KARNATAKA STATE OPEN UNIVERSITY
Mukthagangotri, Mysuru-570006, Karnataka, INDIA
www.ksoumysuru.ac.in

Programme Project Report
As per the UGC (ODL Programmes & OL Programmes) Regulations, 2020

Name of the Programme: **M.Sc. in Bioinformatics**

ABSTRACT

School	Sciences		
Department	Department of Studies and Research in Microbiology		
Duration of the programme	2 Years		
Scheme	Semester (Four Semesters)(Choice Based Credit System-CBCS)		
Credit	82		
SLM	Courses: 31 Theory: 27 Practical: 8	Blocks: 100	Units: 456
	1 Credit = 1 Block	1 Block=4-5 Units	
Instructional delivery	Personal Contact Program, Counselling, Offline/Online classes, Audio/visuals, face to face counselling, Radio programs, Open Educational Resources		
Eligibility for admission	•The eligibility criteria is to bachelor's degrees in science stream with a minimum 50% from a recognized college.		
Staff	Teaching: Core (Full time) Assistant Professors: 05	Competent academic counsellors will be engaged at learner support centres as per requirement.	
Assessment/ evaluation	Continuous Internal assessment and term end examination		
Infrastructure facilities	ICT enabled Lecture halls, laboratory, audio-visual centre, library, internet/WiFi/KSOU student app/KSOU Connect videoconferencing platform/YouTube channel-KSOU Drushyavahini, Data Centre, and KSOU Radio App.		
Quality assurance	Students' feedback, peer review, professional review, editorial committee, accreditation by agencies, academic audit.		
Expected out come	Skills, Employability and Quality and Excellence		

(a) Programme's Mission and Objectives:

Mission:

- To provide education to the learners to embrace the philosophy of learn, earn and return.
- To excel and be recognized as a department that emphasizes outstanding education, cutting-edge research, and service.
- To create a conducive learning environment and student-friendly setting that enables students to attain academic achievement in all domains of Bioinformatics.
- To graduate students with solid problem-solving skills and knowledge.

Objectives:

- Create a skilled workforce in the bioinformatics sector with a focus on meeting the demands of the biotech and pharmaceutical industries in India.
- To acquire the abilities required to gather, comprehend, analyze, and manage data made possible by high-throughput technology.
- Describe how research advances the frontiers of knowledge in this professional subject and give students the opportunity to undertake research through two specific research projects.
- To expose students to local, national, and international work.

(b) Relevance of the Programme with HEI's Mission and Goals:

Since its founding, KSOU has taken an active role in achieving the national goals of higher education, including access, equity, quality, affordability, and accountability. Under the tagline "Higher Education to Everyone, Everywhere," KSOU makes a commitment to reach out to the unreached student population and inspire them to seek higher education.

Bioinformatics is an interdisciplinary field that combines biological, computational, and statistical techniques to manage and analyze large sets of biological data. The field has become increasingly important in the era of big data, where biological data is being generated at an unprecedented rate. An M.Sc. program in Bioinformatics is relevant for several reasons:

Advancements in biological research: Bioinformatics has become essential for the analysis of high-throughput biological data, such as genomics, transcriptomics, proteomics, and metabolomics. With the increasing volume and complexity of biological

data, bioinformatics has become critical in understanding and interpreting the data generated from biological research. Applications in medicine: Bioinformatics has numerous applications in medicine, such as in personalized medicine, drug discovery, and disease diagnosis. By analyzing genomic data, bioinformatics can help identify genetic variations that contribute to disease susceptibility, and it can help develop targeted therapies based on an individual's genetic makeup. Career opportunities: The field of bioinformatics is rapidly expanding, and there is a growing demand for bioinformatics professionals in academia, industry, and government. An M.Sc. in Bioinformatics can lead to careers in various fields, such as biotechnology, pharmaceuticals, healthcare, and academia. Interdisciplinary approach: Bioinformatics is an interdisciplinary field that requires knowledge of biology, computer science, statistics, and mathematics. An M.Sc. in Bioinformatics provides students with a comprehensive understanding of these fields and their applications to biological research. Therefore, this programme is offered in the distance mode as a parallel to the programmes offered by conventional mode.

Goals

- Develop a comprehensive understanding of bioinformatics: Students in an M.Sc. in Bioinformatics program will gain knowledge of biological principles, data analysis techniques, computer science, and statistics. The program aims to provide a deep understanding of bioinformatics and its applications in biological research.
- Develop practical skills: Bioinformatics involves the use of computational tools and software to analyze biological data. An M.Sc. in Bioinformatics program aims to equip students with practical skills in data analysis, programming, and software development.
- Conduct research: Many M.Sc. in Bioinformatics programs require students to conduct research projects as part of their degree requirements. These projects allow students to apply their knowledge and skills to real-world research problems in bioinformatics.
- Prepare for a career in bioinformatics: An M.Sc. in Bioinformatics program prepares students for careers in academia, industry, and government. The program aims to provide students with the necessary skills and knowledge to pursue careers in bioinformatics, such as data analysts, bioinformatics software developers, and research scientists.
- Develop critical thinking skills: Bioinformatics is a complex and rapidly evolving field. An M.Sc. in Bioinformatics program aims to develop students' critical thinking skills, enabling them to analyze and solve complex problems in bioinformatics.

(c) Prospective Target Group of Learners:

- Candidates who have qualified 12+3 or equivalent degree examinations in the concerned subjects conducted by the recognized universities.
- Graduates in the concerned subjects who cannot access the conventional mode of education.
- Graduates in the core subject who have economic, socio-cultural, locational disadvantaged and inclusive groups.
- Graduates in the core subjects working in different sectors.

(d) Appropriateness of Programmes to be conducted in ODL Mode to Acquire Specific Skills and Competence:

Open Distance Learning is gaining momentum due to its flexibility and further, Ministry of Education, Govt. of India has also declared that that ODL degrees are on par with conventional degrees.

The following are the specific skills and competencies expected of a student to acquire during the course of studies:

- M.Sc. Bioinformatics offered by ODL mode is encompassed by the regulations of the UGC.

- The programme has proper mix of both theory and practicals in the ratio of 3:1.

- The contents are delivered by SLM, lectures, practicals and the skills are imparted in the contact classes/counseling classes by way of practicals as per the UGC directions.

- The programme has a well-structured set of self-learning material customized to learner's capacity and aptitude.

- The programme is modulated to assess the learners progress through checks involving assignments and tests. Student seminars, project works, dissertation and field work component are designed at regular stages which will add to the experience of the learners.

- ICT gadgets/resources will be deployed to acquire professional, presentational, analytical and such other skills relevant for course competence and creates a platform for placement.

- KSOU App, KSOU Connect, KSOU Drushyavahini (YouTube), KSOU Radio App, OERs etc., are also in place for the benefit of the students.

(e) Instructional Design:

It is a two year programme in semester (four) and CBCS mode. Curriculum development plays a very vital role in the development of quality of education. Keeping in view of the norms of UGC, the university took the following measures:

1. **Fully Articulated:** Curriculum articulation has been adopted to avoid conflicts across the different areas. Development of a logical and sequential instructions flow from one year to the other is a reality. Curriculum articulation maintained at all levels of studies reducing and eliminating repetition by establishing sound linkages wherever necessary.

2. **Realistic Contents**:

   - Contents are developed keeping in view of the contributions expected of a student in his career.

   - Career role with specific tasks, knowledge, skills, attitudes, and values are considered for development of curriculum.

   - The content of the programme is delivered by way of self-learning materials which is prepared by the academicians of repute both in the university and other institutions.

3. **Evaluation-Conscious:** The curriculum being developed keeping in view of evaluation-conscious, logical, accurate and measurable.

4. **Employability:** The curriculum is being developed to bridge the gap between the academic knowledge and job market requirement at various levels.

5. **Duration of the Programme**: Two academic years under semester scheme (four semesters).

6. **Faculty**: The programme is administered by-
   Assistant Professors – 05. The programme has also Programme Cordinators and Course Coordinators. Competent academic counsellors will be engaged at learner support centres as per requirement.

7. **Supporting Staff (Non-teaching and technical staff)**: Clerk/DEO-01, Office Attender-01, Lab Technician-01, Lab Attender-01.

8. **Student Support Services System**: The programme is learner-friendly and after admission the learners are free to interact with the faculty/office staff through WhatsApp group/telephone/email/social media/and face to face. Each and every information regarding assignment, counselling, contact classes, payment of admission fees, old question papers, date of examinations, issue of hall tickets, scholarships, and declaration, issue of marks cards, are updated step by step. Online student support services for handing other grievances is also done with the help of the supporting staff in the department. Necessary information for learner is also available in the university official website www.ksoumysuru.ac.in

9. **Instructional Delivery Mechanism**: Delivery mechanism is through personal delivery at the time of admission in print media (Prospectus, Student Programme Guide, SLM and Practical Manuals,), web based services, CD drives and the university also proposed to have virtual class room delivery mode. KSOU App, KSOU Connect, KSOU Drushyavahani, KSOU Radio App, Open Educational Resources etc.

10. **Instructional Design**: The instructional design will be made as prescribed by UGC. Curriculum of the programme is approved by the bodies viz. Department Council, Board of Studies, Academic Council, Board of Management, and Ordinance. The curriculum is to be revised periodically.

11. **Department and School:** The programme is administered by the Department of Microbiology which falls under the School of Sciences.

