10 YEARS OF UNIVERSITY RECOGNITION

20 YEARS OF ACADEMIC EXCELLENCE

REVA UNIVERSITY

Bengaluru, India

SCHOOL OF APPLIED SCIENCES

M.Sc. – BIOINFORMATICS

HANDBOOK: 2021-22

Rukmini Educational Charitable Trust

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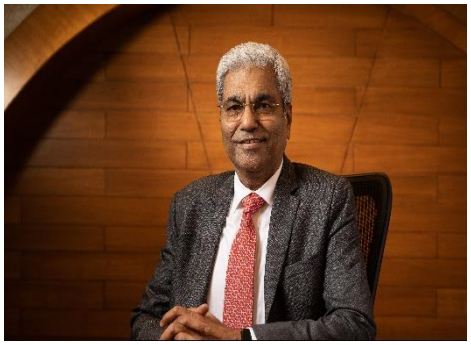
Chancellor's Message



"Education is the most powerful weapon which you can use to change the world."
- Nelson Mandela.

There was a time when survival depended on just the realization of physiological needs. We are indeed privileged to exist in a time when 'intellectual gratification' has become indispensable. Information is easily attainable for the soul that is curious enough to go look for it. Technological boons enable information availability anywhere anytime. The difference, however, lies between those who look for information and those who look for knowledge.

It is deemed virtuous to serve seekers of knowledge and as educators it is in the ethos at REVA University to empower every learner who chooses to enter our portals. Driven by our founding philosophy of 'Knowledge is power', we believe in building a community of perpetual learners by enabling them to look beyond their abilities and achieve what they assumed impossible.

India has always been beheld as a brewing pot of unbelievable talent, acute intellect, and immense potential. All it takes to turn those qualities into power is a spark of opportunity. Being at a University is an exciting and rewarding experience with opportunities to nurture abilities, challenge cognizance and gain competence. For any University, the structure of excellence lies in the transitional abilities of its faculty and its facility. I'm always in awe of the efforts that our academic board puts in to develop the team of subject matter experts at REVA. My faculty colleagues understand our core vision of empowering our future generation to be ethically, morally, and intellectually elite. They practice the art of teaching with a student-centered and transformational approach. The excellent infrastructure at the University, both educational and extra-curricular, magnificently demonstrates the importance of ambience in facilitating focused learning for our students.

A famous British politician and author from the 19th century - Benjamin Disraeli, once said 'A University should be a place of light, of liberty and of learning'. Centuries later this dictum still inspires me, and I believe, it takes teamwork to build successful institutions. I welcome you to REVA University to join hands in laying the foundation of your future with values, wisdom, and knowledge.

Dr. P. Shyama Raju
The Founder and Hon'ble Chancellor, REVA University

Vice-Chancellor's Message

The last two decades have seen a remarkable growth in higher education in India and across the globe. The move towards inter-disciplinary studies and interactive learning have opened several options as well as created multiple challenges. India is at a juncture where a huge population of young crowd is opting for higher education. With the tremendous growth of privatization of education in India, the major focus is on creating a platform for quality in knowledge enhancement and bridging the gap between academia and industry.

A strong believer and practitioner of the dictum "Knowledge is Power", REVA University has been on the path of delivering quality education by developing the young human resources on the foundation of ethical and moral values, while boosting their leadership qualities, research culture and innovative skills. Built on a sprawling 45 acres of green campus, this 'temple of learning' has excellent and state-of-the-art infrastructure facilities conducive to higher teaching-learning environment and research. The main objective of the University is to provide higher education of global standards and hence, all the programs are designed to meet international standards. Highly experienced and qualified faculty members, continuously engaged in the maintenance and enhancement of student-centric learning environment through innovative pedagogy, form the backbone of the University.

All the programs offered by REVA University follow the Choice Based Credit System (CBCS) with Outcome Based Approach. The flexibility in the curriculum has been designed with industry-specific goals in mind and the educator enjoys complete freedom to appropriate the syllabus by incorporating the latest knowledge and stimulating the creative minds of the students. Bench marked with the course of studies of various institutions of repute, our curriculum is extremely contemporary and is a culmination of efforts of great think-tanks - a large number of faculty members, experts from industries and research level organizations. The evaluation mechanism employs continuous assessment with grade point averages. We believe sincerely that it will meet the aspirations of all stakeholders – students, parents and the employers of the graduates and postgraduates of REVA University.

At REVA University, research, consultancy, and innovation are regarded as our pillars of success. Most of the faculty members of the University are involved in research by attracting funded projects from various research level organizations like DST, VGST, DBT, DRDO, AICTE and industries. The outcome of the research is passed on to students through live projects from industries. The entrepreneurial zeal of the students is encouraged and nurtured through EDPs and EACs.

REVA University has entered collaboration with many prominent industries to bridge the gap between industry and University. Regular visits to industries and mandatory internship with industries have helped our students become skilled with relevant to industry requirements. Structured training programs on soft-skills and preparatory training for competitive exams are offered here to make students more employable.

100% placement of eligible students speaks the effectiveness of these programs. The entrepreneurship development activities and establishment of "Technology Incubation Centers" in the University extend full support to the budding entrepreneurs to nurture their ideas and establish an enterprise.

With firm faith in the saying, "Intelligence plus character –that is the goal of education" (Martin Luther King, Jr.), I strongly believe REVA University is marching ahead in the right direction, providing a holistic education to the future generation, and playing a positive role in nation building. We reiterate our endeavor to provide premium quality education accessible to all and an environment for the growth of over-all personality development leading to generating "GLOBAL PROFESSIONALS".

Welcome to the portals of REVA University!

Dr. M. Dhanamjaya,
Vice-Chancellor, REVA University

Director Message

Bioinformatics is an interdisciplinary subject assimilates several disciplines and as such has grown rapidly. M Sc. in Bioinformatics offered by REVA University aims to provide the required skills and knowledge necessary to pursue a successful career in Bioinformatics. This program imparts need based, practical education in contemporary world to develop global competence among students. It strives to prepare students to become leaders in the field of Life Sciences in general and Bioinformatics by encouraging them to inculcate scientific thinking coupled with creative and innovative ideas.

The program provides hands- on training and practical skills in the field of Genomic data science, Programming in R & Python, Biostatistics, Data Mining and Artificial intelligence, big data analytics, Artificial Intelligence & Deep learning, Computational Drug Discovery, Pharmacogenomics, Agri genomics, Nutrigenomics, Metagenomics and Clinical genomics, Cloud based analytics, and web server & Database development, aligning to current demand in the field of industry& research. Maximum number of courses are integrated with cross cutting issues, relevance to professional ethics, gender, human values, environment and sustainability. The curriculum caters to and has relevance to local, national, regional and global developmental needs.

As far as employment is concerned Bioinformatics has become one of the fast-growing sectors. Employment record shows that bioinformatics has a great scope in future. Bioinformaticians can find careers with Life Science, Biopharmaceutical companies, chemical, agricultural, and allied companies, IT industries, molecular diagnostics, and hospitals. They can be employed in the areas of Bioinformatics, Genomics, Proteomics, Statistics, and IT industries in consultancy, services, planning, production, and management of industries. Further, there is great demand for bioinformatics experts in numerous industries and sectors after the completion of MSc Bioinformatics program.

This handbook provides you outline of regulations for master's degree, scheme of instruction, and detailed syllabus. I am sure the students choosing MSc Bioinformatics at REVA University will enjoy the curriculum, teaching and learning environment, the vast infrastructure and the experienced teacher's involvement and guidance. We will strive to provide all needed comfort and congenial environment for their studies. I wish all students a pleasant stay at REVA and grand success in their career.

Prof.Shilpa BR
Deputy Director, SoAS

RUKMINI EDUCATIONAL CHARITABLE TRUST

It was the dream of late Smt. Rukmini Shyama Raju to impart education to millions of underprivileged children as she knew the importance of education in the contemporary society. The dream of Smt. Rukmini Shyama Raju came true with the establishment of Rukmini Educational Charitable Trust (RECT), in the year 2002. **Rukmini Educational Charitable Trust** (RECT) is a Public Charitable Trust, set up in 2002 with the objective of promoting, establishing, and conducting academic activities in the fields of Arts, Architecture, Commerce, Education, Engineering, Environmental Science, Legal Studies, Management and Science & Technology, among others. In furtherance of these objectives, the Trust has set up the REVA Group of Educational Institutions comprising of REVA Institute of Technology & Management (RITM), REVA Institute of Science and Management (RISM), REVA Institute of Management Studies (RIMS), REVA Institute of Education (RIE), REVA First Grade College (RFGC), REVA Independent PU College at Kattigenahalli, Ganganagar and Sanjaynagar and now REVA University. Through these institutions, the Trust seeks to fulfill its vision of providing world class education and create abundant opportunities for the youth of this nation to excel in the areas of Arts, Architecture, Commerce, Education, Engineering, Environmental Science, Legal Studies, Management and Science & Technology.

Every great human enterprise is powered by the vision of one or more extraordinary individuals and is sustained by the people who derive their motivation from the founders. The Chairman of the Trust is Dr. P. Shyama Raju, a developer and builder of repute, a captain of the industry in his own right and the Chairman and Managing Director of the DivyaSree Group of companies. The idea of creating these top notched educational institutions was born of the philanthropic instincts of Dr. P. Shyama Raju to do public good, quite in keeping with his support to other socially relevant charities such as maintaining the Richmond Road Park, building, and donating a police station, gifting assets to organizations providing accident and trauma care, to name a few.

The Rukmini Educational Charitable Trust drives with the main aim to help students who are in pursuit of quality education for life. REVA is today a family of ten institutions providing education from PU to Post Graduation and Research leading to PhD degrees. REVA has well qualified experienced teaching faculty of whom majority are doctorates. The faculty is supported by committed administrative and technical staff. Over 13,000 students study various courses across REVA's three campuses equipped with exemplary state-of-the-art infrastructure and connective environment for the knowledge driven community.

ABOUT REVA UNIVERSITY

REVA University has been established under the REVA University Act, 2012 of Government of Karnataka and notified in Karnataka State Gazette No. 80 dated 27thFebruary, 2013. The University is empowered by UGC to award degrees any branch of knowledge under Sec.22 of the UGC Act. The University is a Member of Association of Indian Universities, New Delhi. The main objective of the University is to prepare students with knowledge, wisdom, and patriotism to face the global challenges and become the top leaders of the country and the globe in different fields.

REVA University located in between Kempegowda International Airport and Bangalore city, has a sprawling green campus spread over 45 acres of land and equipped with state-of-the-art infrastructure that provide conducive environment for higher learning and research. The REVA campus has well equipped laboratories, custom-built teaching facilities, fully air-conditioned library and central computer center, the well-planned sports facility with cricket ground, running track & variety of indoor and outdoor sports activities, facilities for cultural programs. The unique feature of REVA campus is the largest residential facility for students, faculty members and supportive staff.

REVA consistently ranked as one of the top universities in various categories because of the diverse community of international students and its teaching excellence in both theoretical and technical education in the fields of Engineering, Management, Law, Science, Commerce, Arts, Performing Arts, and Research Studies. REVA offers 28 Undergraduate Programmes, 22 Full-time and 2 Part-time Postgraduate Programmes, 18 Ph. D Programmes, and other Certificate/ Diploma/Postgraduate Diploma Programmes in various disciplines. The curriculum of each Programme is designed with a keen eye for detail by giving emphasis on hands-on training, industry relevance, social significance, and practical applications. The University offers world-class facilities and education that meets global standards.

The programs being offered by the REVA University are well planned and designed after detailed study with emphasis with knowledge assimilation, applications, global job market and their social relevance. Highly qualified, experienced faculty and scholars from reputed universities/institutions, experts from industries and business sectors have contributed in preparing the scheme of instruction and detailed curricula for this program. Greater emphasis on practice in respective areas and skill development to suit to respective job environment has been given while designing the curricula. The Choice Based Credit System and Continuous Assessment Graded Pattern (CBCS – CAGP) of education has been introduced in all programs to facilitate students to opt for subjects of their choice in addition to the core subjects of the study and prepare them with needed skills. The system also allows students to move forward under the fast track for those who have the capabilities to surpass others. These programs are taught by well experienced qualified faculty supported by the experts from industries, business sectors and such other organizations. REVA University has also initiated many supportive measures such as bridge courses, special coaching, remedial classes, etc., for slow learners to give them the needed input and build in them confidence and courage to move forward and accomplish success in their career. The University has also entered MOUs with many industries, business

firms and other institutions seeking their help in imparting quality education through practice, internship and assisting students' placements.

REVA University recognizing the fact that research, development, and innovation are the important functions of any university has established an independent Research and Innovation division headed by a senior professor as Dean of Research and Innovation. This division facilitates all faculty members and research scholars to undertake innovative research projects in engineering, science &technology, and other areas of study. The interdisciplinary-multidisciplinary research is given the topmost priority. The division continuously liaisons between various funding agencies, R&D Institutions, Industries, and faculty members of REVA University to facilitate undertaking innovative projects. It encourages student research projects by forming different research groups under the guidance of senior faculty members. Some of the core areas of research wherein our young faculty members are working include Genetics, Molecular Biology, Biotechnology, Biochemistry, Chemical Sciences, Synthetic chemistry, Nano chemistry, Nanotechnology, bioinformatics, Plant and Agricultural Research, Data Mining, Cloud Computing, Image Processing, Network Security, VLSI and Embedded Systems, Wireless Censor Networks, Computer Networks, IOT, MEMS, Nano- Electronics, Wireless Communications, Bio-fuels, Nano-technology for coatings, Composites, Vibration Energies, Electric Vehicles, Multilevel Inverter Application, Battery Management System, LED Lightings, Renewable Energy Sources and Active Filter, Innovative Concrete Reinforcement, Electro Chemical Synthesis, Energy Conversion Devices, Nano-structural Materials, Photo-electrochemical Hydrogen generation, Pesticide Residue Analysis, Nano materials, Photonics, Nana Tribology, Fuel Mechanics, Operation Research, Graph theory, Strategic Leadership and Innovative Entrepreneurship, Functional Development Management, Resource Management and Sustainable Development, Cyber Security, General Studies, Feminism, Computer Assisted Language Teaching, Culture Studies etc.

The REVA University has also given utmost importance to develop the much-required skills through variety of training programs, industrial practice, case studies and such other activities that induce the said skills among all students. A full-fledged Career Development and Placement (CDC) department with world class infrastructure, headed by a dynamic experienced Professor& Dean, and supported by well experienced Trainers, Counselors and Placement Officers. The University also has University-Industry Interaction and Skill Development Centre headed by a Senior Professor & Director facilitating skill related training to REVA students and other unemployed students. The University has been recognized as a Centre of Skill Development and Training by NSDC (National Skill Development Corporation) under Pradhan Mantri Kaushal Vikas Yojana. The Centre conducts several add-on courses in challenging areas of development. It is always active in facilitating student's variety of Skill Development Training programs.

The University has collaborations with Industries, universities abroad, research institutions, corporate training organizations, and Government agencies such as Florida International University, Oklahoma State University, Western Connecticut University, University of Alabama, Huntsville, Oracle India Ltd, Texas Instruments, Nokia University Relations, EMC2, VMware, SAP, Apollo etc., to facilitate student exchange and teacher–scholar exchange programs and conduct training programs. These collaborations with foreign universities also facilitate students to study some of the programs partly in REVA University and partly in

foreign university, viz, M.S in Computer Science one year in REVA University and the next year in the University of Alabama, Huntsville, USA.

The University has also given greater importance to quality in education, research, administration, and all activities of the university. Therefore, it has established an independent Internal Quality division headed by a senior professor as Dean of Internal Quality. The division works on planning, designing, and developing different quality tools, implementing them, and monitoring the implementation of these quality tools. It concentrates on training entire faculty to adopt the new tools and implement their use. The division further works on introducing various examination and administrative reforms.

To motivate the youth and transform them to become innovative entrepreneurs, successful leaders of tomorrow and committed citizens of the country, REVA organizes interaction between students and successful industrialists, entrepreneurs, scientists, and such others from time to time. As a part of this exercise great personalities such as Bharat Ratna Prof. C. N. R. Rao, a renowned Scientist, Dr. N R Narayana Murthy, Founder and Chairman and Mentor of Infosys, Dr. K Kasturirangan, Former Chairman ISRO, Member of Planning Commission, Government of India, Dr. Balaram, Former Director IISc., and noted Scientist, Dr. V S Ramamurthy, Former Secretary, DST, Government of India, Dr. V K Aatre, noted Scientist and former head of the DRDO and Scientific Advisor to the Ministry of Defence Dr. Sathish Reddy, Scientific Advisor, Ministry of Defence, New Delhi and many others have accepted our invitation and blessed our students and faculty members by their inspiring addresses and interaction.

As a part of our effort in motivating and inspiring youth of today, REVA University also has instituted awards and prizes to recognize the services of teachers, researchers, scientists, entrepreneurs, social workers, and such others who have contributed richly for the development of the society and progress of the country. One of such awards instituted by REVA University is **'Lifetime Achievement Award'** to be awarded to successful personalities who have made mark in their field of work. This award is presented on occasion of the "**Founders' Day Celebration"** of REVA University on 6th January of every year in presence of dignitaries, faculty members and students gathering. The first **"REVA Lifetime Achievement Award"** for the year 2015 has been awarded to Shri. Kiran Kumar, Chairman ISRO, followed by Shri. Shekhar Gupta, renowned Journalist for the year 2016, Dr K J Yesudas, renowned play back singer for the year 2017. REVA also introduced "REVA Award of Excellence" in the year 2017 and the first Awardee of this prestigious award is Shri Ramesh Aravind, Actor, Producer, Director, Screen Writer and Speaker.

REVA organizes various cultural programs to promote culture, tradition, ethical and moral values to our students. During such cultural events, the students are given opportunities to unfold their hidden talents and motivate them to contribute innovative ideas for the progress of the society. One of such cultural events is REVAMP conducted every year. The event not only gives opportunities to students of REVA but also students at other Universities and Colleges. During three days of this mega event students participate in debates, Quizzes, Group discussion, Seminars, exhibitions, and variety of cultural events. Another important event is Shubha Vidaaya, - Graduation Day for the final year students of all the programs, wherein, the

outgoing students are felicitated and are addressed by eminent personalities to take their future career in a right spirit, to be the good citizens and dedicate themselves to serve the society and make a mark in their respective spheres of activities. During this occasion, the students who have achieved top ranks and won medals and prizes in academic, cultural and sports activities are also recognized by distributing awards and prizes. The founders have also instituted medals and prizes for sports achievers every year. The physical education department conducts regular yoga class is every day to students, faculty members, administrative staff and their family members and organizes yoga camps for villagers around.

Vision

REVA University aspires to become an innovative university by developing excellent human resources with leadership qualities, ethical and moral values, research culture and innovative skills through higher education of global standards.

Mission

- To create excellent infrastructure facilities and state-of-the-art laboratories and incubation centres
- To provide student-centric learning environment through innovative pedagogy and education reforms
- To encourage research and entrepreneurship through collaborations and extension activities
- To promote industry-institute partnerships and share knowledge for innovation and development.
- To organize society development programs for knowledge enhancement in thrust areas
- To enhance leadership qualities among the youth and enrich personality traits, promote patriotism and moral values.

Objectives

- Creation, preservation and dissemination of knowledge and attainment of excellence in different disciplines
- Smooth transition from teacher - centric focus to learner - centric processes and activities
- Performing all the functions of interest to its major constituents like faculty, staff, students, and the society to reach leadership position.
- Developing a sense of ethics in the University and Community, making it conscious of its obligations to the society and the nation
- Accepting the challenges of globalization to offer high quality education and other services in a competitive manner.

