Central University of Himachal Pradesh

Centre for Computational Biology and Bioinformatics

School of Life Sciences

AGENDA

7th BOARD OF STUDIES MEETING

TO BE HELD ON 29th DEC**EMBER, 2020** at TAB SHAHPUR

Venue: Seminar Hall,
Central University of Himachal Pradesh
Temporary Academic Block, Shahpur

हिमाचल प्रदेश केन्द्रीय विश्वविद्यालय

Central University of Himachal Pradesh

(Established under Central Universities Act 2009)

अस्थाई शैक्षणिक खण्ड, शाहपुर, ज़िला काँगड़ा, हिमाचल प्रदेश -176206

Temporary Academic Block, Shahpur, Distt. Kangra (HP) - 176206

Website: www.cuhimachal.ac.in

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Dr. Mahesh Kulharia
Director,
Centre for Computational Biology and Bioinformatics

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय
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Temporary Academic Block, Shahpur ,Distt. Kangra (HP) - 176206
Website: www.cuhimachal.ac.in

File No: LS/1-5/ CUHP/12/ 75 Dated: 29.12.2020

MINUTES

The 7th **Board of Studies** (BoS) meeting of **Centre for Computational Biology and Bioinformatics** was held on **29th December, 2020** at **11:00 AM** at Central University of Himachal Pradesh, Temporary Academic Block, Shahpur. The following were present:

1.	**Dr. Mahesh Kulharia, Director, Centre for Computational Biology and Bioinformatics, School of Life Sciences**	CONVERNER & CHAIRMAN	Offline Mode
2.	**Prof. Brij Mohan, Ret. Professor, Chaudhary charan kumar Himachal Pradesh Agriculture University**	SUBJECT EXPERT	Online Mode
3.	**Prof. Desh Deepak Singh, Professor, Deapartment of Biotechnology, Punjab University,**	SUBJECT EXPERT	Online Mode
4.	**Prof. Pardeep Kumar, Dean, Professor, Department of Plant Sciences, School of Life Sciences**	MEMBER (VC NOMINEE)	Offline Mode
5.	**Dr. Sunil Kumar, Associate Professor, Department of Animal Sciences, School of Life Sciences**	MEMBER (VC NOMINEE)	Offline Mode
6.	**Dr. Shailender Kumar Verma, Assistant Professor, Centre for Computational Biology and Bioinformatics, School of Life Sciences**	MEMBER	Offline Mode
7.	**Dr. Vikram Singh, Assistant Professor, Centre for Computational Biology and Bioinformatics, School of Life Sciences**	Special Invite	Offline Mode

The Director, Centre for Computational Biology and Bioinformatics (Convener & Chairman), School of Life Sciences welcomed all the members and thanked them for being available for attending this meeting.

29/12/2020

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Agenda Items:

ITEM NO: CBB-BOS-7/20-1: Approved the Minutes of the 6th Meeting of the Board of Studies held on 18th September, 2020.**(Annexure-I)**

ITEM NO: CBB-BOS-7/20-2: Recommended the Change from nomenclature of the Centre for Computational Biology and Bioinformatics to Department of Computational Biology and Bioinformatics. **(Annexure-II)**

ITEM NO: CBB-BOS-7/20-3: Approved the Re-scrutinizing of the Curriculum and addition of new courses for the M.Sc. Binformatics in the CBCS format. **(Annexure-III)**

ITEM NO: CBB-BOS-7/20-4: Approved the detailed syllabus for the M.Sc. Binformatics in the CBCS format (for 2020 Batch onwards). **(Annexure-IV)**

ITEM NO: CBB-BOS-7/20-5: Approved the appointment of Dr. Mahesh Kulharia, Associate Professor, and Centre for Computational Biology and Bioinformatics to become Ph.D. Co-Supervisor/Guide for Ms. Himisha Dixit (Reg.No.CUHP17RDCBB02) doctoral work. **(Annexure-V)**

ITEM NO: CBB-BOS-7/20-6: Approved the little, objectives and synopses of the Ph.D thesis of Ms. Himisha Dixit (Reg.No. CUHP17RDCBB02). **(Annexure-VI)**

ITEM NO: CBB-BOS-7/20-7: Approved the little, objectives and synopses of the Ph.D thesis of Mr. Ashish Panghalia (Reg.No.CUHP17RDCBB01). **(Annexure-VII)**

The meeting ended with votes of thanks by the chair:

Dr. Vikram Singh
Assistant Professor,
Special Invite

29/12/2020
Dr. Shailender Kumar Verma
Assistant Professor, CCBB
CUHP, Dharamshala

29/12/2020
Dr. Sunil Kumar
HoD, Animal Sciences,
(VC Nominee)

Approved Online
Prof. Desh Deepak Singh
(Subject Expert)

Approved Online
Prof. Brij Mohan Sharma
(Subject Expert)

29/12/2020
Prof. Pardeep Kumar
HoD, Plant Sciences,
(VC Nominee)

29/12/2020
Dr. Mahesh Kulharia
Director, CCBB, CUHP,
Convener & Chairman

Gmail mohit lamba <mohitlamba215@gmail.com>

Regarding the 7th Board of Studies agenda CCBB

3 messages

mohit lamba <mohitlamba215@gmail.com> Mon, Jan 18, 2021 at 9:56 AM
To: ddsingh@pu.ac.in, drbrijsharma@gmail.com
Cc: Mahesh Kulharia <kulharia@gmail.com>

Dear Sirs,
Please find the draft regarding the 7th meeting of Board of Studies along with the annexures attached herewith for your kind perusal and approval.
we would really appreciate it if you could find time to give your valuable suggestions/corrections/approval in the next one days.

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*Regards/*सादर,
*Mohit/*मोहित
*Lower Division Clerk,*अवर श्रेणी लिपिक
*School of Life Sciences,*जैविक विज्ञान स्कूल
*School of Earth and Environmental Sciences,*पृथ्वी एवं पर्यावरण विज्ञान स्कूल
*Central University of Himachal Pradesh,*हिमाचल प्रदेश केन्द्रीय विश्वविद्यालय
*TAB-Shahpur:*टैब-शाहपुर.
*Mobile Number: **9991206122,9588584463.***

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831K

Prof. Desh Deepak Singh <ddsingh@pu.ac.in> Mon, Jan 18, 2021 at 11:23 AM
To: mohit lamba <mohitlamba215@gmail.com>
Cc: drbrijsharma@gmail.com, Mahesh Kulharia <kulharia@gmail.com>

Approved

(minutes of 7th meeting of Board of Studies meeting of Center for Computational Biology and bioinformatics of Central University of Himachal Pardesh held on 29th December, 2020 though online mode).

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Prof. Desh Deepak Singh
Professor, Biotechnology Department
BMS-I, South Campus
Panjab University,
Chandigarh-160 014
www. http://biotechnology.puchd.ac.in/
Email: ddsingh@pu.ac.in
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[Quoted text hidden]

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Brij Sharma <drbrijsharma@gmail.com> Mon, Jan 18, 2021 at 2:07 PM

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Annexure- III

TABLE-I: Curricular Framework for M.Sc. Bioinformatics based on Choice Based Credit System (CBCS) (Batch: 2020-21 onwards)

Semester I

Core - Compulsory (10 Credits)	Credits
BIN 401 Sequence Analysis	2
BIN 402 Biomolecular Structure Analysis	2
BIN 403 Linux and Shell Scripting Lab	2
BIN 404 Sequence and Structure Analysis Lab	2
BIN 405 Python Programming Lab I	2

Core Open (6)	Credits
BIN 406 Basics of Biochemistry	2
BIN 407 Concepts of Genetics	2
BIN 408 Basic Mathematics for Life Sciences	2
BIN 409 Statistical Methods	4

Human Making (2)	Credits
BIN 410 History of Science and in India	2

Skill Development (2)	
BIN 411 Fundamentals of machine learning	2

Semester II

Core - Compulsory (10)	Credits
BIN 451 Algorithms in Bioinformatics	4
BIN 452 Fundamentals of Molecular Dynamics simulations	2
BIN 453 Molecular Dynamics Simulation Lab	2
BIN 454 Python Programming Lab II	2

Core Open (6)	Credits
BIN 455 Cell and Molecular Biology	2
BIN 456 Essentials of Immunology	2
BIN 457 Statistical Genetics	2
BIN 458 Biological Database and Management System	2
BIN 459 DBMS Lab	2

Human Making (2)	Credits
BIN 460 Biosafety Issues	2

Skill Development (2)	
BIN 461 Elements of Data Science	2

Semester III

Core Compulsory (8)	Credits
BIN 501 Computer Aided Drug Design Lab	2
BIN 502 R Programming Lab	2
BIN 503 M.Sc. Project	4

Elective Open (4)	Credits
BIN 504 Computational Genomics and Proteomics	4

Elective Specialization (8)	Credits
BIN 505 Computer Aided Drug Discovery	4
BIN 506 Systems Biology and Biological Networks	4

Semester IV

Core Compulsory (12)	Credits
BIN 551 Next Generation Sequencing: Analysis	4
BIN 552 Chemoinformatics	2
BIN 599 M.Sc. Dissertation	6

Elective Specialization (8)	Credits
BIN 553 Fundamentals of Metabolomics	2
BIN 554 Advance topics on Machine Learning	2
BIN 555 Introduction of Synthetic Biology	2
BIN 556 Systems Biology Lab	2

Central University of Himachal Pradesh

Centre for Computational Biology and Bioinformatics
School of Life Sciences

AGENDA

BOARD OF STUDIES MEETING
Scrutinised and Approved on 29th **DECMBER, 2020** at TAB SHAHPUR

Venue: Seminar Hall,
Central University of Himachal Pradesh
Temporary Academic Block, Shahpur

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PROGRAMME OUTCOMES (M.Sc. Bioinformatics)

Student graduating after successful completion of this course shall be able to

- Critically analyse current issues and trends influencing the field of Bioinformatics.
- 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.
- Shall have scientific temperament.
- Establish professional relationships and development of professional competencies
- Develop understanding and reflections on higher educaton policies and practices.

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Semester I

Credits	Core - Compulsory	Credits
10	BIN 401 Sequence Analysis	2
	BIN 402 Biomolecular Structure Analysis	2
	BIN 403 Linux and Shell Scripting Lab	2
	BIN 404 Sequence and Structure Analysis Lab	2
	BIN 405 Python Programming Lab I	2

Credits	Core Open	Credits
6	BIN 406 Basics of Biochemistry	2
	BIN 407 Concepts of Genetics	2
	BIN 408 Basic Mathematics for Life Sciences	2
	BIN 409 Statistical Methods	4

Human Making (2)	Credits
BIN 410 History of Science in India	2

Skill Development (2)	Credits
BIN 411 Fundamentals of machine learning	2

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Website: www.cuhimachal.ac.in

Course Title: Sequence Analysis
Course Code: BIN.401
Total Hours: 30

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 **13 Hours**

Basic concepts of sequence similarity, identity and homology, homologues, orthologues, paralogues and xenologues Pairwise sequence alignments: basic concepts of sequence alignment, Needleman and Wunsch, Smith and Waterman algorithms for pairwise alignments, gap penalties

Unit 2 **10 Hours**

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

Unit 3 **12 Hours**

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 4 **10 Hours**

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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Website: www.cuhimachal.ac.in

Course Title: Biomolecular Structure Analysis
Course Code: BIN.402
Total Hours: 30

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 and carbohydrates.