Table 1: Norms for delivery of M.Sc Bioinformatics programme through distance mode

Semester	Components	No of credits	Study hours	Counseling hours	No. of Assignments
I	**Theory**	14	420	42	8
	Practicals	4	120	120	-
II	**Theory**	14	420	42	8
	Practicals	4	120	120	-
III	**Theory**	14	420	42	8
	Practicals	4	120	120	-
IV	**Theory**	14	420	42	8
	Practicals	4	120	120	-

$10% of total learning hours of a course are earmarked to deliver lecture in PCP/counseling.
* 100% for practical classes.

12. **Details of the syllabi:** See Annexure –I

(f) Procedure for Admissions, Curriculum Transaction and Evaluation:

1. Admission:

(a) The University has adopted transparent admission policy. All information relating to admissions, courses, curriculum, evaluation, student support service, etc. is provided in the prospectus and website of the university regularly. The admission norms prescribed by the UGC would be followed in true spirit. The minimum eligibility for admission shall be as prescribed under the Ordinances framed under Karnataka State Open University Act-1992.

Bachelor degree from a recognized university in any of the following disciplines: Science (Biochemistry, Biology, Botany, Biotechnology, Chemistry, Environmental Science, Life Sciences, Physics, Mathematics, Microbiology, Statistics or Zoology), Agriculture, Medicine, Pharmacy, Veterinary Science, Computer Science**.**

(b) Programme delivery and Activity Planner: The programme deliveries of the courses are through SLM, counselling sessions, practicals, assignments, lectures in contact programmes. The academic calendar of events will be notified well-in-advance on the website of the University.

(c) Financial Assistance:

a. Scholarship for SC/ST students is being awarded.
b. BPL Women candidates get 15% concession on tuition fee only.
c. Cab/auto drivers, their spouse and two children are eligible for 30% concession in the Tuition fee for which they shall produce identity card issued by the competent authority.
d. Defense and ex-service man students get 15% concession on tuition fees in particular subject.
e. University staff members, their spouse and their children (only 2 children) get 25% concession on total admission fees in particular subject.
f. Transgender will get full fees concession.
g. Completely blind students will get full fees concession on their interested subject.
h. Candidates whose parents are demised due to Covid-19 will get full fee concession on total admission fee.
i. Merit scholarships awarded by Government of India.

2. Curriculum Transactions:

(a) Curriculum of the programme is designed on the basis of the proceedings of the workshop.

(b) Curriculum matches with the guidelines of regulatory body in terms of credits, blocks and units.

(c) Department Council, Board of Studies, Academic Council, Board of Management, and the ordinance strengthens the curriculum design.

(d) Students programme guide and study material in SLM and E-content.
(e) Contact program and counselling enable interactions.

3. Evaluation: Students shall be assessed and evaluated through various assessment tools like internal assignment. The academic assessment shall be based on the continuous Internal Assessment and Term-end examinations.
(a) Continuous Internal Assessment: Internal assessment comprises of various tools such as written assignments, seminars, quiz, field work, group discussions etc. It is a continuous/formative assessment adopted by the University.
(b) Term-end Examinations: The university conducts term-end examination at the end of each term. It employs all measures suggested by the UGC to conduct transparent examinations at various centres of the territory.
(c) Board of Examination-Scheme for evaluation: The evaluation system is same as that of the system suggested by the UGC. Single valuation is relied upon; however the re-valuation, third valuation, challenge valuation, photocopy of the answer scripts etc are also adopted to conduct evaluation system transparently and objectively.

4. Details of credits and examination is furnished as under:

M.Sc. Bioinformatics (CBCS Mode)

Sem	Course Code	Course Title	Credits	Counseling/PCP Hours	Max. Marks			Minimum Passing marks		Duration of Exam (hours)
					Internal Assessment	Term end exam	Total Marks	Internal Assessment	Term end exam	
I	MBINDSC-1.1	Basic Biology	4	12	20	80	100	08	32	3
	MBINDSC-1.2	Introduction to Bioinformatics and Computational Biology	4	12	20	80	100	08	32	3
	MBINDSC -1.3	Practical 1	2	60	10	40	50	04	16	3
	MBINDSC -1.4	Practical 2	2	60	10	40	50	04	16	3
	MBINDSE -1.5	Molecular Biology and Genetics	3	09	20	80	100	08	32	3
	MBINDSE -1.6	Introduction to Programming for Bioinformatics	3	09	20	80	100	08	32	3
	MBINDSE -1.7	Biological Databases and Data Mining	3	09	20	80	100	08	32	3
	ELMBIN –01	Interdisciplinary Elective-1	2	06	10	40	50	04	16	$1^{1/2}$
		Total	**20**	**168**	**110**	**440**	**550**	**44**	**176**	-

Note: Out of the three Discipline Specific Electives (MBINDSE -1.5, MBINDSE -1.6, MBINDSE -1.7,), students can choose any two.

Sem	Course Code	Course Title	Credits	Counseling/PCP Hours	Max. Marks			Minimum Passing marks		Duration of Exam (hours)
					Internal Assessment	Term end exam	Total Marks	Internal Assessment	Term end exam	
II	MBINDSC-2.1	Statistics for Bioinformatics	4	12	20	80	100	08	32	3
	MBINDSC-2.2	Bioinformatics Tools and Techniques	4	12	20	80	100	08	32	3
	MBINDSC -2.3	Practical 3	2	60	10	40	50	04	16	3
	MBINDSC -2.4	Practical 4	2	60	10	40	50	04	16	3
	MBINDSE -2.5	Algorithms and Data Structures for Bioinformatics	3	09	20	80	100	08	32	3
	MBINDSE -2.6	Genome Analysis and Annotation	3	09	20	80	100	08	32	3
	MBINDSE -2.7	Structural Bioinformatics	3	09	20	80	100	08	32	3
	ELMBIN –02	Interdisciplinary Elective-2	2	06	10	40	50	04	16	$1^{1/2}$
		Total	**20**	**168**	**110**	**440**	**550**	**44**	**176**	-

Note: Out of the three Discipline Specific Electives (MBINDSE -2.5, MBINDSE -2.6, MBINDSE -2.7), students can choose any two.

Sem	Course Code	Course Title	Credits	Counseling/PCP Hours	Max. Marks			Minimum Passing marks		Duration of Exam (hours)
					Internal Assessment	Term end exam	Total Marks	Internal Assessment	Term end exam	
III	MBINDSC-3.1	Protein Structure and Function	4	12	20	80	100	08	32	3
	MBINDSC-3.2	Next-Generation Sequencing	4	12	20	80	100	08	32	3
	MBINDSC -3.3	Practical 5	2	60	10	40	50	04	16	3
	MBINDSC -3.4	Practical 6	2	60	10	40	50	04	16	3
	MBINDSE -3.5	Metagenomics and Microbial Ecology	3	09	20	80	100	08	32	3
	MBINDSE -3.6	Comparative Genomics and Evolutionary Biology	3	09	20	80	100	08	32	3
	MBINDSE -3.7	Systems Biology and Network Analysis	3	09	20	80	100	08	32	3
	MBINSEC-1	-	2	06	10	40	50	04	16	$1^{1/2}$
		Total	**20**	**168**	**110**	**440**	**550**	**44**	**176**	-

Note: Out of the three Discipline Specific Electives (MBINDSE -3.5, MBINDSE -3.6, MBINDSE -3.7), students can choose any two.

Sem	Course Code	Course Title	Credits	Counseling/PCP Hours	Max. Marks			Minimum Passing marks		Duration of Exam (hours)
					Internal Assessment	Term end exam	Total Marks	Internal Assessment	Term end exam	
IV	MBINDSC-4.1	Machine Learning for Bioinformatics	4	12	20	80	100	08	32	3
	MBINDSC-4.2	Dissertation	6	18	20	80	100	08	32	-
	MBINDSC -4.3	Practical 7	2	60	10	40	50	04	16	3
	MBINDSC -4.4	Practical 8	2	60	10	40	50	04	16	3
	MBINDSE -4.5	Project Management and Scientific Communication	3	09	20	80	100	08	32	3
	MBINDSE -4.6	Genome to Drug and Vaccine	3	09	20	80	100	08	32	3
	MBINDSE -4.7	Laboratory Techniques in Modern Biology	3	09	20	80	100	08	32	3
	MBINSEC-2	-	2	06	10	40	50	04	16	$1^{1/2}$
		Total	**22**	**174**	**110**	**440**	**550**	**44**	**176**	**-**

Note: Out of the three Discipline Specific Electives (MBINDSE -4.5, MBINDSE -4.6, MBINDSE -4.7), students can choose any two. The Students shall study additional mandatory course, for which no assessment will be made

5. Notification: The University would notify its admission policy, financial assistance, delivery of the programme, academic planning and other details on the website of the University for the information of the learners.

(g) Requirement of the Laboratory Support and Library Resources:

(i) Laboratory Support: A well-equipped laboratory facility has been provided for high level performance. Besides, wherever required resources from other Universities/Institutes will be utilized through MOUs.

(ii) Library Resources: The University provides library facility by both traditional and digital means at the learner center with proper security. Further, state of the art library is placed in the headquarters.

(h) Cost estimate of the programme and the provisions:

The approximate cost estimate of the program: Rs. 90,00,000/- (Rs. Ninety lakhs only).