ABOUT SCHOOL OF APPLIED SCIENCES

The School of Applied Sciences offers graduate and post graduate programs in Biotechnology, Biochemistry, Chemistry, Physics and Mathematics which are incredibly fascinating. It aims to attract talented youth and train them to acquire knowledge and skills useful to industrial sectors, research laboratories, and educational institutions. The school presently offers M.Sc. degree programs in Biochemistry, Biotechnology, Bioinformatics, Microbial Technology, Genetics, Chemistry, Physics, Mathematics and B Sc with various combinations viz, Physics Chemistry and Mathematics (PCM), Physics, Mathematics, and Statistics (PMSt), Mathematics, Statistics and Computer Science (MStCs), and Biology (Bioinformatics), Mathematics & Computer Science (BMCs)and Post Graduate Diploma in Clinical Research Management. The school also facilitates research leading to PhD in Biotechnology, Biochemistry, Physics, Chemistry, Mathematics, and related areas of study.

The School of Applied Sciences is shouldered by well qualified, experienced, and highly committed faculty. The state-of-the-art infrastructure digital classrooms, well equipped laboratories, conference rooms and the serene academic atmosphere at REVA University will enhance the transfer as well as creation of knowledge. The school provides an interactive, collaborative peer tutoring environment that encourages students to break down complex problems and develop strategies for finding solutions across a variety of situations and disciplines. The school aims to develop a learning community of critical thinkers who serves as models of innovative problems solving in the university environment to enrich their academic and professional careers.

Vision

To nurture intellect, creativity, character, professionalism, and research culture among students and impart contemporary knowledge in various branches of Chemical, Biological, Physical and Mathematical Sciences that are socially relevant and transform them to become global citizens with leadership qualities.

Mission

- To achieve excellence in studies and research through pedagogy and support interface between industry and academia
- To create intellectual curiosity, academic excellence, and integrity through multidimensional exposure
- To establish state of the art laboratories to support research and innovation and promote mastery of science.
- To inculcate an ethical attitude and make students competitive to serve the society and nation.

Board of Studies in Biotechnology (M.Sc. Bioinformatics)

S. No.	Name, Designation & Affiliation	External/ Internal Member
1	**Bony De Kumar** Genomics Core Manager, School of Medicine & Health Sciences, University of North Dakota, ND 58202-9037	International Academic Member
2	**Dr. Shailesh Kumar** Staff Scientist II, Bioinformatics Laboratory #202 NIPGR, New Delhi	Academic Member
3	**Dr. Mohammad Nasiruddin** Consultant and HOD – Clinical Genomics and Molecular Diagnostics, Anand Diagnostic Laboratory (A Neuberg Associate), Bangalore - 560001	Industry Member
4	**Anupam J Das** CEO and Co-founder, Molsys Pvt Ltd, Bangalore	Industry, Alumni Member
5	**Dr. Gaurav Sharma, PhD** DST-INSPIRE Faculty Scientist, Institute of Bioinformatics and Applied Biotechnology (IBAB), Electronic City, Bengaluru,	Academic Member

M.Sc. Bioinformatics Program Overview

Bioinformatics is the application of computer technology for the management and analysis of biological data. It includes collection, storage, retrieval, manipulation, and modelling of data for analysis, visualization, or prediction through algorithms and software. The global bioinformatics market is expected to account for USD 7,063.7 billion in 2018. It is expected to reach USD 13,901.5 billion by 2023, at a CAGR of 14.5% during the forecast period.

Growth of the bioinformatics market is driven by the growing demand for nucleic acid and protein sequencing, increasing government initiatives and funding, and increasing use of bioinformatics in drug discovery and biomarker development processes. With the introduction of upcoming technologies such as nanopore sequencing and cloud computing. However, factors such as a dearth of skilled personnel to ensure proper use of bioinformatics tools and lack of integration of a wide variety of data generated through various bioinformatics platforms are hindering to use skilled professionals.

Bioinformatics in clinical diagnostics sector includes analysis of human genome with reference to disease diagnosis. This involves study of various omics technologies such as proteomics, metabolomics, metagenomics, epigenetics, and transcriptomics. Data generated through different omics technologies has assisted in the development of bioinformatics methodologies for clinical research and for building human databases. These computational approaches are then used to understand information about the origin, evolution, progression, and treatment of diseases, leading to the development of personalized medicine. Increased use of bioinformatics tools by clinicians also contributes to growth of the bioinformatics market. The aim of the program is to produce postgraduates with – advanced knowledge and understanding of Bioinformatics tools and software's; higher order critical, analytical, problem solving and attitudinal skills (transferable) to meet expectations of biotech industry, academics, and research institutions or to take up entrepreneurial route.

MSc (Bioinformatics) Course at REVA University has been designed to meet the human resources needs of existing and futuristic biotech industries, biotech research organizations and academic institutions. This bioinformatics master's bridges the interfaces between genomics, computing and healthcare and aims to equip you with the skills to analyze, interpret and use biological data to inform and improve healthcare and health outcomes. At REVA University the Bioinformatics Programme focuses on the practical application of Bioinformatics. Depending on previous BSc degree, candidates are requested to follow supplementary introduction courses. Students with BSc in Computer Science follow courses in molecular biology and students with BSc in Life Science courses on programming and computer science. The curriculum commences with training in programming, data science and elementary bioinformatics tools aimed at using existing software to collect, analyze and interpret DNA and protein sequence information and moves on to more open challenges. Afterwards students follow Molecular Systems Biology. The Programme also provide sufficient skills and training on entrepreneurship development in Bioinformatics. The Programme deals with courses on Genomic data science, Programming in R and Python, Biostatistical Analysis, Omics

Technologies, Systems Biology, Big Data Analytics, Cloud computing, data mining and artificial intelligence, deep learning, and many other related courses.

Program Educational Objectives (PEOs)

After few years of graduation, the graduates will:

PEO-1	Equip students with analytical and problem-solving skills to develop new algorithms and tools related the domain of computational biology with an attitude of lifelong learning.
PEO-2	Develop an insight into scientific methodology, advances in bioinformatics research, professionalism, and ethical values.
PEO-3	Acquire skill sets required to become successful entrepreneurs and to establish consultancy services in accordance with current technology and trends.

Program Outcomes (POs)

PO1. Science knowledge: Demonstrate of the knowledge of bioinformatics for the solution of complex biological problems to understand the molecular functions of organism.

PO2. Problem analysis: Bioinformatics can solve some of the biological problems based on the gene identification, protein identification and structure prediction. Drug discovery to predict the exact drug to the disease targets and to produce some solutions on statistical interpretations.

PO3. Conduct investigations of complex problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO4. Modern tool usage: Bioinformatics always uses advanced tools, software's, or algorithms and to create advanced algorithms for product/process development which in turn benefit the society and lifelong learning.

PO5. Environment and sustainability: Understand and implement environmentally friendly approaches in Biopharmaceutical industries to support sustainable development.

PO6. Ethics: Apply ethical principles and commit to professional ethics, responsibilities, and norms in Life Sciences.

PO7. Individual and teamwork: Function effectively as an individual or team work to demonstrate and understand biological problems and manage projects in multidisciplinary and interdisciplinary research.

PO8. Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations and give and receive clear instructions.

PO9. Project management and finance: Demonstrate knowledge and understanding of Bioinformatics algorithms and data management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

PO10. Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

After successful completion of the programme, the graduates shall be able to

PSO1. An ability to integrate algorithms and statistical methods to understand biological data and necessary concepts of information technology.

PSO2. Manage health, medical, and bio-informatics information using best practices in data stewardship; data science and data analytics; and human-centered design and systems.

PSO3. Learn and utilize scripting languages in genomic data science algorithm development and pipeline design of a wide array of technical research skills.

REVA University Regulations for Choice Based Credit System (CBCS) and Continuous Assessment Grading Pattern (CAGP) for Postgraduate Degree programs- 2021-22

(Framed as per the provisions under Section 35 (ii), Section 7 (x) and Section 8 (xvi) & (xxi) of the REVA University Act, 2012)

1. Tie and Commencement:

1.1. These Regulations shall be called the **"REVA University Regulations for Choice Based Credit System (CBCS) and Continuous Assessment Grading Pattern (CAGP) for Post Graduate Degree Programs- 2021-22".**

1.2. These Regulations shall come into force from the date of assent of the Chancellor.

2. The Programs:

The following programs and all Graduate Degree programs to be instituted and introduced in REVA University in coming years shall follow these regulations.

M.Sc. in:

Biotechnology
Bioinformatics
Microbial Technology
Biochemistry
Chemistry
Physics
Mathematics

3. Definitions:

Course: Every course offered will have three components associated with the teaching-learning process of the course, namely:

(i) L= Lecture (ii) T= Tutorial (iii) P=Practice; where:

L stands for **Lecture** session consisting of classroom instruction.

T stands for **Tutorial** session consisting participatory discussion / self-study/ desk work/ brief seminar presentations by students and such other novel methods that make a student to absorb and assimilate more effectively the contents delivered in the Lecture classes.

P stands for **Practice** session, and it consists of Hands-on Experience / Laboratory Experiments / Field Studies / Case Studies that equip students to acquire the much-required skill component.

4. Courses of study and Credits

4.1 The study of various subjects in M. Sc., degree program is grouped under various courses. Each of these course carries credits which are based on the number of hours of teaching and learning.

4.1.1. In terms of credits, every **one-hour session of L amounts to 1 credit per Semester.**

In terms of credits, every **one-hour session of L amounts to 1 credit per Semester** and a minimum of **two-hour session of T or P amounts to 1 credit per Semester** over a period of one Semester of 16 weeks for teaching-learning process.

4.1.2. The total duration of a semester is 20 weeks inclusive of semester-end examination.

4.1.3. A course shall have either or all the four components. That means a course may have only lecture component, or only practical component or combination of any two or all the three components.

4.1.4. ***The concerned BoS will assign Credit Pattern for every course based on the requirement. However, generally, courses can be assigned with 1-4 Credits depending on the size of the course.***

4.1.5. Different **Courses of Study** are labelled and defined as follows:

Core Course:

A course which should compulsorily be studied by a candidate as a core-requirement is termed as a Core course. The CORE courses of Study are of THREE types, viz – (i) Hard Core Course, and (ii) Soft Core Course, (iii) Open Elective and Skill Enhancement Courses

a. Hard Core Course (HC):

The **Hard-Core Course** is a Core Course in the main branch of study and related branch(es) of study, if any that the candidates must complete compulsorily.

b. Soft Core Course (SC):

A Core course may be a **Soft Core** if there is a choice or an option for the candidate to choose a course from a pool of courses from the main branch of study or from a sister/related branch of study which supports the main branch of study.

c. Open Elective Course:

An elective course chosen generally from other discipline / related subject, with an intention to seek exposure to the related subjects other than the main discipline the student is studying is called an O**pen Elective Course.**

d. Skill Enhancement Course:

It is a Hard course to equip students with skill development certificate-based programs required as per the industry expectation. Candidate will seek exposure through workshops and other certificate-based courses.

e. Mandatory Course:

It is a mandatory course to equip students with skill sets required as per the industry expectation. Candidate will seek exposure through workshops and other certificate-based courses.

f. Project Work / Dissertation:

Project work / Dissertation work is a special course involving application of knowledge in solving / analysing /exploring a real-life situation / difficult problem. A project work carrying **FOUR or SIX** credits is called **Minor Project** work / **Dissertation.** A project work of **EIGHT, TEN, TWELVE or SIXTEEN** credits is called **Major Project** work / **Dissertation**. **A Project work may be a hard core, or a Soft Core as decided by the BoS / concerned.**

5. Eligibility for Admission:

5.1. The eligibility criteria for admission to Two Years master's degree Program (4 Semesters) is given below:

Bachelor's degree of three years with Biotechnology or any Life Science subject as one of the cognate / majors / optional subjects with 60% (40% in case of candidates belonging to SC/ST) of marks in aggregate from any recognized University / Institution or any other qualification recognized as equivalent there to.

5.2 Provided further that the eligibility criteria are subject to revision by the Government Statutory Bodies, such as UGC from time to time.

6. Scheme, Duration and Medium of Instructions:

6.1. M.Sc., degree program is of 4 semesters - 2 years' duration. A candidate can avail a maximum of 6 semesters (3 years) including blank semesters, if any to successfully complete M.Sc. degree. Whenever a candidate opts for blank semester, he/she must study the prevailing courses offered by the school when he/she resumes his/her studies.

6.2. The medium of instruction shall be English.

7. Credits and Credit Distribution

7.1. A candidate must earn 90 credits for successful completion of Two-Year Postgraduate degree with a distribution of credits for different courses as given in Table - 1 given below:

Table-1

Credits and Credit Distribution for Two Year Post Graduate degree program in sciences

Course Type	Credits for Two Year (4 Semesters) Post Graduate Degree Programs
Hard Core Course	A minimum of 60 but not exceeding 70
Soft Core Course	A minimum of 10 but not exceeding 30
Open Elective	A minimum of 4
SEC	A minimum of 2
Project/Dissertation	A minimum of 10
MOOC / Swayam/ Coursera/Soft Skill Training	A minimum of 4
Total	**90**

7.2. The concerned BOS based on the credits distribution pattern given above shall prescribe the credits to various types of courses and shall assign title to every course including project work, practical work, field work, self-study elective, as **Hard Core (HC) or Soft Core (SC) Open Elective (OE)**, **Mandatory Course (MC)** and **Skill Enhancement course (SEC)**.

7.3. Every course including project work, practical work, field work, self-study elective should be entitled as **Hard Core (HC) or Soft Core (SC) or Open Elective (OE), Mandatory Course (MC)** and **SEC (Skill Enhancement Course),** by the BoS concerned.

However, following shall be the

RULO (REVA Unique Learning Offerings) courses with credits mentioned against them, common to all branches of study. However, the BOS of respective program/ discipline shall decide about the total credits for RULO courses.

RULO Courses		
S. No.	**Course Title**	**Number of Credits**
1	MOOC / Swayam/ Coursera/Internship /Soft Skill Training	4
	Total	**4**

7.4. The concerned BOS shall specify the desired Program Objectives, Program Educational Objectives, Program Specific Outcomes and Course Outcomes while preparing the curriculum of a particular program.

7.5. A candidate can enrol for a maximum of 30 credits and a minimum of 20 credits per Semester. However, he / she may not successfully earn a maximum of 30 credits per semester. This maximum of 30 credits does not include the credits of courses carried forward by a candidate.

7.6. Only such full-time candidates who register for a minimum prescribed number of credits in each semester from I semester to IV semester and complete successfully 90 credits in 4 successive semesters shall be considered for declaration of Ranks, Medals, Prizes and are eligible to apply for Student Fellowship, Scholarship, Free ships, and such other rewards / advantages which could be applicable for all full-time students and for hostel facilities.

8. Add-on Proficiency Certification / Diploma:

8.1 Add- on Proficiency Certification:

To acquire Add on Proficiency Certification a candidate can opt to complete a minimum of 4 extra credits either in the same discipline /subject or in different discipline / subject in excess to 90 credits for the Two Year Post Graduate degree programs.

8.2 Add on Proficiency Diploma:

To acquire Add on Proficiency Diploma, a candidate can opt to complete a minimum of 18 extra credits either in the same discipline /subject or in different discipline / subject in excess to 90 credits for the Two Year Post Graduate degree programs.

The Add on Proficiency Certification / Diploma so issued to the candidate contains the courses studied and grades earned.

9. Assessment and Evaluation

a) Each course is assessed for a total weight of 100%. Out of the total 100% weight; 50% weight is for Continuous Internal Assessment (CIA or IA) and the remaining 50% for the Semester End Examination (SEE). This applicable for theory, laboratory, workshop, skill development and any such courses

b) Out of 50% weight earmarked for Internal Assessment (IA)- 15% for test-1, 15% for test-2 and 20% for Assignments and this is applicable for theory-based courses.

c). The tests and assignments are conducted as per the semester academic calendar provided by the University.

The details as given in the table.

Component	Description	Conduction	Weight Percentage
C1	Test-1: IA1	8th week from the starting date of semester	15
	Test-2: IA2	16th week from the starting date of semester	15
C2	1 Assignment	7th week	10
	2 Assignment	14th week	10
C3	SEE including practical	between 17th Week-20th Week	50
Results to be Announced			**By the end of 21st Week**

Note: IA or CIA includes C1 and C2

d). The assessment and evaluation procedure for integrated course with theory 4 credits and practical 2 credits that has been designed.

Theory: L: T: P: C - 4-0-0 (Total Contact Hours 4hrs)

Practical's: L: T: P: C - 0-0-2 (Total Contact Hours 3hrs)

Total semester end theory examination and practical examination marks will be scaled down to 50 The marks distribution is - IA1 +IA2 + SEE (Theory and practical) = 25+25+50=100.

e). Students are required to complete courses like technical skills, placement related courses, Open electives and any such value addition or specialized courses through online platforms like SWAYAM/NPTEL/Any other reputed online education aggregator. Students are required to choose the courses on the advice of their course coordinator/Director and required to submit the course completion certificate along with percentage of marks/grade scored in the assessment conducted by the online education aggregator. If the online education aggregator has issued a certificate along with the grade or marks scored to students, such courses will be considered for SGPA calculations, in case the aggregator has issued only a certificate and not marks scored, then such courses will be graded through an examination by concerned School, in case, if grading is not possible, students will be given a pass grade and award the credit and the credits will not be considered for SGPA calculations. The Online/MOOCs courses will not have continuous internal assessment component.

Such of those students who would like to discontinue with the open elective course that they have already registered for earning required credits can do so, however, they need to complete the required credits by choosing an alternative open elective course.

Setting question paper and evaluation of answer scripts.

i. For SEE, three sets of question papers shall be set for each theory course out of which two sets will be by the internal examiners and one set will be by an external examiner. In subsequent years by carrying forward the unused question papers, an overall three sets of question papers should be managed and depending on the consumption of question papers either internal or external examiner be called for setting the question paper to maintain an overall tally of 3 papers with the conditioned mentioned earlier. The internal examiner who sets the question paper should have been course tutor.

ii. The Chairman of BoE shall get the question papers set by internal and external examiners.

iii. The Board of Examiners shall scrutinize and approve the question papers and scheme of valuation. It is the responsibility of the BoE to see that all questions contained in the question paper are within the prescribed syllabus of the concerned course.

iv. There shall be single valuation for all theory papers by internal examiners. However, there shall be moderation by the external examiner who has the subject background. In case no external examiner with subject background is available, a senior faculty member within the discipline shall be appointed as moderator.

v. The SEE examination for Practical work / Field work / Project work/Internship will be conducted jointly by internal and external examiners as detailed below: However, the BoE on its discretion can also permit two internal examiners.

vi. If a course is fully of (L=0): T:(P=0) type or a course is partly P type i.e., (L=3): (T=0) (P=1), then the examination for SEE component will be as decided by the BoS concerned.

10. Evaluation of Practical's and Minor Project / Major Project / Dissertation

10.3.1. A practical examination shall be assessed based on:

a) Knowledge of relevant processes.

b) Skills and operations involved.

c) Results / products including calculation and reporting.

10.3.2. In case a course is fully of P type (L=0: T=0:P=4), the performance of a candidate shall be assessed for a maximum of 100 marks as explained below:

a). Continuous Internal assessment (CIA) = 50 marks

b). Semester end practical examination (SEE) = 50 marks

The 50 marks for continuous assessment shall further be allocated as under (IA or CIA):

i	Conduction of regular practical throughout the semester	20 marks
ii	Maintenance of lab records /industry reports/SDP reports	15 marks
iii	Laboratory test and viva	15 marks
	Total	50 marks

The 50 marks meant for Semester End Examination, shall be allocated as under:

i	Conduction of semester end practical examination	30 marks
ii	Write up about the experiment / practical conducted	10 marks
iii	Viva Voce	10 marks
	Total	50 marks

10.3.3. The SEE for Practical work will be conducted jointly by internal and external examiners. However, if external examiner does not turn up, then both the examiners will be internal examiners.

