॥ सा विद्या या विमुक्तये ॥

स्वामी रामानंद तीर्थ मराठवाडा विद्यापीठ, नांदेड

'ज्ञानतीर्थ', विष्णुपुरी, नांदेड – ४३१ ६०६ (महाराष्ट्र राज्य) भारत

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

'Dnyanteerth', Vishnupuri, Nanded - 431 606 (Maharashtra State) INDIA

स्वामी रामानंद तीर्थ मराठवाडा विद्यापीठ, नांदेड

Established on 17th September, 1994, Recognized By the UGC U/s 2(f) and 12(B), NAAC Re-accredited with'B++' grade

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Academic-1 (BOS) Section

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विज्ञान व तंत्रज्ञान विद्याशाखे अंतर्गत राष्ट्रीय शैक्षणिक धोरण–२०२० नुसार पदवी तृतीय वर्षाचे अभ्यासक्रम (Syllabus) शैक्षणिक वर्ष २०२६–२७ पासून लागू करण्याबाबत.

प रि प त्र क

या परिपत्रकान्वये सर्व संबंधितांना कळविण्यात येते की, दिनांक २२ एप्रिल २०२६ रोजी संपन्न झालेल्या मा.विद्यापरिषद बैठकीतील विषय क्र.०८/६४–२०२६ च्या ठरावानुसार विज्ञान व तंत्रज्ञान विद्याशाखेतील राष्ट्रीय शैक्षणिक धोरण–२०२० नुसार पदवी तृतीय वर्षाचे अभ्यासक्रम (Syllabus) शैक्षणिक वर्ष २०२६–२७ पासून लागू करण्यास मा.विद्यापरिषदेने मान्यता प्रदान केली आहे. त्यानुसार विज्ञान व तंत्रज्ञान विद्याशाखेतील बी.एस्सी. तृतीय वर्षाचे खालील विषयाचे अभ्यासक्रम (Syllabus) शैक्षणिक वर्ष २०२६–२७ पासून लागू करण्यात येत आहे.

01	**B.Sc. III Year Biotechnology (Vocational)**
02	**B.Sc. III Year Bioinformatics**
03	**B.Sc. III Year Biotechnology**

सदरील परिपत्रक व अभ्यासक्रम प्रस्तुत विद्यापीठाच्या www.srtmun.ac.in या संकेतस्थळावर उपलब्ध आहेत. तरी सदरील बाब ही सर्व संबंधितांच्या निदर्शनास आणून द्यावी, ही विनंती.

'ज्ञानतीर्थ' परिसर,
विष्णुपुरी, नांदेड – ४३१ ६०६.
जा.क्र.:शै–१/परिपत्रक/पदवी/बीएस्सी/२०२६–२७/125
दिनांक : ०५.०८.२०२६

5/8

उपकुलसचिव
शैक्षणिक (१–अभ्यासमंडळे) विभाग

प्रत माहिती व पुढील कार्यवाहीस्तव :–

१) मा. कुलगुरू महोदयांचे कार्यालय, प्रस्तुत विद्यापीठ.
२) मा. प्र.कुलगुरू महोदयांचे कार्यालय, प्रस्तुत विद्यापीठ
३) मा. अधिष्ठाता, विज्ञान व तंत्रज्ञान विद्याशाखा, प्रस्तुत विद्यापीठ.
४) मा. संचालक, परिक्षा व मुल्यमापन मंडळ, प्रस्तुत विद्यापीठ.
५) मा. प्राचार्य, सर्व संबंधित संलग्नित महाविद्यालये, प्रस्तुत विद्यापीठ.
६) सिस्टीम एक्सपर्ट, शैक्षणिक विभाग, प्रस्तुत विद्यापीठ. यांना देवून कळविण्यात येते की, परिपत्रक अभ्यासक्रम संकेतस्थळावर प्रसिध्द करण्यात यावेत.

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

STRUCTURE AND SYLLABUS OF FOUR YEAR MULTIDISCIPLINARY

DEGREE PROGRAM WITH MULTIPLE ENTRY AND EXIT OPTION

UNDER

NATIONAL EDUCATION POLICY (NEP 2020)

In

SUBJECT: BIOINFORMATICS

FACULTY OF SCIENCE AND TECHNOLOGY

B. Sc. Third Year

With Effect from June 2026

From the Desk of the Dean, Faculty of Science and Technology

Swami Ramanand Teerth Marathwada University, Nanded, enduring to its vision statement *"Enlightened Student: A Source of Immense Power"*, is trying hard consistently to enrich the quality of science education in its jurisdiction by implementing several quality initiatives. Revision and updating curriculum to meet the standard of the courses at national and international level, implementing innovative methods of teaching-learning, improvisation in the examination and evaluation processes are some of the important measures that enabled the University to achieve the ***3Es, the equity, the efficiency*** and ***the excellence*** in higher education of this region. To overcome the difficulty of comparing the performances of the graduating students and also to provide mobility to them to join other institutions the University has adopted the cumulative grade point average (CGPA) system in the year 2014-2015. Further, following the suggestions by the UGC and looking at the better employability, entrepreneurship possibilities and to enhance the latent skills of the stakeholders the University has adopted the Choice Based Credit System (CBCS) in the year 2018-2019 at graduate and post-graduate level. This provided flexibility to the students to choose courses of their own interests. To encourage the students to opt the world-class courses offered on the online platforms like, NPTEL, SWAYM, and other MOOCS platforms the University has implemented the credit transfer policy approved by its Academic Council and also has made a provision of reimbursing registration fees of the successful students completing such courses.

SRTM University has been producing a good number of high caliber graduates; however, it is necessary to ensure that our aspiring students are able to pursue the right education. Like the engineering students, the youngsters pursuing science education need to be equipped and trained as per the requirements of the R&D institutes and industries. This would become possible only when the students undergo studies with an updated and evolving curriculum to match global scenario.

Higher education is a dynamic process and in the present era the stakeholders need to be educated and trained in view of the self-employment and self-sustaining skills like start-ups. Revision of the curriculum alone is not the measure for bringing reforms in the higher education, but invite several other initiatives. Establishing industry-institute linkages and initiating internship, on job training for the graduates in reputed industries are some of the important steps that the University would like to take in the coming time. As a result, revision of the curriculum was the need of the hour and the New Education Policy 2020 provided such an opportunity. National Education Policy 2020 (NEP 2020) aims at equipping students with knowledge, skills, values, leadership qualities and initiates them for lifelong learning. As a result, the students will acquire expertise in specialized areas of interest, kindle their intellectual curiosity and scientific temper, and create imaginative individuals.

The curriculum given in this document has been developed following the guidelines of NEP2020 and is crucial as well as challenging due to the reason that it is a transition from general science based to the discipline-specific-based curriculum. All the recommendations of the ***Sukanu Samiti*** given in the **NEP Curriculum Framework-2023** have been followed, keeping the disciplinary approach with rigor and depth, appropriate to the comprehension level of learners.

All the Board of Studies (BoS) under the Faculty of Science and Technology of this university have put in their tremendous efforts in making this curriculum of international standard. They have taken care of maintaining logical sequencing of the subject matter with proper placement of concepts with their linkages for better understanding of the students. We take this opportunity to congratulate the Chairman(s) and all the members of various Boards of Studies for their immense contributions in preparing the revised curriculum for the benefits of the stakeholders in line with the guidelines of the **Government of Maharashtra regarding NEP-2020**. We also acknowledge the suggestions and contributions of the academic and industry experts of various disciplines.

We are sure that the adoption of the revised curriculum will be advantageous for the students to enhance their skills and employability. Introduction of the mandatory ***On Job Training, Internship program*** for science background students is praise worthy and certainly help the students to imbibe firsthand work experience, teamwork management. These initiatives will also help the students to inculcate the workmanship spirit and explore the possibilities of setting up of their own enterprises.

Dr. M. K. Patil
Dean
Faculty of Science and Technology

From the Desk of the Chairman, BOS in Biotechnology and Bioinformatics:

The National Education Policy 2020 (NEP 2020) is formulated to revamp education system and lay down road map for new India. This policy is framed based on the fundamental pillars of access, equity, quality, affordability, and accountability and seeks to transform India into a thriving knowledge society and a global knowledge superpower.

Some of the important features of National Education Policy are increasing gross enrolment ratio in higher education ,holistic and multidisciplinary education with multiple entry/exit options, establishment of academic bank of credit setting up of multidisciplinary education and research Universities and National Research Foundation, expansion of open and distance learning to increase gross enrolment ratio, internationalization of education, motivated, energized and capable faculty, online and digital education and effective governance and leadership.

As per the National Education Policy, the Government of Maharashtra has proposed a model curriculum framework and an implementation plan for the State of Maharashtra. It is to suggest and facilitate the implementation of schemes and programs, which improve not only the level of academic excellence but also improve the academic and research environment in the state. The proposed curriculum framework endeavors to empower the students and help them in their pursuit for achieving overall excellence.