(i) Quality Assurance and Expected Programme Outcomes:

The quality will be maintained in the curriculum by taking the following measures:

1. Students feedback:-Students give formal feedback in the prescribed format on the content of the SLM at the term end. Students also give feedback on the lectures/practical classes delivered at the contact program/counselling.
2. Academic peers:- The senior faculty members in the concerned subject also review the study material and the practical manuals. Periodic workshops on the curriculum help enhancing the quality.
3. Academic audit: It promotes quality and standards. Faculty members will be updated in teaching and research through orientation programmes, refresher courses, seminars, workshops and conferences/symposium.
4. Feedback of the industrialists, employers, professionals also step up the quality and standard of the programme.
5. The editorial committee ensures the quality of the SLMs.
6. Academic audit programme.
7. Assessment and accreditation by agencies.
8. CIQA established ensures that the quality standards are met, maintained, and enhanced in all the academic and administrative services.

Expected Programme Outcomes:

1. Knowledge and understanding of the principles of bioinformatics, including genetics, genomics, proteomics, and related fields.
2. Proficiency in the use of various software tools and databases commonly used in bioinformatics research, including sequence analysis tools, data mining algorithms, and statistical analysis software.
3. Ability to design and conduct bioinformatics research projects, including experimental design, data analysis, and interpretation of results.
4. Understanding of the ethical and legal considerations related to bioinformatics research, including issues related to data privacy, intellectual property rights, and the use of animal and human subjects.
5. Proficiency in written and oral communication of scientific research findings, including the ability to write research reports, create presentations, and effectively communicate research results to diverse audiences.

6. Understanding of the interdisciplinary nature of bioinformatics research and the ability to work collaboratively with researchers from diverse backgrounds.
7. Ability to critically evaluate scientific research literature and identify gaps in current knowledge, and propose research hypotheses and experimental designs to address these gaps.

Bench Mark System:

1. Employability and Placement of students.
2. Creation of data base system of learners and alumni association.
3. Achieving quality and excellence in the field.
4. Corporate level services.
5. Community development, networking and collaborations.
6. Furtherance of research and development.

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13/3/23

13-03-23

Director
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SYLLABUS – M. SC. BIOINFORMATICS

Detailed Syllabus

Semester I

MBINDSC-1.1: Basic Biology **4 Credits**

Basic Biology is a fundamental course that covers the fundamental principles of biology. Below is a detailed syllabus for Basic Biology: Introduction to Biology, Definition of Biology, Characteristics of Living Organisms, Levels of Biological Organization, Scientific Method.

Chemistry of Life: Atoms, Molecules, and Compounds, Water and Life, Organic Molecules in Living Organisms, Enzymes and their functions.

Cell Structure and Function: The Cell Theory, Prokaryotic and Eukaryotic Cells, Cell Membrane and Transport, Organelles and their Functions, Cell Division

Genetics and Inheritance: Mendelian Genetics, Chromosomes and Inheritance, DNA Structure and Replication, Protein Synthesis, Genetic Mutations

Evolution: Natural Selection, Evidence for Evolution, Theories of Evolution, Human Evolution

Ecology: Ecosystems and their components, Populations and Communities, Biodiversity and Conservation, Ecological Interactions

Human Anatomy and Physiology: Structure and Function of Major Body Systems, Homeostasis, Nutrition and Digestion, Respiration and Gas Exchange, Circulation and Immunity, Excretion and Water Balance

Diversity of Life: Classification of Organisms, Kingdoms of Life, Animal and Plant Diversity; Fungi and Protists

Biotechnology: Genetic Engineering, Cloning, Bioremediation, Ethical Issues in Biotechnology

Scientific Inquiry: Hypothesis Testing, Experimental Design, Data Analysis, Scientific Communication

References

1. "Biology: The Unity and Diversity of Life" by Cecie Starr and Ralph Taggart, published by Cengage Learning in 2016.
2. "Campbell Biology" by Jane B. Reece, Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, and Robert B. Jackson, published by Pearson in 2019.
3. "Molecular Biology of the Cell" by Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter, published by Garland Science in 2014.
4. "Principles of Biology" by Robert L. Brooker, Eric P. Widmaier, Linda E. Graham, and Peter D. Stiling, published by McGraw-Hill Education in 2017.
5. "Essential Biology" by Neil A. Campbell and Jane B. Reece, published by Pearson in 2021.

MBINDSC-1.2 Introduction to Bioinformatics and Computational Biology 4 Credits

Introduction to Bioinformatics and Computational Biology: What is bioinformatics? Historical perspectives, Applications of bioinformatics and computational biology

Biological Databases: Introduction to biological databases, Types of biological databases, Retrieving data from biological databases

Sequence Alignment and Homology: Sequence alignment, Scoring matrices, Homology and similarity, BLAST and other sequence alignment tools

Gene Prediction and Annotation: Gene prediction methods, Gene annotation, Gene Ontology

Genome Assembly and Annotation: Genome assembly methods, Genome annotation, Genome browsers

Phylogenetic Analysis: Basics of phylogenetics, Phylogenetic trees and networks, Phylogenetic analysis software

Structural Bioinformatics: Protein structure prediction, Protein structure visualization, Structural databases

Protein Function and Interaction: Protein function prediction, Protein interaction prediction, Network analysis

Transcriptomics: RNA-seq data analysis, Differential gene expression analysis, Gene co-expression networks

Proteomics: Mass spectrometry data analysis, Protein identification and quantification, Protein-protein interactions

Metabolomics: Metabolomics data analysis, Metabolic pathway analysis, Metabolite identification

Systems Biology: Systems biology approaches, Biological modeling, Dynamic simulation

Machine Learning in Bioinformatics: Introduction to machine learning, Machine learning in bioinformatics, Applications of machine learning in bioinformatics

Ethical Issues in Bioinformatics and Computational Biology: Intellectual property and data sharing, Privacy and confidentiality, Ethical issues in genome editing

Emerging Technologies in Bioinformatics and Computational Biology: CRISPR/Cas technology, Synthetic biology, Nanotechnology in biosensing

Future Directions in Bioinformatics and Computational Biology: Future challenges and opportunities in bioinformatics and computational biology, Career opportunities in bioinformatics and computational biology

References

1. Bioinformatics: Sequence and Genome Analysis, Second Edition by David W. Mount (2004, Cold Spring Harbor Laboratory Press)
2. Computational Biology: A Practical Introduction to BioData Processing and Analysis with Linux, MySQL, and R by Röbbe Wünschiers (2013, Springer)
3. An Introduction to Bioinformatics Algorithms by Neil C. Jones and Pavel A. Pevzner (2004, MIT Press)
4. Bioinformatics and Functional Genomics by Jonathan Pevsner (2015, Wiley-Blackwell)
5. Exploring Bioinformatics: A Project-Based Approach by Caroline St. Clair and Jonathan E. Visick (2013, Jones and Bartlett Publishers)
6. Introduction to Bioinformatics by Arthur M. Lesk (2013, Oxford University Press)
7. Essential Bioinformatics by Jin Xiong (2006, Cambridge University Press)
8. Computational Biology: Unix/Linux, Data Processing and Programming by Röbbe Wünschiers (2015, Springer)
9. Beginning Perl for Bioinformatics by James Tisdall (2001, O'Reilly Media)
10. Algorithms in Bioinformatics: A Practical Introduction by Wing-Kin Sung (2010, CRC Press)

MBINDSE- 1.5 Molecular Biology and Genetics 3 Credits

Introduction to Molecular Biology and Genetics: Historical perspectives, Central dogma of molecular biology, Applications of molecular biology and genetics

The Structure and Function of DNA: DNA structure, DNA replication, DNA damage and repair.

DNA Packaging and Chromosomes: Chromosome structure and organization, Nucleosome structure, Heterochromatin and euchromatin

DNA Transcription: Transcription initiation, elongation, and termination, RNA polymerase, Promoters and enhancers

RNA Processing and Regulation: RNA splicing, Alternative splicing, RNA editing and degradation

The Genetic Code and Translation: The genetic code, Ribosomes and translation initiation, elongation, and termination, Post-translational modifications

Mutations and Genetic Disorders: Types of mutations, Chromosomal abnormalities, Single gene disorders

Mendelian Genetics: The principles of segregation and independent assortment, Punnett squares and pedigrees, Probability and statistics in genetics

Genetic Variation and Evolution: Types of genetic variation, Genetic drift and gene flow, Natural selection and adaptation

Molecular Techniques in Genetics: PCR, DNA sequencing, Genome editing

Genomics: Introduction to genomics, Genome annotation and analysis, Comparative genomics

Epigenetics: DNA methylation and histone modifications, Epigenetic regulation of gene expression, Epigenetic inheritance

Cancer Genetics: Oncogenes and tumor suppressor genes, Cancer genomics and personalized medicine; Cancer treatment strategies

Medical Genetics: Inherited diseases, Genetic counseling and testing, Prenatal diagnosis

Bioinformatics in Molecular Biology and Genetics: Introduction to bioinformatics, Genomic databases and analysis tools, Applications of bioinformatics in molecular biology and genetics

Future Directions in Molecular Biology and Genetics: Emerging technologies in molecular biology and genetics, Future challenges and opportunities in molecular biology and genetics, Career opportunities in molecular biology and genetics

References

1. Molecular Biology of the Cell, Sixth Edition by Bruce Alberts, Alexander Johnson, Julian Lewis, et al. (2015, Garland Science)

2. Principles of Genetics, Seventh Edition by Robert H. Tamarin (2014, McGraw-Hill Education)

3. Molecular Genetics of Bacteria, Fourth Edition by Larry Snyder and Wendy Champness (2013, ASM Press)
4. Principles of Molecular Biology by Burton E. Tropp (2016, Jones & Bartlett Learning)
5. Genomes, Third Edition by T.A. Brown (2007, Garland Science)
6. Genetic Analysis: An Integrated Approach, Second Edition by Mark F. Sanders and John L. Bowman (2014, Pearson Education)
7. The Cell: A Molecular Approach, Sixth Edition by Geoffrey M. Cooper and Robert E. Hausman (2013, Sinauer Associates)
8. Molecular Biology, Fifth Edition by Robert F. Weaver (2017, McGraw-Hill Education)
9. Molecular Biology Techniques: A Classroom Laboratory Manual, Fourth Edition by Susan Carson, Heather B. Miller, and D. Scott Witherow (2017, Academic Press)
10. Molecular Biology: Principles and Practice, Second Edition by Michael M. Cox and Jennifer Doudna (2016, W.H. Freeman and Company)

MBINDSE -1.6 Introduction to Programming for Bioinformatics 3 Credits

Introduction to Programming: An overview of programming concepts, algorithms, and data structures. This includes programming languages, syntax, variables, functions, control structures, and I/O.