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.

Transactional Mode

Lectures, seminars.

Suggested Reading

1. Liljas, Anders Textbook of structural biology New Jersey: World Scientific, cop. 2009
2. Tooze, Branden An Introduction to Protein Structure. 2014

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Course Title: Linux and Shell Scripting Lab
Course Code: BIN.403
Total Hours: 60

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

Unit 1 **7 Hours**

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

Unit 2 **7 Hours**

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

Unit 3 8 **Hours**

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

Unit 4 8 **Hours**

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

Suggested Readings:

1. Cristopher Negus – Red Hat Linux Bible, Wiley Dreamtech India 2005 edition.

2. YeswantKanethkar – UNIX Shell Programming, First edition, BPB.

Text Books for Enrichment

References :

1. Official Red Hat Linux Users guide by Redhat, Wiley Dreamtech India

2. Graham Glass & King Ables – UNIX for programmers and users, Third Edition, Pearson Education.

3. Neil Mathew & Richard Stones – Beginning Linux Programming, Fourth edition, Wiley Dreamtech India.

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Course Title: Sequence and Structure Analysis Lab
Course Code: BIN.404
Total Hours: 60

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
Secondary Structure Prediction Methods – Chou Fasman, GOR, Neural Networks 3D structure visualization: Pymol, Rasmol, VMD

Suggested Reading:

"Practical Bioinformatics" by Michael Agostino ISBN 978-0-8153-4456-8

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Website: www.cuhimachal.ac.in

Course Title: Python Programming Lab I
Course Code: BIN.405
Total Hours: 60

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

1. 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.

2. 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.

3. 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.

4. 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.
- 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: Basics of Biochemistry
Course Code: BIN.406
Total Hours: 30

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 **16 Hours**

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

Unit 2 **14 Hours**

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

Unit 3 **14 Hours**

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

Unit 4 **16 Hours**

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

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.

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.

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Course Title: Concepts of Genetics
Course Code: BIN.407
Total Hours: 30

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

- gain a deep knowledge about the structures and organisation of nucleic acids
- learn DNA replication, Inheritance patterns

Course Content

Unit 1 **8 Hours**

Introduction and scope of genetics, DNA as genetic material: 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: Basic mechanism of DNA replication.

Unit 2 **7 Hours**

Cell division and Cell cycle: Mitosis, Meiosis Concepts of 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 **7 Hours**

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.

Unit 4 **8 Hours**

Chloroplast and Mitochondrial inheritance, Yeast, *Chlamydomonas/Neurospora* Chromosomal aberrations: Types of changes– deletions, duplications, inversions, translocations,Change in chromosome number: trisomy and polyploidy.

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

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.

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Website: www.cuhimachal.ac.in

Course Title: Basic Mathematics for Life Sciences
Course Code: BIN.408
Total Hours: 30

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

1. Identify and describe the basic mathematical techniques that are commonly used by chemist.
2. Develop skills in vectors, matrices, differential calculus, integral calculus and probability.
3. Apply the principles to a number of simple problems that have analytical solutions.
4. Design different methods to problems related to chemistry.

Course Content

Unit-1 **15 Hours**

Vectors in 2D, 3D and in general, circles, transformation of coordinates, polar coordinates, parametric equations, and the solid analytic geometry of vectors, lines, planes, spherical coordinate.

Unit-2 **15 Hours**

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

Unit-3 **15 Hours**

Using computational tools for: 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-4 **15 Hours**

Tools for applying Basic rules for integration, integration by parts, partial fraction and substitution, definite integrals, evaluation of definite.

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

Suggested readings

The chemistry Mathematics Book, E.Steiner, Oxford University Press (2008).
Mathematical for Physical Chemistry : F. Daniels, Mc. Graw Hill (1959).
Chemical Mathematics D.M. Hirst, Longman (1979).
Basic Mathematics for Chemists, Tebbutt, Wiley (1994).
G. Arfken, H. Weber and F. Harris, *Mathematical Methods for Physicists* (Elsevier Academic Press, Massachusetts, USA) 2012.

Central University of Himachal Pradesh

(Established under Central Universities Act 2009)

Temporary Academic Block, Shahpur, Distt. Kangra (HP) – 176206

Website: www.cuhimachal.ac.in

Course Title: Statistical Methods
Course Code: BIN.409
Total Hours: 60

Credits Equivalent: 4 Credits
(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.

Course Contents:

Unit-I: Introductory concepts (10 Hours)

- Big Data in Biology: Need of Statistical measures to analyze it.
- Statistical population and sample: Types of data, Relative and cumulative frequency.
- Organization and presentation of data.
- Descriptive measures:
  - Measures of Central tendency: Mean, Median, Mode: notation and formulae, grouped data, relative merits
  - Measures of Dispersion: Absolute and relative measures.

Unit-II: Probability concepts (10 Hours)

- Basic probability models: Combinatorics based computation, Bayes' rule
- Basics of Monte Carlo simulations
- 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
- 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 III: Statistics concepts (10 Hours)

- Statistical preliminaries: Sample mean, Sample variance, Standard error
- Continuous models fitting: Method of moments, Method of maximum likelihood, Goodness of fit
- 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, P-hacking, ANOVA

Unit IV: Multivariate analysis (10 Hours)

- Discrete and continuous multivariate distributions
- Covariance and correlation
- Dimensionality reduction: principal component analysis
- Clustering, Classification, Regression
- Model parsimony and over-fitting

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 Henry Brase and Corrinne Pellillo Brase (2011), Understandable Statistics: Concepts and Methods.
J. H. Zar (2019), Biostatistical Analysis, Pearson

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Temporary Academic Block, Shahpur, Distt. Kangra (HP) – 176206
Website: www.cuhimachal.ac.in

Course Title: History of Science in India
Course Code: BIN.410
Total Hours: 30

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 (6 hours)

- 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 (6 hours)

- 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 (6 hours)

- 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 (6 hours)

- 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 (6 Hours)

- 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.

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Website: www.cuhimachal.ac.in

Course Title: Fundamentals of Machine Learning
Course Code: BIN.411
Total Hours: 30

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

Course Content

Unit 1 **8 hours**

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

Unit 2 **6 hours**

Linear regression; SSE; gradient descent; closed form; normal equations; features
Overfitting and complexity; training, validation

Unit 3 **6 hours**

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

Unit 4 **8 hours**

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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Website: www.cuhimachal.ac.in

Semester II

Credits	Core - Compulsory	Credits
10	BIN 451 Algorithms in Bioinformatics	4
	BIN 452 Fundamentals of Molecular Dynamics simulations	2
	BIN 453 Molecular Dynamics Simulation Lab	2
	BIN 454 Python Programming Lab II	2
		2

Credits	Core Open	Credits
6	BIN 455 Cell and Molecular Biology	2
	BIN 456 Essentials of Immunology	2
	BIN 457 Statistical Genetics	2
	BIN 458 Biological Databases and Management System	2
	BIN 459 DBMS Lab	2

Human Making (2)	Credits
BIN 460 Biosafety Issues	2

Skill Development (2)	
BIN 461 Elements of Data Science	2

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Website: www.cuhimachal.ac.in

Course Title: Algorithms in Bioinformatics
Course Code: BIN.451
Total Hours: 60

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.

Course Content

Unit 1: Introduction to algorithms and complexity 8 Hours

Basic Concepts: Algorithmic complexity (spatial and temporal), Biological vs. Computer algorithms, Genetic algorithm.

Standard Notations: Big-Oh, Omega, Theta notations; Hardness of an algorithm.

Linear and non-linear data structures, Stack, Queues, Linked list.

Introduction to algorithm design techniques: Exhaustive search, Greedy Algorithms, Divide and conquer etc.

Searching algorithms: Linear and Binary search; Sorting algorithms: Selection, Bubble, Insertion, Merge, Quick, Heap.

Unit 2: Sequence Analysis 10 Hours

6. Models of DNA evolution: Jukes Cantor, Kimura and Tamura models
7. Derivation of protein evolution models: PAM and BLOSUM
8. Elements of dynamic programming: Edit distance, Longest Common Subsequences, Global and Local Sequence Alignment
9. Working of BLAST: Usage of Finite State Machine, E-value, etc.
10. Introduction to Multiple Sequence Alignment
11. Concepts of Joint, Conditional, Marginal probabilities
12. Markov Chains and Hidden Markov Models: CpG islands, Pairwise alignment using HMMs

Unit 3: Pattern matching 6 Hours

a) Tandem and Interspersed repeats.

b) Repeat finding: Motifs, consensus, position weight matrices

c) Algorithms for derivation of and searching sequence patterns: MEME, PHI-BLAST, SCanProsite and PRATT

d) Algorithms for generation of sequence profiles: PSIBLAST, HMMer,

Unit 4: Phylogenetics **8 Hours**

5. Basics of Molecular Evolution,
6. Tree - terminologies, Binary trees, AVL trees.
7. Tree traversal: Pre-order, In-order, post-order; Breadth-first search, Depth-first search.
8. Evolutionary trees: (I) Distance based methods – UPGMA, NJ, Fitch Margoliash (FM), Minimum Evolution (ME); (II) Character based methods – MP, ML, Bayesian inference algorithm.
9. Tree Evaluation, Bootstrapping.

Unit 5: RNA and Protein Structure Prediction **8 Hours**

- RNA secondary structure: Nussinov algorithm, Energy minimization, Zuker's Algorithm, SCFG.
- RNA tertiary structure: Basics of "minimum free energy" based methods.
- Protein secondary structure: Chou-Fasman, GOR method.
- Protein tertiary structure: Rosetta method, Contact potential method.

Text Books:

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

Additional Readings:

Gusfield (2005), Algorithms on Strings, Trees and Sequences. Cambridge University Press.

Cormen *et al.* (2009), Introduction to Algorithms. MIT Press.

Sung (2009), Algorithms in Bioinformatics: A Practical Introduction. Chapman & Hall/CRC.

Neapolitan and Naimipour (2011), Foundations of Algorithms. Jones & bartlett.

Korf *et al.* (2003), BLAST. O'Reilly

Junker and Schreiber (2008), Analysis of Biological Networks. Wiley-Interscience, New Jersy.

Mitchell (1998), An Introduction to Genetic Algorithms. MIT Press.

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Temporary Academic Block, Shahpur, Distt. Kangra (HP) – 176206

Website: www.cuhimachal.ac.in

Course Title: Fundamentals of Molecular Dynamics Simulation
Course Code: BIN.452
Total Hours: 30

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 **15 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 **15 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 **15 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 **15 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.

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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Temporary Academic Block, Shahpur, Distt. Kangra (HP) – 176206

Website: www.cuhimachal.ac.in

Course Title: Molecular Dynamics Simulation Lab
Course Code: BIN.453
Total Hours: 60

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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Website: www.cuhimachal.ac.in

Course Title: Python Programming Lab II
Course Code: BIN.454
Total Lecture: 60

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.

Lots of practical examples. Also avaiable as a Kindle book: http://www.amazon.com/Python-101-Michael-Driscoll-ebook/dp/B00KQTFHNK

- Problem Solving with Algorithms and Data Structures (http://interactivepython.org/runestone/static/pythonds/index.html(Links to an external site.)Links to an external site.)
- Python Course (http://www.python-course.eu/python3_course.php(Links to an external site.)Links to an external site.)