In view of NEP priority and in keeping with its vision and mission, process of updating the curriculum is initiated and implemented in SRTM University at UG and PG level from the academic year 2023-2024.

Bioinformatics is often considered as the technology of hope for meeting future challenges like feeding our increasing population, cleaning dangerously polluted environments and potentiating healthcare sector etc. Establishment of new IISERs, Central Universities and IITs indicate that we are already on the track of developing infrastructure and human resource. Our dream of becoming future ‘superpower’ will not be possible without Bioinformatics and inclusive efforts. Therefore, it is necessary to attract young and bright students and train them in the field of Bioinformatics.

Keeping in mind, BOS in Biotechnology and Bioinformatics has prepared the curriculum to ensure up-to-date level of understanding of Bioinformatics. Studying Bioinformatics prepares the students for their career working either in educational institutions or industries in which they can directly be involved in the teaching, research and development. Also, to ensure uniform curriculum and its quality at UG/PG level, curriculum of different Indian Universities, syllabus of NET, SET, MPSC, UPSC and the UGC model curriculum are referred to serve as a base in updating the same.

The comments or suggestions from all teachers, students and other stakeholders are welcome for upbringing this curriculum.

Salient Features:

The syllabus of B.Sc. Bioinformatics Third year has been framed to meet the requirement of Choice Based Credit System under NEP 2020. The courses offered here in will train and orient the students in the specific fields of Bioinformatics.

The Core Courses deals with Structural Bioinformatics and CADD, NGS and Genome Informatics, Python for Bioinformatics, Clinical Bioinformatics, Cloud Computing for Bioinformatics, Bioinformatics Workflow Automation, Healthcare Informatics and Microbiome Informatics.

Apart from the core courses, the Value addition Courses deal with Indian Knowledge System in Bioinformatics and Bioinformatics Project Management.

The Skill Enhancement Courses like Linux and Shell Scripting for Bioinformatics and Generative AI and LLMs for Biomedical Research offered during this program are designed with the aim of imparting specific skills to the students which will lead to the self-employability and development of their own enterprises.
This would help students to lay a strong foundation in the field of Bioinformatics.

Overall, after completion of this course, students will also acquire fundamental knowledge and applications of Bioinformatics.

Program Educational Objectives:

The Objectives of this program are:

PEO1: To offer undergraduate program in Bioinformatics based on the needs of industries, academic and research institutions worldwide.

PEO2: To promote and popularize Bioinformatics at grass root level and attract young and budding talents.

PEO3: To expose the students to the different emerging fields of Bioinformatics.

PEO4: To update curriculum by introducing recent advances in the subject that enable the students to face NET, SET, MPSC, UPSC and other competitive examinations successfully.

PEO5: To train and orient the students so as to develop human resource for the educational institutes and other organizations.

PEO6: To inculcate analytical and application-oriented abilities to create active and frontline researchers and human resource for the industries.

PEO7: To develop specific skills amongst students for self-employability and for the development of their own enterprises.

Program Outcomes:

The Outcomes of this program are:

PO1: This Bioinformatics program shall promote and popularize Bioinformatics at grass root level and shall also attract young and budding talents.

PO2: This program will expose the students to the different emerging fields of Bioinformatics.

PO3: This will provide updated curriculum with recent advances in the subject that enable the students to face NET, SET, MPSC, UPSC and other competitive examinations successfully.

PO4: This program shall train and orient the students so as to develop human resource for the educational institutes and other organizations.

PO5: This program shall train and orient the students so as to develop active and frontline researchers and human resource for the industries.

PO6: This will also develop specific skills amongst students for self-employability and for the development of their own enterprises.

Dr. M. M. V. Baig
Chairman, BOS in Biotechnology and Bioinformatics
Swami Ramanand Teerth Marathwada University, Nanded.

Details of the Board of Studies Members in the subject Biotechnology and Bioinformatics under the Faculty of Science & Technology, S.R.T.M. University, Nanded.

Sr No	Name of the Member	Designation	Sr No	Address	Designation
1	Dr M M V Baig Dept of Biotechnology, Yeshwant Mahavidyalaya, Nanded. Mob. No. 9422170641	Chairman	2	Dr. Babasaheb S. Surwase School of Life Sciences SRTM University, Nanded Mob. No.9075829767	Member
3	Dr. Pratap V. Deshmukh Nagnath Arts, Commerce and Science College, Aundha Nagnath, Dist. Hingoli Mob. No. 9637202024	Member	4	Dr. Komal S. Gomare Dept of Biotechnology Dayanand Science College, Latur Mob. No. 9284238413	Member
5	Dr. Vaibhav D. Deshpande General Manager, Quality Corporate Office, Wockhardt, Mumbai Mob. No. 9100988260	Member	-	--	
	Invitee Members				
6	Dr. Laxmikant Kamble School of Life Sciences, SRTM University, Nanded 431606. Mob. No.8669695555	Member	7	Dr B. Y. Gottigalla Dept of Biotechnology, Yeshwant Mahavidyalaya, Nanded. Mob. No. 9960742399	Member
8	Dr. A.B. Gulwe School of Technology, SRTM University Sub Campus, Latur. Mob. No. 7387120874	Member	9	Dr Makarand N. Cherekar Dept. of Biotechnology & Bioinformatics, MGM's College of CS and IT, Nanded. Mob: 9421454254	Member
10	Dr. Nilesh More Dept. of Biotechnology, College of CS & IT, Latur. Mob: 8329502899	Member	11	Dr. Firdous Samad Biradar Dept. of Biotechnology, Dayanand Science College, Latur. Mob 7972993782	Member

Swami Ramanand Teerth Marathwada University, Nanded

Faculty of Science and Technology (Three Optional in the First Year)

Credit Framework for Four Year Multidisciplinary Degree Program with Multiple Entry and Exit

Subject: BIOINFORMTICS (Major) /ZOOLOGY & CHEMISTRY (Minor 1 and Minor 2)

(For illustration BIO, ZOO and CHE combinations are considered, which may change for different combinations)

Year & Level	Sem-ester	Optional 1 (Major) *(From the same Faculty)*	Optional 2 (Minor 1) *(From the same Faculty)*	Optional 3 (Minor 2) *(From the same Faculty)*	Generic Elective (GE) (select from Basket 3 of *Faculties other than Science and Technology*)	Vocational & Skill Enhancement Course	Ability Enhancement Course (AEC) (Basket 4) Value Education Courses (VEC) / Indian Knowledge System (IKS) (Basket 5) *(Common across all faculties)*	Field Work / Project/Internship/ OJT/ Apprenticeship / Case Study Or Co-curricular Courses (CCC) (Basket 6 for CCC) *(Common across all faculties)*	Credits	Total Credits
1	2	3	4	5	6	7	8	9	10	11
3 (5.5)	V	**SBOTCT1301** (T 3Cr) **SBOTCT1302** (T 3Cr) **SBOTIK1303** (T 2Cr) **SBOTCP1301** (P 2Cr) **SBOTCP1302** (P 2Cr) **12 Credits**	**SBOTET1301** (T 3Cr) **SBOTEP1301** (P 1Cr) **4 Cr**		--	**SBOTVC1301** **4 Credits**	--	**SBOTFP1301** **(2 Cr)** **2 Credits**	**22**	**132**
	VI	**SBOTCT1351** (T 3Cr) **SBOTCT1352** (T 3Cr) **SBOTCT1353** (T 2Cr) **SBOTCP1351** (P 2Cr) **SBOTCP1352** (P 2Cr) **12 Credits**	**SBOTET1351** (T 3Cr) **SBOTEP1351** (P 1Cr) **4 Cr**		--	**SBOTVC1351** **2 Credits**	--	**SBOTOJ1351** **4 Credits**	**22**	
	Cum. Cr.	**24**	**14**			**8 + 4 =12**	**22**	**08+2=10**		
Exit option: UG Diploma in Major Bioinformatics and Minor Bioinformatics on completion of 88 credits and additional 4 credits NSQF / internship in Biotechnology										

B. Sc. Third Year Semester V (Level 5.5)

Teaching Scheme

	Course Code	Course Name	Credits Assigned			Teaching Scheme	
			Theory	Practical	Total	Theory (Hrs/ Week)	Practical (Hrs/ Week)
Major 1	SBIOCT-1301	Structural Bioinformatics and CADD	03	--	03	03	--
	SBIOCP-1301	Lab Course based on Structural Bioinformatics and CADD	--	02	02	--	04
Major 2	SBIOCT-1302	NGS and Genome Informatics	03	--	03	03	--
	SBIOCP-1302	Lab Course based on NGS and Genome Informatics	--	02	02	--	04
Major 3 (Elective)	SBIOCT-1303	A] Python for Bioinformatics or B] Clinical Bioinformatics	02	--	02	02	--
	SBIOCP-1303	A] Python for Bioinformatics or B] Lab Course based on Clinical Bioinformatics	--	02	02	--	04
Value Education Courses (VEC) / Indian Knowledge System (IKS)	SBIOIKS-1301	Indian Knowledge System in Bioinformatics	02	--	02	02	08
Vocational/Skill Enhancement Course (Related to Major)	SBIOSC-1301	Linux and Shell in Bioinformatics	--	02	02	--	04
OJT/ FP/CS	SBIOOJ-1301	Project/Internship/OJT/Case Study	--	04	04	--	--
Total Credits			**10**	**12**	**22**	**10**	**24**