Basic Statistics: Descriptive statistics, probability theory, hypothesis testing, and regression analysis.

Bioinformatics and Genomics: Introduction to the field of bioinformatics, genomic data types, sequence alignment, BLAST, and phylogenetic analysis.

Biological Databases: Introduction to biological databases such as NCBI, UniProt, and PDB. This includes searching, retrieving, and analyzing data.

Programming with R: An introduction to the R programming language, including data structures, functions, and data visualization.

Programming with Python: An introduction to the Python programming language, including data structures, functions, and object-oriented programming.

Next-Generation Sequencing (NGS) Data Analysis: Introduction to NGS data types, quality control, alignment, variant calling, and downstream analysis.

Machine Learning in Bioinformatics: Introduction to machine learning techniques, such as clustering, classification, and regression, applied to bioinformatics problems.

Data Visualization: Principles and techniques for creating effective data visualizations, including graphing, mapping, and interactive visualizations.

References

1. Python for Biologists: A Complete Programming Course for Beginners by Martin Jones (2013, CreateSpace Independent Publishing Platform)
2. Beginning Perl for Bioinformatics by James Tisdall (2001, O'Reilly Media)
3. Programming for Computations - Python: A Gentle Introduction to Numerical Simulations with Python by Svein Linge and Hans Petter Langtangen (2016, Springer)
4. Bioinformatics Programming Using Python: Practical Programming for Biological Data by Mitchell L. Model (2009, O'Reilly Media)
5. R Programming for Bioinformatics by Robert Gentleman (2008, CRC Press)
6. Bioinformatics with Python Cookbook: Learn how to use modern Python bioinformatics libraries and applications to do cutting-edge research in computational biology, 2nd Edition by Tiago Antao (2020, Packt Publishing)
7. Python for Bioinformatics, Second Edition by Sebastian Bassi (2010, CRC Press)
8. Bioinformatics Algorithms: An Active Learning Approach, 2nd Edition by Phillip Compeau and Pavel Pevzner (2015, Active Learning Publishers)
9. Mastering Python for Bioinformatics by Dr. Martin Czygan and Dr. Quitze Paul (2015, Packt Publishing)
10. Practical Computing for Biologists by Steven Haddock and Casey Dunn (2020, Sinauer Associates)

MBINDSE-1.7 Biological Databases and Data Mining 3 Credits

Introduction to Biological Databases: An overview of biological databases, including their organization, types, and access methods.

Data Representation and Analysis: An introduction to the fundamental concepts of data representation and analysis, including data types, variables, and basic statistical methods.

Sequence Analysis: An overview of sequence analysis methods and tools, including sequence alignment, sequence similarity, and motif discovery.

Structural Analysis: An introduction to the principles and tools of protein structure analysis, including protein structure prediction, homology modeling, and molecular docking.

Gene Expression Analysis: An overview of the principles and methods of gene expression analysis, including microarray analysis and RNA sequencing.

Network Analysis: An introduction to the principles and tools of network analysis, including graph theory, network visualization, and centrality measures.

Machine Learning in Biological Data Mining: An introduction to the principles and tools of machine learning, including classification, regression, and clustering.

References

1. Biological Data Mining and Its Applications in Healthcare by Xiaoli Li and See-Kiong Ng (2013, World Scientific Publishing)
2. Data Mining Techniques for the Life Sciences by Olivier Caelen, Céline Rouveirol, and Alessandro Lomi (2010, Springer)
3. Handbook of Statistical Genetics, Third Edition by D.J. Balding, M. Bishop, and C. Cannings (2007, Wiley-Blackwell)
4. Biological Database Modeling by Jake Chen (2007, CRC Press)
5. Introduction to Data Mining for the Life Sciences by Rob Sullivan (2012, Springer)
6. Biological Databases: Methods and Protocols by Humana Press (2016, Springer)
7. Mining the Biomedical Literature (Computational Molecular Biology) by Hagit Shatkay and Mark Craven (2012, The MIT Press)
8. Data Mining in Agriculture (Springer Optimization and Its Applications) by Antonio J. Mora-García, Jesús García-Herrero, and José A. Gómez-López (2013, Springer)
9. Biological Knowledge Discovery Handbook: Preprocessing, Mining and Postprocessing of Biological Data by Mourad Elloumi and Albert Y. Zomaya (2014, John Wiley & Sons)
10. Biological Data Mining and Its Applications in Agriculture by F. Tao and R. L. Harnly (2014, Nova Science Publishers)

Second Semester

MBINDSC-2.1 Statistics for Bioinformatics 4 Credits

Introduction to Probability and Statistics: An overview of basic probability concepts, including probability distributions, random variables, and expectation.

Descriptive Statistics: Measures of central tendency, variability, and correlation.

Statistical Inference: Estimation, hypothesis testing, and significance testing.

Linear Regression: Simple and multiple linear regression models.

Analysis of Variance (ANOVA): One-way and two-way ANOVA models.

Nonparametric Methods: Wilcoxon rank-sum test, Kruskal-Wallis test, and Mann-Whitney test.

Multiple Testing: Bonferroni correction, false discovery rate, and permutation testing.

Bayesian Methods: Bayes' theorem, Bayesian inference, and Markov chain Monte Carlo (MCMC) methods.

Machine Learning in Bioinformatics: An introduction to machine learning algorithms, such as decision trees, random forests, and support vector machines.

References

1. An Introduction to Statistical Learning: with Applications in R by Gareth James, Daniela Witten, Trevor Hastie, and Robert Tibshirani (2013, Springer)
2. Statistical Methods in Bioinformatics: An Introduction by Warren J. Ewens and Gregory R. Grant (2005, Springer)
3. Bioinformatics and Functional Genomics by Jonathan Pevsner (2015, Wiley-Blackwell)
4. Statistical Methods for Microarray Data Analysis: Methods and Protocols by Bernd Klaus and Katia Nones (2016, Humana Press)
5. Applied Statistics for Bioinformatics using R by Wim P. Krijnen (2010, Springer)
6. Statistical Methods for Healthcare Performance Monitoring by Peter J. Smith and Karen L. Peckham (2016, CRC Press)
7. Statistics for Bioinformatics: Methods for Multiple Sequence Alignment by Julie Dawn Thompson (2016, John Wiley & Sons)
8. The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Second Edition by Trevor Hastie, Robert Tibshirani, and Jerome Friedman (2009, Springer)
9. Bayesian Methods in Structural Bioinformatics by Thomas Hamelryck, Kanti Mardia, and Jesper Ferkinghoff-Borg (2012, Springer)
10. Statistical Methods in Molecular Biology by Warren J. Ewens and Gregory R. Grant (2001, Springer)

MBINDSC-2.2 Bioinformatics Tools and Techniques 4 Credits

Introduction to Bioinformatics: An overview of the history, scope, and challenges of bioinformatics.

Biological Databases: An overview of biological databases, including their organization, types, and access methods.

Sequence Analysis: An overview of sequence analysis methods and tools, including sequence alignment, sequence similarity, and motif discovery.

Structural Analysis: An introduction to the principles and tools of protein structure analysis, including protein structure prediction, homology modeling, and molecular docking.

Gene Expression Analysis: An overview of the principles and methods of gene expression analysis, including microarray analysis and RNA sequencing.

Network Analysis: An introduction to the principles and tools of network analysis, including graph theory, network visualization, and centrality measures.

Machine Learning in Bioinformatics: An introduction to the principles and tools of machine learning, including classification, regression, and clustering.

Genomics and Proteomics: An overview of the principles and techniques used in genomics and proteomics research, including genome assembly, annotation, and functional analysis.

Metagenomics: An introduction to the principles and tools of metagenomics, including sequencing, assembly, and taxonomic classification.