10.3.4. In case a course is partly P type i.e., (L=3): (T=0) (P=1), then the examination for SEE component will be as decided by the BoS concerned.

10.3.5. The duration for semester-end practical examination shall be decided by the concerned School

Board.

10.4. Evaluation of Minor Project / Major Project / Dissertation:

Right from the initial stage of defining the problem, the candidate must submit the progress reports periodically and present his/her progress in the form of seminars in addition to the regular discussion with the supervisor. At the end of the semester, the candidate must submit final report of the project / dissertation for final evaluation. The components of evaluation are as follows:

1	First Dissertation presentation describing the problem definition	Should be done a semester before the project semester	Weightage: 0%
2	Dissertation Progress presentation 1	7th week from the start date of project semester	Weightage: 25%
3	Dissertation progress presentation 2	14th Week from the start date of project semester	Weightage -25%
4	Final project Viva and Dissertation Submission	17th -20th Week of project Semester	Weightage: 30% for Dissertation Weightage: 20% for Final Viva Voce

11. Provision for Appeal

If a candidate is not satisfied with the evaluation of C1, C2 components, he/she can approach the grievance cell with the written submission together with all facts, the assignments, test papers etc, which were evaluated. He/she can do so before the commencement of semester-end examination. The grievance cell is empowered to revise the marks if the case is genuine and is also empowered to levy penalty as prescribed by the university on the candidate if his/her submission is found to be baseless and unduly motivated. This cell may recommend taking disciplinary/corrective action on an evaluator if he/she is found guilty. The decision taken by the grievance cell is final.

For every program there will be one grievance cell. The composition of the grievance cell is as follows: -

- The Controller of Examination - Ex-officio Chairman / Convener
- One Senior Faculty Member (other than those concerned with the evaluation of the course concerned) drawn from the school / department/discipline and/or from the sister schools / departments/sister disciplines – Member.
- One Senior Faculty Members / Subject Experts drawn from outside the University school / department – Member.

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12. Eligibility to Appear Semester End Examination (SEE)

12.1. Only those students who fulfil a minimum of 75% attendance in aggregate of all the courses including practical courses / field visits etc, as part of the course(s), as provided in the succeeding sections, shall be eligible to appear for SEE examination.

12.2. Requirements to Pass a Course

Students are required to score a total minimum of 40% (Continuous Internal assessment and SEE) in each course offered by the University/ Department for a pass (other than online courses) with a minimum of 20 (40% of 50) marks in final examination

13. Requirements to Pass the Semester

To pass the semester, a candidate must secure minimum of 40% marks in each subject / course of the study prescribed in that semester.

13.1 Provision to Carry Forward the Failed Subjects / Courses:

A student who has failed in a given number of courses in odd and even semesters of first year shall move to third semester of second and final year of the study. However, he / she shall have to clear all courses of all semesters within the double duration, i. e., within four years of admission of the first semester failing which the student has to re-register to the entire program.

13.2 Provision for Supplementary Examination

In case candidate fails to secure a minimum of 25% (13 marks) in Semester End Examination (SEE) and a minimum of 40% marks together with IA and SEE to declare pass in the course, such candidate shall seek supplementary examination of only such course(s) wherein his / her performance is declared unsuccessful. The supplementary examinations are conducted after the announcement of even semester examination results. The candidate who is unsuccessful in each course(s) shall appear for supplementary examination of odd and even semester course(s) to seek for improvement of the performance.

13.3. Provision to Withdraw Course:

A candidate can withdraw any course within ten days from the date of notification of results. Whenever a candidate withdraws a course, he/she must register for the same course in case it is hard core course, the same course, or an alternate course if it is Soft Core Course or Open Elective Course. A DROPPED course is automatically considered as a course withdrawn.

13.4. **Re-Registration and Re-Admission:**

a). In case a candidate's class attendance in aggregate of all courses in a semester is less than 75% or as stipulated by the University, such a candidate is considered as dropped the semester and is not allowed to appear for end semester examination (C3) and he / she shall have to seek re-admission to that semester during subsequent semester / year within a stipulated period.

b). In such case where in a candidate drops all the courses in a semester due to personal reasons, it is considered that the candidate has dropped the semester and he / she shall seek re-admission to such dropped semester.

14. Attendance Requirement:

14.1 All students must attend every lecture, tutorial and practical classes.

14.2 In case a student is on approved leave of absence (e g: - representing the university in sports, games or athletics, placement activities, NCC, NSS activities and such others) and / or any other such contingencies

like medical emergencies, the attendance requirement shall be minimum of 75% of the classes taught.

a) Any student with less than 75% of attendance in aggregate of all the courses including practical courses / field visits etc., during a semester shall not be permitted to appear to the end semester (C4) examination and such student shall seek re-admission as provided in 7.8.4.

b) Teachers offering the courses will place the above details in the School Board meeting during the last week of the semester, before the commencement of C3, and subsequently a notification pertaining to the above will be brought out by the Director of the School before the commencement of C3 examination. A copy of this notification shall also be sent to the office of the Registrar &Controller of Examination.

15. Absence during Mid Semester Examination:

In case a student has been absent from a mid-semester (C1, C2) examination due to the illness or other contingencies he / she may give a request along with necessary supporting documents and certification from the concerned class teacher / authorized personnel to the concerned Head of the School, for make-up examination. The Head of the School may consider such request depending on the merit of the case and after consultation with course instructor and class teacher and arrange to conduct a special test for such candidate(s) well in advance before the C3 examination of that respective semester. Under no circumstances C1, C2 test shall be held after C3 examination.

16. Grade Card and Grade Point

16.1. Provisional Grade Card: The tentative / provisional grade card will be issued by the Controller of Examination at the end of every semester indicating the courses completed successfully. The provisional grade card provides **Semester Grade Point Average** (SGPA).

16.2. Final Grade Card: Upon successful completion of M.Sc., Degree a Final Grade card consisting of grades of all courses successfully completed by the candidate will be issued by the Controller of Examination.

16.3. The Grade and the Grade Point: The Grade and the Grade Point earned by the candidate in the subject will be as given below.

Marks P	**Grade G**	**Grade Point (GP=V x G)**	**Letter Grade**
90 -100	10	v*10	O
80 - 89	9	v*9	A+
70 - 79	8	v*8	A
60 - 69	7	v*7	B+
55 -59	6	v*6	B
50 - 54	5.5	V*5.5	C +
40 -49	5	v*5	P
0 - 39	0	v*0	F
ABSENT			AB

O - Outstanding; A+-Excellent; A-Very Good; B+-Good; B-Above Average; C+-Average; C-Satisfactory; F – Unsatisfactory.

Here, P is the percentage of marks (P=[C1+C2+C3]) secured by a candidate in a course which is **rounded to nearest integer**. V is the credit value of course. G is the grade and GP is the grade point.

16.3.1. Computation of SGPA and CGPA

The Following procedure to compute the Semester Grade Point Average (SGPA)

The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student in each semester, i.e.:

SGPA (Si) = ∑ (Ci x Gi) / ∑Ci where Ci is the number of credits of the ith course and Gi is the grade point scored by the student in the ith course.

Illustration for Computation of SGPA and CGPA

Illustration No. 1

Course	Credit	Grade Letter	Grade Point	Credit Point (Credit x Grade)
Course 1	4	A+	9	4X9=36
Course 2	4	A	8	4X8=32
Course 3	3	B+	7	3X7=21
Course 4	3	O	10	3X10=30
Course 5	3	P	5	3X5=15
Course 6	3	B	6	3X6=18
Course 7	2	O	10	2X10=20
Course 8	2	A	8	2X8=16
	24			188

Thus, **SGPA = 188 ÷ 24 = 7.83**

Illustration No. 2

Course	Credit	Grade letter	Grade Point	Credit Point (Credit x Grade point)
Course 1	4	A	8	4X8=32
Course 2	4	B+	7	4X7=28
Course 3	3	A+	9	3X9=27
Course 4	3	B+	7	3X7=21
Course 5	3	B	6	3X6=18
Course 6	3	P	5	3X5=15
Course 7	2	B+	7	2X7=21
Course 8	2	O	10	2X10=20
	24			175

Thus, **SGPA = 175 ÷ 24 = 7.29**

Illustration No.3

Course	Credit	Grade Letter	Grade Point	Credit Point (Credit x Grade point)
Course 1	4	O	10	4 x 10 = 40
Course 2	4	A+	9	4 x 9 = 36
Course 3	3	B+	7	3 x 7 = 21
Course 4	3	B	6	3 x 6 = 18

Course 5	3	A+	9	3 x 9 = 27
Course 6	3	B+	7	3 x 7 = 21
Course 7	2	A+	9	2 x 9 = 18
Course 8	2	A+	9	2 x 9 = 18
	24			199

Thus**, SGPA = 199 ÷ 24 = 8.29**

Cumulative Grade Point Average (CGPA):

Overall Cumulative Grade Point Average (CGPA) of a candidate after successful completion of the required number of credits (96) for Two Year Post Graduate degree program is calculated considering all the courses undergone by a student over all the semesters of a program i. e.,

$CGPA = \sum (Ci \times Si) / \sum Ci$

Where Si is the SGPA of the ith semester and Ci is the total number of credits in that semester.

The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

Illustration: No.1

CGPA after Final Semester

Semester (ith)	No. of Credits (Ci)	SGPA (Si)	Credits x SGPA (Ci X Si)
1	24	6.83	24 x 6.83 = 163.92
2	26	7.71	26 x 7.71 = 200.46
3	26	8.68	26 x 8.68 = 225.68
4	14	9.20	14 x 9.20 = 128.8
Cumulative	90		718.86

Thus, CGPA = $\frac{24x6.83+26x7.71+26x8.68+14x9.20}{90} = \frac{718.86}{90} =$ 7.99

16.3.2. CONVERSION OF GRADES INTO PERCENTAGE:

Conversion formula for the conversion of CGPA into Percentage is:

Percentage of marks scored = CGPA Earned x 10

Illustration: CGPA Earned 8.10 x 10=81.0

16.3.3. Classification of Results

The final grade point (FGP) to be awarded to the student is based on CGPA secured by the candidate and is given as follows.

CGPA	Grade (Numerical Index) G	Letter Grade	Performance	FGP Qualitative Index
9 >= CGPA 10	10	O	Outstanding	Distinction
8 >= CGPA < 9	9	A+	Excellent	
7 >= CGPA < 8	8	A	Very Good	First Class
6 >= CGPA < 7	7	B+	Good	
5.5> = CGPA < 6	6	B	Above average	Second Class
> 5 CGPA < 5.5	5.5	C	Average	
> 4 CGPA <5	5	P	Pass	Satisfactory

Overall percentage=10*CGPA

17. Challenge Valuation

For all PG courses since it is a double valuation (Internal and External Examiners), candidate shall not have an option to apply for challenge valuation.

Mapping of PEOS with Respect to POs and PSOs

	PO1	P2	PO3	PO4	PO5	PO6	P7	PO8	PO9	PO10	PSO1	PSO2	PSO3
PEO1	√	√	√	√	√	√	√	√	√	√	√	√	√
PEO2	√	√	√	√	√	√	√	√	√	√	√	√	√
PEO3	√	√	√	√	√	√	√	√	√	√	√	√	√

Mapping of Course Outcomes with programme Outcomes

Course Code	**PO/ CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO3
M21SK0101	CO1	2	3	2					3		3	3	3	2
	CO2	2	3	2	2				3		3	3	3	3
	CO3	3	3						2		3	3	3	2
	CO4	2	3	2					2		3	3	3	2
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0102	CO1	2	2	3	2		1	1		1	1	2	1	1
	CO2	1	3	3	1		1		1	3	1	3	1	1
	CO3		2	3	1			1	1	1	2	2	1	3
	CO4	1	1	3				1	1	2	1	2	1	3
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0103	CO1	3	2	3							2	3	2	3
	CO2	3	2	3								3	3	`1
	CO3	2	3	3	3		3	2	2	2	1	3	3	3
	CO4	2	3	2	3		2				1	3	3	2
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0104	CO1	3	3	2	1				1	2	2	2	2	3
	CO2	2	3	3	2	1	1	1	1	2	2	1	1	3
	CO3	2	3	3	2	1	1	1	1	2	2	1	1	3
	CO4	2	2	3	3	1	1	1	1	2	2	2	1	3
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SKS111	CO1	3	3	2	2				1	1	2	3	2	2
	CO2	2	2	3	3					1	2	2	2	2
	CO3	2	3	2	2	2	1		2	2	3	3	3	3
	CO4	3	3	3	2	2	1	2	2	2	3	3	2	2
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SKS112	CO1	2	3	3	2						2	3	3	3
	CO2	2	3	2	3			2	3		3	3	3	3
	CO3	3	2	2		2	3	3	2		3	3	3	3
	CO4	3	3	2			2				3	3	2	3
M21SKS121	CO1	3	3	1	3							3	3	3
	CO2	1	3	2	3		2	1	2	1	1	3	3	1
	CO3	2	3	3	2	1			1	1	1	3	3	3

	CO4	3	3	2	2			1	1	1		2	3	2
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SKS122	CO1	2	2	3					3		3	3	3	3
	CO2	2	2	2			2	2	3		3	3	3	2
	CO3	2	2	3					3		3	3	3	3
	CO4	2	2	2	3			2	3		3	3	3	3
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0105	CO1	2	3	2	3		3				3	3	3	3
	CO2	2	3	3	3			3			3	3	3	3
	CO3	2	2	3			3				3	3	3	3
	CO4	2	3	2	3		3	3			3	3	3	3
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0106	CO1	2	2	3	3							1	2	2
	CO2	2	3	3	3	2		3				3	2	2
	CO3	2	2	3	3			3				3	2	2
	CO4	2	3	3	3					3	3	3	2	2
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0201	CO1	2	2	2	1	1			1	2		2	1	3
	CO2	2	2	3	1	1	2	1	1	2	1	2	1	2
	CO3	2	1	3		1				1	1	2	2	
	CO4	1	3	2	1	1		1	1	2	1	2	1	1
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0202	CO1	2	3	3			3		3		3	3	3	3
	CO2	2	2	3	3				3		3	3	3	3
	CO3	2	3	3	3		3		3		3	3	3	3
	CO4	2	2	3	3	2	3	3	3		3	3	3	
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0203	CO1	3	2	2	3	1				3	2	3	2	3
	CO2	1	2	3	3		1		3	2	1	3	3	1
	CO3	2	3	2	1				1	3	3	3	3	3
	CO4	3	3	3	2	1	1		2	3	1	3	3	3
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0204	CO1	2	3	3	2	2	2	2	3	3	2	2	2	1
	CO2	2	3	3	2	2	2	2	3	3	2	2	3	3
	CO3	3	3	3		2	3	2			3	1	1	1
	CO4	2	3	3	2	2	2	2	3	3	2	2	3	3
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SKS211	CO1	2	3	3					2		3	2		2
	CO2	2	3	3	3				2		3	3	2	2
	CO3	2	3	3		2			2		3	3	2	2
	CO4	2	3	3					2		3	3	2	2

Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SKS212	CO1	2	3	3					2		3	3	1	2
	CO2	2	3	3	3				2		3	2	2	2
	CO3	2	3	3		2			2		3	3	2	2
	CO4	2	3	3					2		3	3	2	2
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SKS221	CO1	2	3	2	3	3	3	3				1	2	2
	CO2	2	3	3	3				2	2	1		3	2
	CO3	3			3	3		2		2			2	3
	CO4	3	3	3	3							3	3	2
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SKS222	CO1	3					2				1	3	3	
	CO2	2	3	3	2			1	2		1	3	3	2
	CO3	3	2	3	3	1	3	2	1	2	1	3	2	
	CO4	3	3	3	1	2	2		3	2	1	3	3	1
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0205	CO1	2	2	2	2	2	1	2	3	3	3	3	1	
	CO2	1	1	3	2	2	1	3	3	3	3	3	1	1
	CO3	2	2	1	2	2		1	2	3	3	1	1	
	CO4	1	2	1	1	2	1	3	2	3	3	3		
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0206	CO1	2	2		3						3	3	2	2
	CO2		3	3							3	3	2	2
	CO3			3	3		2			3		3	2	2
	CO4			3	3			3		3	3	3	2	2
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0301	CO1	1	2	1	1	1			3		3	2	1	2
	CO2	2	3	2	3	2			3		3	3	2	2
	CO3	2	3	3	3	2			3		3	3	2	2
	CO4	2	3	3	3	2			3		3	3	2	2
M21SK0302	CO1	1	2	3	3							2		
	CO2	1	3	3	3	2		3	3	3	3	3	2	2
	CO3	2	3	3	3	2						3	2	2
	CO4	2	2	3	3	2		3	3	3	3	3	2	2
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0303	CO1	2	2	3	3							2		2
	CO2	2	3	3	3	2		3	3	3	3	3	2	2
	CO3	2	2	1	1			2	2	3	1		1	2
	CO4	1	2	3				2	3	3	2			3
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SKS311	CO1	2	2	2	1	2	1	3	2	3	3	3		1
	CO2	2	2	3	1	2		2	2	3	3	2	1	2

	CO3	2	2	3	3	2		1	2	3	2	1	1	3
	CO4		1	2	3	2	1	2	3	3	1	2		1
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SKS312	CO1	2	3	2	3	3			2	2			3	2
	CO2	2	3	3	3	3	3				1		2	3
	CO3	3	3	3	3	3							2	3
	CO4	3	3	3	3			2	2	1			3	3
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SKS321	CO1	2	2	2	1	2	1	2	2	3	3	2		1
	CO2	1	2	2	2	2		2	3	3	3	3	1	2
	CO3	1	2	1		1		1	1		1	1		
	CO4	1	3	3		2		1	1	1	1	1		1
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SKS322	CO1	2	2	2	1	2	1	2	2	3	3	2		1
	CO2	1	2	2	2	2		2	3	3	3	3	1	2
	CO3	1	2	1		1		1	1		1	1		
	CO4	1	3	3		2		1	1	1	1	1		1
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SLO301	CO1	2	2	2	1	2	1	2	2	3	3	2		1
	CO2	1	2	2	2	2		2	3	3	3	3	1	2
	CO3	1	2	1		1		1	1		1	1		3
	CO4	1	3	3		2		1	1	1	1	1		1
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0304	CO1	2	3	3	3	2		3				3	3	2
	CO2	3	2	3								2	2	3
	CO3	3	2	3	3			3		3	3	3	3	2
	CO4	2	3	3	3			3				3	3	3
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0305	CO1	2	2	2	1	2	1	2	2	3	3	2		1
	CO2	1	2	2	2	2		2	3	3	3	3	1	2
	CO3	1	2	1		1		1	1		1	1		
	CO4	1	3	3		2		1	1	1	1	1		1
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0306	CO1	2	2	2	1	2	1	2	2	3	3	2	2	1
	CO2	1	2	2	2	2		2	3	3	3	3	1	2
	CO3	1	2	1		1		1	1		1	1	2	
	CO4	1	3	3		2		1	1	1	1	1	2	1
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SK0401	CO1	2	3	3	3							3	2	2
	CO2	2	2	3	3	3	3					2	3	2
	CO3	2	2	3	3	3	3		3	3	3	3	3	3
	CO4	3	3	3	3	3	3	3	3	3	3	3	3	3

Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SKON01	CO1	2	2	3			3					1	3	3
	CO2	3	2	3								1	3	3
	CO3	3	3	3							3	1	2	3
	CO4	3	3	3							3	1	2	3
Course Code	**PO / CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PS01	PS02	PS03
M21SKON02	CO1	2	2	3			3					1	2	3
	CO2	3	2	3								1	2	3
	CO3	3	3	3							3	1	2	3
	CO4	3	3	3							3	1		3