B. Sc. Third Year Semester V (Level 5.5)

Examination Scheme

[40%Continuous Assessment (CA) and 60% End Semester Assessment (ESA)]

Subject	Course Code	Course Name	Theory				Practical		Total
			Continuous Assessment (CA) Avg. of			ESA			
			TestI	Test II (5)	(T1+T2)/2	Total	CA	ESA	
Major 1	SBIOCT-1301	Structural Bioinformatics and CADD	15	15	30	45	--	--	75
	SBIOCP-1301	Lab Course based on Structural Bioinformatics and CADD	--	--	--	--	20	30	50
Major 2	SBIOCT-1302	NGS and Genome Informatics	15	15	30	45	--	--	75
	SBIOCP-1302	Lab Course based on NGS and Genome Informatics	--	--	--	--	20	30	50
Major 3 (Elective)	SBIOCT-1303	A] Python for Bioinformatics or B] Clinical Bioinformatics	--	--	--	--	20	30	50
	SBIOCP-1303	A] Python for Bioinformatics or B] Lab Course based on Clinical Bioinformatics	--	--	--	--	20	30	50
Value Education Courses (VEC) / Indian Knowledge System (IKS)	SBIOIKS-1301	Indian Knowledge System in Bioinformatics	20	20	20	30	--	--	50
Vocational/Skill Enhancement Course (Related to Major)	SBIOSC-1301	Linux and Shell in Bioinformatics	--	--	--	--	20	30	50
OJT/ FP/CS	SBIOOJ-1301	Project/Internship/OJT/Case Study	--	--	--	--	40	60	100

B. Sc. Third Year Semester VI (Level 5.5)

Teaching Scheme

	Course Code	Course Name	Credits Assigned			Teaching Scheme	
			Theory	Practical	Total	Theory (Hrs/ Week)	Practical (Hrs/ Week)
Major 1	SBIOCT-1351	Cloud Computing for Bioinformatics	03	--	03	03	--
	SBIOCP-1351	Lab Course based on Cloud Computing for Bioinformatics	--	02	02	--	04
Major 2	SBIOCT-1352	Bioinformatics Workflow Automation	03	--	03	03	--
	SBIOCP-1352	Lab Course based on Bioinformatics Workflow Automation	--	02	02	--	04
Major 3 (Elective)	SBIOCT-1353	A] Healthcare Informatics B] Microbiome Informatics	02	--	02	02	--
	SBIOCP-1353	A] Lab Course based on Healthcare Informatics B] Lab Course based on Microbiome Informatics	--	02	02	--	04
Value Education Courses (VEC) / Indian Knowledge System (IKS)	SBIOVC-1351	Bioinformatics Project Management	02	--	02	02	08
Vocational/Skill Enhancement Course (Related to Major)	SBIOSC-1351	Generative AI and LLMs for Biomedical Research	--	02	02	--	04
OJT/ FP/CS	SBIOOJ-1351	Project/Internship/OJT/Case Study	--	04	04	--	--
Total Credits			**10**	**12**	**22**	**10**	**24**

B. Sc. Third Year Semester VI (Level 5.5)

Examination Scheme

[40%Continuous Assessment (CA) and 60% End Semester Assessment (ESA)]

Subject	Course Code	Course Name	Theory				Practical		Total
			Continuous Assessment(CA) Avg. of			ESA			
			TestI	Test II(5)	(T1+T2)/2	Total	CA	ESA	
Major 1	SBIOCT-1351	Cloud Computing for Bioinformatics	15	15	30	45	--	--	75
	SBIOCP-1351	Lab Course based on Cloud Computing for Bioinformatics	--	--	--	--	20	30	50
Major 2	SBIOCT-1352	Bioinformatics Workflow Automation	15	15	30	45	--	--	75
	SBIOCP-1352	Lab Course based on Bioinformatics Workflow Automation	--	--	--	--	20	30	50
Major 3 (Elective)	SBIOCT-1353	A] Healthcare Informatics B] Microbiome Informatics	--	--	--	--	20	30	50
	SBIOCP-1353	A] Lab Course based on Healthcare Informatics B] Lab Course based on Microbiome Informatics	--	--	--	--	20	30	50
Value Education Courses (VEC) / Indian Knowledge System (IKS)	SBIOVE-1351	Bioinformatics Project Management	20	20	20	30	--	--	50
Vocational/Skill Enhancement Course (Related to Major)	SBIOSC-1351	Generative AI and LLMs for Biomedical Research	--	--	--	--	20	30	50
OJT/ FP/CS	SBIOOJ-1351	Project/Internship/OJT/Case Study	--	--	--	--	40	60	100

SBIOCT-1301-: Structural Bioinformatics and CADD

Credits: 03 **B.Sc. Bioinformatics** **Hours: 45**

Course pre-requisite: Students should have basic knowledge of: Biomolecules and protein structure, Fundamentals of biochemistry, Basic bioinformatics databases and tools, molecular biology, Basic computer applications and internet usage

Course objectives:

- To introduce the principles of structural bioinformatics and molecular modeling.
- To familiarize students with computational approaches used in drug discovery and protein structure analysis.
- To provide hands-on understanding of molecular visualization, docking, and structure-based drug design tools.

Course Outcomes: After completing this course, students shall be able to

- Explain the concepts of protein structure, structural databases, and molecular interactions.
- Apply molecular visualization and docking tools for structural analysis and drug design.
- Analyze protein-ligand interactions and evaluate computational drug discovery workflows.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**1.0**	**Introduction to Structural Bioinformatics**	12
	1.1	Overview of Structural Bioinformatics; Importance in Biology and Drug Discovery	
	1.2	Levels of Protein Structure: Primary, Secondary, Tertiary, Quaternary	
	1.3	Structural Databases: PDB, SCOP, CATH	
	1.4	Molecular Interactions: Hydrogen Bonds, Hydrophobic and Electrostatic Interactions	
2.0	**2.0**	**Protein Structure Determination and Visualization**	11
	2.1	X-ray Crystallography: Principle and Applications	
	2.2	NMR Spectroscopy and Cryo-Electron Microscopy Basics	
	2.3	Molecular Visualization Tools: PyMOL, Chimera, etc.	
	2.4	Protein Structure Validation and Ramachandran Plot	
3.0	**3.0**	**Computer-Aided Drug Design (CADD)**	11
	3.1	Introduction to Drug Discovery and CADD Approaches	

	3.2	Structure-Based and Ligand-Based Drug Design	
	3.3	Molecular Docking: Principles and Applications	
	3.4	Drug-Likeness, ADMET and Lipinski's Rule of Five	
4.0	**4.0**	**Applications and Recent Advances in Structural Bioinformatics**	11
	4.1	Homology Modeling and Protein Structure Prediction	
	4.2	Molecular Dynamics Simulation: Basic Concepts	
	4.3	Applications of AI and Machine Learning in Drug Discovery	
	4.4	Case Studies: COVID-19 Drug/Vaccine Design and Precision Medicine	
		Total	
			45

Reference Books

1. Mount, D. W., & Mount, D. W. (2001). *Bioinformatics: sequence and genome analysis* (Vol. 564). Cold Spring Harbor, NY: Cold spring harbor laboratory press.
2. Yoon, J. (2003). Structural Bioinformatics: Philip E. Bourne and Helge Weissig, Eds. Wiley-Liss, Hoboken, NJ. www. wiley. com. 2003. 649 pp. $69.95. *Pharmaceutical Research*, *20*(12), 2044.
3. Branden, C. I., & Tooze, J. (2012). *Introduction to protein structure*. Garland Science.
4. Leach, A. R. (2001). *Molecular modelling: principles and applications*. Pearson education.
5. Patrick, G. L. (2023). *An introduction to medicinal chemistry*. Oxford university press.

