Course in Computational Biology and Bioinformatics

Scheme of Courses for Pre Ph.D. Course in Computational Biology and Bioinformatics

Course Code	C/E*	Course Name	Credits	Credits for students
CPE-RPE	C	Research and Publication Ethics	2	2
BIN – 601	C	Research Methodology	4	4
BIN – 602	C	**Indian Knowledge System**	2	2
BIN – 603	C	**Pedagogy of teaching learning Process**	2	2
BIN – 604	E	Sequence and Structural Bioinformatics	4	**12**
BIN – 605	E	Statistical Mechanics	4	
BIN – 606	E	Scientific Programming Lab	4	
BIN – 607	E	Molecular Dynamics Lab	4	
BIN -608	E	Plant Bioinformatics	4	
BIN – 609	E	Machine Learning Algorithms	4	
BIN – 610	E	Scientific Writing and Presentation Skills	4	
Total				**22**

*Students can select any **three elective** papers from above scheme.

C- Compulsory

E-Elective

Mode of Transaction:

Lecture, Laboratory based Practical, Seminar, Group discussion, Team teaching, Self-learning.