References for getting better, once you know the basics

- Python Essential Reference (http://www.dabeaz.com/per.html): The definitive reference for both Python and much of the standard library.
- Hitchhikers Guide to Python (http://docs.python-guide.org/en/latest): Under active development, and still somewhat incomplete, but there is good stuff.
- Writing Idiomatic Python (https://www.jeffknupp.com/writing-idiomatic-python-ebook): Focused on not just getting the code to work, but how to write it in a really "Pythonic" way.
- Fluent Python (http://shop.oreilly.com/product/0636920032519.do): All python3, and focused on getting the advanced details right. Good place to go once you've got the basics down.
- Python 3 Object Oriented Programming (https://www.packtpub.com/application-development/python-3-object-oriented-programming (Links to an external site.)Links to an external site.): Nice book specifically about Object Oriented programming stucture, and how to do it in Python. From local Author and founder of the Puget Sound Programming Python (PuPPy) meetup group, Dusty Phillips.

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Temporary Academic Block, Shahpur, Distt. Kangra (HP) – 176206

Website: www.cuhimachal.ac.in

Course Name: Cell and Molecular Biology
Course Code: BIN.455
Total Lectures: 30

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 **8 Lectures**

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

Unit – II **8 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.

Unit – III **6 Lectures**

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

Unit – IV **6 Lectures**

Transcription: transcription and transcription factors, Transcriptional and post-transcriptional 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.

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demontration; 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 Code: **: Essentials of Immunology**

Course Code: BIN.456

Total Lectures: 30

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 **12 Lectures**

Immune System: The cells and organs of immune system, humoral immunity-immunoglobulin, basic structure, classes and subclasses, structural and functional relationships, nature of antigen, antigen-antibody reaction, antibody diversity, class switching, B and T cell development.

Unit: II **7 Lectures**

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: III **6 Lectures**

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: IV **5 Lectures**

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.

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Website: www.cuhimachal.ac.in

Course Code: : Statistical Genetics
Course Code: BIN.457
Total Lectures: 30

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 **7 Hours**

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

UNIT II **8 Hours**

- Multipoint analysis of mendalian loci
- Introduction to quantitative genetics
- Major gene detection and segregation analysis

UNIT III **8 Hours**

- Interval mapping & CIM
- QTL mapping & GWAS
- Statistics for population genetics

UNIT V **7 Hours**

- Statistics for genetic epidemiology and biomedical sciences
- Statistics for evolutionary genetics and epigenetic research
- Statistical genetics for animal and plant breeding

Text Books:

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

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Website: www.cuhimachal.ac.in

Course Code: : BDBMS
Course Code: BIN.458
Total Lectures: 30

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 **15 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 **15 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 **15 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 **15 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.

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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Website: www.cuhimachal.ac.in

Course Code: : DBMS Lab
Course Code: BIN.459
Total Lectures: 30

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

1. Data Definition, Table Creation, Constraints,
2. Insert, Select Commands, Update & Delete Commands.
3. Nested Queries & Join Queries
4. Views
5. High level programming language extensions (Control structures, Procedures and Functions).
6. Front end tools
7. Forms
8. Triggers
9. Menu Design
10. Reports.

Transactional Modes: Laboratory based practicals; 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.

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Temporary Academic Block, Shahpur, Distt. Kangra (HP) – 176206

Website: www.cuhimachal.ac.in

Course Title: Biosafety Issues

Course Code: BIN.460
Total Hours: 30

Learning Outcomes: The course is designed to introduce students to biosafety guidelines of DBT, Ministry of Science & Technology, Government of India and the World Health Organization.

Course Contents:

UNIT-I: Introduction 6 hours
- Introduction to the biosafety guidelines
- Constitution of institutional biosafety committees (IBSCs) and its functions
- Microbiological risk assessment

UNIT-II: Biohazards and biosafety levels 6 hours
- Biosafety level 1
- Biosafety level 2
- Biosafety level 3
- Biosafety level 4

UNIT-III: Laboratory biosecurity, equipment and good lab practices 6 hours
- Laboratory biosecurity concepts2
- Biological safety cabinets and equipment
- Laboratory techniques
- Disinfection and sterilization
- Introduction to the transport of infectious substances

UNIT-IV: Scientific Considerations 6 hours
- Biosafety and recombinant DNA technology
- Chemicals, fire, electrical, noise and ionizing radiation hazards
- Human health and environmental considerations
- Containment facilities

UNIT-V: National; International frameworks on biosafety 6 hours
- Guidelines by Ministry of Environment and Forests (MoEF), & DBT Government of India
- International binding and non-binding instruments on Biosafety
- Potential overlaps and conflicts between treaties and trade concerns
- Competent authorities to regulate the biosafety issues
- Safety checklist

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

Suggectged Readings:

1. Guidelines and Handbook for Institutional Biosafety Committees (IBSCs) by Department of Biotechnology, Ministry of Science & Technology, Government of India.
2. Laboratory biosafety manual (3 rd edition) by the World Health Organization, Geneva.

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Website: www.cuhimachal.ac.in

Course Title:: Elements of Data Science
Course Code: 461
Total Hours: 30

Course Objectives:

This course is designed to introduce students to the underlying concepts about the most demanding job of the 21st century – "The Data Scientist". Data is termed as the "new gold" and the students will learn about the science of extracting knowledge from the Big Data. The applications covered will span Weather predictions, Oil drilling, Seismic activities, Biological data analysis, Social media analytics among many others. Students are encouraged to gain technical know-how about the discussed concepts using Python.

Course Contents:

Unit I: Big Data and Data Science (3 Hours)

- How big is Big Data
- Facets of Data
- The Data Science process
- Data Scientist's Toolkit

Unit II: Basics of Python (5 Hours)

- **The Basics:** Getting Python, The Zen of Python, Whitespace formatting, Modules, Arithmetic, Functions, Strings, Exceptions, Lists, Tuples, Dictionaries, Sets, Control Flow, Sorting, List Comprehensions, Generators and Iterators, Randomness, Regular expressions, etc.

- **Visualizing Data:** Matplotlib, Bar charts, Line charts, Scatterplots etc.

Unit III: Getting Data and Working with Data (3 Hours)

- Reading files
- Scraping the web
- Using APIs
- Cleaning, Munging and Manipulating Data
- Rescaling the Data

Unit IV: Machine Learning (5 Hours)

Supervised Learning:

- Classification: Naïve Bayes, Support Vector Machines, Decision Trees

- Regression: Linear, Polynomial, Logistic

Unsupervised Learning

- Clustering: k-means, Hierarchical
- Dimensionality Reduction: Principal Component Analysis

Unit V: Enabling technologies for Data Science (4 Hours)

Brief introduction to the NoSQL, Hadoop, MongoDB and Cassandra, Map-Reduce, Hive, Pig

Text Books:

1. Joel Grus (2019). Data Science from Scratch, O'Reilly
2. Cielen, Meysman, Ali (2015). Introducing Data Science, Manning Publications.

Additional Readings:

1. Blum, Hopcroft, Kannan (2020). Foundations of Data Science, Cambridge University Press
2. VanderPlas (2016). Python Data Science Handbook, O'Reilly
3. Kroese et al. (2020). Data Science and Machine Learning: Mathematical and Statistical Methods, CRC Press.

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Semester III

Credits	Core - Compulsory	Credits
8	BIN 501 Computer Aided Drug Design Lab	2
	BIN 502 R Programming Lab	2
	BIN 503 M.Sc. Project	4

Credits	Elective Open	Credits
4	BIN 504 Computational Genomics and Proteomics	4

Credits	Elective (Specialization) Structural Bioinformatics	Credits
8	BIN 505 Computer Aided Drug Discovery	4
	BIN 506 Systems Biology and Biological Networks	4

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Website: www.cuhimachal.ac.in

Course Title: Computer Aided Drug Design Lab
Course Code: BIN.501
Total Hours: 60

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

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Website: www.cuhimachal.ac.in

Course Title: R Programming Lab
Course Code: BIN.502
Total Hours: 60

Course Objectives: This course deals with the fundamentals and hands-on-experiments on R.

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

- Basics of R programming.
- Hand-on practice on common R commands for statistical analysis
- Learn application of R in bioinformatics and life science research

Unit I **16 Hours**

Introduction and installation of R and R studio; basic syntax; data-types; variables; operators; decision making; loops; functions; strings; vectors; lists; matrices; arrays; factors; data frames; R-packages

Unit II **16 Hours**

Data visualization: pie charts, bar charts, boxplots; histograms, line graphs, scatterplots; mean, median & mode; regression analysis; normal and binomial distribution, analysis of covariance, time series analysis, decision tree, random forest, Chi-square test

Unit III **14 Hours**

Pairwise sequence alignment; SeqinR package; comparing two sequences using dotplots; pairwise DNA sequence alignment; Bioconductor packages, protein sequence alignment by using Needleman-Wunch and Smith-Waterman algorithms; multiple sequence alignments; building phylogenetic tree using R

Unit IV **14 Hours**

Finding start and stop codons using R; predicting the protein sequence for an ORF; length of ORF; comparing the number of genes in two species; application of Hidden Markov Models in nucleotide and protein sequence analysis

Transactional Modes: Lecture; Tutorial; Hand-on-experiments; Self-learning.

Suggested Readings

- Michael J. Crawley, The R Book, Wiley, (2012)
- Robert Gentleman, R programming for Bioinformatics, CRC Press, (2009).
- Grolemund, Garret (2014) Hands-on Programming with R
- Wickham, Hadley (2015) Advanced R 1st ed. (Advanced R 2nd ed, 2019.)
- Wickham, Hadley (2015) R Packages.

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Website: www.cuhimachal.ac.in

Course Title: M.Sc. Project
Course Code: BIN.503
Total Hours: 120

Course Objective and Learning Outcomes: The objective of project would be to ensure that the student learns the fundamentals 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
Continuous Assessment		
1.	Research work and Report writing	60
2.	Continuous evaluation of student by guide	20
Research Presentation		
3.	Presentation and defense of research work (Viva)	120
	Total	200*

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

a. Supervisor
b. Subject Expert as nominated by honourable VC

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Website: www.cuhimachal.ac.in

Course Title: Computational genomics and Proteomics
Course Code: BIN.504
Total Hours: 60

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 I **14 Hours**

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 **16 Hours**

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

Unit 3 **16 Hours**

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

Unit 4 **14 Hours**

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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Website: www.cuhimachal.ac.in

Course Title: Computer Aided Drug Discovery
Course Code: BIN.505
Total Hours: 60

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 **15 Hours**

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 **15 Hours**

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 **15 Hours**

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 **15 Hours**

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

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Website: www.cuhimachal.ac.in

Course Title: Systems Biology and Biological Networks
Course Code: BIN.506
Total Hours: 60

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.