Online Resources and Databases

1. Protein Data Bank (PDB): https://www.rcsb.org
2. SWISS-MODEL Workspace: https://swissmodel.expasy.org
3. PubChem Database: https://pubchem.ncbi.nlm.nih.gov
4. AutoDock Tools: https://autodock.scripps.edu
5. UCSF Chimera: https://www.cgl.ucsf.edu/chimera
6. PyMOL Molecular Graphics System: https://pymol.org
7. ADMET Prediction Tools: https://admetlab3.scbdd.com

SBIOCP-1301: Lab Course based on Structural Bioinformatics and CADD

Credits: 02 **B.Sc. Bioinformatics** **Hours: 60**

Sr. No.	List of Experiments:
1	Retrieval of protein structures from Protein Data Bank (PDB)
2	Visualization of protein structures using PyMOL or UCSF Chimera
3	Identification of secondary structure elements in proteins

4	Analysis of molecular interactions in protein-ligand complexes
5	Generation and interpretation of Ramachandran plots
6	Homology modeling using SWISS-MODEL
7	Molecular docking using AutoDock or PyRx
8	Drug-likeness analysis using Lipinski's Rule of Five
9	ADMET prediction using online computational tools
10	Mini project: Protein-ligand interaction analysis for a selected disease target

Major 2

SBIOCT-1302: NGS and Genome Informatics

Credits: 03 **B.Sc. Bioinformatics** **Hours: 45**

Course pre-requisite: Students should have basic knowledge of: Molecular biology and genetics, DNA structure and genome organization, Basics of bioinformatics databases and sequence analysis, Computer applications and biological data handling, Scientific computing concepts

Course objectives:

- To introduce the principles and workflows of Next-Generation Sequencing (NGS).
- To familiarize students with genome informatics tools, databases, and sequence analysis methods.
- To provide practical exposure to computational analysis of genomic datasets and interpretation of sequencing results.

Course Outcomes: After completing this course, students shall be able to

- Explain the principles, platforms, and applications of NGS technologies.
- Analyze genomic sequence data using bioinformatics tools and genome databases.
- Interpret sequencing results and apply genome informatics approaches in biological research and precision medicine.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**1.0**	**Introduction to NGS Technologies**	08
	1.1	Overview of Genome Sequencing and Evolution of Sequencing Technologies	

	1.2	Principles of Next-Generation Sequencing (NGS)	
	1.3	NGS Platforms: Illumina, Ion Torrent, PacBio, Nanopore	
	1.4	Applications of NGS in Genomics, Transcriptomics, and Clinical Research	
2.0	**2.0**	**NGS Data Generation and Processing**	08
	2.1	Sample Preparation and Library Construction	
	2.2	Sequence Read Formats: FASTQ, SAM, BAM, VCF	
	2.3	Quality Control and Preprocessing of NGS Data	
	2.4	Sequence Alignment and Genome Assembly Basics	
3.0	**3.0**	**Genome Informatics and Data Analysis**	08
	3.1	Genome Browsers and Databases: NCBI, UCSC Genome Browser, Ensembl	
	3.2	Variant Detection: SNPs, Indels, Structural Variations	
	3.3	Functional Annotation of Genomic Variants	
	3.4	RNA-Seq and Differential Gene Expression Analysis Basics	
4.0	**4.0**	**Applications and Recent Advances in Genome Informatics**	06
	4.1	Metagenomics and Microbiome Analysis	
	4.2	Cancer Genomics and Precision Medicine	
	4.3	AI and Machine Learning Applications in Genome Analysis	
	4.4	Ethical Issues and Data Management in Genomic Research	
		Total	30

Reference Books

1. Janitz, M. (Ed.). (2011). *Next-generation genome sequencing: towards personalized medicine*. John Wiley & Sons.
2. Pevsner, J. (2015). *Bioinformatics and functional genomics*. John Wiley & Sons.
3. Lesk, A. M. (2017). *Introduction to genomics*. Oxford University Press.
4. Brown, T. A. (2023). *Genomes 5*. CRC Press.
5. Mount, D. W., & Mount, D. W. (2001). *Bioinformatics: sequence and genome analysis* (Vol. 564). Cold Spring Harbor, NY: Cold spring harbor laboratory press.

Online Resources and Databases

1. **NCBI Genome Database:** https://www.ncbi.nlm.nih.gov
2. **Ensembl Genome Browser:** https://www.ensembl.org
3. **UCSC Genome Browser:** https://genome.ucsc.edu
4. **Galaxy Project:** https://usegalaxy.org
5. **FASTQC Tool:** https://www.bioinformatics.babraham.ac.uk/projects/fastqc
6. **Integrative Genomics Viewer (IGV):** https://igv.org
7. **1000 Genomes Project:** https://www.internationalgenome.org

SBIOCP-1302: Lab Course based on NGS and Genome Informatics

Credits: 02 **B.Sc. Bioinformatics** **Hours: 60**

Sr. No.	List of Experiments:
1	Retrieval of genomic data from NCBI and Ensembl databases
2	Visualization of genomic regions using UCSC Genome Browser
3	Quality assessment of FASTQ files using FastQC
4	Sequence trimming and preprocessing of NGS reads
5	Sequence alignment using BLAST or BWA (demonstration/basic workflow)
6	Exploration of SAM/BAM file formats and visualization using IGV
7	Identification of sequence variants using publicly available datasets
8	Functional annotation of genomic variants using online tools
9	Basic RNA-Seq differential expression analysis using Galaxy platform
10	Mini project: Analysis and interpretation of a sample NGS dataset

(Elective- A)

SBIOCT-1303: A] Python for Bioinformatics

Credits: 02 **B.Sc. Bioinformatics** **Hours: 30**

Course pre-requisite:

Students should have basic knowledge of: Fundamentals of computer programming, Basic mathematics and statistics, Biological sequence data concepts, Computer applications and operating systems

Course Objective:

- To introduce Python programming concepts for scientific and biological computing.
- To develop skills in data handling, visualization, and computational analysis using Python.
- To familiarize students with Python libraries widely used in bioinformatics and data science.

Course Outcomes:

- Understand Python programming fundamentals and scientific computing concepts.
- Apply Python libraries for biological data analysis and visualization.
- Develop simple computational solutions for bioinformatics problems using Python.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**01**	**Introduction to Python Programming**	08
	1.1	Introduction to Python: Features, Installation, IDEs and Execution	
	1.2	Variables, Data Types, Operators, and Expressions	
	1.3	Conditional Statements and Looping Structures	
	1.4	Functions, Modules, and File Handling	
2.0	**02**	**Scientific Computing Libraries in Python**	08
	2.1	Introduction to NumPy Arrays and Mathematical Operations	
	2.2	Data Manipulation using Pandas DataFrames	
	2.3	Data Visualization using Matplotlib and Seaborn Basics	
	2.4	Statistical Operations and Basic Data Analysis	
3.0	**03**	**Python Applications in Bioinformatics**	08
	3.1	Biological Sequence Analysis using Biopython	
	3.2	Reading and Processing FASTA and FASTQ Files	
	3.3	Sequence Alignment and GC Content Analysis	
	3.4	Accessing Biological Databases using Python	
4.0	**04**	**Advanced Applications and Recent Trends**	06
	4.1	Introduction to Machine Learning Libraries (Scikit-learn Basics)	
	4.2	Data Visualization for Genomics and Proteomics	
	4.3	Automation of Bioinformatics Tasks using Python Scripts	
	4.4	Applications of Python in AI and Computational Biology	
		Total	
			30

Reference Books:

1. Bassi, S. (2017). *Python for bioinformatics*. Chapman and Hall/CRC.
2. Model, M. L. (2009). *Bioinformatics programming using python: practical programming for biological data*. " O'Reilly Media, Inc.".
3. McKinney, W. (2012). *Python for data analysis: Data wrangling with Pandas, NumPy, and IPython*. " O'Reilly Media, Inc.".
4. B Downey, A. (2012). Think Python: How to Think Like a Computer Scientist-2e.

5. Guttag, J. V. (2013). *Introduction to computation and programming using Python*. Mit Press.

Online Resources and Documentation

- **Python Official Documentation: https://www.python.org**
- **Biopython Documentation: https://biopython.org**
- **NumPy Documentation: https://numpy.org**
- **Pandas Documentation: https://pandas.pydata.org**
- **Matplotlib Documentation: https://matplotlib.org**
- **Jupyter Notebook: https://jupyter.org**
- **Scikit-learn Documentation: https://scikit-learn.org**

SBIOCP-1303: A] Lab Course based on Python for Bioinformatics

Credits: 02 **B.Sc. Bioinformatics** **Hours: 60**

Sr. No.	List of Experiments:
1	Installation and setup of Python, Jupyter Notebook, and Anaconda
2	Writing Python programs using variables, loops, and functions
3	Reading and writing biological data files using Python
4	Creating NumPy arrays and performing mathematical operations
5	Data analysis and manipulation using Pandas DataFrames
6	Plotting graphs and charts using Matplotlib
7	Reading FASTA sequences using Biopython
8	Calculating nucleotide frequencies and GC content using Python
9	Accessing biological databases and retrieving sequences programmatically
10	Mini project: Development of a simple bioinformatics analysis tool using Python

(Elective- B)

SBIOCT-1303: B] Clinical Bioinformatics

Credits: 02 **B.Sc. Bioinformatics** **Hours: 30**

Course pre-requisite:

Students should have basic knowledge of: Molecular biology and genetics, Human physiology and disease biology, Bioinformatics databases and sequence analysis, Basics of genomics and NGS technologies, Scientific computing concepts.