M.Sc. (Bioinformatics) Program

Scheme of Instruction (effective from Academic Year 2021-22)

S. No	Course code	Course title	HC/ SC	L	T	P	C	Hours/ Week
FIRST SEMESTER								
1	M21SK0101	Introduction to Genomic Data Science	HC	4	0	0	4	4
2	M21SK0102	Introduction to R Programming	HC	4	0	0	4	4
3	M21SK0103	Programming in Python	HC	4	0	0	4	4
4	M21SK0104	Fundamentals of Biostatistics	HC	4	0	0	4	4
5	M21SKS111	Genetic Diseases & Counselling	SC	4	0	0	4	4
	M21SKS112	Biological Pathways						
6	M21SKS121	Fundamental of Computer & Networking	SC	2	0	0	2	2
	M21SKS122	Biology of Prokaryotic & Eukaryotic Organisms						
	Practical Courses							
7	M21SK0105	Fundamentals of Genomic Data Science	HC	0	0	2	2	4
8	M21SK0106	R & Python Programming	HC	0	0	2	2	4
Total credits				**22**	**0**	**4**	**26**	**30**
Note: Industrial visits will be organized to Public/Private Sectors in Bengaluru.								
S. No	**Course code**	**Course title**	**HC/ SC/ SEC**	**L**	**T**	**P**	**C**	**Hours/ Week**
SECOND SEMESTER								
1	M21SK0201	Advanced Genomic Data Science	HC	4	0	0	4	4
2	M21SK0202	Big Data Analytics	HC	4	0	0	4	4
3	M21SK0203	Advanced R & Python Programming	HC	4	0	0	4	4
4	M21SK0204	Research methodology & IPR	HC	4	0	0	4	4
5	M21SKS211	Web server & Database Development	SC	2	0	0	2	2
	M21SKS212	Advanced Web based technology						
6	M21SKS221	Genetics & Epigenetics	SC	2	0	0	2	2
	M21SKS222	Cloud Based Analytics						
	Practical courses							
8	M21SK0205	Advanced Genome Data Science	HC	0	0	2	2	4
9	M21SK0206	Research methodology & Programming	HC	0	0	2	2	4
Total credits				**20**	**0**	**4**	**24**	**28**
Industrial visits will be organized to Public/Private Sectors in Bengaluru.								
S. No	**Course code**	**Course title**	**HC/ SC/ OE**	**L**	**T**	**P**	**C**	**Hours/ Week**
THIRD SEMESTER								
1	M21SK0301	Artificial Intelligence & Deep learning Techniques	HC	4	0	0	4	4
2	M21SK0302	Integrated Omics	HC	4	0	0	4	4
3	M21SK0303	Computational Drug Discovery	HC	4	0	0	4	4
4	M21SKS311	Clinical & Pharmacogenomics	SC	2	0	0	2	2
	M21SKS312	Nutrigenomics & Agri genomics						

5	M21SKS321	Metagenomics	SC	2	0	0	2	2
	M21SKS322	AI based tool Development						
6	M21SLO301	Organic Farming	OE	4	0	0	4	2
7	M21SK0304	Skill enhancement course	HC	2	0	0	2	2
8	M21PTM301	Soft Skill Training (Common)	MC	3	0	0	0	3
		Practical Courses						
9	M21SK0305	Artificial Intelligence & Omics	HC	0	0	2	2	4
10	M21SK0306	Computational Drug Discovery	HC	0	0	2	2	4
Total Credits				**25**	**0**	**4**	**26**	**31**
Industrial visits will be organized to Public/Private Sectors in Bengaluru.								
S. No	**Course code**	**Course title**	**HC/ SC/ OE**	**L**	**T**	**P**	**C**	**Hours/ Week**
FOURTH SEMESTER								
1	M21SK0401	Industrial Project/ Internship	HC	0	0	10	10	10
2	M21SKON01	MOOC/SWAYAM/ Other -1	-	0	0	0	2	-
3	M21SKON02	MOOC/SWAYAM/ Other -2	-	0	0	0	2	-
Total Credits				**0**	**0**	**10**	**14**	**10**

Semester-wise Summary of Credit Distribution

Semester	**L**	**T**	**P**	**Credits**
First	22	-	4	26
Second	20	-	4	24
Third	25	-	4	26
Fourth	-	-	10	14
Total				**90**

Distribution of Credits Based on Type of Courses

Semester	**Hard Core (HC)**	**Soft Core (SC)**	**Open Elective (OE)**	**SEC**	**Total Credits**
First	20	6	0	-	26
Second	20	4	-	-	24
Third	20	6	4	0	26
Fourth	8	4	-	-	12
Total	64	20	4	2	90

M.Sc. (Bioinformatics) Program
Detailed Syllabus
(Effective from Academic Year 2021-22)

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0101	**INTRODUCTION TO GENOMICS DATA SCIENCE**	HC	4	0	0	4	4

Prerequisites/Pre reading for the course:

Basic molecular biology, genetics and statistical information is essential to understand genomics.

Course objectives

The overall objectives of the course are:

1. The course is mainly focused on the Understanding genetics and genomic concepts.
2. Explore genomic techniques and genomic data types from healthcare and agriculture.
3. Access and utilize high performance computing resources to carry out genomics analysis to problem solving in real research problems.
4. The students will become familiar with the use of a wide range of genomic algorithms and pipelines.

Course outcomes

After completing the course, the student should be able to:

1. The students are more familiar about the genome sequencing and library preparation protocols.
2. The student has broad knowledge on genomic data analysis tools and software's.
3. Student can analyze the genomic data and interpretation of data based on healthcare and agriculture resources.
4. Problem-solving skills, including the ability to develop new algorithms and analysis methods.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	3	2					3		3	3	3	2
CO2	2	3	2	2				3		3	3	3	3
CO3	3	3						2		3	3	3	2
CO4	2	3	2					2		3	3	3	2

Course content

Unit-I: Biological Databases **13 hours**

Biological data types and its classification, sequence and structure file formats, data mining. Nucleic Acid Databases: DNA, RNA, Protein databases: Protein sequence, Protein Structure, Protein interaction, protein expression databases; Gene Expression Database, Phenotypic databases; Disease databases, signaling pathway and metabolic pathway databases; Plant Genome databases, Microbial Genome databases.

Unit-II: Genome Overview **13 hours**

Genomes, Transcriptome and Proteomes, The Human Genome, why is the Human Genome Project Important? Genome Anatomies, an Overview, the Anatomy of the Eukaryotic and Prokaryotic Genome, the

Repetitive DNA Content of Genomes. How genes work, Gene-protein relations, Genetic fine structure, Mutational sites Complementation, Genome Mapping, Sequencing of Genomes and Applications.

Unit-III: Genome Sequencing Technologies **13 hours**

DNA Sequencing, First generation DNA sequences, Drawbacks of the first-generation sequencing methods. Next generation Sequencing (NGS): Emergence of NGS, 454 Pyrosequencing, Illumina Genome Analyzer, Applied Biosystems Sequencing, Ion Torrent Sequencing, Polonator Technology, Nanopore Sequencing, Single Molecule Real Time DNA sequencing, Comparison of Next generation sequencing techniques, Drawbacks of NGS, NGS File formats & applications.

Unit-IV: Genomic Data Analysis **13 hours**

Genomic sequencing: Data storage in SRA and ENA databases, pre-processing of raw sequence reads quality analysis, adaptor removal, trimming, Denovo Genome sequence assembly, Reference sequence assembly, and Challenges of Genome assembly, Aligning of NGS Sequencing reads, SNP and InDel detection, Annotation of Sequence Variation, and functional prediction.

Reference books

1. Richard Durbin, Sean R. Eddy, Anders Krogh, Graeme Mitchison. **"Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acid"**, Cambridge University Press, 1999.
2. Ju Han Kim. **"Genome Data Analysis",** Springer Singapore, 2019.
3. Ali Masoudi-Nejad, Zahra Narimani, Nazanin Hosseinkhan. **"Next Generation Sequencing and Sequence Assembly", Methodologies and Algorithms,** Springer; 2013.
4. Stuart M. Brown, **"Next-Generation DNA Sequencing Informatics",** Cold Spring Harbor Laboratory Press, 2013.
5. Y. M. Kwon and S. C. Ricke; **"High Throughput Next Generation Sequencing: Methods and Applications"**, Humana Press; 2011.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0102	**INTRODUCTION TO R PROGRAMMING**	HC	4	0	0	4	4

Prerequisites/Pre reading for the course:

Basic knowledge on statistics and computer operating is required to understand R programming.

Course Objectives

1. The course is mainly focused on the Understanding biological data types and file structures.
2. Emphasize on data analysis algorithms and pipelines to predict data structures and analysis methods.
3. The course also helps to understand the R programming techniques to analyze the statistical data.
4. The course also helps to create algorithms using R program to data analytics.

Course Outcome

By the end of the course the student will be able to:

1. The students are more familiar about the statistics and analyze using R program.
2. Understand the statistical properties of data & how to implement hypothesis testing.
3. Implement statistical solutions using the R statistics software ecosystem.
4. Knowledge and awareness of descriptive statistics to analyze various industrial applications.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	3	2		1	1		1	1	2	1	1
CO2	1	3	3	1		1		1	3	1	3	1	1
CO3		2	3	1			1	1	1	2	2	1	3
CO4	1	1	3				1	1	2	1	2	1	3

Course content

Unit-I: R Basics **13 hours**

Introduction to R, Scope and objectives of R, Applications of R, R Environment, Installing R, Running the R Program, CRAN, Command Packages, Get Packages of R commands, Running and Manipulating Packages, R Nuts and Bolts: Entering input, Evaluation, R objects, Numbers, Attributes, Creating Vectors, Mixing Objects, Explicit Coercion, Matrices, Lists, Factors, Missing Values, Data frames, Names.

Unit-II: Data Manipulation in R **13 hours**

Data sorting, Find and remove duplicates record, cleaning data, recoding data, merging data, Slicing of Data, Merging Data, apply functions, Manipulating Objects: Viewing Objects within objects, Constructing Data Objects, Forms of Data Objects: Testing and Converting.

Unit-III: Descriptive Statistics and Tabulation **13 hours**

Statistics for Vectors: Commands with single and multiple values, cumulative statistics, Statistics for Data frames, Summary Tables: Making contingency tables. Simple Hypothesis testing: Student t-test, U-Test, Paired t and U-test, Correlation and covariance, Tests for Association: Chi-squared test, Monte Carlo Simulation.

Unit-IV: Graphical Analysis

Introduction to R Graphics, creating high-quality graphics in R, visualizing data in 1D, 2D and more than two dimensions, Scatter plots, Line plots, Bar pots, Pie charts, Heat maps, Venn Diagrams, Intersect Plots, Histograms, Density plots, Box plots, ROC plots, data transformations, Graphics with R and ggplots.

Reference Books

1. Dr. Mark Gardener. **"Beginning R: The Statistical Programming Language",** John Wiley & Sons, Inc. 2012.
2. Roger D. Peng. **"R Programming for Data Science"**, Lean Publishing process, 2018.
3. David Dietrich, Barry Heller, Beibei Yang. **Data Science & Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data**. John Wiley & Sons, Inc, 2015.
4. Rafael A. Irizarry. **"Introduction to Data Science: Data Analysis and Prediction Algorithms with R"**. HarvardX Data Science Series, 2019.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0103	**PROGRAMMING IN PYTHON**	HC	4	0	0	4	4

Prerequisites/Pre reading for the course:

Basic knowledge on statistics and computer operating is required to understand python programming.

Course Objectives

1. The course is mainly focused basic Python programming and command usage.
2. The course is also aiming to provide bioinformatics applications and data science.
3. The course is also introducing the detailed programming to read sequences and structures.
4. The Biopython also has wide range of applications in the data science and algorithm development in genomic science.

Course Outcome

By the end of the course the student will be able to:

1. The students will have a python commands, objects, and data structures.
2. The students will be able to develop algorithms using python programming to solve biological datasets.
3. The students can use numerical algorithms to analyze big data using python.
4. Students can be able to develop bioinformatic algorithms, tools, and software's.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	3							2	3	2	3
CO2	3	2	3								3	3	`1
CO3	2	3	3	3		3	2	2	2	1	3	3	3
CO4	2	3	2	3		2				1	3	3	2

Course content

Unit-I: Introduction to Python **13 hours**

Introduction, why python? brief history, Python programming, environment and environment setup, python libraries, objects and classes, attributes, creating python classes, modules and packages, python data structures, Variables; operators; decision making; loops. Numbers, lists, strings, tuples, dictionary; functions in Python; modules in Python; files and file operations in Python.

Unit-II: Variables and Data types **13 Hours**

Simple values: Booleans, Integers, Floats and Strings, Expressions: Numerical operators, Logical Operations, String Operations, Names, Functions and Modules: Assigning Names, Defining the functions: Function parameters, Comments and Documentation, Assertions, Default parameter values, Using Modules: Importing Python Files.

Unit-III: Biopython-I **13 hours**

Sets, Sequences: Strings, Bytes and Byte arrays, Rangers, Tuples, Lists, Mappings: Dictionaries, Streams-Files & Generators, Collection-Related Expression Features: Comprehensions & Functional parameters,

Control Statements: Conditionals, loops, Iterations, Exception Handlers, Defining Classes: Instance Attributes, Class Attributes, Class and Method Relationships: Decomposition, Inheritance, Utilities: System Environment, The File system, working with Text, Persistent Storage. Extended Examples

Unit-IV: Biopython-II **13 hours**

Biopython components: Alphabet, Seq, MutableSeq, SeqRecord, Align, ClustalW, SeqIO, AlignIO, BLAST, Data, Entrez, PDB, ProSite, Restriction, SeqUtils, Sequencing, SwissProt, Web Applications: CGI in Python.

Reference Textbooks

1. Mitchell L. Model, **"Bioinformatics Programming using Python: Practical Programming for Biological Data"**, O'Reilly Media", 1st Edition, 2009.
2. Mark Lutz and David Ascher, **"Learning Python"**, O'Reilly Media, 5th Edition, 2013.
3. Jeff Chang, Brad Chapman, Iddo Friedberg, Thomas Hamelryck, **"Biopython Tutorial and Cookbook",** 2018.
4. Sebastian Bassi. **"Python for Bioinformatics"**, CRC Press, 2018.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0104	**FUNDAMENTALS OF BIOSTATISTICS**	HC	4	0	0	4	4

Prerequisites/Pre reading for the course:

Basic knowledge on statistics and biology with data generation techniques.

Course Objectives

1. This course is intended for life scientists from all levels and disciplines who are not experts in statistics.
2. The course is also aiming to provide statistics attempt to gain or improve our understanding of the world using the information gleaned from sets of data.
3. It introduces selected important topics in Biostatistical concepts and reasoning.
4. This course represents an introduction to the field of data and data types.

Course outcomes

By the end of the course the student will be able to:

1. The students can learn and understand the biological data generation and statistical analysis methods.
2. The students learn about biometric data, probability, testing of hypothesis and analysis of categorical data.
3. The students can be able to analyze big data and research data for biological interpretations.
4. At the end of the course the student will be able to demonstrate the necessary skill sets to be able to interpret statistical data.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	2	1				1	2	2	2	2	3
CO2	2	3	3	2	1	1	1	1	2	2	1	1	3
CO3	2	3	3	2	1	1	1	1	2	2	1	1	3
CO4	2	2	3	3	1	1	1	1	2	2	2	1	3

Course content

Unit-I: Descriptive statistics **13 hours**

Central Tendency: arithmetic Mean, median, mode, range; Standard Deviation, Standard Error, coefficient of variation, Probability, random sampling, and hypothesis testing, Distributions: Binomial and Poisson distribution; Normal probability distribution, Handling Univariate, Bivariate and Multivariate data,

Unit-II: Hypothesis testing **13 hours**

Distribution and variance: Student's t distribution, Chi-square distribution, testing of hypothesis, F-distribution, One-way ANOVA, two-way ANOVA, linear regressions, and correlations. Analysis of Frequencies.

Unit-III: Biostatistics and data science **13 hours**

Introduction to Biostatistics, Applications of Biostatistics, Epidemiology: principles, uses, Epidemiological approaches, numbers and rates, analytic epidemiology, causations, Public health practice, health and diseases, Outbreak Investigation: Case/control studies; sorting data, merging and combining data sets, Numerical and tabular summaries, Graphical Displays, numerical methods for linear equation and matrices, Crammers rule, Gaussian elimination method, Crouts method, Similarity transformation, Eigen values and Eigen vectors of a matrix, Numerical solution of differential and integral equations.

Unit-IV: Dynamical Statistics **13 hours**

Discrete Population Models, Continuous Population Models: Exponential Growth, Logistic growth, Equilibrium solutions; Discrete Linear Systems: Simple Structured Models, Finding the Growth Rate and Stable Distribution, Matrices and vectors, Population models in matrix; Pharmacokinetics, Pharmacodynamics (PK/PD), compartment models, enzyme kinetics, Phase plane analysis, stability in linear and nonlinear systems.

Reference Textbooks

1. Wayne W. Daniel, **"Biostatistics: A Foundation for analysis in the Health Sciences"** 9th Edition, Wiley Publications. 2009.
2. Olive Jean Dunn, Virginia A. Clark, **"Basic Statistics: A Primer for the Biomedical Sciences"** Forth Edition. Wiley Publications. 2009.
3. Douglas S. Shafer, Zhiyi Zhang, **"Beginning Statistics",** prince publications, 2012.
4. Robert R. Sakal and F. James Rohlf, **"Introduction to Biostatistics":** Second Edition, Dover Publications. Inc, 2011.

5. Gerald Van Belle, Lloyd D. Fisher, Patrick J Headgerty, Thomas Lumley **"Biostatistics: A Methodology for the Health Sciences",** Second Edition, Wiley Publications, 2004.
6. Daniel W.W., **"Biostatistics a Foundation for Analysis in the Health Sciences"**, John Wiley & sons, 2000.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SKS111	**GENETIC DISEASES AND COUNSELLING**	HC	4	0	0	4	4

Prerequisites/Pre reading for the course:

Basic knowledge on Genetics and biology of understanding human diseases.

Course Objectives

1. The course aims to understand genes, gene mutations, and genetic diseases.
2. It also aims to provide the advanced research molecular genetics of Mendelian disorders.
3. The students can learn contemporary overview of genetic variation and on how mutations are identified and assessed for their contribution to phenotype.
4. Students will learn to genetic counselling and follow the ethical concepts.

Course outcomes

By the end of the course the student will be able to:

1. Understand the major areas on Genetic diseases and its causes.
2. Some molecular mechanisms of genetic disease
3. Students can understand the diagnostics techniques on genetic diseases.
4. Students will become professional genetic counsellors and genetic classifiers.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	2	2				1	1	2	3	2	2
CO2	2	2	3	3					1	2	2	2	2
CO3	2	3	2	2	2	1		2	2	3	3	3	3
CO4	3	3	3	2	2	1	2	2	2	3	3	2	2

Course content

Unit-I Introduction to of cytogenetics & diseases 13 hours

History of human cytogenetics, confirmation of human chromosome number, morphology of human chromosomes, non-banding techniques, classification of human chromosomes into different groups (A-G), international system for human cytogenetic nomenclature, various conferences held to discuss chromosome nomenclature, karyotyping. Chromosome abnormalities and human genetic diseases: numerical and structural (markers, isochromosomes, ring chromosomes, deletion, duplication, insertions, translocations, and inversions) abnormalities; sex chromosome abnormalities, autosomal abnormalities, uniparental disomy, Chromosome breakage studies (chromatid and chromosome breaks) and their applications.