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)

10. Introduction to noise in biological systems. Intrinsic vs. extrinsic noise. System behaviour and role of noise.

11. Stochastic Methods for modelling biological systems (Master equation, Gillespie's stochastic simulation algorithm)
12. 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:

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

Additional Readings:

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

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Semester IV

Credits	Core - Compulsory	Credits
12	BIN 551 Next Generation Sequencing Analysis	4
	BIN 552 Chemoinformatics	2
	BIN 553 M.Sc. Dissertation	6

Credits	Elective Open	Credits
8	BIN 554 Fundamentals of Metabolomics	2
	BIN 555 Advance topics on Machine Learning	2
	BIN 556 Introduction of Synthetic Biology	2
	BIN 557 Systems Biology Lab	2

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Course Title: Next Generation Sequencing: Analysis
Course Code: BIN.551
Total Lecture: 60

Learning Outcomes: On completion of the course the student should be able to understand the basics of next generation sequencing and data analysis

Course Contents:

UNIT-I: First generation sequencing technologies: An introduction (12 hours)
Maxum-Gilbert and Sanger sequencing
Next generation sequencing technologies
NGS file formats : Preprocessing of raw reads: quality control (FastQC), adapter clipping, quality trimming

UNIT-II: Genome sequence assembly (12 hours)
De novo genome sequence assembly
Use of paired end reads in assembly
Data preprocessing and sequence read correction methods
Assembly errors and evaluation of assembly methods

UNIT-III: De novo assembly algorithms (12 hours)
The overlap graph approach
De Bruijn graph approach
Classification of De Novo assembly algorithms
Comparison of algorithms

Unit IV: Tools and Techniques (12 hours)
Introduction to read mapping (Alignment methods, Mapping heuristics)
Read mapping (BWA, BWA-MEM, Bowtie2, STAR, segemehl), Mapping output (SAM/BAM format), Usage of important NGS toolkits (samtools), Mapping statistics
Visualization of mapped reads (IGV, UCSC)
DNA variant calling

UNIT-V: Applications of NGS (12 hours)
- Comparative genomics
- Functional genomics
- Diagnostics and Exom sequencing
- Microbiome studies

Suggested Readings

1. Ali-Masoudi-Nejad, Zahra Narimani, Nazanin Hosseinkhan. Next Generation Sequencing and Sequence Assembly: Methodologies and Algorithms, SpringerBriefs in Systems Biology, 2013. ISBN 978-1-4614-7726-6.

Other references (Review articles)

1. Rogers, J., and Gibbs, R.A. (2014) Comparative primate genomics: emerging patterns of genome content and dynamics. Nat Rev Genet, 15 (5), 347–359.

2. Werner, T. (2010) Next generation sequencing in functional genomics. Briefings Bioinforma. , 11
(5), 499–511.
3. Bamshad, M.J., Ng, S.B., Bigham, A.W., et al. (2011) Exome sequencing as a tool for Mendelian disease gene discovery. Nat Rev Genet, 12 (11), 745–755.
4. Alkan, C., Coe, B.P., and Eichler, E.E. (2011) Genome structural variation discovery and genotyping. Nat Rev Genet, 12 (5), 363–376.
5. Cooper, G.M., and Shendure, J. (2011) Needles in stacks of needles: finding disease-causal variants in a wealth of genomic data. Nat Rev Genet, 12 (9), 628–640.
6. Kuczynski, J., Lauber, C.L., Walters, W.A., et al. (2012) Experimental and analytical tools for studying the human microbiome. Nat. Rev. Genet., 13 (1), 47–58.

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Website: www.cuhimachal.ac.in

Course Title: Cheminformatics
Course Code: BIN.552
Total Hours: 30

Learning outcomes: On successful completion of this module, students should be able to: the students will obtain some knowledge and will get training in

- Data organization and search in chemical databases;
- QSAR and pharmacophores modelling;
- Chemical data visualization and analysis
- Virtual screening tools and efficiency assessments

Course Content

Unit I: 8 Hours

Cheminformatics as a theoretical chemistry discipline: definition, main concepts and areas of application.

Representing chemical structures on computer. Molecular graphs. Connectivity tables. Adjacency and distance matrices. Linear representations SMILES and SMIRKS.

Unit 2 7 Hours

Molecular descriptors. Definition and main requirements. Different types of descriptors: constitutional, topological indices, geometry-based, surface-based, substructural fragments, lipophilicity, etc.

Unit 3 7 Hours

Chemical Space concept. Graph-based chemical space: scaffolds, frameworks and R-groups. Scaffold tree approach. Descriptor-based chemical space: distance and similarity metrics

Unit 4 8 Hours

Virtual screening workflow. Drug-likeness filters and structural alerts. Parameters of screening efficiency.

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

Suggested Readings

- A. Leach, V. Gillet "An Introduction to Chemoinformatics", Springer, 2007
- "Tutorials in Chemoinformatics", A. Varnek, Ed. , WILEY, 2017

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Website: www.cuhimachal.ac.in

Course Title: M.Sc. Dissertation
Course Code: BIN.599
Total Hours: 240

Course Objective and Learning Outcomes: The objective of dissertation would be to ensure that the student learns the fundamentals 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
Continuous Assessment		
1.	Research work and Report writing	50
2.	Continuous evaluation of student by guide	50
Research Presentation		
3.	Presentation and defense of research work (Viva)	300
	Total	400*

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

a. External Examiner as approved by Honourable VC
b. Dean's Nominee's from allied department
c. Supervisor

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Website: www.cuhimachal.ac.in

Course Title: Fundamentals of Metabolomics
Course Code: BIN.553
Total Hours: 30

Course Objectives: This course deals with the fundamentals of metabolomics and its application in life sciences.

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

- Understand the basics of metabolomics
- Learn the overall workflow of metabolomics starting from sample preparation to data analysis
- Understand the application of metabolomics in life sciences research

Unit I **8 Hours**

Introduction to metabolites, metabolism and metabolomics; structural diversity of metabolites, controlling rates and levels; metabolons; metabolites as a part of cellular interactome; sampling and sample preparation for metabolomics; quenching; obtaining metabolites from biological samples; metabolites in the extracellular medium

Unit II **8 Hours**

Introduction to the analytical tools and techniques for metabolome analysis; chromatography techniques; mass spectrometry; GC-MS; LC-MS; ESI-MS; NMR based metabolomics; targeted and untargeted metabolomics

Unit III **7 Hours**

Organizing the metabolomics data; qualitative and quantitative data; data structure; pre-processing of data; deconvolution of spectroscopic data; data normalization and transformations; PCA and Fisher discriminant analysis;

Unit IV **7 Hours**

Hierarchical and *k*-means clustering techniques; decision theory, *k*-nearest neighbour and tree-based classification techniques; application of metabolomics in microbial, plants and biomedical sciences.

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

Suggested Readings

- **Silas G. Villas-bôas, Ute Roessner, Michael A. E. Hanse, Jorn Smedsgaard, Jens Nielsen**, Metabolome Analysis: An Introduction, Wiley, (2007).

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Temporary Academic Block, Shahpur, Distt. Kangra (HP) – 176206

Website: www.cuhimachal.ac.in

Course Title: Advance topics in Machine Learning
Course Code: BIN.554
Total Hours: 30

Course Content

Unit 1 **4 Hours**

Introduction: Overview of Machine Learning field with intro to statistics Data Cleaning, imputation, cross-validation

Unit 2 **8 Hours**

Unsupervised Methods: Clustering: Distance Metrics, K-Means, leader, Jarvis-Patrick, hierarchical clustering;

Clustering: Self-organized maps, EM-algorithm; Dimensionality Reduction: PCA, LDA, Sammon's

Unit 3 **8 Hours**

Supervised Methods: Classification: K-NN, naïve Bayes, decision trees, boosting and bagging;

Unit 4 **10 Hours**

Classification: Ensemble methods, random Forests; Support vector machines Neural networks; Introduction to Deep learning

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

Suggested Readings

1. Data Mining: Concepts and Techniques, Third Edition by Han, Kamber, and Pei, 2011.
2. Pattern Recognition and Machine Learning by Christopher Bishop; 2007.
3. Applied Predictive Modeling by Max Kuhn and Kjell Johnson; 2013.
4. An Introduction to Statistical Learning and Applications in R by James, Witten, Hastie, Tibshirani; 2014.
5. Python for Data Analysis by Wes McKinney; 2013.

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Website: www.cuhimachal.ac.in

Course Title: Introduction of Synthetic Biology
Course Code: BIN.555
Total Hours: 30
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 (3 Hours)

- 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 (5 Hours)

- 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 (4 Hours)

- 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 (4 Hours)

- 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 (4 Hours)

- 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.**

Central University of Himachal Pradesh

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Temporary Academic Block, Shahpur, Distt. Kangra (HP) – 176206

Website: www.cuhimachal.ac.in

Course Title: Systems Biology Lab
Course Code: BIN.555
Total Hours: 30

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

Central University of Himachal Pradesh

Centre for Computational Biology and Bioinformatics

School of Life Sciences

AGENDA

9th BOARD OF STUDIES MEETING

TO BE HELD ON **27th SEPTEMBER, 2021** SHAHPUR CAMPUS

Venue: Seminar Hall,
Central University of Himachal Pradesh
Shahpur Campus

हिमाचल प्रदेश केन्द्रीय विश्वविद्यालय
Central University of Himachal Pradesh

(Established under Central Universities Act 2009)

शैक्षणिक खण्ड, शाहपुर, ज़िला काँगड़ा, हिमाचल प्रदेश -176206

Academic Block, Shahpur, Distt. Kangra (HP) - 176206

Website: www.cuhimachal.ac.in

कार्यसूची–अनुक्रमणिका

Agenda Item No.	PARTICULARS	Information
मद CBB–BOS–9/21–1	23.03.2021 को आयोजित हुई **संगणकीय जीव विज्ञान एवं जैव सूचना केंद्र** की आठवीं पाठ्य समिति (8th BOS) के कार्यवृत अनुमोदन हेतु प्रस्तुत है ।	अनुलग्नक – I
मद CBB–BOS–9/21–2	राष्ट्रीय शिक्षा नीति (एनईपी–2020) के अनुसार M.Sc. Bioinformatics के लिए नए पाठ्यक्रमों में संशोधन के हेतु प्रस्ताव प्रस्तुत है ।	अनुलग्नक – II
मद CBB–BOS–9/21–3	पी–एच.डी. (CBB) कार्यक्रम के नामांकन में परिवर्तन का प्रस्ताव प्रस्तुत है |	अनुलग्नक – III
मद CBB–BOS–9/21–4	पी–एच.डी. (Bioinformatics) कार्यक्रम के पाठ्यक्रम कार्य के लिए नए पाठ्यक्रम आरम्भ करने की स्वीकृति हेतु प्रस्ताव प्रस्तुत है । 1. IKS – 02 क्रेडिट 2. Pedagogy of Teaching Learning Process – 02 क्रेडिट	अनुलग्नक – IV
मद CBB–BOS–9/21–5	विभिन्न एंट्री–एग्जिट सिस्टम को अपनाने के हेतु प्रस्ताव प्रस्तुत है ।	अनुलग्नक – V
मद CBB–BOS–9/21–6	**संगणकीय जीव विज्ञान एवं जैव सूचना केंद्र** में प्रायोगिक (Practical) एवं मौखिक (Viva–Voce) परीक्षा हेतु बाह्य परीक्षकों की सूची के अनुमोदन हेतु प्रस्ताव प्रस्तुत है ।	अनुलग्नक – VI
मद CBB–BOS–9/21–7	**संगणकीय जीव विज्ञान एवं जैव सूचना केंद्र** में पी–एच.डी. शोधार्थियों के लिए पर्यवेक्षक आबंटन का प्रस्ताव प्रस्तुत है |	अनुलग्नक – VII
मद CBB–BOS–9/21–8	कोई अन्य मामले जो कि अध्यक्ष की अनुमति से विचार– विमर्श किए जांएगे ।	

डॉ. महेश कुल्हारिया
निदेशक,
संगणकीय जीव विज्ञान एवं जैव सूचना केंद्र

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय
Central University of Himachal Pradesh
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Temporary Academic Block, Shahpur, Distt. Kangra (HP) - 176206
Website: www.cuhimachal.ac.in

File No: LS/1-5(Vol.II)/CUHP/12/173

Dated: 23.03.21

Centre for Computational Biology and Bioinformatics

School of Life Sciences

Minutes of the 8th Board of Studies meeting held on 23rd March, 2021

The meeting of the **8th Board of Studies** of the **Centre for Computational Biology and Bioinformatics**, School of Life Sciences was held on **23rd March, 2021** by circulation **(Through Online Mode).**

Following Decision were taken in BOS meeting as per the Agenda.