Course Objective:

- To introduce the principles and applications of clinical bioinformatics in healthcare and precision medicine.
- To familiarize students with clinical genomic data analysis and interpretation.
- To provide knowledge of computational tools and databases used in disease diagnostics and personalized medicine.

Course Outcomes:

- Explain the role of bioinformatics in clinical diagnostics and healthcare applications.
- Analyze clinical genomic data using bioinformatics databases and tools.
- Interpret genetic variations and apply computational approaches in precision medicine and disease research.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**01**	**Introduction to Clinical Bioinformatics**	08
	1.1	Overview of Clinical Bioinformatics and Precision Medicine	
	1.2	Human Genome and Genetic Variations	
	1.3	Clinical Genomics and Personalized Healthcare	
	1.4	Applications of Bioinformatics in Disease Diagnosis	
2.0	**02**	**Clinical Genomic Data and Databases**	08
	2.1	Clinical Databases: ClinVar, OMIM, dbSNP, COSMIC	
	2.2	Interpretation of Genetic Variants and Mutations	
	2.3	Pharmacogenomics and Drug Response Prediction	
	2.4	Cancer Genomics and Biomarker Identification	
3.0	**03**	**Clinical Data Analysis and Bioinformatics Tools**	08
	3.1	NGS Data Analysis in Clinical Research	
	3.2	Variant Calling and Functional Annotation	
	3.3	Genome Browsers and Clinical Data Visualization	
	3.4	AI and Machine Learning Applications in Clinical Bioinformatics	
4.0	**04**	**Ethics, Regulations and Recent Advances**	06
	4.1	Ethical Issues and Privacy in Clinical Genomics	
	4.2	Electronic Health Records (EHR) and Healthcare Data Standards	
	4.3	Role of Clinical Bioinformatics in Precision Oncology	

	4.4	Recent Advances: AI-assisted Diagnostics and Digital Health	
		Total	
			30

Reference Books:

- Trent, R. J. (Ed.). (2008). *Clinical bioinformatics* (Vol. 141). Totowa: Humana.
- Pevsner, J. (2015). *Bioinformatics and functional genomics*. John Wiley & Sons.
- Lesk, A. M. (2017). *Introduction to genomics*. Oxford University Press.
- Skuse, G. R. (1991). Principles of medical genetics: Thomas D. Gelehrter and Francis S. Collins. Baltimore: Williams and Wilkins, 1990, $34.95 (ix+ 324 pages), ISBN 0-683-03447-2.
- Ginsburg, G. S., & Willard, H. F. (2008). *Genomic and personalized medicine: V1-2* (Vol. 1). Academic Press.

Online Resources and Databases:

- **ClinVar Database:** https://www.ncbi.nlm.nih.gov/clinvar
- **OMIM (Online Mendelian Inheritance in Man):** https://www.omim.org
- **dbSNP Database:** https://www.ncbi.nlm.nih.gov/snp
- **COSMIC Database:** https://cancer.sanger.ac.uk/cosmic
- **cBioPortal for Cancer Genomics:** https://www.cbioportal.org
- **UCSC Genome Browser:** https://genome.ucsc.edu
- **Galaxy Project:** https://usegalaxy.org

SBIOCP-1303: B] Lab Course based on Clinical Bioinformatics

Credits: 02 **B.Sc. Bioinformatics** **Hours: 60**

Sr. No.	List of Experiments:
1	Retrieval of clinical variant information from ClinVar and dbSNP
2	Exploration of disease-gene associations using OMIM database
3	Visualization of genomic regions using UCSC Genome Browser or Ensembl
4	Functional annotation of variants using online annotation tools
5	Analysis of cancer mutation datasets using COSMIC or cBioPortal
6	Identification of SNPs associated with inherited diseases
7	Pharmacogenomics data analysis and drug-response interpretation

8	Basic NGS variant analysis workflow using Galaxy platform
9	Case study analysis of precision medicine applications
10	Mini project: Clinical interpretation of genomic data for a selected disease

Skill Enhancement Course
SBIOSC-1301: Linux and Shell Scripting in Bioinformatics

Credits: 02 **B.Sc. Bioinformatics** **Hours: 60**

Course pre-requisite:

Students should have basic knowledge of: Computer fundamentals and operating systems, File handling and programming concepts, Biological sequence data formats, Basic bioinformatics tools and databases.

Course Objectives:

- To introduce Linux operating system concepts and command-line environment for bioinformatics applications.
- To develop shell scripting skills for automation of biological data analysis tasks.
- To familiarize students with Linux-based bioinformatics tools and workflow management.

Course Outcomes:

- Understand Linux operating system fundamentals and command-line utilities.
- Write shell scripts for automating bioinformatics and data processing tasks.
- Apply Linux and shell scripting tools in biological sequence analysis and workflow execution.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**1.0**	**Introduction to Linux Operating System**	08
	1.1	Overview of Linux OS, File System Structure and Distributions	
	1.2	Linux Commands for File and Directory Management	

	1.3	File Permissions, Users, Groups, and Process Management	
	1.4	Text Editors and Basic Networking Commands in Linux	
2.0	**2.0**	**Linux Utilities and Bioinformatics Data Handling**	08
	2.1	Text Processing Utilities: grep, awk, sed, cut, sort	
	2.2	Working with Biological File Formats: FASTA, FASTQ, GFF	
	2.3	Compression, Archiving, and File Transfer Commands	
	2.4	Introduction to Linux-based Bioinformatics Tools	
3.0	**3.0**	**Shell Scripting Fundamentals**	06
	3.1	Introduction to Shells and Bash Scripting	
	3.2	Variables, Operators, Conditional Statements, and Loops	
	3.3	Functions, Arrays, and Script Execution	
	3.4	Automating Sequence Analysis and File Processing Tasks	
4.0	**4.0**	**Advanced Applications in Bioinformatics**	08
	4.1	Pipeline Development and Workflow Automation Basics	
	4.2	Introduction to HPC and Cloud Computing Environment	
	4.3	Using Linux in NGS Data Analysis and Genome Informatics	
	4.4	Case Studies: Automation of Bioinformatics Workflows	
		Total	30

Sr. No.	List of Experiments:
1	Installation and basic navigation in Linux operating system
2	Practice of Linux file and directory management commands
3	Managing file permissions, users, and processes in Linux
4	Using text processing commands (grep, awk, sed) on biological datasets
5	Handling FASTA and FASTQ files using Linux commands
6	Writing basic shell scripts using variables and loops
7	Automating sequence counting and GC-content calculation using shell scripts
8	Creating shell scripts for file parsing and report generation
9	Running basic bioinformatics tools in Linux environment
10	Mini project: Develop an automated shell script pipeline for biological sequence analysis

References:

1. Wünschiers, R. (2004). *Computational biology: Unix/Linux, data processing and programming*. Springer.
2. Srinivas, V. R. (2005). *Bioinformatics: A Modern Approach*. PHI Learning Pvt. Ltd..

3. Robbins, A., & Beebe, N. H. (2005). *Classic Shell Scripting: Hidden Commands that Unlock the Power of Unix*. " O'Reilly Media, Inc.".
4. Shotts, W. (2026). *The Linux command line: a complete introduction*. No Starch Press.
5. Buffalo, V. (2015). *Bioinformatics data skills: Reproducible and robust research with open source tools*. " O'Reilly Media, Inc.".
6. Kanetkar, Y. P. (2003). *UNIX shell programming*. BPB publications.

Online Resources and Documentation:

1. **Linux Documentation Project:** https://tldp.org
2. **GNU Bash Documentation:** https://www.gnu.org/software/bash
3. **Linux Journey:** https://linuxjourney.com
4. **Galaxy Project:** https://usegalaxy.org
5. **NCBI Linux Tools:** https://www.ncbi.nlm.nih.gov
6. **Bioinformatics Data Skills Resources:** https://bioinfdata.skills.org

Indian Knowledge System

SBIOIKS-1301: Indian Knowledge System in Bioinformatics

Credits: 02 **B.Sc. Bioinformatics** **Hours: 30**

Course pre-requisite:

Students should have basic knowledge of: Fundamentals of biology and bioinformatics, Basics of Indian Knowledge Systems (IKS), Biological databases and computational biology, Computer applications and scientific computing

Course Objectives:

- To introduce the concepts of Indian Knowledge Systems and their relevance to biological sciences and bioinformatics.
- To explore traditional Indian medicinal knowledge, genomics, and computational approaches in biological research.
- To integrate ancient Indian biological concepts with modern bioinformatics tools and technologies.