References

1. Bioinformatics: Tools and Applications by David Edwards and Chris Saunders (2018, Springer)
2. Bioinformatics for Biologists by Pavel Pevzner and Ron Shamir (2011, Cambridge University Press)
3. Bioinformatics Algorithms: An Active Learning Approach by Phillip Compeau and Pavel Pevzner (2015, Active Learning Publishers)
4. Beginning Perl for Bioinformatics by James Tisdall (2001, O'Reilly Media)
5. Bioinformatics with R Cookbook by Paurush Praveen Sinha (2014, Packt Publishing)
6. Essential Bioinformatics by Jin Xiong (2006, Cambridge University Press)
7. Bioinformatics: Principles and Applications by Zhumur Ghosh and Bibekanand Mallick (2017, CRC Press)
8. Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools by Vince Buffalo (2015, O'Reilly Media)
9. Python for Biologists: A Complete Programming Course for Beginners by Martin Jones (2013, CreateSpace Independent Publishing Platform)
10. Advanced Python for Biologists by Martin Jones (2014, CreateSpace Independent Publishing Platform)

MBINDSE-2.5. Algorithms and Data Structures for Bioinformatics 3 Credits

Introduction to Algorithms: An overview of basic algorithmic concepts, including algorithm design, complexity analysis, and algorithmic paradigms.

Data Structures: An introduction to common data structures used in bioinformatics, including arrays, linked lists, trees, and graphs.

Sequence Alignment Algorithms: An overview of sequence alignment algorithms, including global and local alignment, dynamic programming, and heuristic algorithms.

Genome Assembly Algorithms: An introduction to genome assembly algorithms, including overlap-layout-consensus, de Bruijn graph, and hybrid approaches.

Phylogenetic Tree Algorithms: An overview of phylogenetic tree algorithms, including distance-based, maximum likelihood, and Bayesian methods.

Gene Finding Algorithms: An introduction to gene finding algorithms, including hidden Markov models, gene structure prediction, and gene function prediction.

Network Algorithms: An overview of network algorithms, including graph theory, network flow, and clustering algorithms.

Machine Learning Algorithms: An introduction to machine learning algorithms, including decision trees, support vector machines, and neural networks.

References

1. Bioinformatics Algorithms: An Active Learning Approach by Phillip Compeau and Pavel Pevzner (2015, Active Learning Publishers)
2. Data Structures and Algorithms with Python by Kent D. Lee and Steve Hubbard (2015, Springer)
3. Algorithms in Bioinformatics: 15th International Workshop, WABI 2015, Atlanta, GA, USA, September 10-12, 2015, Proceedings by Maxime Crochemore and Christina Boucher (2015, Springer)
4. Algorithms in Bioinformatics: 16th International Workshop, WABI 2016, Aarhus, Denmark, August 22-24, 2016, Proceedings by Rolf Backofen and Sebastian Will (2016, Springer)
5. Algorithms in Bioinformatics: 17th International Workshop, WABI 2017, Boston, MA, USA, August 21-23, 2017, Proceedings by Russell Schwartz and Knut Reinert (2017, Springer)
6. Practical Algorithms for Image Analysis with CD-ROM: Description, Examples, and Code by Lawrence O. Hall and Eric A. Stahlberg (2000, Cambridge University Press)

7. Algorithms and Data Structures for External Memory by Jeffrey Scott Vitter (2008, Now Publishers Inc.)
8. Handbook of Algorithms for Physical Design Automation by Charles J. Alpert and Dinesh P. Mehta (2008, CRC Press)
9. Introduction to Algorithms, 3rd Edition by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein (2009, The MIT Press)
10. The Algorithm Design Manual, 2nd Edition by Steven S. Skiena (2008, Springer)

MBINDSE-2.6 Genome Analysis and Annotation 3 Credits

Introduction to Genomics: An overview of the principles of genomics, including genome structure, organization, and function.

Genome Sequencing: An introduction to genome sequencing techniques, including shotgun sequencing, whole genome sequencing, and next-generation sequencing.

Genome Assembly: An overview of genome assembly techniques, including de novo assembly, reference-based assembly, and hybrid assembly.

Genome Annotation: An introduction to genome annotation techniques, including gene prediction, functional annotation, and comparative genomics.

Comparative Genomics: An overview of comparative genomics techniques, including genome alignment, synteny analysis, and phylogenomics.

Gene Expression Analysis: An introduction to gene expression analysis techniques, including microarray analysis, RNA sequencing, and differential gene expression analysis.

Proteomics: An overview of proteomics techniques, including protein identification, quantification, and post-translational modification analysis.

Metagenomics: An introduction to metagenomics techniques, including sequencing, assembly, and taxonomic classification.

References

1. Genome Annotation and Finding Repetitive DNA Elements by Dongqing Huang (2016, Springer)
2. Genome Annotation: Techniques and Best Practices by Anna Zhukova (2021, Springer)
3. Genome Annotation: Principles, Methods, and Challenges by Debmalya Barh and Vasco Azevedo (2015, Nova Science Publishers)

4. Handbook of Genome Research, Two Volume Set: Genomics, Proteomics, Metabolomics, Bioinformatics, Ethical and Legal Issues by Mohamed Al-Rubeai and Martin Fussenegger (2016, Wiley)

5. Bioinformatics and Genome Analysis by David W. Mount (2004, Cold Spring Harbor Laboratory Press)

6. Genome-Wide Association Studies: From Polymorphism to Personalized Medicine by Mehdi Pirooznia and Brian H. Shirts (2016, Springer)

7. Genome Annotation and Analysis in Fungi by Gustavo H. Goldman and Diego Mauricio Riaño-Pachón (2016, Springer)

8. Genomics and Bioinformatics: An Introduction to Programming Tools for Life Scientists by Tore Samuelsson (2015, Springer)

9. Principles of Genome Analysis and Genomics by Sandra I. Kim and Julian Parkhill (2015, Garland Science)

10. Advanced Technologies for Meat Processing by Fidel Toldrá (2006, CRC Press)

MBINDSE-2.7 Structural Bioinformatics 3 Credits

Introduction to Protein Structure: An overview of the principles of protein structure, including protein folding, secondary structure, and tertiary structure.

Protein Structure Prediction: An introduction to protein structure prediction techniques, including homology modeling, ab initio modeling, and molecular dynamics simulation.

Protein Structure Analysis: An overview of protein structure analysis techniques, including molecular docking, ligand binding analysis, and protein-protein interaction analysis.

Protein Engineering: An introduction to protein engineering techniques, including site-directed mutagenesis, protein design, and directed evolution.

Nucleic Acid Structure: An overview of the principles of nucleic acid structure, including DNA and RNA structure, base pairing, and DNA replication.

RNA Structure Prediction: An introduction to RNA structure prediction techniques, including comparative sequence analysis, free energy minimization, and molecular dynamics simulation.

Nucleic Acid Structure Analysis: An overview of nucleic acid structure analysis techniques, including RNA folding, RNA-protein interaction analysis, and DNA-protein interaction analysis.

References

1. Structural Bioinformatics, Second Edition by Jenny Gu and Philip E. Bourne (2014, Wiley-Blackwell)

2. Protein Structure Prediction: Methods and Protocols, Second Edition by David M. Webster (2014, Humana Press)
3. Structural Bioinformatics of Membrane Proteins by Luca Monticelli and Jeremy C. Smith (2015, Royal Society of Chemistry)
4. Molecular Modeling and Simulation: An Interdisciplinary Guide, Second Edition by Tamar Schlick (2010, Springer)
5. Introduction to Protein Structure by Carl-Ivar Brändén and John Tooze (1999, Garland Science)
6. Computational Structural Biology: Methods and Applications by Thomas E. Creighton (2008, Wiley-Interscience)
7. Molecular Modelling: Principles and Applications, Second Edition by Andrew R. Leach (2001, Pearson Education)
8. NMR Spectroscopy in Structural Biology: Techniques and Applications by Kurt Wüthrich (2012, World Scientific)
9. Computational Methods for Protein Structure Prediction and Modeling: Volume 2: Structure Prediction by Ying Xu and Dong Xu (2007, Springer)
10. Structural Genomics and Drug Discovery: Methods and Protocols by Michael G. Rossmann and Shuguang Yuan (2008, Humana Press)

Semester III

MBINDSC-3.1 Protein Structure and Function 4 Credits

Introduction to Protein Structure and Function: An overview of the principles of protein structure and function, including protein folding, secondary structure, and tertiary structure.

Methods for Determining Protein Structure: An introduction to protein structure determination techniques, including X-ray crystallography, NMR spectroscopy, and cryo-electron microscopy.

Protein Structure Analysis: An overview of protein structure analysis techniques, including molecular docking, ligand binding analysis, and protein-protein interaction analysis.

Enzyme Kinetics: An introduction to enzyme kinetics, including enzyme classification, enzyme kinetics equations, and enzyme inhibition.

Protein Engineering: An overview of protein engineering techniques, including site-directed mutagenesis, protein design, and directed evolution.

Protein-Protein Interactions: An introduction to protein-protein interactions, including protein complex formation, protein interaction networks, and protein interaction databases.

Protein Localization and Transport: An overview of protein localization and transport mechanisms, including protein targeting signals, protein translocation, and vesicle transport.