Agenda Item-No: CBB-BOS-8/21-1: Minutes of the 7th BoS Meeting held on 29th Dec 2020. (Annexure I)

Decision:
All members agreed and approved the Minutes of the 7th BoS Meeting held on 29th Dec 2020. (Annexure I).

Agenda Item-No: CBB-BOS-8/21-2: Change of the title of the PhD thesis of Smt. Neha, CUHP13RDCBB03 report attached (Annexure II)

Decision:
All members agreed and approved the change of the title of the PhD thesis of Smt. Neha, CUHP13RDCBB03 report attached (Annexure II)

The meeting ended with a vote of thanks by the chair.

Dr. Shailender Kumar Verma
Member

Dr. Sunil Kumar
VC's Nominee

23/3/21

Prof. Pardeep Kumar
VC's Nominee

Prof. BrijMohan
Subject Expert

Dr. Deshdeepak Singh
Subject Expert

Dr. Mahesh Kulharia
Chairman & Convenor

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय

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File No: LS/1-5(Vol.II)/CUHP/12/ **Dated:**

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The meeting ended with a vote of thanks by the chair.

Dr. Shailender Kumar Verma
Member

Dr. Sunil Kumar
VC's Nominee

Prof. Pardeep Kumar
VC's Nominee

Prof. BrijMohan
Subject Expert

Dr. Deshdeepak Singh
Subject Expert

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Agenda Item-No: CBB-BOS-8/21-2: Change of the title of the PhD thesis of Smt. Neha, CUHP13RDCBB03 report attached **(Annexure II)**

Decision:
All members agreed and approved the change of the title of the PhD thesis of Smt. Neha, CUHP13RDCBB03 report attached (Annexure II)

The meeting ended with a vote of thanks by the chair.

Dr. Shailender Kumar Verma
Member

Dr. Sunil Kumar
VC's Nominee

Prof. Pardeep Kumar
VC's Nominee

Prof. BrijMohan
Subject Expert

Dr. Deshdeepak Singh
Subject Expert

Dr. Mahesh Kulharia
Chairman & Convenor

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PO Box: 21, Dharamshala, Himachal Pradesh-176215

Research Progress Monitoring Committee

Date: 14/10/2020

1. Name of the Candidate: Neha
2. Registration No.: CUHP13RDCBB03
3. Date of Joining: 06/01/2014
4. Place of work: School of Life Sciences, Central University of Himachal Pradesh
5. Members of the Research Progress Monitoring Committee:
   1. Dr. Mahesh Kulharia (Director)
   2. Dr. P. Aparoy (Supervisor)
   3. Dr. Sunil Kumar (Dean's Nominee)
6. Dates of previous Research Progress Monitoring Committee: 27/06/2018

The following to be filled by the members of the Committee

Member

a) Has the candidate presented her/his work well? **Yes**

b) Has the candidate put in enough work in the given period? **Yes**

c) Do you recommend the candidate to go through the pre-Ph.D. viva (for candidates in their last Research Progress Monitoring Committee): **Yes**

d) Comments of the Research Progress Monitoring Committee members on the progress of research work during the period under the report.

The work progressed well and the candidate can give Pre-Ph.D. presentation. The title of the work can be changed as proposed by the student.

Dr. Sunil Kumar
(Dean's Nominee)

Dr. P. Aparoy
(Supervisor)
(D. POLAMARASETTY APAROY)

Dr. Mahesh Kulharia
(Director)

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Research Progress Committee Report- IV

1. Name of the candidate:	Neha
2. Enrolment/Registration number:	CUHP13RDCBB03
3. School:	School of Life Sciences
4. Department/Centre:	Centre for Computational Biology and Bioinformatics
5. Name of the Supervisor	Dr. Polamarasetty Aparoy
6. Title of Thesis:	**Proposed Title:** **Hints for COX-2 inhibitor design: Molecular dynamics based SAR characterization and ligand based analysis.** Previous Title: Application of Molecular dynamics based free energy calculation methods for identification of novel COX-2 inhibitors
7. Research activities: a) Work done so far	**Work done since 2018** • Identification of novel drug like candidates against COX-2. • Structure and ligand based virtual screeningusing a pool of small molecule databases containing compounds of natural products, primary and secondary metabolites and FDA approved database. • A cluster of amino acids i.e., Gln178, Ser339, Tyr341, Arg499, Phe504, Val509 and Ala513 were found consistence in making interactions with different inhibitors. • MD based studies to characterize the SAR of different classes of COX-2 inhibitors. • Structural insights into the dual inhibition of COX-2/5-LOX. **Work done earlier** • Ligand based Virtual Screening to identify potential dual

	inhibitors of COX-2 /5-LOX. • Ligand based pharmacophore modelling using CLOXIBs • Molecular descriptor profiling against COX-2 inhibitors • MD based studies to characterize the SAR of diaryl heterocyclic COX-2 inhibitors • Role of Ser516 in interactions with heterocyclic ring of COXIBs was shown. • Calculation of energetic contribution of identified amino acids • Molecular dynamics simulation based free energy calculations for COX-2 inhibitors. • Interaction based analysis of COX-2 inhibitors. • Docking studies of COX-2 inhibitors using AutoDock. • Docking of mPGES-1 inhibitors using AutoDock Vina, Dock and AutoDock. • Review of Literature.
b) Future plan	• Pre-PhD presentation • Thesis submission • Manuscript preparation

8. Conferences/Seminars/workshops attended and the posters, talks presented:

- Poster presentation at **"Accelerating Biology 2016: Decoding the deluge"** held during January 19-21, 2016 organized by Bioinformatics Group, C-DAC Pune.
- **"International workshop on Cancer Drug Discovery and Development"** held during June 22-28, 2016 at University of Hyderabad, Hyderabad.
- **"National Symposium on Bioinformatics & Computational Systems Biology"** held during November 12-14, 2016 at Central University of Himachal Pradesh, Himachal Pradesh.

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9. Research work published in conference proceedings/ peer-reviewed journal:

[1] Gupta A, **Chaudhary N**, Kakularam KR, Pallu R, Polamarasetty A. The Augmenting Effects of Desolvation and Conformational Energy Terms on the Predictions of Docking Programs against mPGES-PLoS One. 2015;10 (8):e0134472. doi: 10.1371/journal.pone.0134472.

[2]**Chaudhary N**, Aparoy P. Deciphering the mechanism behind the varied binding activities of COXIBs through Molecular Dynamic Simulations, MM-PBSA binding energy calculations and per residue energy decomposition studies. J Biomol Struct Dyn. 2016 Mar 16:1-27.

[3] Gupta A, **Chaudhary N**, Aparoy P. MM-PBSA and per-residue decomposition energy studies on 7-Phenyl-imidazoquinolin-4(5H)-one derivatives: Identification of crucial site points at microsomal prostaglandin E synthase-1 (mPGES-1) active site.Int J Biol Macromol. 2018 Nov;119:352-359.

[4]**Chaudhary N**, Aparoy P.Application of per-residue energy decomposition to identify the set of amino acids critical for in silico prediction of COX-2 inhibitory activity. Heliyon. 2020 Oct; 6 (10): e04944

[5] **Chaudhary N**, Gupta A, Aparoy P. Molecular descriptor based profiling of COX-2 inhibitors to identify features directing COX-2 inhibition. (Under preparation)

[6] **Chaudhary N**, Choudhary A, Aparoy P. Development of a ligand-based pharmacophore model using PHASE and database searching: An approach for dual inhibition against COX-2 and 5-LOX. (Under preparation)

To be filled in by the candidate

1. Have you submitted your work report? **Yes**
2. Are there any specific problems ?
   i. **Thesis title change**
   ii. **Allotment of Administrative supervisor**
3. Would you like to suggest / modify any objectives: **None**

Date: 31-Oct-2020

Signature of the Candidate

P. Apa Roy
Signature of the Supervisor
(Dr. POLAMARASETTY APAROY)

Signature of Director of the Centre

Annexure IIa

Scheme of curriculum to be considered 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. Bioinformaticsto be considered by the Board of Studies

The students will be admitted on the basis of enterance examination which will have the two sections in the following pattern:

Section A (Non-Optional)

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 (With options)

There will be 4 sets of questions (each 20%)

A: Physics	20%
B: Chemistry	20%
C: Computer Sciences	20%
D: Mathematics	20%

out of which a student will have to **compulsorily** opt for any one.

Eligibility of the prospective students to be considered 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 demontration; 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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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 of lectures / organized classroom activity / contact hours; of laboratory work / practical / field work / tutorial / teacher-led activity and 1 of other work-load 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.

Course Contents:

Unit-I: Introductory concepts

- Big Data in Biology: Need of Statistical measures to analyze it.
- Statistical population and sample: Types of data, Relative and cumulative frequency.
- Organization and presentation of data.
- Descriptive measures:
- Measures of Central tendency: Mean, Median, Mode: notation and formulae, grouped data, relative merits
- Measures of Dispersion: Absolute and relative measures.

Unit-II: Probability concepts ()

- Basic probability models: Combinatorics based computation, Bayes' rule
- Basics of Monte Carlo simulations
- 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
- Continuous probability models: Cumulative distribution function, Density functions
- Continuous probability distributions:
- Uniform distribution, (ii) Normal distribution: Standard deviation, Variance, Skewness and Kurtosis, z-score (iii) Exponential distribution.

Unit III: Statistics concepts I

- Statistical preliminaries: Sample mean, Sample variance, Standard error
- Continuous models fitting: Method of moments, Method of maximum likelihood, Goodness of fit

Unit IV: Statistics concepts II

- Family of normal distributions: Standard normal distribution, The central limit theorem, Chi-squared distribution
- Statistical inference: Confidence intervals, Student-t distribution, Significance tests, pvalues, P-hacking, ANOVA

Unit V: Multivariate analysis

- Discrete and continuous multivariate distributions
- Covariance and correlation
- Dimensionality reduction: principal component analysis
- Clustering, Classification, Regression
- Model parsimony and over-fitting

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 Henry Brase and Corrinne Pellillo Brase (2011), Understandable Statistics: Concepts and Methods.
J. H. Zar (2019), Biostatistical Analysis, Pearson

Central University of Himachal Pradesh

(Established under Central Universities Act 2009)
Academic Campus, Shahpur, Distt. Kangra (HP) – 176206
Website: www.cuhimachal.ac.in

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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Website: www.cuhimachal.ac.in

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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Website: www.cuhimachal.ac.in

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
2. Tooze, Branden An Introduction to Protein Structure. 2014

Central University of Himachal Pradesh

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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.