Unit-II Complex diseases **13 hours**

Introduction to Complex diseases, cancer and heart diseases, origin, types (types of tumors, stages of malignancy), basic terminology, Basic mechanisms regulating normal tissue homeostasis: regulation of cell-proliferation, growth, differentiation, and apoptosis; aberrations in regulatory mechanisms that result in cancer. The nature of commonly occurring mutations in cancerous tissue, gain of function, loss of function, copy number variation (CNV)etc.; signaling pathways commonly affected in cancers; oncogenes: mechanisms of activation and action, different functions of oncogenes, rationale for therapeutic targeting. Tumor suppressor genes and functions.

Unit-III Genetic Diseases **13 hours**

Mendelian disorders: Etiology and Pathogenesis of Hemophilia-A, microparticles and their role in hematological disorders, Genetic Diversity, Epistasis, Complex Syndromes, Thalassemia's and other haemoglobinopathies, Epidemiology of genetic diseases, model organisms to study human diseases, **Mouse and other animals:** advantages and disadvantages of using mammalian systems, similarity in physiology and organ function with humans, **Zebrafish:** advantages and disadvantages of zebra fish D. rerio as a system to study human diseases, economy and ease of culture, ease of performing cellular and genetic studies. **D. melanogaster:** Overall advantages and disadvantages of D. melanogaster as a system to study human diseases. **C. elegans:** Overall advantages of C. elegans as a system to study human diseases.

Unit-IV Genetic counselling and ethics **13 hours**

Introduction to genetic counselling, Impact of illness on patients and families, Morbidity and support services, access to education and economic support, social practices, and health cost issues. Incidental detection of other genetic disorders on pedigree evaluation and NGS testing, manifesting carriers, later onset genetic disorders including neuro-genetic disorders. Clinical ethics, ethical issues in prenatal diagnosis and newer reproductive technologies, Genetic testing in adult-onset disorders, Testing of vulnerable populations, Research ethics.

Reference Books

1. Dijana Plaseska-Karanfilska, **"Human Genetic Disease",** In Tech Publishers, Croatia, Europe 2011.
2. Maria Puiu, **"Genetic Disorders"**, In Tech Publishers, Croatia, Europe 2013.
3. Kenji Ikehara, **"Advances in the Study of Genetic Disorders"**, In Tech Publishers, Croatia, Europe 2011.
4. Dhavendra Kumar**, "Genetic disorders of Indian Subcontinent"**, Kluwer publications, India 2010.
5. S Gersen and MB Keagel. **"The Principles of Clinical Cytogenetics"**, Springer Science and Business Media Publication, 2013.
6. Fan, Yao-Shan. **"Molecular Cytogenetics Protocols and Applications"**, Humana Press, 2003.
7. R.J. McKinlay Gardner, Grant R Sutherland, and Lisa G. Shaffer, **"Chromosome abnormalities and Genetic counselling",** Oxford University Press, 4th Edition. 2011.
8. Peter S Harper, **"Practical Genetic Counselling",** Elsevier, 7th Edition. 2010.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SKS112	**BIOLOGICAL PATHWAYS**	HC	4	0	0	4	4

Prerequisites/Pre reading for the course:

Basic knowledge on cell biology and cell-cell interactions.

Course objectives

1. The course aims to understand the biological systems of cells and biochemicals networks.
2. To get the knowledge on biological and molecular pathways in various biological applications.
3. To understand the neural networks and network reconstruction methods to predict human diseases.
4. To emphasize modeling of genetic networks, cell-cell interactions, and evolutionary dynamics.

Course outcomes

By the end of the course the student will be able to:

1. The students can be able to understand the major areas on biological and networks.
2. The students can be able to get more knowledge on molecular mechanisms of genetic disease and pathways.
3. The students can be analyzing cellular systems, genetic network evolution, and cellular decision-making.
4. Students can be applying and explore the subject of systems biology in more depth of research.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	3	3	2						2	3	3	3
CO2	2	3	2	3			2	3		3	3	3	3
CO3	3	2	2		2	3	3	2		3	3	3	3
CO4	3	3	2			2				3	3	2	3

Course content

Unit-I: Systems Biology **13 hours**

Concepts of systems biology, Molecules to pathways, pathways to networks, mathematical representation of cell biological system, network building and analysis, topology to function, Modeling of Biochemical systems, Disease Target Identification & Validation, Gene regulations Mechanism, Gene Regulations & Mechanism of cell, Kinetic Analysis, Mathematical modeling, Pathway reconstruction, Computational Methods, databases, tools, and Software's in systems Biology.

Unit-II: Biological Pathways **13 hours**

Metabolic Pathways: Catabolic pathways, cellular respiration, anabolic pathways; Genetic pathways: gene regulatory pathways, Signal transduction pathways: Extracellular receptors-GPCR, Tyrosine, Ser/Thr and Histidine-specific protein kinase, integrins, Toll-like receptors, ligand-gated ion channels. Intracellular receptors, MAPK/ERK pathways, cAMP-dependent pathway, apoptosis pathways.

Unit-III: Mathematical Modelling **13 hours**

Mathematical Representations of Cell Biological Systems, Simulations of Cell Biological Systems, Experimental technologies, network building, Analysis, and data organizations, building networks, Analysis

of networks, topology to function. Strengths and Limitations of Different Types of Models, Systems Biomedicine, Systems Pharmacology and Therapeutics.

Unit-IV: Statistical Approaches in Systems biology **13 hours**

Introduction to Statistical Methods for Complex Systems, Bayesian Inference and Computation, Data Integration: Towards Understanding Biological Complexity, Protein Interaction Networks and Their Statistical Analysis, Inference of Signaling Pathway Models, Modelling Transcription Factor Activity, Host-Pathogen Systems Biology, Statistical Metabolomics: Bayesian Challenges in the Analysis of Metabolomic Data, Systems Biology of microRNA.

Reference Books

1. Andres Kriete, Roland Eils, **"Computational Systems Biology"**, Elsevier Academic Press. 2006.
2. Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald, Hans Lehrach, and Ralf Herwig. **"Systems Biology: A Textbook"**, Wiley-Vch Publications, 2009.
3. Michael Stumpf, David J. Balding, Mark Girolami. **"Handbook of Statistical Systems Biology"**. Wiley Publications, 2011.
4. Andres Kriete, Roland Eils, **"Computational Systems Biology"**, Elsevier, 2013.
5. Darren J. Wilkinson, **"Stochastic Modelling for Systems Biology"**. Chapman and Hall, CRC Press, 2020.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SKS121	**FUNDAMENTALS OF COMPUTER & NETWORKING**	SC	2	0	0	2	2

Prerequisites/Pre reading for the course:

Basic knowledge on computer operating and Microsoft skills.

Course Objectives

1. Use and define the vocabulary associated with computer technology.
2. Identify the components of computer systems and state their function.
3. Differentiate between the various operating systems and application programs that are available for personal computers.
4. Understand the relationship between computer hardware and software.

Course outcomes

By the end of the course the student will be able to:

1. Bridge the fundamental concepts of computers with the present level of knowledge of the students.
2. Familiarize operating systems, programming languages, peripheral devices, networking& multimedia.
3. Understand how logic circuits and Boolean algebra forms as the basics of digital computer.
4. Demonstrate the building up of Sequential and combinational logic from basic gates.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	1	3							3	3	3
CO2	1	3	2	3		2	1	2	1	1	3	3	1
CO3	2	3	3	2	1			1	1	1	3	3	3
CO4	3	3	2	2			1	1	1		2	3	2

Course content

Unit-I: Fundamentals of computer **13 hours**

Computer Basics, computer components, Types of computers, Input and output devices, CPUs, Hardware, software, Computer memory, Operating systems: Programming software, Application software, DOS, UNIX, Linux, Windows, Macintosh, Algorithms, flowcharts, Computer Organization & Design, Computer network, LAN (local area network). Computer Virus, Number systems, Internet, intranet, extranet, websites.

Unit-II: Working with Documents **13 hours**

Microsoft office: Word, Excel, PowerPoint, OneNote; Edit, creating graphs, tables, sending emails, animation; Introduction to MS EXCEL-Use of worksheet to enter data, edit data, copy data, move data. Use of in-built statistical functions for computations of Mean, S.D., Correlation, regression coefficients etc. Graphical tools in EXCEL for presentation of data. Use of bar diagram, histogram, scatter plots, etc.

Unit-III: Introduction to computer Networks **13 hours**

Data Communication, Components-Message, sender, receiver, Transmission medium, Protocol, Data representation, Data Flow, Networks, Organizational computational models, Network Services, Characteristics of transmission Media, cable media, Wireless Media.

Unit-IV: Fundamentals of Networking **13 hours**

Computer Networking- Introduction, Types of networking: LAN, WLAN, WAN, PAN, SAN, CAN, VPN, Important terms, and concepts in networking: IP address, Nodes, Routers, Switches, Ports, Network cable types, Computer Networks, and the internet: HTTP, IP, TCP, UDP, FTP, Network Topology: Bus Topology, Ting Topology, Star Topology, Mesh Topology.

Reference Books

1. Peter Nortons, **"Introduction to Computers",** Sixth Edition, Published by Tata McGraw Hill, 2006.
2. P K Sinha & Priti Sinha, **"Computer Fundamentals",** Fourth Edition, BPB Publications. 2012.
3. M Morris Mano, **"Digital Logic and Computer design"**, Fourth Edition, Prentice Hall. 2012.
4. Thomas C Bartee, **"Digital computer Fundamentals",** Sixth Edition, TATA McGraw Hill, 1985.
5. Thomas L Floyd- **"Digital Fundamentals"**, Ninth edition, PEARSON Prentice Hall. 2015.
6. Malvino& Leach, **"Digital Principles and Applications"**, Sixth Edition, Tata McGraw Hill, 2006

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SKS122	**BIOLOGY OF PROKARYOTIC & EUKARYOTIC ORGANISMS**	SC	2	0	0	2	2

Prerequisites/Pre reading for the course:

Basic knowledge on biology of organisms and classifications.

Course Objectives

1. The course is designed to understand the basics of biology.
2. To understand the broad knowledge on prokaryotic and eukaryotic organisms.
3. To get knowledge on molecular mechanisms of organisms.
4. To understand the pathogenetic and non-pathogenic organization and classifications.

Course outcomes

By the end of the course the student will be able to:

1. Understand the basic concepts of prokaryotic and eukaryotic organism.
2. Familiarize with molecular mechanism of organisms.
3. To illustrate the mechanism of human diseases and explore the disease functions.
4. To develop and analyze the data from the biological systems and pathogenesis.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	3					3		3	3	3	3
CO2	2	2	2			2	2	3		3	3	3	2
CO3	2	2	3					3		3	3	3	3
CO4	2	2	2	3			2	3		3	3	3	3

Course content

Unit-I: Biology of Prokaryotes **13 hours**

Introduction to the Microbial World, Prokaryotic cell, Characteristics, Prokaryotic cell structure, Components, Reproduction in prokaryotes Cellular and Sub cellular organization of Prokaryotes, Bacterial Chromosomes: DNA Structure, DNA Replication, nucleotide and Segregation, Bacterial Cell Division, RNA and bacterial gene expression, protein synthesis, genetic analysis.

Unit-II: Prokaryotic Gene Expression **13 hours**

Gene expressions and regulatory mechanism of prokaryotes, operons and regulations, posttranslational control and modifications of proteins, Global regulatory networks and signal transduction pathways, Microbial diseases, and pathogenesis. Microbes in Industrial applications.

Unit-III: Biology of Eukaryotes **13 hours**

Eukaryotes: Cellular structure, cell components, cellular junctions, Mitochondria, Chloroplast, Cytoskeleton, extracellular matrix, apoptosis, cell cycle, Eukaryotic genome, DNA, RNA and Protein

Structure, DNA replication, Transcription, Translation, Mutation – Occurrence, kinds of Mutation, spontaneous & induced Mutation, Mutagens – Physical and chemical, detection of Mutation.

Unit-IV: Essentials of cell biology in Eukaryotes **13 hours**

Cellular structures, cell distribution, cellular energetics, signaling pathways that control gene activity, TGF receptor, Cytokine receptors, receptor tyrosine kinases, MAP kinase pathways. Control of Cells by Environmental Influences. Boundary Creation by Extracellular Signals. Cell-Cycle Control in Mammalian Cells, Checkpoints in Cell-Cycle Regulation.

REFERENCE BOOKS

1. Cooper, G.M., Hausman, R.E. **"The Cell: A molecular approach"**. ASM Press and Sinauer Associates 5th Edition 2009.
2. De Robertis, E.D.P. **"Cell and Molecular Biology"**. Lippincott Williams and Williams 6th Edition 2008.
3. Klug, W.S., Cummings, M.R., Spencer, C. A. Benjamin Cummings, **"Concepts of Genetics"**, 11th Edition 2009.
4. Russell, P. J. iGenetics, **"A Molecular Approach"**. Benjamin Cummings, 3rd Edition, 2009.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0105	**FUNDAMENTALS OF GENOMIC DATA SCIENCE**	HC	0	0	2	2	4

Prerequisites/Pre reading for the course:

Basic knowledge on molecular biology and genetics is the prerequisites of the course.

Course objectives

1. This course imparts knowledge on understanding genomes, sequences, and file formats.
2. This course is intended to introduce biological databases and algorithms.
3. It also introduces sequence retrieval, alignment, evolutionary studies, and genome annotation.
4. This course provides knowledge to handle biological data generated by the sequencing projects and its analysis.

Course outcomes

1. Students can learn hands on experience on biological databases, Tools, and software's.
2. Students can utilize the bioinformatics algorithms and tools in industrial applications.
3. Students can also use bioinformatics tools and software's in big data science.
4. Students can be able to understand the techniques of genomics to study gene expression.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	3	2	3		3				3	3	3	3
CO2	2	3	3	3			3			3	3	3	3
CO3	2	2	3			3				3	3	3	3
CO4	2	3	2	3		3	3			3	3	3	3

Course Content

1. Biological Databases
2. Biological data formats
3. Sequence Alignment
4. Phylogenetic Analysis
5. Gene structure Prediction (DNA, RNA)
6. Protein Structure prediction
7. Pattern Matching
8. Clustering Analysis
9. Genome Annotation
10. Molecular interaction networks

Reference Books

1. Wing-Kin Sung, **"Algorithms in Bioinformatics: A Practical Introduction"**. Chapman & Hall/CRC, 2008.
2. Edwards David, Stajich Jason, Hansen David, **"Bioinformatics: Tools and Applications"**, Springer-Verlag New York. 2009.
3. Jin Xiong, **"Essential Bioinformatics",** Cambridge University Press, 2006.
4. T.R. Sharma, **"Genome Analysis and Bioinformatics: A Practical Approach"** 1st Edition, IK International publishing house Pvt. Ltd. 2009.
5. Cynthia Gibas, Per Jambeck, **"Developing Bioinformatics Computer Skills",** O'Reilly & Associates, 2001.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0106	**R & PYTHON PROGRAMMING**	HC	0	0	2	2	4

Prerequisites/Pre reading for the course:

Basic knowledge on Statistics and fundamentals of computers.

Course objectives

1. This course provides knowledge to handle biological problems in Bioinformatics.
2. Providing general properties and unique aspects of the R & Python language
3. To provide knowledge how to how to write own software packages.
4. To learn R & python programming to solve the biological problem.

Course outcomes

1. To provide general properties and unique aspects of the Perl & Python language
2. Students can be able to understand the basic of python programming.
3. Students can learn the practical data management and manipulation tasks in python.
4. Students can develop bioinformatics software development using Python programming.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	3	3							1	2	2
CO2	2	3	3	3	2		3				3	2	2
CO3	2	2	3	3			3				3	2	2
CO4	2	3	3	3					3	3	3	2	2

Course content

1. Getting data into R
2. Extracting subsets of data frames by value
3. Sorting data, merging data, and Exporting data
4. Simple functions: tapply, sapply, summary, table
5. Basic plotting tools
6. Revisiting the plot function
7. Loops
8. Functions and If Statements
9. Analysis of variance
10. Test of Significance
11. DNA/RNA/Protein Sequence Generation.
12. Write a script to search for genes from GenScan.
13. To store a DNA/Protein sequence.
14. To Load sequence from a remote server.
15. Reading DNA/Protein sequence from Files.
16. To Count the number of nucleotides in a DNA Sequence.
17. To split the sequence into Codons.
18. To align the sequence using local BLAST.
19. To calculating the reverse complement of DNA sequence.
20. To concatenating DNA Fragments Transcription: DNA to RNA

Reference books

1. Robert G, **"R programming in Bioinformatics"**, CRC press, Taylor and Francis Group, USA, 2008.
2. Own J, Robert. M, and Andrew R., **"Introduction to Scientific programming and simulation using R",** CRC Press, Taylor and Francis Group, USA, 2014.
3. Norman M. And Norman S. Matloff **"The Art of R programming: A tour of statistical software Design"**, No Starch Press Inc, USA, 2011.
4. Mitchell L. Model, **"Bioinformatics Programming using Python: Practical Programming for Biological Data"**, O'Reilly Media", 1st Edition, 2009.
5. Mark Lutz and David Ascher, **"Learning Python",** O'Reilly Media, 5th Edition, 2013
6. Sebastian Bassi, **"Python for Bioinformatics, Mathematical and Computational Biology Series"**, Chapman, and Hall/CRC, 2018.

SECOND SEMESTER

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0201	**ADVANCED GENOMIC DATA SCIENCE**	HC	4	0	0	4	4

Prerequisites/Pre reading for the course:

Knowledge on Genomic sequencing and file formats

Course objectives

1. To acquire the knowledge about genome anatomies and the techniques of genomics to study gene expression.
2. To apply the techniques to study gene expression.
3. To learn the basic databases and data formats
4. To grasp the significance of sequence alignment methods and the concept of phylogenetic analysis.

Course outcomes

By the end of the course the student will be able to:

1. Understand the basics of genomics sequencing, data types and algorithms.
2. Students can be able to apply the algorithms in sequencing data analysis and data interpretation.
3. Students can be able to integrate the statistical methods for comparative analysis and data mining.
4. Students can be using the genomic data analysis techniques in research and consultancy services.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	2	1	1			1	2		2	1	3
CO2	2	2	3	1	1	2	1	1	2	1	2	1	2
CO3	2	1	3		1				1	1	2	2	
CO4	1	3	2	1	1		1	1	2	1	2	1	1

Course content

Unit-I: Sequence Data curation **13 hours**

NGS Data retrieval: SRA Databases, ENA Data bases, DRA Search, Sequence Quality control, trimming, error correction and pre-processing of data, Quality control tools: FastQC, PRINSEQ, FastX toolkit, MultiQC. Adaptor removal: Cutadapt, ShortRead, Trimmomatic.

Unit-II: Sequence Alignment **13 hours**

Genome Annotation and Alignment: Alignment algorithms: Dynamic Programming Algorithms, Scoring Matrices: PAM, BLOSUM, Gap Penalties, Edit distance and alignments; Global Sequence alignment: Needleman-Wunsch Algorithm, Local Sequence Alignment: Smith–Waterman Algorithm. Rapid gaps edit, Heuristic Versions of Smith Waterman: FASTA and BLAST - Statistics of Sequence Alignment Score: E-Value, P-Value.

Unit-III: Clustering & Tree Algorithms **13 hours**

Multiple Sequence alignment: CLUSTAL, Centre-based Clustering, Clustering via Cliques, Phylogenetic Analysis: Distance based & Character-based tree reconstruction, Evolutionary Trees and Ultra metrics, Additive distance trees, perfect Phylogeny Problem, Small Parsimony Problem, Nearest Neighbor Interchange; Gene expression Analysis: Hierarchical clustering, k-means clustering.

