

University of Mumbai



No. AAMS_UGS/ICC/2024-25/137

CIRCULAR:-

Attention of all the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments is invited to this office Circular No. AAMS_UGS/ICC/2023-24/23 dated 08th September, 2023 relating to the NEP UG & PG Syllabus.

They are hereby informed that the recommendations made by the **Ad-hoc Board of Studies in Biotechnology** at its meeting held on 09th July, 2024 and subsequently passed by the Board of Deans at its meeting held on 3rd September, 2024 vide item No. 6.1(N) have been accepted by the Hon'ble Vice Chancellor as per the power confirmed upon him under section 12 (7) of the Maharashtra Public Universities Act, 2016 and that in accordance therewith syllabus for **M.Sc.(Biotechnology) Sem – III & IV** is introduced as per appendix (NEP 2020) with effect from the academic year 2024-25.

(The Circular is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
21st September, 2024


(Dr. Prasad Karande)
REGISTRAR

To

All the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments.

BOD 6.1(N) 03/09/2024

Copy forwarded with Compliments for information to:-

- 1) The Chairman, Board of Deans,
- 2) The Dean, Faculty of Science,
- 3) The Chairman, **Ad-hoc Board of Studies in Biotechnology**
- 4) The Director, Board of Examinations and Evaluation,
- 5) The Director, Department of Students Development,
- 6) The Director, Department of Information & Communication Technology,
- 7) The Director, Centre for Distance and Online Education (CDOE) Vidyanagari,
- 8) The Deputy Registrar, Admission, Enrolment, Eligibility & Migration Department (AEM),

Copy forwarded for information and necessary action to :-	
1	The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Dept)(AEM), dr@eligi.mu.ac.in
2	The Deputy Registrar, Result unit, Vidyanagari drresults@exam.mu.ac.in
3	The Deputy Registrar, Marks and Certificate Unit,. Vidyanagari dr.verification@mu.ac.in
4	The Deputy Registrar, Appointment Unit, Vidyanagari dr.appointment@exam.mu.ac.in
5	The Deputy Registrar, CAP Unit, Vidyanagari cap.exam@mu.ac.in
6	The Deputy Registrar, College Affiliations & Development Department (CAD), deputyregistrar.uni@gmail.com
7	The Deputy Registrar, PRO, Fort, (Publication Section), Pro@mu.ac.in
8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
9	The Deputy Registrar, Research Administration & Promotion Cell (RAPC), rapc@mu.ac.in
10	The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA) dy.registrar.tau.fort.mu.ac.in ar.tau@fort.mu.ac.in
11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
12	The Deputy Registrars, Finance & Accounts Section, fort draccounts@fort.mu.ac.in
13	The Deputy Registrar, Election Section, Fort drelection@election.mu.ac.in
14	The Assistant Registrar, Administrative Sub-Campus Thane, thanesubcampus@mu.ac.in
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16	The Assistant Registrar, Ratnagiri Sub-centre, Ratnagiri, ratnagirisubcentar@gmail.com
17	The Director, Centre for Distance and Online Education (CDOE), Vidyanagari, director@idol.mu.ac.in
18	Director, Innovation, Incubation and Linkages, Dr. Sachin Laddha pinkumanno@gmail.com
19	Director, Department of Lifelong Learning and Extension (DLLE), dlleuniversityofmumbai@gmail.com

Copy for information :-	
1	P.A to Hon'ble Vice-Chancellor, vice-chancellor@mu.ac.in
2	P.A to Pro-Vice-Chancellor pvc@fort.mu.ac.in
3	P.A to Registrar, registrar@fort.mu.ac.in
4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

To,

1	The Chairman, Board of Deans pvc@fort.mu.ac.in
2	Faculty of Humanities, Dean 1. Prof.Anil Singh Dranilsingh129@gmail.com Associate Dean 2. Dr.Suchitra Naik Naiksuchitra27@gmail.com 3.Prof.Manisha Karne mkarne@economics.mu.ac.in
	Faculty of Commerce & Management, Dean 1. Dr.Kavita Laghate kavitalaghate@jbims.mu.ac.in Associate Dean 2. Dr.Ravikant Balkrishna Sangurde Ravikant.s.@somaiya.edu 3. Prin.Kishori Bhagat kishoribhagat@rediffmail.com