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

Central University of Himachal Pradesh
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Website: www.cuhimachal.ac.in

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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Course Title: Computational Genomics and Proteomics
Course Code: BIN 466
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:

- 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 I
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 **1**
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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Course Title: Algorithms in Bioinformatics
Course Code: BIN467
Total Hours: 40

L	T	P	Cr
4	0	0	4

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

Course Content

Unit 1: Introduction to algorithms and complexity

1. Basic Concepts: efficiency, analysis and order of an algorithm. Biological vs. Computer algorithms
2. Standard Notations: Big-O notation, NP-hard problems. Few examples: Sorting, Finding optimal change, Traveling salesman problem etc.

Unit 2: Algorithm Design

3. Introduction to algorithm design techniques: Exhaustive search, Greedy Algorithms, Divide and conquer etc.
4. Motif finding problem: Brute force algorithm, Greedy algorithm

Unit 3: Dynamic Programming and Finite State Machines

1. Elements of Dynamic Programming: Edit distance, Longest Common Subsequences.
2. Global and Local Sequence Alignment
3. Markov Chains and Hidden Markov Models
4. Pairwise alignment using HMMs

Unit 4: Pattern matching, trees and clustering

1. Introduction to hash table, keyword tree, suffix tree
2. Ukkonen's linear time suffix tree algorithm
3. Constant time lowest common ancestor retrieval
4. Hierarchical and k-means clustering
5. Evolutionary trees: distance based construction
6. Evolutionary trees: character based construction

Unit 5: Genetic Algorithms

1. Elements of genetic algorithms
2. Cellular automata
3. Systems modeling using genetic algorithms: examples from biological and ecosystems
4. Implementing a genetic algorithm.

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

Suggested Readings:

1. Aho, Alfred V., John E. Hopcroft, and Jeffrey D. Ullman. The Design and Analysis of Computer Algorithms. Reading, MA: Addison-Wesley, 1974. ISBN: 0201000296.

2. Data Structures and Algorithms. Reading, MA: Addison-Wesley, 1983. ISBN: 0201000237.
3. Baase, Sara. Computer Algorithms: Introduction to Design and Analysis. 2nd ed. Reading, MA: Addison-Wesley, 1988. ISBN: 0201060353.
4. Bentley, Jon Louis. Programming Pearls. Reading, MA: Addison-Wesley, 1986. ISBN: 0201103311.
5. More Programming Pearls: Confessions of a Coder. Reading, MA: Addison-Wesley, 1988. ISBN: 0201118890.
6. Brassard, Gilles, and Paul Bratley. Algorithmics: Theory and Practice. Englewood Cliffs, NJ: Prentice-Hall, 1988. ISBN: 0130232432.
7. Even, Shimon. Graph Algorithms. Rockville, MD: Computer Science Press, 1979. ISBN: 0914894218.
8. Garey, Michael R., and David S. Johnson. Computers and Intractibility: A Guide to the Theory of NP-Completeness. San Francisco, CA: W. H. Freeman & Co., 1979. ISBN: 0716710447.
9. Gusfield, Dan. Algorithms on Strings, Trees, and Sequences: Computer Science and Computational Biology. Cambridge, UK: Cambridge University Press, 1997. ISBN: 0521585198.

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Website: www.cuhimachal.ac.in

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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Website: www.cuhimachal.ac.in

Course Title: Fundamentals of Molecular Dynamics simulations
Course Code: BIN 469
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:

- 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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Website: www.cuhimachal.ac.in

Course Title: Python Programming Lab-II
Course Code: BIN 470
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 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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Website: www.cuhimachal.ac.in

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

L	T	P	Cr
2	0	0	2

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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Website: www.cuhimachal.ac.in

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

L	T	P	Cr
4	0	0	4

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 Contents

Unit 1: Introductory Interdisciplinary Concepts
Definition and scope of Systems biology and Synthetic biology.
Introduction to biological complexity -- Self organization, Emergence, Chaos, Robustness.
First-order systems: fixed points and stability, population growth. bifurcations.
Second-order systems: phase portraits, fixed points and linearization. attractors and limit cycles. Hopf bifurcations. Software: XPPAut

Unit 2: Deterministic Modelling in Systems Biology
Chemical Kinetics, Michaelis-Menten Kinetics, Hill equations.
Deterministic Methods of systems modelling (Euler and RK4)
Modelling positive and negative feedback.
Examples from natural systems: Predator-Prey, Circadian Rhythms, p53-mdm2.
Examples from synthteic systems: Brusselator, Repressilator.

Unit 3: Design principles of Biological Networks
Introduction to Networks. Basic terminology, Random networks: Erdös-Renyi model, Watts-Strogatz model.
Scale-free networks, Modular and hierarchical networks. Dynamics on networks. Topology of genetic, metabolic, social, ecological and language networks.
Flux balance analysis.

UNIT 4: Analysis of Biological Networks 1
Global Properties: average path length, network diameter, centrality measures, clustering coefficients
etc. Local Properties: regulatory motifs and graphlets in networks.

Unit 5: Analysis of Biological Networks 2
Motifs in TRNs: discussion on FFL, SIM and other motifs. Network Clustering: clique based clustering, center based clustering
Petri Nets. Softwares: Pajek, Cytoscape, Mfinder, Graphviz etc.

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

Suggested reading:
1. Steven H. 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.
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.

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Course Title: Essentials of Immunology
Course Code: BIN 517
Total Lectures: 20

L	T	P	Cr
2	0	0	2

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.

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Course Title: Research Methodology
Course Code: BIN 518
Total Hours: 40

L	T	P	Cr
4	0	0	4

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)

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

L	T	P	Cr
0	0	2	2

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

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

L	T	P	Cr
4	0	0	2

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

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

L	T	P	Cr
0	0	16	8

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

L	T	P	Cr
2	0	0	2

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*

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

L	T	P	Cr
4	0	0	4

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

L	T	P	Cr
4	0	0	2

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

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 and Applications	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.

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IV Semester Examination Result: MSc (Computational Biology & Bio-Informatics) Academic Year 2016-17

Sr. No.	Registration / Enrolment No.	Course Code	CBB 428			CBB 499A			CBB 522			CBB 523			CBB 525			CBB 527			Grand Total				Remarks
		Credits	2			8			2			2			2			4							
		Maximum Marks	100			400			100			100			100			200							
		Name of the Student	Total Mark Obtained	GP	LG	Total Mark Obtained	GP	LG	Total Mark Obtained	GP	LG	Total Mark Obtained	GP	LG	Total Mark Obtained	GP	LG	Total Mark Obtained	GP	LG	SPM	SGPA	SLG	Credits Earned	
1	CUHP15CBB01	Amita	70.00	8	A+	300.00	8	A+	54.00	5	B	66.00	7	A	59.50	6	B+	141.00	8	A+	**69.05**	**7.40**	A	20	Pass
2	CUHP15CBB02	Anju Sharma	62.00	7	A	260.00	7	A	61.00	7	A	68.00	7	A	69.50	7	A	155.00	8	A+	**67.55**	**7.20**	A	20	Pass
3	CUHP15CBB03	Deepika Rana	59.00	6	B+	300.00	8	A+	65.00	7	A	63.00	7	A	65.50	7	A	146.00	8	A+	**69.85**	**7.50**	A+	20	Pass
4	CUHP15CBB04	Diksha Sharma	65.00	7	A	260.00	7	A	50.00	5	B	64.00	7	A	69.00	7	A	147.00	8	A+	**65.50**	**7.00**	A	20	Pass
5	CUHP15CBB05	Gurmeet Kumari	56.00	6	B+	300.00	8	A+	58.00	6	B+	67.00	7	A	63.50	7	A	155.00	8	A+	**69.95**	**7.40**	A	20	Pass
6	CUHP15CBB06	Ishu	73.00	8	A+	300.00	8	A+	64.00	7	A	75.00	8	A+	53.50	5	B	151.00	8	A+	**71.65**	**7.60**	A+	20	Pass
7	CUHP15CBB07	Komal	57.00	6	B+	280.00	8	A+	62.00	7	A	77.00	8	A+	73.00	8	A+	150.00	8	A+	**69.90**	**7.70**	A+	20	Pass
8	CUHP15CBB08	Mamta Masand	64.00	7	A	280.00	8	A+	69.00	7	A	72.00	8	A+	76.50	8	A+	161.00	9	O	**72.25**	**8.00**	A+	20	Pass
9	CUHP15CBB09	Meenakshi Kaundal	67.00	7	A	280.00	8	A+	60.00	7	A	72.00	8	A+	61.00	7	A	143.00	8	A+	**68.30**	**7.70**	A+	20	Pass
10	CUHP15CBB10	Meenu	67.00	7	A	280.00	8	A+	59.00	6	B+	71.00	8	A+	64.50	7	A	150.00	8	A+	**69.15**	**7.60**	A+	20	Pass
11	CUHP15CBB11	Mohita Mahajan	77.00	8	A+	280.00	8	A+	82.00	9	O	87.00	9	O	76.50	8	A+	157.00	8	A+	**75.95**	**8.20**	A+	20	Pass
12	CUHP15CBB13	Neha Chouhan	77.00	8	A+	340.00	9	O	80.00	9	O	86.00	9	O	83.00	9	O	146.00	8	A+	**81.20**	**8.70**	O	20	Pass
13	CUHP15CBB14	Nisha	72.00	8	A+	300.00	8	A+	76.00	8	A+	80.00	9	O	78.50	8	A+	153.00	8	A+	**75.95**	**8.10**	A+	20	Pass
14	CUHP15CBB15	Nitin Thapa	62.00	7	A	320.00	9	O	64.00	7	A	70.00	8	A+	62.00	7	A	151.00	8	A+	**72.90**	**8.10**	A+	20	Pass
15	CUHP15CBB16	Poonam Alias Sarita Devi	69.00	7	A	280.00	8	A+	66.00	7	A	67.00	7	A	67.50	7	A	170.00	9	O	**71.95**	**7.80**	A+	20	Pass
16	CUHP15CBB17	Preeti Salaria	64.00	7	A	280.00	8	A+	66.00	7	A	75.00	8	A+	68.00	7	A	154.00	8	A+	**70.70**	**7.70**	A+	20	Pass
17	CUHP15CBB18	Priyanka Kumari	63.00	7	A	300.00	8	A+	54.00	5	B	64.00	7	A	56.00	6	B+	150.00	8	A+	**68.70**	**7.30**	A	20	Pass
18	CUHP15CBB19	Pushpa Kumari	62.00	7	A	260.00	7	A	64.00	7	A	65.00	7	A	69.00	7	A	148.00	8	A+	**66.80**	**7.20**	A	20	Pass
19	CUHP15CBB20	Reetu Devi	69.00	7	A	260.00	7	A	74.00	8	A+	71.00	8	A+	67.00	7	A	148.00	8	A+	**68.90**	**7.40**	A	20	Pass
20	CUHP15CBB21	Rhythm Sharma	66.00	7	A	280.00	8	A+	70.00	8	A+	66.00	7	A	62.50	7	A	163.00	9	O	**70.75**	**7.90**	A+	20	Pass
21	CUHP15CBB22	Ritika	64.00	7	A	300.00	8	A+	67.00	7	A	67.00	7	A	74.00	8	A+	158.00	8	A+	**73.00**	**7.70**	A+	20	Pass
22	CUHP15CBB23	Savita	57.00	6	B+	280.00	8	A+	59.00	6	B+	70.00	8	A+	67.00	7	A	157.00	8	A+	**69.00**	**7.50**	A+	20	Pass
23	CUHP15CBB24	Shikha Bharti	62.00	7	A	260.00	7	A	71.00	8	A+	66.00	7	A	61.00	7	A	151.00	8	A+	**67.10**	**7.30**	A	20	Pass
24	CUHP15CBB25	Shilpa Chauhan	71.00	8	A+	300.00	8	A+	85.00	9	O	84.00	9	O	78.50	8	A+	171.00	9	O	**78.95**	**8.40**	A+	20	Pass
25	CUHP15CBB26	Shivani	73.00	8	A+	300.00	8	A+	71.00	8	A+	68.00	7	A	66.50	7	A	155.00	8	A+	**73.35**	**7.80**	A+	20	Pass
26	CUHP15CBB27	Shiwani Dhiman	73.00	8	A+	300.00	8	A+	72.00	8	A+	75.00	8	A+	78.00	8	A+	143.00	8	A+	**74.10**	**8.00**	A+	20	Pass
27	CUHP15CBB28	Vandna Kumari	74.00	8	A+	340.00	9	O	83.00	9	O	84.00	9	O	69.00	7	A	167.00	9	O	**81.70**	**8.70**	O	20	Pass
28	CUHP15CBB29	Varsha Patial	64.00	7	A	280.00	8	A+	67.00	7	A	64.00	7	A	55.50	6	B+	159.00	8	A+	**68.95**	**7.50**	A+	20	Pass
29	CUHP15CBB30	Vijay Singh	58.00	6	B+	280.00	8	A+	51.00	5	B	54.00	5	B	50.00	5	B	116.00	6	B+	**60.90**	**6.50**	A	20	Pass