Unit-IV: Applications of Genomic Data **13 hours**

Transcriptome (RNA) sequencing: Differential gene expression analysis, Exome sequencing: Variant detection and disease prediction, ChIP-sequence, biological theories on ChIP-sequence analysis, Understanding the non-coding genome, Disease gene identification, DNA fragment evaluation, Peak identification, two condition comparison, Saturation analysis, Motif finding and related theories.

Reference Books

1. Ju Han Kim, Genome Data Analysis, Springer Singapore, 2019.
2. Ali Masoudi-Nejad, Zahra Narimani, Nazanin Hosseinkhan; **"Next Generation Sequencing and Sequence Assembly: Methodologies and Algorithms",** Springer; 2013.
3. Stuart M. Brown, **"Next-Generation DNA Sequencing Informatics"**, Cold Spring Harbor Laboratory Press, 2013.
4. Y. M. Kwon and S. C. Ricke; **"High Throughput Next Generation Sequencing: Methods and Applications"**; Humana Press; 2011.
5. S. Knudsen, **"Guide to Analysis of DNA Microarray data"**, Wiley, 2nd edition. 2004.
6. B. R. Korf and M. B. Irons; **"Human Genetics and Genomics"**; Wiley, 4th edition. 2013.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0202	**BIG DATA ANALYTICS**	HC	4	0	0	4	4

Prerequisites/Pre reading for the course:

Knowledge on Statistics and Genome sequencing data types

Course objectives

1. This course is designed to understand big data technologies are rapidly being used for healthcare and agriculture research.
2. Learn the advancement in biomedical and life sciences research is contributing for generation of huge amount of data at an unprecedented speed and scale.
3. Understand the algorithms for genomics and proteomics instruments are producing the terabytes of data.
4. The Bioinformatics and Big Data Analytics are providing new opportunities to discover new knowledge and create novel methods to take better decisions.

Course outcomes

By the end of the course the student will be able to:

1. The students can be able to understand the application of different big data algorithms.
2. Students will get awareness regarding current challenges in global pharmaceutical and healthcare industry.
3. Students will work individually to analyze large data and helps to provide consultancy support.
4. Students can become on entrepreneurs and big data consultants.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	3	3			3		3		3	3	3	3
CO2	2	2	3	3				3		3	3	3	3
CO3	2	3	3	3		3		3		3	3	3	3
CO4	2	2	3	3	2	3	3	3		3	3	3	

Course content

Unit-I: Big Data Science **13 hours**

Big Data and Cloud, Data Analytics and X-informatics, Python for Big Data Applications and Analytics: NumPy, SciPy, Matplotlib, Using Future Grid for Big Data Applications and Analytics, Technology Recommender Systems - K-Nearest Neighbors, Clustering, and heuristic methods.

Unit-II: Clouds and Big Data Processing **13 hours**

Clouds, Features of Data, Information, intelligence algorithms, infrastructure, and data structure, Health informatics case studies, Genomics, Proteomics, and Information Visualization,

Unit-III: Big Data on Genomics **13 hours**

GWAS Studies, Variant Analysis, Differential Gene expression Analysis Using EdgeR, CummeRbund, DEseq, DEseq2, Case Studies

Unit-IV: Data Storage & Ethics **13 hours**

Data Collection and Representation and Privacy: Data Sampling and Collection, Managing Datasets Responsibility and Data Cannibalism, Is the premise of data science flawed? Inference and Privacy, Re-identification of Data, Data Ethics, Data Ownership, Anonymity, Data Validity.

Reference Books

1. Seymour Lipschutz., **"Data Structures"**, Tata Mc-Graw-Hill publication. 2007
2. T.H. Cormen, C. E. Leiserson, R.L. Rivest., **"Introduction to Algorithms (3rd Ed.)"**, The MIT Press. 2007
3. Wayne W. Daniel, **"Biostatistics (9 Ed.)",** Wiley 2004.
4. Seymour Lipschutz and John Schiller., **"Schaum's Outlines –Introduction to Probability and Statistics"** TATA McGraw-Hill edition. 1998.
5. Bernard Lo, **"Resolving Ethical Dilemmas: A Guide for Clinicians",** Fifth Edition. 2013.
6. Helga Kuhse, Peter Singer, **"A Companion to Bioethics"**. Willy online library, 2009.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0203	**ADVANCED R AND PYTHON PROGRAMMING**	HC	4	0	0	4	4

Prerequisites/Pre reading for the course:

Knowledge on basic statistics and computer programming,

Course objectives

1. This course is designed to understand R programming modules and algorithms to analyze big data.
2. Learn the advancement in microarray data analysis techniques using R and Python programming.
3. Learn and analyze the NGS data analysis using R and Python programming.
4. Learn the algorithms and modules to understand big data analysis using R and Python programming.

Course outcomes

By the end of the course the student will be able to:

1. The students can be able to understand the application of R and Python programming.
2. Students will get awareness regarding current challenges in algorithms and implementations.
3. Students will work individually to analyze large data and helps to provide consultancy support.
4. Students can become on entrepreneurs and big data consultants.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	2	3	1				3	2	3	2	3
CO2	1	2	3	3		1		3	2	1	3	3	1
CO3	2	3	2	1				1	3	3	3	3	3
CO4	3	3	3	2	1	1		2	3	1	3	3	3

Course content

Unit-I: Bioconductor **13 hours**

Using Bioconductor, Install Bioconductor Packages, Find Bioconductor Packages, update and upgrading installed BioConductor packages, BiocManager::install ()? BiocAnalyzer, BioConductor Packages, Vignettes, Biostrings, Workflows: Annotation, Arrays, gene regulation, high throughput assays, methylation Array Analysis.

Unit-II: Microarray Analysis **13 hours**

Microarray Analysis using R, Quality Analysis: Affy, Affycore Tools, Annotation DB, AffyQCReports, Limma Packages, DEseq, RankProd, Annotate, GOstats, GO.db, Case studies.

Unit-III: High Throughput sequencing **13 hours**

Biostrings, GenomicRanges, ShortRead, ShortReadQ, AlignedRead, Rsamtools, GRanges, GRangesList and GappedAlignments, BioC-Seq packages including ShortRead, Rsamtools, rtracklayer, GenomicFeatures and BSgenome, Ballgown, IRanges, EdgeR, DEseq2.

Unit-IV: Python for Genomic Data Science **13 hours**

Bio. Affy: CelFiles; Bio.Align: AlignInfo, ClustalOmega, ClustalW, Dialign, MSAProbs, Bio.AlignIO: EmbossIO, FastaIO, Interfaces; Bio.Cluster, Bio.Data: CodonTable, IUPACData, SCOPData; Bio.Emboss: Primer3, PrimerSearch; Bio.Expasy: Prosite, ScanProsite, BioFSSP, motif objects, Seqfam, python for genomic data, PRINSEQ, GATK, SAMtools and VCF Tools.

Reference Books

1. Jeff Chang, Brad Chapman, Iddo Friedberg, Thomas Hamelryck, **"Biopython Tutorial and Cookbook"**. 2019.
2. Tiago Antao, **"Bioinformatics with Python Cookbook"**, Packt Publishing. 2015.
3. Robert G, **"R programming in Bioinformatics"**, CRC press, Taylor and Francis Group, USA, 2008.
4. Own J, Robert. M, and Andrew R., **"Introduction to Scientific programming and simulation using R"**, CRC Press, Taylor and Francis Group, USA, 2014.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0204	**RESEARCH METHODOLOGY AND IPR**	HC	4	0	0	4	4

Prerequisites/Pre reading for the course:

Knowledge on basic science and research experimental studies.

Course objectives

1. This course is designed to understand the basics of research methods.
2. The course also understands the statistical methods to understand the research problems.
3. It also helps the method of collecting literature and designs the objectives.
4. It also provide the IPR methods to the genomic research.

Course outcomes

By the end of the course the student will be able to:

1. The students can start to develop the project objectives and to collect literatures.
2. Additionally, students will get awareness regarding research challenges.
3. The students can also understand the requirement of IP concepts in research
4. The students also apply the research ethics in process, and product development.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	3	3	2	2	2	2	3	3	2	2	2	1
CO2	2	3	3	2	2	2	2	3	3	2	2	3	3
CO3	3	3	3		2	3	2			3	1	1	1
CO4	2	3	3	2	2	2	2	3	3	2	2	3	3

Course content

Unit-1: Research: The search for knowledge **13 hours**

Acquiring knowledge on Research, Qualities of a Research, Hypothesis, induction and deduction in research, Scientific Methods, Research Methodology and Research Methods, Research Process, Academic Research, Philosophy of Research: Philosophy and Science, Epistemology, Empiricism, Rationalism Experimental Research: Cause-Effect Relationships, Hypothesis in Experiments, Validation of Experiments, Experimental Design.

Unit-II: Planning and Writing Research proposal and publications 13 hours

Research Projects, finding a Research problem, Analysis of Research Ideas, planning a proposal, proposal outline, presentation and evaluation of proposals, Students outline of research work, major funding agencies, Tools for identifying literature, types of publications, Citation indexes, citation Analysis, bibliography databases, meta search engines, plagiarism, Thesis, or dissertation.

Unit-III: Essentials of Scientific writing 13 hours

Introduction, Purpose of Scientific Writing, writing with the reader in mind, research communications, format of a research paper, writing research paper, review articles, why papers reject early?, style and language, numbers, date and abbreviations, publishing ethics, steps in scientific writing, Checklist of information on a journal, Peer reviewing, Revolution in scientific communications.

Unit-IV: IPR and Bioethics 13 hours

General Introduction to IP Right, Patents, Industrial Designs and Layout Designs of Integrated Circuits and Utility Models, Trademarks, Domain names and Geographical Indications, Copyright and Related Rights, Plant Varieties Protection, Biotechnology and Traditional Knowledge. Bioethics, Research ethics, Clinical ethics, Ethics in Genomics, Ethics in reproductive medicine and Women's health.

Reference Books

1. Dr Marcel van der Perk, **"A guide for scientific writing"**, Utrecht University. 2015.
2. C.George Thomas, **"Research Methodology and Scientific Writing"**, Second Edition. 2019.
3. Bernard Lo, **"Resolving Ethical Dilemmas: A Guide for Clinicians"**, Fifth Edition. 2013.
4. Helga Kuhse, Peter Singer, **"A Companion to Bioethics"**. Willy online library, 2009.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SKS211	**WEB SERVER & DATABASE DEVELOPMENT**	SC	2	0	0	2	2

Prerequisites/Pre reading for the course:

Knowledge on Computer programming, networking, and HTML Scripting.

Course objectives

1. Design simple web pages using markup languages like HTML and XHTML
2. It Compare, contrast, and apply the key algorithmic design paradigms: divide and conquer, greedy method, dynamic programming techniques

3. The Explain the types of operating system and ability to create threads and perform interposes communication.
4. Able to understand the basic concepts of DBMS and ER Model and How to draw ER Diagrams

Course outcomes

By the end of the course the student will be able to:

1. Create dynamic web pages using DHTML and java script that is easy to navigate and use
2. Additionally, students will get aware about the database development.
3. Understand various web services and how these web services interact.
4. Develop real time application using server-side programming and Web Services

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	3	3					2		3	2		2
CO2	2	3	3	3				2		3	3	2	2
CO3	2	3	3		2			2		3	3	2	2
CO4	2	3	3					2		3	3	2	2

Course content

Unit-I: Introduction on Web Servers **13 hours**

Web Servers: Nginx, Apache Http Server, IIS server, ftp servers, DNS server, Lighttpd, IP address, Web server software's, Application server: unicorn, Rainbows, and Puma, Database servers: Sun Java system web server, Jigsaw server.

Unit-II: Web server administration **13 hours**

Windows server administration, Server configuration, compressing and archiving files, accessing files from windows server, Linux server administration, Server configuration, Working with files and process management. Installation of software in Linux. compressing and archiving files

Unit-III: Database Development **13 hours**

Introduction on RDBMS and SQL: Relational databases and Codd rules, Entity–relationship model Diagrams, Normalization of tables: Creating forms, add, manipulate, delete forms and data, Table joins, Relational algebra: SELECT, PROJECT and JOINS, SQL, PL/SQL, and MS/SQL.

Unit-IV: Database design & Management **13 hours**

Functions of database systems, database management system, database components, database development process, conceptual design and data modelling, introduction to database design process, understanding business process, entity relationship data model, table structure and normalization.

Reference Books

1. Douglas J. Reilly, **"Inside Server-Based Applications",** Microsoft Press, 1999.
2. Tony Steidler-Dennison, **"Run Your Own Web Server Using Linux & Apache"** 2006.

3. Rod Trent, Trent, **"IIS 5.0: A Beginner's Guide",** 2001.
4. Paulraj Ponniah Ph.D., **"Database Design and Development: An Essential Guide for IT Professionals",** 2003.
5. Lee Chao, **"Database Development and Management",** 2006.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SKS212	**ADVANCED WEB BASED TECHNOLOGY**	SC	2	0	0	2	2

Prerequisites/Pre reading for the course:

Knowledge on Computer programming and HTML Scripting.

Course objectives

1. This course is designed to understand the programming technology to develop databases.
2. To design the website application and tools to include in databases.
3. To acquire knowledge on HTML, CSS, JAVA, and PHP to develop websites.
4. To learn JAVA Script programming to develop supportive platforms for database development.

Course outcomes

By the end of the course the student will be able to:

1. After completing this course students will be able to develop databases.
2. Additionally students will create databases frontend, backend and upload the content.
3. Create dynamic web pages using DHTML and java script that is easy to navigate and use
4. Program server-side web pages that must process request from client-side web pages.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	3	3					2		3	3	1	2
CO2	2	3	3	3				2		3	2	2	2
CO3	2	3	3		2			2		3	3	2	2
CO4	2	3	3					2		3	3	2	2

Course content

Unit: 1 HTML **13 hours**

Basic Structure of HTML Page, Creating and HTML document, Mark-up tags, Heading-Paragraphs, line breaks, HTML tags, elements of HTML, Working with text, Lists, tables, frames, hyperlinks, images and multimedia, forms, and controls.

Unit-II: Dynamic HTML **13 hours**

Dynamic HTML with Java Script: Data validation, opening a new window, Messages and Confirmations, the status bar, writing to a different frame, Rollover buttons, Moving images, multiple pages in a single download, a text-only menu system, Floating logos.

Unit-III: CSS, and PHP **13 hours**

CSS: Introduction, A Simple Specification, Concepts of CSS, Creating Style Sheet, CSS Properties, CSS Styling: Background, Text Format, Font Properties, Controlling Fonts; Working with block elements and objects, Working with Lists and Tables, CSS Id and Class, Box Model: Introduction, Border properties, Padding Properties, Margin properties; CSS Advanced: Grouping, Dimension, Display, Positioning, Floating, Align, Pseudo class, Navigation Bar, Image Sprites, Attribute sector; CSS Color; Creating page Layout and Site Designs. PHP.

Unit-IV: Java Scripts **13 hours**

Basic Java scripts, data types the building blocks of coding, using variables to hold data, Java Script operators, and assignment syntax, Java script objects and arrays, conditions and loops, arrays, and array methods.

Reference Textbooks

1. J. Murach and R. Harris, PHP and MySQL, Mike Murach & Associates, Inc., 2010.
2. P. Deitel, H. Deitel, A. Deitel, Internet & World Wide Web HOW TO PROGRAM, 5 th ed, Pearson, 2012.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SKS221	**GENETICS & EPIGENETICS**	SC	2	0	0	2	2

Prerequisites/Pre reading for the course:

Knowledge on Genetics and genomics

Course Objectives

1. To provide in-depth knowledge in cancer genome structure, analysis, and interpretation.
2. To highlight various techniques involved in understanding cancer genomes.
3. To understand the techniques of genomics to study gene expression.
4. To learn analytical techniques used for epigenetic analysis and characterization.

Course outcomes

By the end of the course the student will be able to:

1. After completing this course students will be able to understand the genetics and epigenetic characters of diseases.
2. Students can apply the genomic data analysis techniques to predict the disease genes to identify the targets.
3. Students can understand the epigenetic techniques to predict the diseases and disease progression.
4. It also helps to learn the methods of gene expression patterns for epigenetic analysis.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	3	2	3	3	3	3				1	2	2

CO2	2	3	3	3				2	2	1		3	2
CO3	3			3	3		2		2			2	3
CO4	3	3	3	3							3	3	2

Course content

Unit-I: Cancer Genetics **13 hours**

The Genomics, Epigenomics and Transcriptomics of Cancer, Somatic mutations, Cancer Genomics, Methodological approaches and background, Expression Arrays, SNPs, Biomarker discovery through genomics, Cancer genome analysis, Preclinical models for genomics.

Unit-II: Genetic analysis **13 hours**

DNA repair, cellular responses, Genetic variation, Genes the environment and the organism, genome structure and engineering, Nature of heritable change, from genes to processes. The impact of genetic variation, sources of variation, balanced polymorphism, Evolutionary genetics.

Unit-III: Epigenetics **13 hours**

Epigenetic organization: Histone Modifications, Heterochromatin and euchromatin-Organization, Regulation of Gene Expression, Chromosome Territory Organization within the Nucleus. DNA Methylation Analysis by MALDI Mass Spectrometry, All Things ChIP: ChIP-chip, ChIP-Sequence, ChIP-PCR, Computational Epigenetics.

Unit-IV: Epigenetic analysis **13 hours**

Histone modifications influence chromatin structure, DNA modifications influence chromatin structure, methods used to study epigenetics, Epigenetic Profiling Techniques, Data Resources for Standardization, Annotation, and Harmonization, Functional Annotation: Pathways, Chromatin states, gene expression, Identification of Genetic Drivers of Epigenetic Marks.

Reference Books

1. Nessa Carey, **"The epigenetics revolution",** Columbia University Press, North America, 2011.
2. Jefferey M. Craig and Nicolas C. Wong, **"Epigenetics", A Reference manual",** Caister Academic press, Norfolk, UK, 2011.
3. Robert A. Myers, **"Epigenetic regulation and Epigenomics",** Wiley-Blackwell 2012.
4. Krishnarao Appasani, **"Epigenomics: From Chromatin Biology to Therapeutics",** Cambridge University Press, 2012.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SKS222	**CLOUD BASED ANALYTICS**	SC	2	0	0	2	2

Prerequisites/Pre reading for the course:

Knowledge on cloud-based servers and computing techniques.

Course objectives

1. To provide insight into cloud computing and architecture.

2. To understand how cloud computing can enables in genomic data.
3. To deal with management of complex virtual environments,
4. To store, manage, and process of big genomic data.

Course outcomes

By the end of the course the student will be able to:

1. Students will be able to understand the cloud architecture to store large genomic data.
2. Students can learn how to understand the large genomic data and file conversion to store data in cloud architecture.
3. Validate and execute plans towards cloud computing such as security, privacy, and interoperability.
4. Students can learn and apply cloud-based methods in genomic data analysis.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3					2				1	3	3	
CO2	2	3	3	2			1	2		1	3	3	2
CO3	3	2	3	3	1	3	2	1	2	1	3	2	
CO4	3	3	3	1	2	2		3	2	1	3	3	1

Course content

Unit-I: Cloud based genome informatics **13 hours**

Cloud based analytics: Desktop based access, Data flow, enhancement, implementation, Data as a Service (DaaS), Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS).

Unit-II: Cloud servers for data analysis **13 hours**

Cloud servers: use galaxy: get data, collection operation, expression tools, general text tools, text manipulation, filter, and sort, join, subtract and groups, data mash, genomic file manipulation, common genomic tools, genomic analysis tools. Amazon cloud servers, Google genomics cloud, Microsoft cloud, IBM Apsara cloud, case studies.