	Faculty of Science & Technology Dean 1. Prof. Shivram Garje ssgarje@chem.mu.ac.in Associate Dean 2. Dr. Madhav R. Rajwade Madhavr64@gmail.com 3. Prin. Deven Shah sir.deven@gmail.com
	Faculty of Inter-Disciplinary Studies, Dean 1. Dr. Anil K. Singh aksingh@trcl.org.in Associate Dean 2. Prin. Chadrashekhhar Ashok Chakradeo cachakradeo@gmail.com
3	Chairman, Board of Studies,
4	The Director, Board of Examinations and Evaluation, dboee@exam.mu.ac.in
5	The Director, Board of Students Development, dsd@mu.ac.in DSW directr@dsw.mu.ac.in
6	The Director, Department of Information & Communication Technology, director.dict@mu.ac.in

**BOD – 3/9/2024
12 (7) of M.P.U.A. 2016
Item No. – 6.1 (N)**

As Per NEP 2020

University of Mumbai



**Title of the P.G. Program
M.Sc. (Biotechnology)**

**Syllabus for
Semester – Sem.- III & IV**

**Ref: GR dated 16th May, 2023 for Credit
Structure of PG**

(With effect from the academic year 2024-25)



(As per NEP 2020)

Sr. No.	Heading	Particulars
1	Title of program O: _____	M.Sc. (Biotechnology)
2	Scheme of Examination R: _____	NEP 50% Internal 50% External, Semester End Examination Individual Passing in Internal and External Examination
3	Standards of Passing R: _____	40%
4	Credit Structure R: <u>SP-60B</u>	Attached herewith
5	Semesters	Sem. III & IV
6	Program Academic Level	6.5
7	Pattern	Semester
8	Status	New
9	To be implemented from Academic Year	2024-25

Sign of the BOS
Chairman
Dr. Varsha Kelkar-Mane
Ad-hoc BoS
(Biotechnology)

Sign of the
Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science &
Technology

Sign of the
Offg. Dean
Prof. Shivram S. Garje
Faculty of Science &
Technology

1) Scheme of Examination: (THEORY AND PRACTICALS) :

a) Summative assessments (THEORY):

For 2 credit courses

25 M (1 hr)

Q.1 Answer any 1 question out of two (Covering Module 1 & 2)	8 M
Q.2 Answer any 1 question out of two (Covering Module 1 & 2)	7 M
Q.3 One or 2 marks answers. Questions based on problem solving/ analytical skills/ critical thinking (Covering Module 1 & 2)	10 M

For 4 credit courses

50 M (2 hr)

Q1. Answer any 2 questions out of 3 (based on Module I)	10 M
Q2. Answer any 2 questions out of 3 (based on Module II)	10 M
Q3. Answer any 2 questions out of 3 (based on Module III)	10 M
Q4. Answer any 2 questions out of 3 (based on Module IV)	10 M
Q5. Write one Essay type answer out of 3 (based on Module I-IV)	10 M

b) Formative assessments (informal and formal tests administered during the learning process).

For 2 credit courses

25M

- Group tasks/ Assignments/ Quizzes at the time of completion of each Module 15M
- Spoken/oral examination after completion of each Module 10M

For 4 credit courses

50M

At least 2 of the following for 25M each to be designed

Open book test/assignments/presentation/quiz/role play/MCQ/problem solving

c) Summative assessments (PRACTICALS):

Summative assessments For 2 credits	25 M
Format will be shared prior to examinations	

Formative assessment For 2 credits	25 M
Submission of 1 assignment: Poster/presentation based on history/discovery/Application /problems based on techniques/experiments performed	15 M
Viva/Field visit report-	10 M