References

1. Principles of Protein X-Ray Crystallography by Jan Drenth (2010, Springer)
2. Protein Structure: A Practical Approach, Second Edition by T. E. Creighton (1997, IRL Press)
3. Protein Structure and Function by David Whitford (2005, John Wiley & Sons)
4. Proteins: Structure and Function by David E. Metzler (2003, Wiley-Interscience)
5. Introduction to Protein Structure, Second Edition by Carl Branden and John Tooze (1998, Garland Science)
6. From Protein Structure to Function with Bioinformatics by Daniel John Rigden (2017, Springer)
7. Protein Structure, Stability, and Folding by Kenneth P. Murphy (1995, CRC Press)
8. Biochemistry: The Molecular Basis of Life, Fifth Edition by Trudy McKee and James R. McKee (2016, Oxford University Press)
9. Introduction to Protein Science: Architecture, Function, and Genomics by Arthur Lesk (2017, Oxford University Press)
10. Computational Approaches to Protein Structure Prediction and Protein-Protein Interaction by Zhijun Li and Yaoqi Zhou (2013, Springer)

MBINDSC-3.2 Next-Generation Sequencing 4 Credits

Introduction to NGS: History and evolution of NGS, Fundamentals of NGS: sequencing by synthesis, library preparation, and sequencing platforms, Comparison of different NGS platforms: Illumina, PacBio, Nanopore, and others, Quality control and data preprocessing

NGS Applications: Whole-genome sequencing, exome sequencing, transcriptome sequencing, epigenome sequencing, and others, Single-cell sequencing and its applications, Long-read sequencing and its applications, Metagenomics and its applications

NGS Data Analysis: Read alignment and mapping, Variant calling and annotation, Transcript quantification and differential expression analysis, Epigenetic analysis: DNA methylation, histone modifications, and chromatin accessibility, Introduction to bioinformatics tools and pipelines for NGS data analysis

NGS Data Interpretation: Functional annotation of genetic variants, Pathway and network analysis, Gene ontology and functional enrichment analysis, Interpretation of epigenetic data, Visualization and communication of NGS data

NGS Experiment Design and Execution: Experimental design and sample preparation, Library preparation and quality control, Sequencing setup and parameters, Data analysis and interpretation

NGS-Based Research Studies: Critical evaluation of NGS-based research studies, Impact of NGS on genomics research, Future directions and emerging applications of NGS

References

1. Next Generation Sequencing: Translation to Clinical Diagnostics by Timothy J. Day and Sarah J. South (2013, Academic Press)
2. Next-Generation Sequencing Data Analysis by Xinkun Wang (2014, Springer)
3. Practical Applications of Next-Generation Sequencing in Cancer Research by Jianliang Dai, Jiajie Hu, and Wei Zhang (2019, Springer)
4. Next-Generation DNA Sequencing Informatics, Second Edition by Stuart M. Brown (2013, Cold Spring Harbor Laboratory Press)
5. Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools by Vince Buffalo (2015, O'Reilly Media)
6. Next-Generation Sequencing in Cancer Research, Volume 2: From Basepairs to Bedsides by Antonello Lorenzini and Riccardo Schiavon (2016, Springer)
7. Clinical Applications of Next-Generation Sequencing by Volker Hauck and Matthias Wiemann (2016, Springer)
8. Next-Generation Sequencing Technologies and Challenges in Personalized Medicine by Xiaowu Chen and Zhongming Zhao (2016, CRC Press)
9. Next-Generation Sequencing in Plant Systematics by Eva H. Stukenbrock and Ralph Bock (2016, Springer)
10. Statistical Analysis of Next Generation Sequencing Data by Somnath Datta and Saurabh Sinha (2014, Springer)

MBINDSE-3.5 Metagenomics and Microbial Ecology 3 Credits

Introduction to Metagenomics: History and evolution of metagenomics, Fundamentals of metagenomics: sample collection, DNA extraction, sequencing platforms, and data analysis, Comparison of different metagenomics approaches: 16S rRNA sequencing, whole-genome sequencing, and others, Quality control and data preprocessing

Metagenomics Applications: Microbial diversity and community structure, Functional analysis of microbial communities, Microbial interactions and networks, Single-cell metagenomics and its applications, Long-read sequencing and its applications; Functional metagenomics and its applications

Metagenomics Data Analysis: Read assembly and binning, Taxonomic profiling and functional annotation, Comparative metagenomics and statistical analysis, Introduction to bioinformatics tools and pipelines for metagenomics data analysis

Metagenomics Data Interpretation: Functional annotation of microbial genes, Pathway and network analysis, Metabolic modeling and flux analysis, Interpretation of functional metagenomics data, Visualization and communication of metagenomic data

Metagenomics Experiment Design and Execution: Experimental design and sample collection, DNA extraction and library preparation, Sequencing setup and parameters, Data analysis and interpretation

Metagenomics-Based Research Studies: Critical evaluation of metagenomics-based research studies, Impact of metagenomics on microbial ecology, Future directions and emerging applications of metagenomics

References

1. "Metagenomics: Methods and Protocols" edited by Wolfgang Streit and Rolf Daniel (2018) - Publisher: Humana Press
2. "Metagenomics for Microbiology" edited by Jacques Izard and Maria Rivera (2014) - Publisher: Academic Press
3. "Microbial Ecology: Fundamentals and Applications" by Ronald M. Atlas and Richard Bartha (2018) - Publisher: Wiley-Blackwell
4. "Metagenomics and its Applications in Agriculture, Biomedicine and Environmental Studies" edited by Kuldeep Dhama and Shoor Vir Singh (2020) - Publisher: Springer
5. "Advances in Microbial Ecology" edited by K.G. Mukerji, C. Manoharachary, and J. Singh (2015) - Publisher: Springer
6. "Methods in Microbiology: Environmental Microbiology and Microbial Ecology" edited by Juan Luis Ramos (2014) - Publisher: Academic Press
7. "Microbial Ecology of the Oceans" edited by David L. Kirchman (2018) - Publisher: Wiley-Blackwell
8. "Functional Metagenomics: Tools and Applications" edited by Marco Galardini and Renee M. Tsolis (2021) - Publisher: Humana Press
9. "Microbial Ecology in Sustainable Agroecosystems" edited by Brajesh K. Singh and Ratna Prabha (2021) - Publisher: Springer

10. "Metagenomics: Applications, Challenges, and Opportunities" edited by Diana Marco and Antonio Martin-Meizoso (2019) - Publisher: CRC Press

MBINDSE-3.6 Comparative Genomics and Evolutionary Biology 3 Credits

Introduction to Comparative Genomics: History and evolution of comparative genomics,Fundamentals of comparative genomics: gene and genome evolution, gene function, gene regulation, genome assembly, and annotation, Comparison of different comparative genomics approaches: genome-wide association studies, comparative transcriptomics, and comparative proteomics, Quality control and data preprocessing

Comparative Genomics Applications: Comparative genomics of model organisms, Comparative genomics of non-model organisms, Comparative genomics of microorganisms, Evolutionary genomics and its applications, Single-cell genomics and its applications, Metagenomics and its applications, Phylogenomics and its applications

Comparative Genomics Data Analysis: Genome assembly and annotation, Comparative genomics analysis of coding and non-coding regions, Genome-wide association studies and quantitative trait loci mapping, Comparative transcriptomics and proteomics analysis, Introduction to bioinformatics tools and pipelines for comparative genomics data analysis

Comparative Genomics Data Interpretation: Functional annotation of genes and gene networks, Genome structure and evolution, Gene regulation and expression, Comparative phylogenetics and evolutionary history, Visualization and communication of comparative genomics data

Comparative Genomics Experiment Design and Execution: Experimental design and sample collection, DNA extraction and library preparation, Sequencing setup and parameters, Data analysis and interpretation

Comparative Genomics-Based Research Studies: Critical evaluation of comparative genomics-based research studies, Impact of comparative genomics on evolutionary biology, Future directions and emerging applications of comparative genomics

References

1. "Comparative Genomics: Volume 1" edited by Nicholas H. Bergman (2021) - Publisher: Humana Press
2. "Evolutionary Biology: An Introduction" by Douglas J. Futuyma (2017) - Publisher: Sinauer Associates
3. "Comparative Genomics: Volume 2" edited by Nicholas H. Bergman (2021) - Publisher: Humana Press
4. "Principles of Genome Analysis and Genomics" by Sandy B. Primrose and Richard M. Twyman (2018) - Publisher: Wiley-Blackwell
5. "Evolution: The Story of Life" by Douglas Palmer (2021) - Publisher: DK

6. "Comparative Genomics: Recombination and Genome Evolution" edited by Jan O. Korbel and Nizar N. Batada (2009) - Publisher: Springer
7. "Evolutionary Analysis" by Scott Freeman and Jon C. Herron (2019) - Publisher: Pearson
8. "Comparative Genomics: Methods and Protocols" edited by Joana Vieira and Nicolas Galtier (2021) - Publisher: Springer
9. "The Evolution of the Genome" by T. Ryan Gregory (2020) - Publisher: Academic Press
10. "Phylogenomics: An Introduction" edited by Rob DeSalle and Jeffrey L. Boore (2019) - Publisher: Springer

MBINDSE-3.7 Systems Biology and Network Analysis 3 Credits

Introduction to Systems Biology: History and evolution of systems biology, Fundamentals of systems biology: molecular interactions, cellular networks, and systems modeling, Comparison of different systems biology approaches: bottom-up, top-down, and hybrid approaches, Quality control and data preprocessing

Systems Biology Applications: Gene regulatory networks, Protein-protein interaction networks, Metabolic networks, Signaling networks, Network medicine and its applications, Synthetic biology and its applications

Network Inference and Analysis: Network inference methods: correlation-based, Bayesian, and machine learning-based methods, Network topology analysis: centrality measures, clustering, and module detection, Network dynamics: modeling, simulation, and analysis of network behavior, Network visualization and communication