Abbrevations:

CIA: Cumulative Internal Assessment
MTE: Mid-term Examination
ESE: End Semester Examination
GP: Grade Point
LG: Letter Grade
SPM: Semester Percentage Marks
SGPA: Semester Grade Point Average
SLG: Semester Letter Grade
CGPA: Cumulative Grade Point Average

Percentage of Marks	GP	LG	Description of the Letter Grade
90-100	10	O+	Outstanding
80-89	9	O	Excellent
70-79	8	A+	Very Good
60-69	7	A	Good
55-59	6	B+	Average
50-54	5	B	Pass
00-49	-	F	Fail
Absent	-	Ab	
Incomplete	-	I	

CGPA/SGPA Range	LG	Description of the Letter Grade
9.50 - 10.00	O+	Outstanding
8.50 - 9.49	O	Excellent
7.50 - 8.49	A+	Very Good
6.50 - 7.49	A	Good
5.50 - 6.49	B+	Average
5.00 - 5.49	B	Pass
0 - 4.99	F	Fail

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Controller of Examinations

Central Univeristy of Himachal Pradesh

(Established Under Central Universities Act 2009)

IV Semester Examination Result: M.Sc. Computational Biology & Bioinformatics Academic Year 2017-18

Sr. No.	Registration / Enrolment No.	Course Code	CBB 422						CBB 499A				CBB 513						CBB 525						CBB 522						CBB 523						Grand Total				Remarks
		Credits	2						8				4						2						2						2										
		Maximum Marks	25	25	50	100			200	400			50	50	100	200			25	25	50	100			25	25	50	100			25	25	50	100							
		Name of the Student	CIA	MTE	ESE	Total Mark Obtained	GP	LG	ESE	Total Mark Obtained	GP	LG	CIA	MTE	ESE	Total Mark Obtained	GP	LG	CIA	MTE	ESE	Total Mark Obtained	GP	LG	CIA	MTE	ESE	Total Mark Obtained	GP	LG	CIA	MTE	ESE	Total Mark Obtained	GP	LG	SPM	SGPA	SLG	Credits Earned	
1	CUHP16CBB01	ANKITA DHIMAN	18.25	21	37	76.25	8	A+	324	324.00	9	O	37	39	71	147.00	8	A+	23	19	31	73.00	8	A+	20	17	34	71.00	8	A+	19	15	30	64.00	7	A	**75.53**	**8.30**	A+	20	Pass
2	CUHP16CBB02	ANUPAMA	17.25	17	31	65.25	7	A	300	300.00	8	A+	36	32	64	132.00	7	A	19	15	28	62.00	7	A	20	15	28	63.00	7	A	18	13	27	58.00	6	B+	**68.03**	**7.30**	A	20	Pass
3	CUHP16CBB03	APRAJITA SOOD	18.25	18	32	68.25	7	A	272	272.00	7	A	34	32	75	141.00	8	A+	21	19	31	71.00	8	A+	17	13	31	61.00	7	A	17	10	25	52.00	5	B	**66.53**	**7.10**	A	20	Pass
4	CUHP16CBB04	ARAK CHOUDHARY	20.25	21	31	72.25	8	A+	300	300.00	8	A+	39	40	84	163.00	9	O	23	21	35	79.00	8	A+	22	18	33	73.00	8	A+	21	15	32	68.00	7	A	**75.53**	**8.10**	A+	20	Pass
5	CUHP16CBB05	BASUDEV PANIGRAHI	18	17	32	67.00	7	A	272	272.00	7	A	34	38	63	135.00	7	A	21	18	36	75.00	8	A+	19	14	35	68.00	7	A	20	13	25	58.00	6	B+	**67.50**	**7.00**	A	20	Pass
6	CUHP16CBB06	BINDIYA KAUNDAL	20.25	17	34	71.25	8	A+	260	260.00	7	A	33	40	77	150.00	8	A+	22	18	42	82.00	9	O	19	18	34	71.00	8	A+	19	15	26	60.00	7	A	**69.43**	**7.60**	A+	20	Pass
7	CUHP16CBB07	DEEPIKA KUMARI	16.75	19	33	68.75	7	A	320	320.00	9	O	32	36	73	141.00	8	A+	21	17	37	75.00	8	A+	19	17	33	69.00	7	A	20	15	30	65.00	7	A	**73.88**	**8.10**	A+	20	Pass
8	CUHP16CBB08	DIKSHA KUMARI	19.5	20	34	73.50	8	A+	324	324.00	9	O	35	40	73	148.00	8	A+	23	17	35	75.00	8	A+	20	18	39	77.00	8	A+	20	15	28	63.00	7	A	**76.05**	**8.30**	A+	20	Pass
9	CUHP16CBB09	DIPALI	16.5	17	25	58.50	6	B+	248	248.00	7	A	27	28	57	112.00	6	B+	23	16	30	69.00	7	A	17	14	32	63.00	7	A	19	13	24	56.00	6	B+	**60.65**	**6.60**	A	20	Pass
10	CUHP16CBB10	DIVYA BHARTI	15.75	17	37	69.75	7	A	288	288.00	8	A+	36	42	74	152.00	8	A+	21	20	40	81.00	9	O	20	16	40	76.00	8	A+	19	17	31	67.00	7	A	**73.38**	**7.90**	A+	20	Pass
11	CUHP16CBB11	INDU BALA	16.5	16	35	67.50	7	A	244	244.00	7	A	32	30	56	118.00	6	B+	23	18	34	75.00	8	A+	19	16	39	74.00	8	A+	18	13	27	58.00	6	B+	**63.65**	**6.90**	A	20	Pass
12	CUHP16CBB13	MANISHA SATAUN	17.5	14	29	60.50	7	A	272	272.00	7	A	33	32	67	132.00	7	A	22	17	37	76.00	8	A+	19	14	35	68.00	7	A	18	13	28	59.00	6	B+	**66.75**	**7.00**	A	20	Pass
13	CUHP16CBB14	NANDINI RANA	19.75	17	30	66.75	7	A	280	280.00	8	A+	31	33	50	114.00	6	B+	22	17	33	72.00	8	A+	18	12	34	64.00	7	A	18	15	25	58.00	6	B+	**65.48**	**7.20**	A	20	Pass
14	CUHP16CBB15	NIRJALA DEVI	15	17	29	61.00	7	A	284	284.00	8	A+	32	29	69	130.00	7	A	21	18	33	72.00	8	A+	19	13	39	71.00	8	A+	18	13	27	58.00	6	B+	**67.60**	**7.50**	A+	20	Pass
15	CUHP16CBB16	RASHMI SHARMA	18	18	31	67.00	7	A	324	324.00	9	O	34	33	71	138.00	7	A	20	19	40	79.00	8	A+	20	12	34	66.00	7	A	19	14	28	61.00	7	A	**73.50**	**7.90**	A+	20	Pass
16	CUHP16CBB17	RIMIKA SHARMA	16.75	17	28	61.75	7	A	340	340.00	9	O	32	40	71	143.00	8	A+	24	22	40	86.00	9	O	21	15	42	78.00	8	A+	20	16	31	67.00	7	A	**77.58**	**8.30**	A+	20	Pass
17	CUHP16CBB18	RUPENDER SINGH	17.5	20	29	66.50	7	A	280	280.00	8	A+	36	29	60	125.00	7	A	20	20	34	74.00	8	A+	16	14	35	65.00	7	A	17	15	29	61.00	7	A	**67.15**	**7.50**	A+	20	Pass
18	CUHP16CBB19	SABIR KHAN	18.5	18	32	68.50	7	A	260	260.00	7	A	35	40	71	146.00	8	A+	19	19	34	72.00	8	A+	19	16	35	70.00	8	A+	21	15	28	64.00	7	A	**68.05**	**7.40**	A	20	Pass
19	CUHP16CBB20	SAKSHI SINGH	14.75	17	26	57.75	6	B+	300	300.00	8	A+	36	36	62	134.00	7	A	22	16	29	67.00	7	A	18	16	39	73.00	8	A+	17	14	27	58.00	6	B+	**68.98**	**7.30**	A	20	Pass
20	CUHP16CBB21	SAVITA CHOUDHARY	14.5	19	32	65.50	7	A	244	244.00	7	A	32	33	65	130.00	7	A	22	17	33	72.00	8	A+	16	15	38	69.00	7	A	17	14	25	56.00	6	B+	**63.65**	**7.00**	A	20	Pass
21	CUHP16CBB22	SHEFALI CHAUDHARY	18.5	20	34	72.50	8	A+	312	312.00	8	A+	34	35	62	131.00	7	A	21	19	37	77.00	8	A+	19	15	37	71.00	8	A+	19	14	29	62.00	7	A	**72.55**	**7.70**	A+	20	Pass
22	CUHP16CBB23	SHIKHA	16	18	31	65.00	7	A	248	248.00	7	A	32	31	64	127.00	7	A	21	16	32	69.00	7	A	18	16	35	69.00	7	A	18	14	24	56.00	6	B+	**63.40**	**6.90**	A	20	Pass
23	CUHP16CBB24	SHILPA DEVI	15.75	18	35	68.75	7	A	340	340.00	9	O	32	33	65	130.00	7	A	20	17	35	72.00	8	A+	20	20	35	75.00	8	A+	21	16	33	70.00	8	A+	**75.58**	**8.10**	A+	20	Pass
24	CUHP16CBB25	SHILPA SHARMA	18	17	35	70.00	8	A+	268	268.00	7	A	37	36	59	132.00	7	A	23	20	33	76.00	8	A+	17	16	37	70.00	8	A+	19	13	25	57.00	6	B+	**67.30**	**7.20**	A	20	Pass
25	CUHP16CBB26	SHIVANI DHIMAN	16.75	16	33	65.75	7	A	324	324.00	9	O	33	33	71	137.00	7	A	21	18	33	72.00	8	A+	17	16	40	73.00	8	A+	18	12	22	52.00	5	B	**72.38**	**7.80**	A+	20	Pass
26	CUHP16CBB27	SHIVANI DHIMAN	16.5	16	28	60.50	7	A	280	280.00	8	A+	30	32	64	126.00	7	A	21	17	34	72.00	8	A+	18	14	37	69.00	7	A	17	13	27	57.00	6	B+	**66.45**	**7.40**	A	20	Pass
27	CUHP16CBB28	SHIVANI THAKUR	14.5	18	33	65.50	7	A	272	272.00	7	A	35	31	72	138.00	7	A	22	17	36	75.00	8	A+	16	15	39	70.00	8	A+	17	13	24	54.00	5	B	**67.45**	**7.00**	A	20	Pass
28	CUHP16CBB29	SWETA DEVI	14.5	18	36	68.50	7	A	328	328.00	9	O	39	42	82	163.00	9	O	22	20	39	81.00	9	O	22	22	39	83.00	9	O	21	17	36	74.00	8	A+	**79.75**	**8.70**	O	20	Pass
29	CUHP16CBB30	VISHAL BHAT	16.5	14	26	56.50	6	B+	220	220.00	6	B+	28	34	54	116.00	6	B+	19	18	16	37.00		F	17	15	28	60.00	7	A	17	12	21	50.00	5	B	**55.83**	**6.00**	B+	18	Fail