Summative Assessments For 4 credit	50M
Format will be shared prior to examinations	

Formative assessment For 4 credits	50M
Submission of at least 2 of the following for 25M each assignments/ Poster/presentation based on history/discovery/Application/Problems based on techniques/spots/identification experiments performed	

Sem III

Research Project 4 credits

It is mandatory for students to review minimum 5 recent research papers from indexed journals / Journals with ISSN numbers under the guidance of mentors / in house faculty and write a review article/report/work plan that would be presented during the practical examinations for 100M (50% by internal examiner and 50% by external examiner) Plagiarism check certificate to be appended in the report submitted.

Sem IV

Research Project- 6 credits

Research project /Training under the guidance of industry/ R&D mentors / in house faculty with wet lab and/or *in-silico* experience in fields in /or allied to Biotechnology. The project would be graded during the practical examinations based on the submitted project / dissertation report as well as a power-point presentation. (50% by internal examiner and 50% by external examiner).



Sign of HOD

Professor Varsha Kelkar Mane
University Dept of Biotechnology

Sign of Dean,

Professor Shivram Garje
Name of the Faculty: Science

R: SP-60B

	Le vel	Sem (2 Yr)	Major		R M	OJT / FP	R P	Cu m. Cr.
			Mandatory*	Electives Any one Credits 4				
II	6.5	Sem III	Course 1 Nanobiotechnology Credits 4 Course 2 Environmental Biotechnology Credits 4 Course 3 Practical – lab work Credits 4 Course 4 Bioanalytical and Biophysical techniques Credits 2	Elective Course 1 Food Biotechnology and Nutraceuticals Credits 4 (2 credits theory + 2 credits practicals) OR Elective Course 2 Clinical Biochemistry Credits 4 (2 credits theory + 2 credits practical) OR Elective Course 3 Advanced Epidemiology and Applied Microbiology Credits 4 (2 credits theory + 2 credits practicals) OR Elective course 4 Any of MOOCs Credits 4	-	-	4	22
		Sem IV	Course 1 Omics and Systems Biology Credits 4 Course 2 Drug Discovery and Clinical Studies Credits 4 (2 credits theory + 2 credits practicals) Course 3 Molecular Enzymology Credits 4 (2 credits theory + 2 credits practicals)	Elective Course 1 Biologics and regulatory affairs Credits 4 OR Elective Course 2 NGS and Bioinformatics Credits 4 (2 credits Theory + 2 credits) OR Elective course 3 Any of MOOCs Credits 4	-	-	6	22
		Cum. Cr.for PG Diploma	26	8			10	44
		Cum Cr for 2 Yr	54	16	4	4	10	88

Semester – III

Syllabus
M.Sc. (Biotechnology)
(Sem. III & IV)

Semester –III

Course 1 -- Nanobiotechnology

Credits 4

Course Outcomes: On successful completion of the course the learner would be
CO1: acquainted with the perspective of Nanotechnology at national and international levels.
CO2: well versed with approaches used for nanoparticle synthesis.
CO3: able to introduce examples of nanoparticles present in nature.
CO 4: able to understand the role of various characterization techniques used in nanotechnology

Modules	Topics	Credits	No of lectures
Module I: Introduction to Nanotechnology	Introduction to Nanotechnology (1 lecture), Nano-Geosystem for Abiotic Nanoparticles Formation Nanoscience and their applications (3 lectures), Nano-Biosystem Consisting of Biotic Nanoparticles (3 lectures), Examples of Nanotechnology in Ayurveda (3 lectures), Nanotechnology research development and innovation in India, Nanotechnology and Regulation (3 lectures), Global and Indian Perspective, Global trends in Nanotechnology (2 lectures)	4	15
Module II: Synthesis of Nanomaterials	Nanometre scale materials: Nanometre-Scale Metals, Metal Oxides, Nano polymers, Quantum Dots, Nanocarbons /Carbon nanostructures, (4 lectures) Synthesis of nanometre-scale materials: Top-down and bottom-up approach, Physical methods of synthesis -Mechanical methods- ball milling, Melt Mixing, Physical method deposition, Laser Vaporization (Ablation) method (4 lectures),Chemical methods of synthesis – introduction and advantages, introduction to Colloids and synthesis of Colloids, sol-gel method, hydrothermal synthesis (4 lectures), Biological methods of synthesis- synthesis using microorganisms, synthesis using plants, synthesis using DNA (3 lectures)		15