Course Outcomes: Students will be able to…

- Explain the role of Indian Knowledge Systems in biological sciences and healthcare.
- Analyze traditional medicinal and biological knowledge using bioinformatics approaches.
- Apply computational tools for studying medicinal plants, Ayurveda, genomics, and systems biology.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**1.0**	**Introduction to Indian Knowledge Systems and Life Sciences**	08
	1.1	Overview of Indian Knowledge Systems (IKS) and Traditional Sciences	
	1.2	Ancient Indian Concepts of Biology, Health, and Environment	
	1.3	Introduction to Ayurveda, Siddha, and Traditional Medicinal Systems	
	1.4	Relevance of IKS in Modern Biological and Computational Sciences	
2.0	**2.0**	**Medicinal Plants, Ayurveda and Bioinformatics**	08
	2.1	Medicinal Plants and Traditional Herbal (Photochemical) Knowledge	
	2.2	Ayurgenomics and Personalized Medicine Concepts	
	2.3	Databases Related to Medicinal Plants and Ayurveda	
	2.4	Computational Analysis of Phytochemicals and Herbal Compounds	
3.0	**3.0**	**Bioinformatics Applications in Traditional Knowledge**	06
	3.1	Molecular Docking of Herbal Compounds and Drug Targets	
	3.2	Genomics and Systems Biology in Ayurveda Research	
	3.3	Network Pharmacology and Polyherbal Formulations	
	3.4	AI and Data Science Applications in Traditional Medicine Research	
4.0	**4.0**	**Ethics, Conservation and Recent Advances**	08
	4.1	Intellectual Property Rights and Traditional Knowledge Protection	
	4.2	Biodiversity Conservation and Sustainable Use of Medicinal Plants	
	4.3	Integrative Medicine and Precision Health Approaches	
	4.4	Case Studies: COVID-19 Herbal Research, Ayurgenomics, Precision Health	
		Total	30

References:

1. Kapoor, K., & Singh, A. K. (Eds.). (2005). *Indian knowledge systems* (Vol. 1). New Delhi: Indian Institute of advanced study.
2. Caldecott, T. (2006). *Ayurveda: The divine science of life*. Elsevier Health Sciences.

3. Joshi, K. (2012). Insights into Ayurvedic biology—sA conversation with Professor MS Valiathan. *Journal of Ayurveda and Integrative Medicine*, *3*(4), 226.
4. *Sharma, V., & Sarkar, I. N. (2013). Bioinformatics opportunities for identification and study of medicinal plants. Briefings in bioinformatics, 14(2), 238-250.*
5. Mukerji, M., & Prasher, B. (2011). Ayurgenomics: A new approach in personalized and preventive medicine. *Sci Cult*, *77*(1-2), 10-7.

Online Resources and Databases:

1. IMPPAT Database (Indian Medicinal Plants, Phytochemistry and Therapeutics) https://cb.imsc.res.in/imppat
2. National Medicinal Plants Board (NMPB): https://nmpb.nic.in
3. PubChem Database: https://pubchem.ncbi.nlm.nih.gov
4. AYUSH Research Portal: https://ayushportal.nic.in
5. PubMed Database: https://pubmed.ncbi.nlm.nih.gov
6. Cytoscape: https://cytoscape.org
7. AutoDock Tools: https://autodock.scripps.edu

SEMESTER VI

SBIOCT-1351-: Cloud Computing for Bioinformatics

Credits: 03 **B.Sc. Bioinformatics** **Hours: 45**

Course pre-requisite:

Students should have basic knowledge of:

- Bioinformatics databases and biological data formats
- Computer networks and operating systems
- Fundamentals of programming and databases
- Genomics and high-throughput biological data concepts

Course objectives:

- To introduce cloud computing concepts and big data technologies used in bioinformatics.
- To familiarize students with computational infrastructure for large-scale biological data analysis.
- To develop understanding of cloud-based bioinformatics tools, workflows, and data management systems.

Course Outcomes: After completing this course, students shall be able to

- Explain cloud computing models and big data concepts in bioinformatics applications.
- Apply cloud platforms and big data tools for storage and analysis of biological datasets.
- Analyze large-scale genomic and biomedical datasets using distributed computing approaches.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**1.0**	**Introduction to Cloud Computing and Big Data**	12
	1.1	Introduction to Cloud Computing: Concepts and Characteristics	
	1.2	Cloud Service Models: IaaS, PaaS, SaaS	
	1.3	Big Data Concepts: Volume, Velocity, Variety, Veracity	
	1.4	Applications of Cloud Computing and Big Data in Bioinformatics	
2.0	**2.0**	**Cloud Platforms and Bioinformatics Infrastructure**	11
	2.1	Overview of AWS, Google Cloud, and Microsoft Azure	
	2.2	Virtual Machines, Containers, and Docker Basics	
	2.3	Cloud Storage Systems and Biological Data Management	
	2.4	Galaxy Platform and Cloud-Based Bioinformatics Workflows	
3.0	**3.0**	**Big Data Technologies in Bioinformatics**	11
	3.1	Introduction to Hadoop and MapReduce	
	3.2	Apache Spark for Biological Data Processing	
	3.3	Handling NGS and Omics Data using Big Data Approaches	

	3.4	Data Integration and Visualization of Large Biological Datasets	
4.0	**4.0**	**Advanced Applications and Recent Trends**	11
	4.1	AI and Machine Learning in Big Biological Data Analysis	
	4.2	Cloud-Based Precision Medicine and Healthcare Informatics	
	4.3	Data Security, Privacy, and Ethical Issues in Cloud Bioinformatics	
	4.4	Case Studies: Genomics Projects and Biomedical Big Data Applications	
		Total	
			45

Reference Books

1. Shyam, G. (2021). *Cloud computing: Concepts and technologies*. CRC Press.
2. Madhusudhan, H. S., Gupta, P., Rawat, P. S., & Saini, D. K. (Eds.). (2025). *Artificial Intelligence and Cloud Computing Applications in Biomedical Engineering*. CRC Press.
3. Ye, S. Q. (Ed.). (2016). *Big data analysis for bioinformatics and biomedical discoveries*. CRC Press.
4. Malviya, R., Sharma, P. K., Sundram, S., Dhanaraj, R. K., & Balusamy, B. (Eds.). (2022). *Bioinformatics tools and big data analytics for patient care*. CRC Press.
5. Lytras, M. D., & Papadopoulou, P. (Eds.). (2017). *Applying big data analytics in bioinformatics and medicine*. IGI Global.
6. Ankam, V. (2016). *Big data analytics*. Packt Publishing Ltd.

Online Resources and Databases

Online Resources and Platforms

1. **Amazon Web Services (AWS):** https://aws.amazon.com
2. **Google Cloud Platform:** https://cloud.google.com
3. **Microsoft Azure:** https://azure.microsoft.com
4. **Galaxy Project:** https://usegalaxy.org
5. **Docker Documentation:** https://www.docker.com
6. **Apache Hadoop:** https://hadoop.apache.org
7. **Apache Spark:** https://spark.apache.org

SBIOCP-1351: Lab Course based on Cloud Computing for Bioinformatics

Credits: 02 **B.Sc. Bioinformatics** **Hours: 60**

Sr. No.	List of Experiments:
1	Introduction to cloud platforms: Google Colab and Galaxy Server
2	Uploading and managing biological datasets on cloud storage
3	Running basic bioinformatics workflows using Galaxy platform
4	Installation and use of Docker containers for bioinformatics tools
5	Exploration of AWS or Google Cloud bioinformatics resources
6	Processing large FASTQ datasets using cloud-based tools
7	Introduction to Hadoop and MapReduce demonstrations
8	Data visualization of genomic datasets using Python or cloud tools
9	Analysis of NGS datasets using cloud-enabled workflows
10	Mini project: Cloud-based analysis of a biological dataset using workflow automation

SBIOCT-1352: Bioinformatics Workflow Automation

Credits: 03 **B.Sc. Bioinformatics** **Hours: 45**

Course pre-requisite: Students should have basic knowledge of:

- Bioinformatics tools and databases
- Linux operating system and command-line basics
- Shell scripting and programming fundamentals
- NGS and biological data analysis workflows

Course objectives:

- To introduce workflow automation concepts and reproducible research practices in bioinformatics.
- To familiarize students with workflow management systems and pipeline development tools.
- To provide practical exposure to automating biological data analysis pipelines and computational workflows.

Course Outcomes: After completing this course, students shall be able to

- Explain the principles of workflow automation and reproducible bioinformatics research.
- Develop and execute automated bioinformatics pipelines using workflow management tools.
- Apply workflow automation techniques for efficient analysis of large-scale biological datasets.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**1.0**	**Introduction to Workflow Automation**	12
	1.1	Introduction to Bioinformatics Workflows and Pipelines	
	1.2	Concepts of Workflow Automation and Reproducible Research	
	1.3	Concepts of Workflow Automation and Reproducible Research	
	1.4	Applications of Workflow Automation in Genomics and Omics Research	
2.0	**2.0**	**Workflow Management Systems and Tools**	11
	2.1	Introduction to Nextflow and Snakemake	
	2.2	Linux Shell Scripting for Workflow Automation	
	2.3	Workflow Execution using Galaxy Platform	
	2.4	Docker and Containerization Basics for Bioinformatics Pipelines	
3.0	**3.0**	**Pipeline Development and Data Processing**	11
	3.1	Designing NGS Analysis Pipelines	
	3.2	Data Preprocessing and Quality Control Automation	
	3.3	Workflow Parallelization and Resource Management	
	3.4	Workflow Logging, Monitoring, and Error Handling	
4.0	**4.0**	**Advanced Applications and Emerging Trends**	11
	4.1	Cloud-Based Workflow Automation in Bioinformatics	
	4.2	AI-Assisted Workflow Optimization and Automation	
	4.3	FAIR Data Principles and Workflow Documentation	
	4.4	Case Studies: Automated Genomics and Multi-Omics Pipelines	
		Total	
			30

Reference Books

1. Buffalo, V. (2015). *Bioinformatics data skills: Reproducible and robust research with open source tools*. " O'Reilly Media, Inc.".
2. Haddock, S. H. D., & Dunn, C. W. (2011). *Practical computing for biologists* (p. 538). Sunderland, MA: Sinauer Associates.