Data Integration and Multi-omics Analysis: Multi-omics data integration and analysis, Data-driven network inference and analysis, Integration of systems biology with other fields, such as bioinformatics, genomics, and proteomics, Introduction to bioinformatics tools and pipelines for systems biology data analysis

Systems Biology Experiment Design and Execution: Experimental design and sample collection, Data acquisition and preprocessing, Mathematical modeling and simulation, Data analysis and interpretation

Systems Biology-Based Research Studies: Critical evaluation of systems biology-based research studies, Impact of systems biology on network analysis, Future directions and emerging applications of systems biology

References

1. "Systems Biology: A Textbook" edited by Edda Klipp, Wolfram Liebermeister, Christoph Wierling, and Axel Kowald (2016) - Publisher: Wiley-Blackwell

2. "Networks, Crowds, and Markets: Reasoning About a Highly Connected World" by David Easley and Jon Kleinberg (2010) - Publisher: Cambridge University Press
3. "Introduction to Systems Biology" by Sangdun Choi (2021) - Publisher: Springer
4. "Modeling and Analysis of Dynamic Systems" by Charles M. Close and Dean K. Frederick (2016) - Publisher: CRC Press
5. "Systems Biology in Practice: Concepts, Implementation and Application" edited by Edda Klipp, Ralf Herwig, and Axel Kowald (2015) - Publisher: Wiley-VCH
6. "Graph Theory and Complex Networks: An Introduction" by Maarten van Steen and Guido J. van den Berg (2020) - Publisher: Springer
7. "Systems Biology: Mathematical Modeling and Model Analysis" edited by Andreas Kremling and Sebastian J. Schultheiss (2013) - Publisher: Springer
8. "An Introduction to Network Science" by Albert-László Barabási (2016) - Publisher: Cambridge University Press
9. "Computational Systems Biology: Second Edition" edited by Andres Kriete and Roland Eils (2013) - Publisher: Academic Press
10. "Network Analysis and Synthesis: A Modern Systems Theory Approach" by Saeed Moaveni (2019) - Publisher: Wiley

Semester IV

MBINDSC-4.1 Machine Learning for Bioinformatics 4 Credits

Introduction to Machine Learning: Overview of machine learning and its applications in bioinformatics, Types of machine learning algorithms: supervised, unsupervised, and reinforcement learning, Data preprocessing techniques: feature selection, normalization, and dimensionality reduction, Evaluation metrics for machine learning models

Supervised Machine Learning: Decision trees and random forests, Support vector machines, Artificial neural networks, Deep learning and its applications in bioinformatics

Unsupervised Machine Learning: Clustering algorithms: K-means, hierarchical clustering, and DBSCAN, Dimensionality reduction algorithms: PCA, t-SNE, and UMAP, Topic modeling and its applications in natural language processing

Reinforcement Learning and Its Applications: Overview of reinforcement learning and its applications in bioinformatics, Applications of reinforcement learning in drug discovery and design, Applications of reinforcement learning in personalized medicine

Image Analysis and Its Applications: Image analysis techniques for bioinformatics: segmentation, feature extraction, and classification, Deep learning-based image analysis

techniques: convolutional neural networks (CNNs), Applications of image analysis in genomics and proteomics

Machine Learning-Based Research Studies: Critical evaluation of machine learning-based research studies in bioinformatics, Ethical considerations in machine learning-based research studies, Future directions and emerging applications of machine learning in bioinformatics

References

1. "Machine Learning for Bioinformatics: Methods, Applications, and Challenges" edited by Kuldip K. Paliwal and Ugur Sezerman (2010) - Publisher: Wiley-Blackwell
2. "Machine Learning for Health Informatics: State-of-the-Art Techniques and Future Challenges" edited by Andreas Holzinger, Igor Jurisica, and Mourad Elloumi (2021) - Publisher: Springer
3. "Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools" by Vince Buffalo (2015) - Publisher: O'Reilly Media
4. "Deep Learning Techniques for Biomedical and Health Informatics" edited by Xingquan Zhu and Guoxian Yu (2021) - Publisher: Springer
5. "Bioinformatics Algorithms: An Active Learning Approach" by Phillip Compeau and Pavel Pevzner (2015) - Publisher: Active Learning Publishers
6. "Practical Machine Learning for Computer Vision" by Martin Görner, Ryan Gillard, and Valliappa Lakshmanan (2021) - Publisher: O'Reilly Media
7. "Bioinformatics and Functional Genomics" by Jonathan Pevsner (2015) - Publisher: Wiley-Blackwell
8. "Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery" by David Edwards and Chris Saunders (2019) - Publisher: Wiley-Blackwell
9. "Machine Learning in Bio-Signal Analysis and Diagnostic Imaging" edited by Nilanjan Dey and Amira S. Ashour (2020) - Publisher: Springer
10. "Python Machine Learning for Beginners: The Ultimate Beginner's Guide to Learning Python Machine Learning Step by Step" by Mark Howard (2019) - Publisher: Independently published

MBINDSC-4.2: Dissertation **6 Credits**

MBINDSE-4.5 Project Management and Scientific Communication **3 Credits**

Introduction to Project Management: Overview of project management principles and tools, Project planning and scheduling, Resource allocation and management, Risk management and contingency planning

Project Execution and Control: Project monitoring and control, Project reporting and documentation, Change management and scope management, Team management and leadership

Scientific Communication: Writing and Presenting: Overview of scientific communication principles and tools, Writing research proposals, scientific papers, and other scientific documents, Preparing scientific presentations: posters, oral presentations, and webinars, Strategies for effective communication with different audiences

Scientific Communication: Ethics and Social Responsibility: Ethical considerations in scientific communication, Best practices for responsible scientific communication, Public engagement and outreach in scientific research, Social media and scientific communication

Project Management and Scientific Communication in Industry: Project management and scientific communication in the biotech and pharma industry, Regulatory affairs and project management, Team dynamics and communication in industry, Intellectual property and project management

Project Management and Scientific Communication in Academia: Project management and scientific communication in academia, Grant writing and project management, Publishing and scientific communication in academia, Research collaborations and project management

References

1. "Project Management for Research: A Guide for Graduate Students" by Adedeji B. Badiru and Christina F. Rusnock (2019) - Publisher: CRC Press
2. "Scientific Writing and Communication: Papers, Proposals, and Presentations" by Angelika H. Hofmann (2019) - Publisher: Oxford University Press
3. "Effective Scientific Communication: A Practical Guide to Plan, Present, Publish and Promote Your Research" by Alejandro Martínez-Ruiz and Alberto Martínez-Moreno (2019) - Publisher: Springer
4. "Project Management for Scientists and Engineers" by Borysowich, Christine, and Gorman, D. John (2018) - Publisher: Elsevier
5. "The Craft of Scientific Communication" by Joseph E. Harmon and Alan G. Gross (2010) - Publisher: University of Chicago Press
6. "Successful Scientific Writing: A Step-by-Step Guide for the Biological and Medical Sciences" by Janice R. Matthews, Robert W. Matthews, and Janice R. Matthews (2014) - Publisher: Cambridge University Press

7. "Project Management for Research and Development: Guiding Innovation for Positive R&D Outcomes" by Lory Mitchell Wingate and Thomas J. Grynkiewicz (2017) - Publisher: CRC Press
8. "Science Research Writing for Non-Native Speakers of English" by Hilary Glasman-Deal (2010) - Publisher: Imperial College Press
9. "Project Management for Scientists and Researchers" by Nabil N. El-Haggar (2016) - Publisher: CRC Press
10. "The Scientist's Guide to Writing: How to Write More Easily and Effectively throughout Your Scientific Career" by Stephen B. Heard (2016) - Publisher: Princeton University Press

MBINDSE-4.6 Genome to Drug and Vaccine **3 Credits**

Introduction to Genomics and Pharmacogenomics, Introduction to genomics and pharmacogenomics, DNA sequencing technologies and platforms

Pharmacogenomics and personalized medicine, Ethical and legal issues in genomics, Genome Analysis and Annotation

Genome assembly and annotation, Identification of genetic variation and polymorphisms, Functional annotation of genes and proteins

Comparative genomics and phylogenetic analysis, Bioinformatics Tools and Databases, Introduction to bioinformatics tools and databases

Sequence alignment and homology analysis, Genome browsing and visualization tools

Gene expression analysis and pathway analysis tools

Drug Discovery and Development, Drug discovery and development process, Drug target identification and validation

High-throughput screening and lead identification, Preclinical and clinical trials, Vaccine Development and Immunology

Principles of immunology, Types of vaccines and vaccine design, Vaccine production and formulation

Vaccine efficacy and safety testing, Genomics and Pharmacogenomics Applications, Pharmacogenomics applications in drug development

Genomic medicine and clinical genomics, Genomics and personalized medicine

Ethics and social implications of genomics and pharmacogenomics

References

1. "Principles of Pharmacogenetics and Pharmacogenomics" by Dennis A. Smith, published by Lippincott Williams & Wilkins in 2012.
2. "Genomic and Personalized Medicine" edited by Geoffrey S. Ginsburg and Huntington F. Willard, published by Academic Press in 2013.
3. "Bioinformatics for Beginners: Genes, Genomes, Molecular Evolution, Databases and Analytical Tools" by Supratim Choudhuri, published by Academic Press in 2014.
4. "Drug Discovery and Development: Technology in Transition" edited by Sean Ekins and Jinghai J. Xu, published by Elsevier in 2016.
5. "Vaccines: Preventing Diseases and Protecting Health" edited by Myron M. Levine, Joachim Hombach, and Kathryn M. Edwards, published by Academic Press in 2017.
6. These books cover various aspects of Genome to Drug and Vaccine and are widely used as reference materials in undergraduate and graduate courses related to genomics, bioinformatics, pharmacology, and immunology.