Unit-III: Cloud based genome analysis **13 hours**

Cloud reproducibility, revitalizing archived data, Variations on the cloud, Advantages of cloud computing for genomics researchers, Genomics software development and boosting power, Privacy, security, and regulation.

Unit-IV: Cloud partners in genomics **13 hours**

Data transfer and storage, Workflow automation for secondary analysis, Data aggregation and governance, Interpretation and deep learning for tertiary analysis, Data transfer and migration, secure collaboration, genome data sharing. Open databases, cost optimization.

References

1. Shanrong Zhao, Kirk Watrous, Chi Zhang and Baohong Zhang, **"Cloud Computing for Next-Generation Sequencing Data Analysis".** CRC Press, 2016.
2. Lizhe Wang, Rajiv Ranjan, Jinjun Chen, Boualem Benatallah. **"Cloud Computing".** CRC Press. 2017.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0205	**ADVANCED GENOME DATA SCIENCE**	HC	0	0	2	2	2

Prerequisites/Pre reading for the course:

Knowledge on genomics and next generation sequencing techniques.

Course objectives

1. To acquire the knowledge about genome anatomies and techniques of genomics to study gene expression.
2. To apply the techniques to study gene expression.
3. To learn the basic databases and data formats
4. To grasp the significance of sequence alignment methods and the concept of phylogenetic analysis.

Course outcomes

By the end of the course the student will be able to:

1. Understand the basics of genomics sequencing, data types and algorithms.
2. Students can be able to apply the algorithms in sequencing data analysis and data interpretation.
3. Students can be able to integrate the statistical methods for comparative analysis and data mining.
4. Students can be using the genomic data analysis techniques in research and consultancy services.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	2	2	2	1	2	3	3	3	3	1	
CO2	1	1	3	2	2	1	3	3	3	3	3	1	1
CO3	2	2	1	2	2		1	2	3	3	1	1	
CO4	1	2	1	1	2	1	3	2	3	3	3		

Course content

1. Genomic Data Files

2. Sequence Analysis using Galaxy.

3. Transcriptome-Seq data analysis: Quality Analysis, Annotation and Alignment, Differential gene expression Analysis

4. Exome-Seq data analysis: Variant Analysis, Disease gene prediction

5. ChIP-Seq data analysis: Peak calling, Motif identification,

Reference books

1. Lele Buckingham and Maribeth L. Flaws, **"Molecular Diagnostics: Fundamentals, Methods & Clinical applications",** CRC Press, Taylor & Francis Group, 2007.
2. N. F. Britton, Xihong Lin, Nicola Mulder, Maria Victoria Schneider, **"Computational Exome and Genome analysis".** CRC Press, Taylor & Francis Group. 2018.
3. Coleman W.B, **"Molecular Diagnostics for the Clinical Laboratorian",** 2nd Ed. Humana Press 2006.
4. Ali Masoudi-Nejad, Zahra Narimani, Nazanin Hosseinkhan; **"Next Generation Sequencing and Sequence Assembly, Methodologies and Algorithms"**, Springer; 2013.
5. Stuart M. Brown, **"Next-Generation DNA Sequencing Informatics",** Cold Spring Harbor Laboratory Press, 2013.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0206	**RESEARCH METHODOLOGY & PROGRAMMING**	HC	0	0	2	2	2

Prerequisites/Pre reading for the course:

Knowledge on basic science and research experimental studies.

Course objectives

1. This course is designed to understand the basics of research methods.
2. The course also understands the statistical methods to understand the research problems.
3. It also helps the method of collecting literature and designs the objectives.
4. It also provide the IPR methods to the genomic research.

Course outcomes

By the end of the course the student will be able to:

1. The students can start to develop the project objectives and to collect literatures.
2. Additionally, students will get awareness regarding research challenges.
3. The students can also understand the requirement of IP concepts in research.
4. The students also apply the research ethics in process, and product development.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2		3						3	3	2	2
CO2		3	3							3	3	2	2
CO3			3	3		2			3		3	2	2
CO4			3	3			3		3	3	3	2	2

Course content

1.BWA,

2.BOWTIE,

3.TOPHAT

4.SAMTOOLS,

5.BAMTOOLS

6.VCF

7.Varscan, GATK

8.PRIMER3

9.BpWrapper

10.Scientific Writing Case studies

Reference Books

1. Jeff Chang, Brad Chapman, Iddo Friedberg, Thomas Hamelryck, **"Biopython Tutorial and Cookbook"**. 2019.
2. Tiago Antao, **"Bioinformatics with Python Cookbook",** Packt Publishing. 2015.
3. Robert G, **"R programming in Bioinformatics",** CRC press, Taylor and Francis Group, USA, 2008.

THIRD SEMESTER

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0301	**ARTIFICIAL INTELLIGENCE & DEEP LEARNING**	HC	4	0	0	4	4

Prerequisites/Pre reading for the course:

Knowledge on R and Python programming.

Course objectives

1. Machine learning gives computers the ability to learn without being explicitly programmed.
2. It encompasses a broad range of approaches to data analysis with applicability across the biological sciences.
3. It introduces commonly used algorithms and provides insight into their theoretical underpinnings.
4. Students will apply these algorithms to real biological datasets using the R language and environment.

Course outcomes

By the end of the course the student will be able to:

1. Describe recent advances in genomics, transcriptomics, proteomics, and metabolomics.
2. Understand current genomics technologies and illustrate how these can be used to study gene function.
3. Obtain and analyze data relating to specific genes using general and plant-specific databases, proteomics and metabolomics online portals, next generation sequencing tools and next generation mapping portals.
4. Design a set of experiments to address a particular biological question.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	1	2	1	1	1			3		3	2	1	2
CO2	2	3	2	3	2			3		3	3	2	2
CO3	2	3	3	3	2			3		3	3	2	2
CO4	2	3	3	3	2			3		3	3	2	2

Course content

Unit-I: Artificial intelligence **13 hours**

Introduction, Basic principles of AI, Problems: Reasoning, problem solving, knowledge representation, automated planning and scheduling, machine learning, Natural language processing, perception, motion and manipulation, social intelligence, general intelligence. Text Mining: Numerical Representation of Text, Association Rule Mining, Transudative Classification.

Unit: II: AI Approaches on Human Genome: **13 hours**

Introduction, computational neuroscience, cybernetics, symbolic AI, cognitive simulation, sub-symbolic, statistical learning, integrating AI approaches, AI Tools, AI Applications. Graph Mining: Frequent Sub graph Mining. Clustering in Bioinformatics, Graph Mining for Cheminformatics and Drug Discovery.

Unit-III: Deep learning techniques **13 hours**

Sequence Analysis using SVMs: String Kernels, Large Scale Data Structures, Heterogeneous data, Structured Output learning: Hidden Markov Models & Dynamic Programming, Discriminative Approaches (CRFs & HMSVMs), and Large-Scale Approaches. Neural Networks, Recurrent Neural Network, Convolutional Neural Network, Autoencoder, Deep Belief Network, Transfer Learning in Deep Learning.

Unit-IV: Sequence modeling **13 hours**

Unfolding Computational Graphs, Recurrent Neural Networks, Birectional Recurrent and Recursive Nets, Encoder-Decoder Sequence to Sequence Architectures, Deep Recurrent Networks, Recursive Neural Networks, The Challenge of Long-Term Dependencies, and Echo state Networks, Monte Carlo Methods, Sampling and Monte Carlo Methods, Importance Sampling, Markov Chain Monte Carlo Methods, Gibbs Sampling, the Challenge of Mixing between Separated Modes.

Reference Books

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, **"Deep learning"**, Posts and Telecom Press. 2019.
2. Sushmita Mitra, Sujay Datta, Theodore Perkins, George Michailidis, **"Introduction to Machine Learning and Bioinformatics",** 1st Edition Chapman and Hall/CRC. 2019.
3. Stephen Marsland, **"Machine Learning: An Algorithmic Perspective",** Second Edition 2nd Edition, Chapman, and Hall/CRC.2014.
4. Professor Yi Pan and Professor Albert Y. Zomaya, **"Machine Learning in Bioinformatics",** John Wiley & Sons, Inc., Hoboken, New Jersey. 2009.
5. Stuart Russell, Peter Norvig., **"Artificial Intelligence: A Modern Approach"** 3rd Edition, Pearson, 2014.
6. Prateek Joshi., **"Artificial Intelligence with Python: A Comprehensive Guide to Building Intelligent Apps for Python Beginners and Developers"**, Packt Publishing., 2017.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0302	**INTEGRATED OMICS**	HC	4	0	0	4	4

Prerequisites/Pre reading for the course:

Knowledge on Genomics and bioinformatics tools and software's.

Course objectives

1. Be able to integrate different omics and simulate biological functions using constraint-based models.
2. Build biological networks based on different omics data, as well as integrated multi-omics networks.
3. Use different biological network analysis techniques to compare different cell-types or conditions.
4. Identify key methods for analysis and integration of omics data based on a given dataset.

Course outcomes

By the end of the course the student will be able to:

1. Students can integrate the view of biological network construction and integration, constraint-based modeling,
2. Students can utilize the multi-omics integration through Machine Learning, and data-driven hypothesis generation.
3. Students will work individually to any kind of omics datasets.
4. Understand strengths and pitfalls of key machine learning techniques in multi-omics analysis.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	1	3	3	3							2		
CO2	1	3	3	3	2		3	3	3	3	3	2	2
CO3	2	3	3	3	2						3	2	2
CO4	2	3	3	3	2		3	3	3	3	3	2	2

Course content

Unit-I: Multiomics **13 hours**

Omics Approaches in Cancer Research: Genomics, Epigenomics, Transcriptomics, Proteomics, Metabolomics, Interactomics, Cytomics, Phenomics, Bioinformatics, From Omics to Personalized Medicine, Challenges and Prospective.

Unit-II: Omics Data Integration **13 hours**

ID Mapping, Quality issues - Data standards, curation, ontologies and metadata, Multiple ways to integrate multi-omics data, case studies from studying human diseases, Analysis, and visualization: Cytoscape, InterMine, Ondex/QTLNetMiner, Multiomics factor analysis (MOFA), iCluster, Challenges and best practice for working in an integrated manner with genomic, transcriptomic, and proteomic data. Integrating GWAS variants with functional genomics data to identify disease causal cell types and genes.

Unit-III: Omics Gene Mutation **13 hours**

Array Based technologies: Array Comparative Genomic Hybridization (aCGH), Oligonucleotide Microarray analysis, SNP Arrays, Sequence-Based Technologies: Mutational analyses of cancer genome, Digital Karyotyping, Gene Expression Profiling, Identification of Discriminative Genes, Effects of Genomic Structure, Effects of Cellular Pathways.

Unit-IV: Integrated software tools and web applications **13 hours**

BioCyc/MetaCyc, Cytoscape with MODAM and Cytoscape with Omics Analyzer, Ingenuity Pathway Analysis, MapMan, Reactome, FlyBase, Human Metabolome Database (HMDB), KEGG, Lipid Maps, Plant Metabolic Network, Worm Base, Yeast Metabolome Data (YMD), Saccharomyces Genome database (SGD),

Reference Books & Articles

1. Hasin, Y., Seldin, M. &Lusis, **"A. Multi-omics approaches to disease".** Genome Biol, 2017.

2. Pinu FR, Beale DJ, Paten AM, et al. **"Systems Biology and Multi-Omics Integration: Viewpoints from the Metabolomics Research Community".** Metabolites. 9(4):76. 2019.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0303	**COMPUTATIONAL DRUG DISCOVERY**	HC	4	0	0	4	4

Prerequisites/Pre reading for the course:

Knowledge on bioinformatics and genomic techniques with basic molecular biology techniques.

Course objectives

1. This course is designed to introduce the students with the different challenges in drug discovery and to use the advanced computational tools in drug design.
2. This course will explore the process of drug development, from target identification to final drug registration.
3. It will present drug development as a process involving target selection, lead discovery using computer-based methods and combinatorial chemistry/high-throughput screening.
4. Along the way you will learn about molecular recognition, computer aided drug design, and toxicology as applied to the development of new medicines.

Course outcomes

By the end of the course the student will be able to:

1. After completing this course students will be able to understand the application of different computational tools in drug discovery.
2. Additionally, students will get awareness regarding current challenges in global pharmaceutical industry.
3. Students will work individually to the on-drug discovery process of a given drug.
4. Students can become an entrepreneurs and consultants on bioinformatics and drug discovery.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	1	3	3	3							2		
CO2	2	3	3	3	2		3	3	3	3	3	2	2
CO3	2	3	1	1	2		2	2	3	1		1	2
CO4	1	3	3	3	3		2	3	3	2			3

Course content

Unit-1: Basics of Cheminformatics **13 hours**

Introduction to Cheminformatics, Evolution of Cheminformatics, High-Throughput Synthesis and Screening, History of Chemical Information Science, Use of Cheminformatics, Prospects of Cheminformatics. Chemical database design, Database Concepts, Structured Query Language, Chemical Database Design, Bio Catalyst Database, The MOS Database, The Failed Reaction Database, Protecting Groups Database, Solid-Phase Synthesis Database

Unit: II **13 hours**

Computational Chemistry: Introduction to Computational Chemistry, Classical Potential Energy Methods, Quantum Chemistry Introduction & Principles, Theories of Quantum Chemistry, Symmetry & Sample Z-Matrix, Geometry Optimization, Semi-Empirical Methods, Molecular Mechanics & Forces, Primary, secondary, and tertiary sources of chemical information, Database search methods: chemical indexing, proximity searching, 2D and 3D structure and substructure searching.

Unit-III: Disease Target Identification **13 hours**

Drug discovery process. Target identification and validation, lead optimization and validation. Methods and Tools in Computer-aided molecular Design, Analog Based drug design: - Pharmacophore (3D database searching, conformation searches, deriving and using 3D Pharmacophore, constrained systematic search, Genetic Algorithm, clique detection techniques, maximum likelihood method) and QSAR. Structure based drug design: - Docking, De Novo Drug Design (Fragment Placements, Connection Methods, Sequential Grow), Virtual screening.

Unit-IV: Structure Activity Relationship **13 hours**

Introduction to QSAR, QSPR, Various Descriptors used in QSARs: Electronics; Topology; Quantum Chemical based Descriptors. Regression Analysis, The Significance and Validity of QSAR Regression Equations, Partial Least Squares (PLS) Analysis, Multi Linear Regression Analysis. Use of Genetic Algorithms, Neural Networks and Principal Components Analysis in the QSAR equations.

Reference Books

1. Tari, Leslie W., **"Structure-Based Drug Discovery"**. Humana Press, 2012
2. Jhoti, Harren, Leach, Andrew R., **"Structure-based Drug Discovery",** Springer Netherlands., 2007
3. PandiVeerapandian., **"Structure-Based Drug Design"** 1st Edition. 2012.
4. Mohammed Iftekhar, Shaik Jameel, **"Computational Drug Discovery: Drug Discovery Process & Methods",** Createspace Independent Pub., 2015.
5. D. C. Young., **"Computational Drug Design: A Guide for Computational and Medicinal Chemists",** 1st edition, Wiley-Interscience; 2009.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SKS311	**CLINICAL & PHARMACOGENOMICS**	SC	2	0	0	2	2

Prerequisites/Pre reading for the course:

Knowledge on bioinformatics and genomic techniques.

Course objectives

1. The course aims principles of human genetics and genomics as they apply to improving the problems in drug therapy optimization and patient care, thus providing basic understanding of discipline of Pharmacogenomics.

2. To understand the genetic basis of variability in drug response can contribute to drug efficacy and toxicity, adverse drug reactions and drug-drug interaction.
3. To develop genetic component of patient variability to deliver effective individualized pharmaceutical care.
4. To develop and manage the new genomics based diagnostic tools as they become available as well as make best treatment choices.

Course outcomes

By the end of the course the student will be able to:

1. Students can understand the basic principles of human genetics and heredity as they apply to inter-individual variation in treatment response.
2. Students can explore the genetic variability in drug response, drug metabolism, drug transportation and drug receptor prediction.
3. Students can develop the contribution of drug disposition and action, leading to changes in pharmacokinetics, pharmacodynamics, and clinical outcome.
4. Recognize the societal and ethical implications of genetic testing and the resultant individualization of drug therapy.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	2	1	2	1	3	2	3	3	3		1
CO2	2	2	3	1	2		2	2	3	3	2	1	2
CO3	2	2	3	3	2		1	2	3	2	1	1	
CO4	3	1	2	3	2	1	2	3	3	1	2		1

Course content

Unit-I: Introduction to Clinical Genomics **13 hours**

Principles of genomic medicine, Phenotype to Genotypes, Cytogenetics and Arrays, complex disorders and classical gene identification, Mutation patterns, Interpreting CNVs for beginners, Dysmorphology, how to setup a NGS Lab, NGS Setup and Data analysis, Copy number variations, Therapy and cancer, Novel cancer immunotherapy approaches. Tools for Variant interpretation.

Unit-II: Clinical Data Analysis **13 hours**

Technical Aspects and Chemistries of NGS, Clinical Genome Sequencing, Targeted Hybrid Capture Method, Amplification based methods, Base Calling, Read Mapping and Coverage Analysis, Single Nucleotide Variant Detection, Insertion and Deletions, Translocation Detection, CNVs, Interpretation: Reference Database for Disease Association, Reporting of Clinical Genomics test results, Reporting software's, Regulation, Reimbursement and Legal Issues.

Unit-III: Introduction to Pharmacogenomics **13 hours**

Historical aspects of Pharmacogenetics- Pharmacogenomics- Biomarkers- and the promise of personalized medicine, Pharmacogenetics at population level, Customized therapy, barriers, Pharmacogenomics

approaches to improve drug delivery clinical outcomes, Genetic polymorphism, personalized medicine and drug prescription, Clinical Pharmacogenomics, and drug interactions.

Unit-IV: Technologies in Pharmacogenomics **13 hours**

Single nucleotide polymorphism, interethnic differences in drug response- Alcohol and aldehyde dehydrogenases, Identification of Pharmacogenomics Biomarker Classifiers in Cancer, Toxic genomics, Application to Oncology Drug Development, Strategies to Identify Pharmacogenomic, Biomarkers: Candidate Gene, Pathway-Based, and Genome-Wide Approaches, case studies.

Reference Books

1. Shashikant Kulkarni, John Pfeifer. **"Clinical Genomics",** Elsevier Publications, 2015.
2. Han Brunner; Christian Gilissen, **"Clinical Genomics and NGS",** 2018.
3. Karen Y. He, Dongliang Ge, and Max M. He. **"Big Data Analytics for Genomic Medicine"** Int. International Journal of Molecular Sciences. 2017.
4. Wiley-Blackwell, **"Pharmacogenomics: The search for individualized therapies**". 2010.
5. Yui-Wing Francis Lam Stuart Scott, **"Pharmacogenomics: Challenges and Opportunities in Therapeutic Implementation",** Second Edition, 2018.
6. Innocenti, F., & van Schaik, R. H. N. **"Pharmacogenomics. Methods in Molecular Biology".** 2013.
7. Despina Sanoudou, **"Clinical Applications of Pharmacogenetics".** 2012.
8. Sandosh Padmanabhan. **"Handbook of Pharmacogenomics and Stratified Medicine".** 2014.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SKS312	**NUTRIGENOMICS & AGRIGENOMICS**	SC	2	0	0	2	2

Prerequisites/Pre reading for the course:

Knowledge on bioinformatics and genomic techniques.

Course objectives

1. The course is aimed to understand the genetics and genomic techniques in agriculture.
2. Genomic sequencing and data analysis techniques help to select in plant breeding techniques.
3. QTL analysis of inbreeding and breeding for plants and animals.
4. To understand and apply the techniques of genomics to study and improve plant variety.