3. Youens-Clark, K. (2021). *Mastering python for bioinformatics*. " O'Reilly Media, Inc.".
4. Kurs, J. P., Simi, M., & Campagne, F. (2015). *Nextflow Workbench Documentation Booklet*. Fabien Campagne.
5. Flynt, C., Lakshman, S., & Tushar, S. (2017). *Linux Shell Scripting Cookbook*. Packt Publishing Ltd.

Online Resources and Documentation

1. Nextflow Documentation: https://www.nextflow.io
2. Snakemake Workflow System: https://snakemake.readthedocs.io
3. Galaxy Project: https://usegalaxy.org
4. Docker Documentation: https://www.docker.com
5. FAIR Principles: https://www.go-fair.org/fair-principles
6. FastQC Tool: https://www.bioinformatics.babraham.ac.uk/projects/fastqc

SBIOCP-1352: Lab Course based on Bioinformatics Workflow Automation

Credits: 02 **B.Sc. Bioinformatics** **Hours: 60**

Sr. No.	List of Experiments:
1	Installation and setup of workflow tools (Nextflow/Snakemake)
2	Writing simple shell scripts for automation of biological data processing
3	Creating a basic workflow using Snakemake
4	Developing a simple Nextflow pipeline for FASTQ data analysis
5	Running automated quality control using FastQC in a workflow
6	Workflow execution and monitoring using Galaxy platform
7	Using Docker containers for reproducible bioinformatics analysis
8	Automating sequence alignment and report generation
9	Cloud-based workflow execution using Google Colab or Galaxy Cloud
10	Mini project: Development of an automated NGS or omics analysis pipeline

(Elective- A)

SBIOET-1353: A]] Healthcare Informatics

Credits: 02 **B.Sc. Bioinformatics** **Hours: 30**

Course pre-requisite:

- Biology and healthcare systems
- Fundamentals of bioinformatics and databases
- Computer applications and data management
- Basics of genomics and biomedical data

Course Objective:

- To introduce the concepts and applications of digital health and healthcare informatics.
- To familiarize students with healthcare data systems, electronic health records, and clinical information management.
- To provide understanding of AI, big data, and digital technologies in modern healthcare systems.

Course Outcomes:

- Explain the principles and components of digital health and healthcare informatics systems.
- Analyze healthcare data using informatics tools and digital platforms.
- Apply computational technologies and AI concepts in healthcare data management and clinical decision support.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**01**	**Introduction to Digital Health and Healthcare Informatics**	08
	1.1	Introduction to Digital Health and Healthcare Informatics	
	1.2	Components of Healthcare Information Systems	
	1.3	Electronic Health Records (EHR) and Electronic Medical Records (EMR)	
	1.4	Applications of Bioinformatics in Healthcare and Clinical Research	
2.0	**02**	**Healthcare Data Management and Standards**	08
	2.1	Clinical Data Types and Healthcare Databases	
	2.2	Healthcare Data Standards: HL7, FHIR, DICOM	
	2.3	Data Privacy, Security, and Ethical Issues in Healthcare Informatics	
	2.4	Health Information Exchange and Interoperability	

3.0	**03**	**AI and Data Analytics in Healthcare**	08
	3.1	Introduction to AI and Machine Learning in Healthcare	
	3.2	Clinical Decision Support Systems (CDSS)	
	3.3	Healthcare Data Analytics and Visualization	
	3.4	Applications of Genomics and Precision Medicine in Digital Health	
4.0	**04**	**Emerging Technologies and Future Trends**	06
	4.1	Telemedicine and Mobile Health (mHealth) Technologies	
	4.2	Wearable Devices and Internet of Medical Things (IoMT)	
	4.3	Cloud Computing and Big Data in Healthcare	
	4.4	Recent Advances: AI-assisted Diagnostics and Smart Healthcare Systems	
		Total	
			30

Reference Books:

1. Shortliffe, E. H., Shortliffe, E. H., Cimino, J. J., & Cimino, J. J. (2014). *Biomedical informatics: computer applications in health care and biomedicine*. Springer.
2. Shortliffe, E. H., Shortliffe, E. H., Cimino, J. J., & Cimino, J. J. (2014). *Biomedical informatics: computer applications in health care and biomedicine*. Springer.
3. Kudyba, S. P. (2018). *Healthcare informatics: improving efficiency through technology, analytics, and management*. CRC Press.
4. Rivas, H., & Wac, K. (Eds.). (2018). *Digital health: scaling healthcare to the world*. Springer.
5. Pevsner, J. (2015). *Bioinformatics and functional genomics*. John Wiley & Sons.

Online Resources and Databases

1. World Health Organization (WHO) Digital Health: https://www.who.int/health-topics/digital-health
2. Health Level Seven International (HL7): https://www.hl7.org
3. FHIR Standards: https://www.hl7.org/fhir
4. National Center for Biotechnology Information (NCBI): https://www.ncbi.nlm.nih.gov
5. Centers for Disease Control and Prevention (CDC) Digital Health Resources https://www.cdc.gov
6. OpenMRS Healthcare Platform: https://openmrs.org
7. Google Health: https://health.google

SBIOCP-1303: A] Lab Course based on Healthcare Informatics

Credits: 02 **B.Sc. Bioinformatics** **Hours: 60**

Sr. No.	List of Experiments:
1	Exploration of Electronic Health Record (EHR) systems and interfaces
2	Analysis of healthcare datasets using spreadsheet or Python tools
3	Study of healthcare data standards (HL7, FHIR, DICOM)
4	Retrieval and interpretation of clinical genomics data from public databases
5	Visualization of healthcare data using charts and dashboards
6	Case study analysis of telemedicine and digital health platforms
7	Demonstration of clinical decision support systems (CDSS)
8	Exploration of wearable healthcare device data and monitoring systems
9	Healthcare data privacy and ethical compliance exercises
10	Mini project: Design and analysis of a digital health or healthcare informatics application

(Elective- B)

SBIOET-1303: B] Microbiome Informatics

Credits: 02 **B.Sc. Bioinformatics** **Hours: 30**

Course pre-requisite:

Students should have basic knowledge of:

- Molecular biology and microbiology
- Genetics and genomics
- Bioinformatics databases and sequence analysis
- NGS technologies and biological data formats

Course Objective:

- To introduce the concepts and applications of metagenomics and microbiome informatics.
- To familiarize students with sequencing technologies and computational tools used in microbiome analysis.
- To provide understanding of microbial diversity analysis and microbiome-based biological research.

Course Outcomes:

- Explain the principles and workflows of metagenomics and microbiome informatics.
- Analyze microbial sequencing data using bioinformatics tools and databases.
- Interpret microbiome datasets and evaluate their applications in health, environment, and biotechnology

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**01**	**Introduction to Metagenomics and Microbiome Science**	08
	1.1	Introduction to Metagenomics and Microbiome Informatics	
	1.2	Microbial Diversity and Microbial Communities	
	1.3	Culture-Dependent and Culture-Independent Methods	
	1.4	Applications of Microbiome Research in Health, Agriculture, and Environment	
2.0	**02**	**NGS Technologies and Metagenomic Data Generation**	08
	2.1	16S rRNA Sequencing and Whole Metagenome Sequencing	
	2.2	Sample Collection, DNA Extraction, and Library Preparation	
	2.3	Sequence Data Formats and Quality Control	
	2.4	Metagenomic Databases and Repositories	
3.0	**03**	**Microbiome Data Analysis and Bioinformatics Tools**	08
	3.1	Taxonomic Classification and OTU/ASV Analysis	
	3.2	Sequence Alignment and Functional Annotation	
	3.3	Microbiome Analysis Tools: QIIME, MOTHUR, MG-RAST	
	3.4	Data Visualization and Statistical Analysis in Microbiome Studies	
4.0	**04**	**Applications and Recent Advances**	06
	4.1	Human Gut Microbiome and Disease Associations	
	4.2	Environmental and Agricultural Metagenomics	
	4.3	AI and Machine Learning in Microbiome Informatics	
	4.4	Recent Advances: Personalized Nutrition, Probiotics, and Precision Medicine	
		Total	
			30

Reference Books:

1. Izard, J., & Rivera, M. (Eds.). (2025). *Metagenomics for microbiology*. Academic Press.
2. Streit, W. R., & Daniel, R. (2017). *Metagenomics*. Springer New York.
3. Pevsner, J. (2015). *Bioinformatics and functional genomics*. John Wiley & Sons.