Abbrevations:

CIA: Cumulative Internal Asses
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SLG: Semester Letter Grade
CGPA: Cumulative Grade Point

Percentage of Marks	GP	LG	Description of the Letter Grade
90-100	10	O+	Outstanding
80-89	9	O	Excellent
70-79	8	A+	Very Good
60-69	7	A	Good
55-59	6	B+	Average
50-54	5	B	Pass
00-49	-	F	Fail
Absent	-	Ab	
Incomplete	-	I	

CGPA/SGPA Range	LG	Description of the Letter Grade
9.50 - 10.00	O+	Outstanding
8.50 - 9.49	O	Excellent
7.50 - 8.49	A+	Very Good
6.50 - 7.49	A	Good
5.50 - 6.49	B+	Average
5.00 - 5.49	B	Pass
0 - 4.99	F	Fail

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Controller of Examinations

Central Univeristy of Himachal Pradesh

(Established Under Central Universities Act 2009)

IV Semester Examination Result: M.Sc. Computational Biology & Bioinformatics (Academic Year 2018-19) held in June 2019

Sr. No.	Registration / Enrolment No.	Course Code	CBB 428						CBB 499A				CBB 513						CBB 522						CBB 523						CBB 525						Grand Total				Remarks
		Credits	2						8				4						2						2						2										
		Maximum Marks	25	25	50	100			200	400			50	50	100	200			25	25	50	100			25	25	50	100			25	25	50	100							
		Name of the Student	CIA	MTE	ESE	Total Mark Obtained	GP	LG	ESE	Total Mark Obtained	GP	LG	CIA	MTE	ESE	Total Mark Obtained	GP	LG	CIA	MTE	ESE	Total Mark Obtained	GP	LG	CIA	MTE	ESE	Total Mark Obtained	GP	LG	CIA	MTE	ESE	Total Mark Obtained	GP	LG	SPM	SGPA	SLG	Credits Earned	
1	CUHP17CBB01	AKRUTI SHARMA	22	21	33	76.00	8	A+	320	320.00	9	O	40	23	84	147.00	8	A+	19	20	36	75.00	8	A+	21	15	34	70.00	8	A+	20	21	37	78.00	8	A+	**76.60**	**8.40**	A+	20	Pass
2	CUHP17CBB03	APARNA BHARDWAJ	23	22	41	86.00	9	O	320	320.00	9	O	42	42	77	161.00	9	O	22	18	41	81.00	9	O	21	18	39	78.00	8	A+	21	22	38	81.00	9	O	**80.70**	**8.90**	O	20	Pass
3	CUHP17CBB04	DEEPANSHI AWASTHI	23	23	44	90.00	10	O+	340	340.00	9	O	43	44	80	167.00	9	O	24	22	43	89.00	9	O	22	23	47	92.00	10	O+	24	23	46	93.00	10	O+	**87.10**	**9.30**	O	20	Pass
4	CUHP17CBB05	DEEPIKA	22	21	34	77.00	8	A+	280	280.00	8	A+	41	40	71	152.00	8	A+	15	17	34	66.00	7	A	19	19	36	74.00	8	A+	21	20	34	75.00	8	A+	**72.40**	**7.90**	A+	20	Pass
5	CUHP17CBB06	DEEPIKA BHARMORIA	20	19	31	70.00	8	A+	272	272.00	7	A	38	39	74	151.00	8	A+	18	14	42	74.00	8	A+	19	15	29	63.00	7	A	18	17	25	60.00	7	A	**69.00**	**7.40**	A	20	Pass
6	CUHP17CBB08	IBHA THAKUR	20	19	26	65.00	7	A	260	260.00	7	A	38	19	54	111.00	6	B+	15	13	32	60.00	7	A	16	16	30	62.00	7	A	17	15	12	0		F	**62.00**	**6.78**	A	18	Fail
7	CUHP17CBB09	JYOTI VERMA	21	19	27	67.00	7	A	304	304.00	8	A+	38	30	61	129.00	7	A	15	14	39	68.00	7	A	19	19	36	74.00	8	A+	18	14	32	64.00	7	A	**70.60**	**7.50**	A+	20	Pass
8	CUHP17CBB10	KAJAL SHARMA	21	20	25	66.00	7	A	268	268.00	7	A	38	23	73	134.00	7	A	16	18	34	68.00	7	A	18	15	31	64.00	7	A	16	15	24	55.00	6	B+	**65.50**	**6.90**	A	20	Pass
9	CUHP17CBB11	KANCHAN BALA	20	18	25	63.00	7	A	240	240.00	7	A	38	18	63	119.00	6	B+	15	13	31	59.00	6	B+	16	14	28	58.00	6	B+	15	14	14	0		F	**59.89**	**6.56**	A	18	Fail
10	CUHP17CBB14	MUKUL KUMAR	21	19	38	78.00	8	A+	304	304.00	8	A+	40	28	88	156.00	8	A+	19	19	39	77.00	8	A+	19	19	35	73.00	8	A+	17	20	25	62.00	7	A	**75.00**	**7.90**	A+	20	Pass
11	CUHP17CBB15	NAVEEN CHAUDHARY	20	13	23	56.00	6	B+	264	264.00	7	A	37	25	59	121.00	7	A	16	15	30	61.00	7	A	17	14	30	61.00	7	A	16	15	15	0		F	**62.56**	**6.89**	A	18	Fail
12	CUHP17CBB16	PANKAJ KUMAR	19	14	26	59.00	6	B+	280	280.00	8	A+	37	30	68	135.00	7	A	15	15	33	63.00	7	A	14	16	30	60.00	7	A	17	16	19	0		F	**66.33**	**7.33**	A	18	Fail
13	CUHP17CBB17	PAWANA DEVI	16	20	A	#VALUE!	##	###	292	292.00	8	A+	36	27	A	#VALUE!	##	##	18	14	A	#VALUE!	##	##	17	17	A	#VALUE!	##	##	14	18	A	#VALUE!	##	##	**#VALUE!**	**#VALUE!**	#VALUE!	######	Fail
14	CUHP17CBB18	POONAM	21	21	32	74.00	8	A+	300	300.00	8	A+	38	37	74	149.00	8	A+	18	13	37	68.00	7	A	19	16	33	68.00	7	A	17	17	38	72.00	8	A+	**73.10**	**7.80**	A+	20	Pass
15	CUHP17CBB19	RUPINDER KAUR	21	20	27	68.00	7	A	260	260.00	7	A	38	34	74	146.00	8	A+	16	12	36	64.00	7	A	16	13	34	63.00	7	A	16	18	30	64.00	7	A	**66.50**	**7.20**	A	20	Pass
16	CUHP17CBB20	SACHIN SHARMA	23	14	35	72.00	8	A+	336	336.00	9	O	41	40	66	147.00	8	A+	19	16	36	71.00	8	A+	20	20	38	78.00	8	A+	17	20	37	74.00	8	A+	**77.80**	**8.40**	A+	20	Pass
17	CUHP17CBB21	SAKSHI	22	15	35	72.00	8	A+	288	288.00	8	A+	39	35	68	142.00	8	A+	20	16	35	71.00	8	A+	21	17	39	77.00	8	A+	19	17	36	72.00	8	A+	**72.20**	**8.00**	A+	20	Pass
18	CUHP17CBB22	SHIKHA SHARMA	23	22	36	81.00	9	O	268	268.00	7	A	38	38	69	145.00	8	A+	18	14	38	70.00	8	A+	20	18	38	76.00	8	A+	19	22	33	74.00	8	A+	**71.40**	**7.70**	A+	20	Pass
19	CUHP17CBB23	SHIVALI DOGRA	20	16	24	60.00	7	A	272	272.00	7	A	38	17	70	125.00	7	A	15	11	33	59.00	6	B+	18	16	29	63.00	7	A	16	12	15	0		F	**64.33**	**6.89**	A	18	Fail
20	CUHP17CBB24	SWATI	22	16	29	67.00	7	A	268	268.00	7	A	39	32	67	138.00	7	A	16	14	36	66.00	7	A	19	14	31	64.00	7	A	19	16	32	67.00	7	A	**67.00**	**7.00**	A	20	Pass
21	CUHP17CBB25	TANIYA CHANDEL	20	16	29	65.00	7	A	268	268.00	7	A	37	30	62	129.00	7	A	17	16	37	70.00	8	A+	16	15	33	64.00	7	A	15	16	15	0		F	**66.22**	**7.11**	A	18	Fail
22	CUHP17CBB26	VARSHA KUMARI	21	17	33	71.00	8	A+	340	340.00	9	O	40	31	59	130.00	7	A	22	13	38	73.00	8	A+	22	17	34	73.00	8	A+	14	16	34	64.00	7	A	**75.10**	**8.10**	A+	20	Pass
23	CUHP17CBB27	VISHALI	21	15	30	66.00	7	A	260	260.00	7	A	37	30	67	134.00	7	A	16	18	40	74.00	8	A+	16	18	32	66.00	7	A	17	19	32	68.00	7	A	**66.80**	**7.10**	A	20	Pass

Prepared by

Checked by

Controller of Examinations

Abbrevations:	Percentage of Marks	GP	LG	Description of
CIA: Cumulative In	90-100	10	O+	tstanding
MTE: Mid-term Ex	80-89	9	O	xcellent
ESE: End Semeste	70-79	8	A+	ery Good
GP: Grade Point	60-69	7	A	Good
LG: Letter Grade	55-59	6	B+	Average
SPM: Semester Pe	50-54	5	B	Pass
SGPA: Semester G	00-49	-	F	Fail
SLG: Semester Let	Absent	-	Ab	
CGPA: Cumulative	Incomplete	-	I	

CGPA/SGPA Range	LG	Description of the Letter
9.50 - 10.00	O+	Outstanding
8.50 - 9.49	O	Excellent
7.50 - 8.49	A+	Very Good
6.50 - 7.49	A	Good
5.50 - 6.49	B+	Average
5.00 - 5.49	B	Pass
0 - 4.99	F	Fail