Course outcomes

By the end of the course the student will be able to:

1. Evaluate the relative limitations and merits of different technologies for crop and animal improvement.
2. Demonstrate a detailed understanding of genetic inheritance of traits and the methods utilized for reporting genetic merit.
3. Discuss in detail the relative importance of genotype and environment in the inheritance of metric traits.
4. Evaluate scientific, practical, and ethical issues in the application of genetics to animal and plant improvement.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	3	2	3	3			2	2			3	2
CO2	2	3	3	3	3	3				1		2	3
CO3	3	3	3	3	3							2	3
CO4	3	3	3	3			2	2	1			3	3

Course content

Unit-I Introduction to Nutrigenomics **13 hours**

Nutrigenomics: Scope and Importance to Human Health and Industry, Transporter gene polymorphisms - interaction with effects of micronutrients in humans. Polymorphisms in genes affecting the uptake and transport of omega-6 and omega-3 polyunsaturated fatty acids: interactions with dietary lipids and chronic disease risk. Nutrigenomics approaches to unraveling physiological effects of complex foods. The intestinal microbiota - role in nutrigenomics.

Unit-II: Disease Risk and Case studies **13 hours**

Modulating the risk of diseases through nutrigenomics (Cardiovascular, Diabetes, Bowel disease, obesity and cancer); modulating the malnutrition through nutrigenomics. Bringing nutrigenomics to the food industry: Short-term gene expression regulation by nutritional factors. Diet and epigenetics. Industry-Academia partnerships as an important challenge; Bringing nutrigenomics to the public.

Unit-III: Genomic Approaches in Plant breeding **13 hours**

Overview of molecular breeding, the cultivar development process, and genetic gain; Sequence-based gene discovery and comparative genomics approaches; Demonstration of "in silico" gene discovery strategies; Databases for discovery of plant improvement genes. Molecular Markers development.

Unit-IV: Agrigenomic Data Analysis **13 hours**

Breeder tools: Marker Assisted Background Selection, Trait Mapping, Diversity analysis, Population Genetics, Parentage Verification, DNA Fingerprinting; Case studies.

Reference Books

1. QI Lu. **"Gene-Diet Interactions in Complex Disease: Current Findings and Relevance for Public Health",** Curr Nutr Rep 2012.
2. Tucker K. L., Smith C. E., Lai C. Q., Ordovas J. M. **"Quantifying diet for nutrigenomic studies"** Annual review of nutrition. 2013.
3. Perry G. H., Dominy N. J., Claw k. G., Lee A.S., Fiegler H., Redon R. **"Diet and the evolution of human amylase gene copy number variation",** Nat Genet 2007.
4. Norheim F, Gjelstad IM, Hjorth M, Vinknes KJ. **"Molecular nutrition research: the modern way of performing nutritional science."** Journal Nutrients, 2012.
5. Phillips CM. **"Nutrigenetics and metabolic disease: current status and implications for personalized nutrition".** Nutrients. 2013.

6. Chakravarthy R**., "Agri Informatics: An Introduction",** ICFAI University Press, 2006.
7. Chittaranjan Kole, Albert G., **"Principles and Practices of Plant Genomics: Advanced Genomics",** Volume 3. Abbott. Science Publishers, 2010.
8. Christopher A. Cullis, **"Plant Genomics and Proteomics",** Wiley Publishers, 2007.
9. Hany A. El-Shemy, **"Plant Genomics"**, Horizon Scientific Press, 2009
10. Poonam Chilana, Anu Sharma and Anil Rai, **"Insect genomic resources: status, availability and future"**, Current Science, Vol. 102, No. 4: 25, 2012.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SKS321	**METAGENOMICS**	SC	2	0	0	2	2

Prerequisites/Pre reading for the course:

Knowledge on Genomics and bioinformatics techniques.

Course objectives

1. The course is aimed to design appropriate microbiome-focused experiments.
2. Understand the advantages and limitations of metagenomic data analysis.
3. Apply appropriate statistics to undertake rigorous data analysis.
4. Visualize datasets to gain intuitive insights into the composition and/or activity.

Course objectives

By the end of the course the student will be able to:

1. Students can familiarity with the goals of typical microbial community studies and common culture-independent molecular technologies used to assay them.
2. Students can perform metagenomic and metatranscriptomic data analysis for taxonomic, functional, and strain-level characterization of communities using reproducible workflows.
3. Students can perform multivariate statistical analyses; combine multiple measurement types in microbial communities, and how to visualize associated results.
4. Students can use the metagenomic techniques for lifelong learning in healthcare industries.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	2	1	2	1	2	2	3	3	2		1
CO2	1	2	2	2	2		2	3	3	3	3	1	2
CO3	1	2	1		1		1	1		1	1		
CO4	1	3	3		2		1	1	1	1	1		1

Course content

Unit-I: Introduction to Metagenomics **13 hours**

Metagenomics, Types of metagenomes: Amplicon, Shotgun, Functional Metagenomics; Selection of samples, pure culture and in consortium, cultivable and non-cultivable microbial analysis; Bacterial genomes and basic functions, Mutations and phenotypes, Basics of genetic analysis, Implementation and suppression, transposons, Conjugation, Mechanisms of gene regulation. Next-generation sequencing approaches to Metagenomics.

Unit-II: Metagenome Sequencing **13 hours**

Metagenome of Environmental, soil, human mouth, skin, colon, oesophagus, stomach, and vagina samples: Sample preparation, Library preparation, sequencing, functional classification, taxonomy, and functional annotation. The Human microbiome: Case studies.

Unit-III: Metagenomics and phylogenetics **13 hours**

Community structure profiling across microbial samples, Phylogenetic diversity of microbial communities, 16S community profiling by analysis of ribosomal amplicons, Extracting 16S sequences from assembled data.

Unit-IV: Metagenomic Applications **13 hours**

The sampling process and library construction for metagenomic analysis, Comparison of metagenome analysis techniques, Soil health, Soil metagenomics, Culture dependent approaches.

Reference Books

1. Diana Marco Universidad Nacional de Cordoba, Argentina, **"Metagenomics: Theory, Methods and Applications",** Caister Academic Press, 2010
2. Wren, B Dorrell, N, **"Functional Microbial Genomics: Methods in Microbiology",** Academic Press Inc, 2002.
3. Streit, Wolfgang, Daniel, Rolf (Eds.) **"Metagenomics, Methods and Protocols",** Springer, 2010.
4. Fancello, L., Raoult, D., and Desnues, C. **"Computational tools for viral Metagenomics and their application in clinical research"**. Virology 434, 2012
5. Norman Grossblatt, (Ed), **"The new science of Metagenomics",** National Academic Press, Washington, 2007.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SKS322	**AI BASED TOOL DEVELOPMENT**	SC	2	0	0	2	2

Prerequisites/Pre reading for the course:

Knowledge on big data analytics and data mining techniques.

Course objectives

1. The course aims to understand the AI techniques used to develop AI based tools and software's.
2. It Introduced advanced programming languages based on current industry applications.
3. It also helps to understand the existed tools used to develop different frameworks.
4. It also helps to create and use the AI based web tools and server for analyzing genomic data.

Course outcomes

By the end of the course the student will be able to:

1. The students can use python programming to develop AI based tools.
2. Students Can understand the AI based algorithms to develop tools and frameworks.

3. Students can use the AI tools and frameworks for genomic data science
4. Students can use the AI frameworks and severs to analyze the big data and genomic data.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	2	1	2	1	2	2	3	3	2		1
CO2	1	2	2	2	2		2	3	3	3	3	1	2
CO3	1	2	1		1		1	1		1	1		3
CO4	1	3	3		2		1	1	1	1	1		1

Course content

Unit-I: Artificial Intelligence in genomics **13 hours**

Exploring Genomic Data and AI in Healthcare, Challenges, and limitations of AI Techniques in genomic data science. Machine learning applications in genetics and genomics.

Unit-II:AI Based Framework Development **13 hours**

Installing Anaconda, Fundamentals of reinforcement learning, Deep Q-learning, Deep Convolutional Q-learning, A3C Intuition, implementation, Visualization, ANN Artificial Neural Networks), CNN (Convolutional Neural Networks).

Unit-III: AI Tools and Frameworks **13 hours**

AI Tool Development, Framework Design, AI Tools and Frameworks: Scikit Learn, TensorFlow, Theano, Caffe, MxNet, Keras, PyTorch, CNTK, Auto ML, OpenNN, H20: Open-Source AI Platform, Google ML Kit.

Unit-IV: AI web tool development **13 hours**

AI Web design and development, AI designer, Sketch2code, Impersonal interactions, Website Development Machine, Machine centralized research, Testing and Quality assurance.

Reference Books

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, **"Deep learning",** Posts and Telecom Press, 2019.
2. Sushmita Mitra, Sujay Datta, Theodore Perkins, George Michailidis, **"Introduction to Machine Learning and Bioinformatics",** 1st Edition Chapman and Hall/CRC. 2019.
3. Stephen Marsland, **"Machine Learning: An Algorithmic Perspective",** Second Edition 2nd Edition, Chapman, and Hall/CRC.2014.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0305	**SKILL ENHANCEMENT COURSE**	HC	0	0	2	2	3

Course outcomes

1. Acquire hands on training in various modules required from research and industry perspective
2. Enhance the knowledge horizon from practical point of view supplementing the knowledge in theory.
3. Provide firsthand experience in various techniques learned at lab level to a higher level.
4. Equip the students with skill sets to carry out the research projects effectively.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	3	3	3	2		3				3	3	2
CO2	3	2	3								2	2	3
CO3	3	2	3	3			3		3	3	3	3	2
CO4	2	3	3	3			3				3	3	3

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0305	**ARTIFICIAL INTELLIGENCE & OMICS**	SC	0	0	2	2	3

Prerequisites/Pre reading for the course:

Knowledge on biology, computer science and mathematics.

Course objectives

1. Machine learning gives computers the ability to learn without being explicitly programmed.
2. It encompasses a broad range of approaches to data analysis with applicability across the biological sciences.
3. It introduces commonly used algorithms and provides insight into their theoretical underpinnings.
4. Students will apply these algorithms to real biological datasets using the R language and environment.

Course outcomes

By the end of the course the student will be able to:

1. Students can understand the deep learning techniques and their applications.
2. Students also implement the genomic data resource to predict the diseases.
3. Students can use different deep learning techniques and omics techniques to genomic data resources.
4. Students can analyze the genomic data by using AI techniques.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	2	1	2	1	2	2	3	3	2		1
CO2	1	2	2	2	2		2	3	3	3	3	1	2
CO3	1	2	1		1		1	1		1	1		
CO4	1	3	3		2		1	1	1	1	1		1

Course content

1. Data Simulation
2. Text Mining
3. Clustering Analysis of Biological Data
4. Graph Design for Drug Discovery
5. Neural Networks
6. Monte Carlo Simulation
7. Cytoscape
8. InterMine

9. Ondex/QTLNetMiner
10. Multiomics factor analysis (MOFA)
11. iCluster
12. GWAS

Reference Books

1. Stephen Marsland, **"Machine Learning: An Algorithmic Perspective",** Second Edition 2nd Edition, Chapman and Hall/CRC.2014.
2. Professor Yi Pan and Professor Albert Y. Zomaya, **"Machine Learning in Bioinformatics",** John Wiley & Sons, Inc., Hoboken, New Jersey. 2009.
3. Stuart Russell, Peter Norvig., **"Artificial Intelligence: A Modern Approach",** 3rd Edition, Pearson, 2014
4. Prateek Joshi., **"Artificial Intelligence with Python: A Comprehensive Guide to Building Intelligent Apps for Python Beginners and Developers",** Packt Publishing., 2017.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0306	**COMPUTATIONAL DRUG DISCOVERY**	SC	0	0	2	2	3

Prerequisites/Pre reading for the course:

Knowledge on bioinformatics, chemistry, and biology.

Course objectives

1. The course aims to introduce the disease identification methods and target selection.
2. It also helps to build the protein structure, modelling and protein validation of protein structures.
3. The course also helps to understand the chemical properties as drug like prediction.
4. The course also helps to implement and virtually screen best active potential lead molecules has potential lead molecules.

Course outcomes

By the end of the course the student will be able to:

1. Students can learn the basics of drug discovery and to identify the disease targets.
2. The students also develop different homology modelled proteins and validate the protein structures.
3. Students can develop the chemical structures and predict docking to predict as best active potential lead molecules.
4. Students can use the software's and tools for computational drug discovery

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	2	1	2	1	2	2	3	3	2	2	1
CO2	1	2	2	2	2		2	3	3	3	3	1	2
CO3	1	2	1		1		1	1		1	1	2	
CO4	1	3	3		2		1	1	1	1	1	2	1

Course content

1. Disease target Identification
2. Homology Modeling
3. Structure Validation
4. Active Site Amino Acids Prediction
5. Ligand Design
6. Pharmacophore Modeling
7. Pharmacokinetics
8. Molecular Docking Studies
9. Virtual Screening
10. Molecular Dynamics

Reference Books

1. Tari, Leslie W., **"Structure-Based Drug Discovery"**. Humana Press, 2012
2. Jhoti, Harren, Leach, Andrew R., **"Structure-based Drug Discovery",** Springer Netherlands., 2007
3. PandiVeerapandian., **"Structure-Based Drug Design"** 1st Edition. 2012.
4. Mohammed Iftekhar, Shaik Jameel, **"Computational Drug Discovery: Drug Discovery Process & Methods",** Createspace Independent Pub., 2015.
5. D. C. Young., **"Computational Drug Design: A Guide for Computational and Medicinal Chemists",** 1st edition, Wiley-Interscience; 2009.

FOURTH SEMESTER

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SK0401	**INDUSTRIAL PROJECT / INTERNSHIP**	SC	0	0	10	10	10

Course outcomes

1. Apply fundamental and disciplinary concepts and methods in ways appropriate to their principal areas of study.
2. Demonstrate the skill sets acquired and employ the knowledge of current information in the domain.
3. Apply technological tools and techniques specific to the professional field of study.
4. Acquire real time exposure to the systematic execution of research components and methodology.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	3	3	3							3	2	2
CO2	2	2	3	3	3	3					2	3	2
CO3	2	2	3	3	3	3		3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3

Internship: Minimum of four weeks duration internship should be carried out by the student either in industry or in an R&D organization, including educational institutes with excellent research culture. In case, if a student is unable to secure internship either in industry or in an R&D organization, a project may be carried out within the university. The student is expected to submit a formal report at the end of the internship Programme. The student shall be awarded the marks for internship based on the (a) presentation and (b) comprehensive viva by the panel of examiners constituted by the school.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SKON01	**SWAYAM/ MOOC -1**	SC	0	0	0	2	0

Course outcomes

1. Enhance the conceptual knowledge and ensure academic achievement in the subject domain offered through the e learning.
2. Gain additional expertise gained in the process of e-learning.
3. Acquire intellectual skills such as domain-specific and generic abilities involved in reasoning, comprehension and thinking abilities.
4. Inculcate the problem-solving, and decision-making skills related to the subject domain.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	3			3					1	3	3
CO2	3	2	3								1	3	3
CO3	3	3	3							3	1	2	3
CO4	3	3	3							3	1	2	3

MOOC / SWAYAM Online Courses: Globally, MOOC (Massive Open Online Course) platforms are gaining much popularity. Considering the popularity and relevance of MOOCs, Government of India has also launched an indigenous platform, SWAYAM. SWAYAM (Study Webs of Active Learning for Young Aspiring Minds) is basically an integrated MOOCs platform for distance education that is aimed at offering

all the courses from school level (Class IX) to post-graduation level. The platform has been developed collaboratively by MHRD (Ministry of Human Resource Development) and AICTE (All India Council for Technical Education) with the help of Microsoft and is capable of hosting 2,000 courses.

A student shall register and successfully complete any of the courses available on SWAYAM / MOOC. Student shall inform the MOOC/SWAYAM coordinator of the school about the course to which he/she has enrolled. The duration and credits of the course shall vary depending upon the agency offering MOOC / SWAYAM courses. The student should submit the certificate issued by the agency offering SWAYAM / MOOC courses to the coordinator of the school, the grades obtained in the course shall be forwarded to concerned authority of the University.

Course code	Course Title	HC/ SC/ OE	L	T	P	C	Hrs./ Wk.
M21SKON01	**SWAYAM/ MOOC -2**	SC	0	0	0	2	0

Course outcomes

1. Enhance the conceptual knowledge and ensure academic achievement in the subject domain offered through the e learning.
2. Gain additional expertise gained in the process of e-learning.
3. Acquire intellectual skills such as domain-specific and generic abilities involved in reasoning, comprehension and thinking abilities.
4. Inculcate the problem-solving, and decision-making skills related to the subject domain.

Mapping of Course Outcomes with Programme Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	3			3					1	2	3
CO2	3	2	3								1	2	3
CO3	3	3	3							3	1	2	3
CO4	3	3	3							3	1		3

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CAREER OPPORTUNITIES

Having a degree will open doors to the world of opportunities for you. But Employers are looking for much more than just a degree. They want graduates who stand out from the crowd and exhibit real life skills that can be applied to their organizations. Examples of such popular skills employers look for include:

1. Willingness to learn
2. Self-motivation
3. Teamwork
4. Communication skills and application of these skills to real scenarios
5. Requirement of gathering, design and analysis, development, and testing skills
6. Analytical and Technical skills
7. Computer skills
8. Internet searching skills
9. Information consolidation and presentation skills
10. Role play
11. Group discussion, and so on

REVA University, therefore, has given utmost importance to develop these skills through variety of training programs and such other activities that induce the said skills among all students. A full-fledged Career Counselling and Placement division, namely Career Development Centre (CDC) headed by well experienced senior Professor and Dean and supported by dynamic trainers, counsellors and placement officers and other efficient supportive team does handle all aspects of Internships and placements for the students at REVA University. The prime objective of the CDC is to liaison between REVA graduating students and industries by providing a common platform where the prospective employer companies can identify suitable candidates for placement in their respective organization. The CDC organizes pre-placement training by professionals and also arranges expert talks to our students. It facilitates students to career guidance and improve their employability. In addition, CDC forms teams to perform mock interviews. It makes you to enjoy working with such teams and learn many things apart from working together in a team. It also makes you to participate in various student clubs which helps in developing team culture, variety of job skills and overall personality.

The need of the hour in the field of Biotechnology is not only knowledge in the subject, but also the skills to do the job proficiently, team spirit and a flavor of innovation. This kept in focus, the CDC has designed the training process, which will commence from second semester along with the curriculum. Special coaching in personality development, career building, English proficiency, reasoning, puzzles, and communication skills to every student at REVA University is given with utmost care. The process involves continuous training and monitoring the students to develop their soft skills including interpersonal skills that will fetch them a job of repute around his / her interest and march forward to make better career. The School of Chemical and Biological sciences also have emphasized subject based skill training through lab practice, internship, project work, industry interaction and many such skilling techniques. The students during their day-to-day studies are made to practice these skill techniques as these are inbuilt in the course curriculum. Concerned teachers also continuously guide and monitor the progress of students.

The University has also established University-Industry Interaction and Skill Development Centre headed by a Senior Professor & Director to facilitate skill related training to REVA students and other unemployed students around REVA campus. The center conducts variety of skill development programs to students to suite to their career opportunities. Through this skill development center, the students shall compulsorily complete at least two skill / certification-based programs before the completion of their degree. The University has collaborations with Industries, Corporate training organizations, research institutions and Government agencies like NSDC (National Skill Development Corporation) to conduct certification programs. REVA University has been recognized as a Centre of Skill Development and Training by NSDC (National Skill Development Corporation) under Pradhan Mantri Kaushal Vikas Yojana.

The University has also signed MOUs with Multi-National Companies, research institutions, and universities abroad to facilitate greater opportunities of employability, students' exchange programs for higher learning and for conducting certification programs.

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