4. Beiko, R. G., Hsiao, W., & Parkinson, J. (Eds.). (2018). *Microbiome analysis: methods and protocols*. Totowa, NJ: Humana Press.
5. Lesk, A. M. (2019). *Introduction to bioinformatics*. Oxford university press.

Online Resources and Databases:

1. MG-RAST Metagenomics Server: https://www.mg-rast.org
2. QIIME 2 Documentation: https://qiime2.org
3. NCBI Sequence Read Archive (SRA): https://www.ncbi.nlm.nih.gov/sra
4. Human Microbiome Project (HMP): https://www.hmpdacc.org
5. EMBL-EBI Metagenomics: https://www.ebi.ac.uk/metagenomics
6. MOTHUR Software: https://mothur.org
7. Krona Visualization Tool: https://github.com/marbl/Krona/wiki

SBIOCP-1353: B] Lab Course based on Microbiome Informatics

Credits: 02 **B.Sc. Bioinformatics** **Hours: 60**

Sr. No.	List of Experiments:
1	Retrieval of metagenomic datasets from NCBI SRA or MG-RAST
2	Quality assessment of microbiome sequencing data using FastQC
3	Analysis of 16S rRNA sequences using QIIME or online platforms
4	Taxonomic classification of microbial communities
5	OTU/ASV table generation and diversity analysis
6	Functional annotation of metagenomic sequences
7	Data visualization using Krona plots or heatmaps
8	Comparative analysis of microbiome datasets
9	Statistical analysis of microbiome diversity indices
10	Mini project: Computational analysis of a selected microbiome dataset

Skill Enhancement Course
SBIOSC-1351: Generative AI and LLMs for Biomedical Research

Credits: 02 **B.Sc. Bioinformatics** **Hours: 30**

Course pre-requisite:

- Basics of Biology and Bioinformatics
- Fundamental Knowledge of Python Programming
- Understanding of Machine Learning Concepts
- Familiarity with Biological Databases and Genomics

Course Objectives:

- To introduce the concepts of Generative AI, Large Language Models (LLMs), and their applications in biomedical research.
- To provide knowledge of AI-driven biomedical data analysis, scientific text mining, and healthcare applications.
- To develop practical skills in using AI tools, APIs, and prompt engineering for biomedical and healthcare informatics tasks.

Course Outcomes:

After successful completion of this course, students will be able to:

- Understand the principles, architectures, and workflows of Generative AI and Large Language Models in biomedical sciences.
- Apply AI tools and LLM-based techniques for biomedical text mining, omics analysis, and healthcare data interpretation.
- Develop basic AI-assisted biomedical applications using prompt engineering, APIs, and ethical AI practices.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**1.0**	**Introduction to Generative AI and Biomedical Applications**	08
	1.1	Fundamentals of Artificial Intelligence, Machine Learning, and Deep Learning	
	1.2	Introduction to Generative AI and Large Language Models (LLMs)	
	1.3	Applications of AI in Biomedical Research and Healthcare	
	1.4	Ethical, Legal, and Regulatory Considerations in Biomedical AI	
2.0	**2.0**	**LLM Architectures and Biomedical Data Processing**	08
	2.1	Neural Networks, Transformers, and Attention Mechanisms	
	2.2	Biomedical Text Data, EHR Data, and Scientific Literature	

		Mining	
	2.3	Biomedical Knowledge Graphs and Embeddings	
	2.4	Data Preprocessing, Tokenization, and Fine-Tuning Concepts	
3.0	**3.0**	**Generative AI Tools and Bioinformatics Applications**	06
	3.1	Prompt Engineering for Biomedical Research	
	3.2	AI-Assisted Drug Discovery and Protein Structure Prediction	
	3.3	AI Applications in Genomics, Transcriptomics, and Precision Medicine	
	3.4	AI Tools: ChatGPT, BioGPT, Gemini, AlphaFold, Hugging Face, and Google Colab	
4.0	**4.0**	**Advanced Applications and Future Trends**	08
	4.1	AI in Clinical Decision Support Systems and Digital Health	
	4.2	Retrieval-Augmented Generation (RAG) in Biomedical Informatics	
	4.3	AI Model Evaluation, Bias, Explainability, and Reproducibility	
	4.4	Future Trends: Multimodal AI, Autonomous Agents, and Personalized Healthcare	
		Total	30

References:

1. Goodfellow, I., Bengio, Y., Courville, A., & Bengio, Y. (2016). *Deep learning* (Vol. 1, No. 2, pp. 1-800). Cambridge: MIT press..
2. Lewis, P., Perez, E., Piktus, A., Petroni, F., Karpukhin, V., Goyal, N., ... & Kiela, D. (2020). Retrieval-augmented generation for knowledge-intensive nlp tasks. *Advances in neural information processing systems*, *33*, 9459-9474.
3. Raschka, S. (2024). *Build a large language model (from scratch)*. Simon and Schuster.
4. Gen AI Documentation and Research Papers.
5. OpenAI API and Prompt Engineering Documentation.
6. Hugging Face Transformers Documentation.
7. Nature Reviews Bioinformatics articles on AI in Healthcare and Genomics.
8. Research articles from PubMed, NCBI, and IEEE Xplore related to Generative AI in Biomedicine.

Sr. No.	List of Experiments:
1	Basic Prompt Engineering using Gemini, ChatGPT for Biomedical Queries
2	Biomedical Text Summarization using LLMs
3	Biomedical Question Answering using Pretrained Models
4	Protein Structure Prediction using AlphaFold Database
5	Drug Discovery Dataset Exploration using AI Tools

Value Education
SBIOVE-1351: Bioinformatics Project Management

Credits: 02 **B.Sc. Bioinformatics** **Hours: 30**

Course pre-requisite:

- Basic Knowledge of Bioinformatics and Biotechnology
- Fundamentals of Computer Applications and Databases
- Understanding of Research Methodology and Data Analysis
- Basic Knowledge of Software Development Life Cycle (SDLC)

Course Objectives:

- To introduce principles and methodologies of project management in bioinformatics and healthcare domains.
- To develop skills in planning, execution, monitoring, and management of bioinformatics projects.
- To provide practical exposure to project documentation, teamwork, risk management, and AI-assisted project workflows.

Course Outcomes: Students will be able to…

After successful completion of this course, students will be able to:

- Understand project management concepts, tools, and methodologies relevant to bioinformatics research and industry.
- Plan, manage, and execute bioinformatics projects including data analysis workflows and collaborative research projects.
- Apply project management software, documentation standards, and quality assurance practices in biomedical and healthcare informatics projects.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**1.0**	**Introduction to Bioinformatics Project Management**	08
	1.1	Fundamentals of Project Management and SDLC	
	1.2	Types of Bioinformatics and Healthcare Projects	
	1.3	Project Life Cycle: Initiation, Planning, Execution, Monitoring, and Closure	
	1.4	Roles, Responsibilities, and Team Management in Bioinformatics Projects	
2.0	**2.0**	**Project Planning and Resource Management**	08
	2.1	Requirement Gathering and Scope Definition	
	2.2	Work Breakdown Structure (WBS), Scheduling, and Gantt Charts	
	2.3	Budgeting, Cost Estimation, and Resource Allocation	

	2.4	Risk Management, Quality Assurance, and Regulatory Compliance	
3.0	**3.0**	**Bioinformatics Workflow and Data Management**	06
	3.1	Management of Genomics, Proteomics, and Clinical Data Projects	
	3.2	Bioinformatics Pipelines and Workflow Automation	
	3.3	Version Control, Documentation, and Collaborative Platforms	
	3.4	Agile, Scrum, and DevOps Practices in Bioinformatics	
4.0	**4.0**	**Advanced Applications and Emerging Trends**	08
	4.1	AI and Cloud Computing in Bioinformatics Project Management	
	4.2	Research Ethics, Data Privacy, and Intellectual Property Rights	
	4.3	Scientific Communication, Reporting, and Publication Management	
	4.4	Case Studies of Industry and Research-Based Bioinformatics Projects	
		Total	30

References:

1. Schwalbe, K. (2010). *Information technology project management, revised*. Course Technology Press.
2. Heldman, K. (2018). *PMP: project management professional exam study guide*. John Wiley & Sons.
3. Badiru, A. B., Rusnock, C. F., & Valencia, V. V. (2018). *Project management for research: a guide for graduate students*. CRC press.
4. *Tsitoara, M. (2019). Beginning Git and GitHub: a comprehensive guide to version control, project management, and teamwork for the new developer. Apress.*
5. Pipinellis, A. (2018). *GitHub Essentials: Unleash the power of collaborative development workflows using GitHub*. Packt Publishing Ltd.

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