MBINDSE-4.7 Laboratory Techniques in Modern Biology 3 Credits

Introduction to Laboratory Techniques in Modern Biology: Course overview and expectations, Safety in the laboratory, Equipment and materials, Record keeping and data analysis

Basic Laboratory Techniques: Sterile techniques, Pipetting and dilution, pH measurement and buffer preparation, Spectrophotometry, Gel electrophoresis, Centrifugation

Molecular Biology Techniques: DNA extraction, Polymerase chain reaction (PCR), Restriction enzyme digestion, DNA cloning and transformation, Southern blotting, DNA sequencing

Protein Techniques: Protein extraction and purification, Electrophoresis and Western blotting, Enzyme assays, Protein-protein interactions

Microscopy Techniques: Light microscopy, Fluorescence microscopy, Confocal microscopy, Electron microscopy

Bioinformatics: Sequence analysis, Database searching, Multiple sequence alignment, Phylogenetic analysis

Cell Culture Techniques: Cell culture principles, Cell line establishment, Primary cell culture, Transfection and transduction, Cryopreservation

Advanced Topics: CRISPR/Cas9 gene editing, Single-cell analysis, Proteomics, Metabolomics

Scientific Communication: Scientific writing, Data visualization, Oral presentation skills, Science communication to a general audience

References

1. Molecular Cloning: A Laboratory Manual by Joseph Sambrook, David W. Russell, and Peter MacCallum, 4th edition (2012), Cold Spring Harbor Laboratory Press.

2. Essential Cell Biology by Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter, 4th edition (2013), Garland Science.

3. Current Protocols in Molecular Biology edited by Frederick M. Ausubel, Roger Brent, Robert E. Kingston, David D. Moore, J.G. Seidman, John A. Smith, and Kevin Struhl, (1987 - present), John Wiley & Sons.

4. Basic Methods in Microscopy: Protocols and Concepts from Cells: A Laboratory Manual by Jennifer Lippincott-Schwartz, Graham T. Johnson, and Eric H. Betzig, 2nd edition (2017), Cold Spring Harbor Laboratory Press.

5. Principles of Biochemistry by Albert L. Lehninger, David L. Nelson, and Michael M. Cox, 6th edition (2012), W.H. Freeman and Company.

6. The Immune System by Peter Parham, 4th edition (2014), Garland Science.

7. Laboratory Techniques in Biochemistry and Molecular Biology edited by T.S. Work and E. Work, 2nd edition (1995), Elsevier Science.

8. Essential Techniques for Molecular Biology by Michael L. Summers, 1st edition (2009), Cambridge University Press.

9. Molecular Biology of the Cell by Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter, 6th edition (2014), Garland Science.

10. Basic Methods in Antibody Production and Characterization by Gary C. Howard, 1st edition (2000), CRC Press.

Sem	Course Code	Course Title	Credits	Counseling/PCP Hours	Max. Marks			Minimum Passing marks		Duration of Exam (hours)
					Internal Assessment	Term end exam	Total Marks	Internal Assessment	Term end exam	
II	MBINDSC-2.1	Statistics for Bioinformatics	4	12	20	80	100	08	32	3
	MBINDSC-2.2	Bioinformatics Tools and Techniques	4	12	20	80	100	08	32	3
	MBINDSC -2.3	Practical 3	2	60	10	40	50	04	16	3
	MBINDSC -2.4	Practical 4	2	60	10	40	50	04	16	3
	MBINDSE -2.5	Algorithms and Data Structures for Bioinformatics	3	09	20	80	100	08	32	3
	MBINDSE -2.6	Genome Analysis and Annotation	3	09	20	80	100	08	32	3
	MBINDSE -2.7	Structural Bioinformatics	3	09	20	80	100	08	32	3
	ELMBIN –02	Interdisciplinary Elective-2	2	06	10	40	50	04	16	$1^{1/2}$
		Total	**20**	**168**	**110**	**440**	**550**	**44**	**176**	-

Note: Out of the three Discipline Specific Electives (MBINDSE -2.5, MBINDSE -2.6, MBINDSE -2.7), students can choose any two.

Sem	Course Code	Course Title	Credits	Counseling/PCP Hours	Max. Marks			Minimum Passing marks		Duration of Exam (hours)
					Internal Assessment	Term end exam	Total Marks	Internal Assessment	Term end exam	
III	MBINDSC-3.1	Protein Structure and Function	4	12	20	80	100	08	32	3
	MBINDSC-3.2	Next-Generation Sequencing	4	12	20	80	100	08	32	3
	MBINDSC -3.3	Practical 5	2	60	10	40	50	04	16	3
	MBINDSC -3.4	Practical 6	2	60	10	40	50	04	16	3
	MBINDSE -3.5	Metagenomics and Microbial Ecology	3	09	20	80	100	08	32	3
	MBINDSE -3.6	Comparative Genomics and Evolutionary Biology	3	09	20	80	100	08	32	3
	MBINDSE -3.7	Systems Biology and Network Analysis	3	09	20	80	100	08	32	3
	MBINSEC-1	Development of Biofertilizers and Biopesticides	2	06	10	40	50	04	16	$1^{1/2}$
		Total	**20**	**168**	**110**	**440**	**550**	**44**	**176**	-

Note: Out of the three Discipline Specific Electives (MBINDSE -3.5, MBINDSE -3.6, MBINDSE -3.7), students can choose any two.

Sem	Course Code	Course Title	Credits	Counseling/PCP Hours	Max. Marks			Minimum Passing marks		Duration of Exam (hours)
					Internal Assessment	Term end exam	Total Marks	Internal Assessment	Term end exam	
IV	MBINDSC-4.1	Machine Learning for Bioinformatics	4	12	20	80	100	08	32	3
	MBINDSC-4.2	Dissertation	6	18	20	80	100	08	32	-
	MBINDSC -4.3	Practical 7	2	60	10	40	50	04	16	3
	MBINDSC -4.4	Practical 8	2	60	10	40	50	04	16	3
	MBINDSE -4.5	Project Management and Scientific Communication	3	09	20	80	100	08	32	3
	MBINDSE -4.6	Genome to Drug and Vaccine	3	09	20	80	100	08	32	3
	MBINDSE -4.7	Laboratory Techniques in Modern Biology	3	09	20	80	100	08	32	3
	MBINSEC-2	Development of Biofertilizers and Biopesticides	2	06	10	40	50	04	16	$1^{1/2}$
		Total	**22**	**174**	**110**	**440**	**550**	**44**	**176**	-

Note: Out of the three Discipline Specific Electives (MBINDSE -4.5, MBINDSE -4.6, MBINDSE -4.7), students can choose any two. The Students shall study additional mandatory course, for which no assessment will be made

5. Notification: The University would notify its admission policy, financial assistance, delivery of the programme, academic planning and other details on the website of the University for the information of the learners.

(g) Requirement of the Laboratory Support and Library Resources:

(i) Laboratory Support: A well-equipped laboratory facility has been provided for high level performance. Besides, wherever required resources from other Universities/Institutes will be utilized through MOUs.

(ii) Library Resources: The University provides library facility by both traditional and digital means at the learner center with proper security. Further, state of the art library is placed in the headquarters.

(h) Cost estimate of the programme and the provisions:

The approximate cost estimate of the program: Rs. 90,00,000/- (Rs. Ninety lakhs only).

(i) Quality Assurance and Expected Programme Outcomes:

The quality will be maintained in the curriculum by taking the following measures:

1. Students feedback:-Students give formal feedback in the prescribed format on the content of the SLM at the term end. Students also give feedback on the lectures/practical classes delivered at the contact program/counselling.
2. Academic peers:- The senior faculty members in the concerned subject also review the study material and the practical manuals. Periodic workshops on the curriculum help enhancing the quality.
3. Academic audit: It promotes quality and standards. Faculty members will be updated in teaching and research through orientation programmes, refresher courses, seminars, workshops and conferences/symposium.
4. Feedback of the industrialists, employers, professionals also step up the quality and standard of the programme.
5. The editorial committee ensures the quality of the SLMs.
6. Academic audit programme.
7. Assessment and accreditation by agencies.
8. CIQA established ensures that the quality standards are met, maintained, and enhanced in all the academic and administrative services.

Expected Programme Outcomes:

1. Knowledge and understanding of the principles of bioinformatics, including genetics, genomics, proteomics, and related fields.
2. Proficiency in the use of various software tools and databases commonly used in bioinformatics research, including sequence analysis tools, data mining algorithms, and statistical analysis software.
3. Ability to design and conduct bioinformatics research projects, including experimental design, data analysis, and interpretation of results.
4. Understanding of the ethical and legal considerations related to bioinformatics research, including issues related to data privacy, intellectual property rights, and the use of animal and human subjects.
5. Proficiency in written and oral communication of scientific research findings, including the ability to write research reports, create presentations, and effectively communicate research results to diverse audiences.