Module III: Nanotechnology in nature	Self-Assembly of nanoparticles: Mechanism of Self Assembly, Examples of Self Assembly -Self-Assembly of Nanoparticles Using Organic Molecules, Self-Assembly in Biological Systems, Self-Assembly in Inorganic Materials. (5 lectures) Examples of Nanostructures in Nature Superhydrophobic surfaces of plants, Biomineralization of silica by diatoms, Silicification by sponges, Magnetic particles in animals and microorganisms, Serpent Sea star, beak of squid, beard of Mussels (5 Lectures) Biological nanostructures and Nanorobotics: ATP synthase, the kinesin, myosin, dynein, flagella modulated motion. (5 lectures)		15
Module IV: Properties and Characterization of nanoparticles	Characterization of Nanoparticles: Microscopy-SEM, TEM, Scanning Tunnelling Microscopy, Atomic Force Microscopy (3 lectures) UV-Vis Spectroscopy, Dynamic Light Scattering, X-Ray Diffraction, FTIR, X Ray Photoelectron Spectroscopy (5 lectures) Plasmonic material, Localised Surface Plasmon Resonance, Nano magnetism, types of magnetic materials (3 lectures) Nanotoxicology: Toxicity of Nanomaterials, Factors Responsible for the Nanomaterial Toxicity, Routes of Exposure to Engineered nanoparticles, Mechanisms of Nanoparticle toxicity, toxicology of nanocarriers (4 lectures)		15

References:

1. History of Nanotechnology from Prehistoric to Modern times, Madhuri Sharan, Wiley (2019)
2. Nanotechnology development in India: An overview, Amit Kumar, Research & Information system for developing countries (RIS), Dec 2014.
3. A Laboratory Course in Nanoscience and Nanotechnology by Poinern, Gérard Eddy Jai, CRC press.
4. Nanostructures, nanomaterials synthesis, properties applications by Guozhong Cao, Imperial College press.
5. Nanotechnology-Principles and Practices, Sulabha K. Kulkarni (auth.) -Springer International Publishing (2015).
6. Nanobiotechnology II_ More Concepts and Applications-Chad A. Mirkin, Christof M. Niemeyer - Wiley VCH (2007)
7. Bio directed synthesis and assembly of nanomaterials., Crookes-Goodson, W. J., Slocik, J. M., & Naik, R. R. *Chemical Society Reviews*, 37(11)(2008)..

8. Nanorobotics: a field inspired by nature, Chapter 7. In: Bar-Cohen, Y. (ed.) Biomimetics: Biologically Inspired Technologies Ummat, A., Dubey, A., Mavroidis, C.: Bio. CRC, Boca Raton (2006)
9. Nanomedicine in drug delivery-Arun Kumar - CRC Press _ Taylor & Francis (2013)
10. The Nanoscope: Encyclopedia of Nanoscience and Nanotechnology, Diwan, P., & Bharadwaj, A. (Eds.). (2005). Pentagon Press. Volume 3
11. NanoBioTechnology_BioInspired Devices and Materials of the Future, Oded Shoseyov, Ilan Levy (2008, Humana Press)
12. "The Promising Future in Medicine: Nanorobots." Apoorva Manjunath, and Vijay Kishore, Biomedical Science and Engineering, vol. 2, no. 2 (2014).
13. Textbook of Nanoscience and Nanotechnology by B.S. Murty, P. Shankar, Baldev Raj, B B Rath, James Murday.
14. Toxicology of Nanomaterials-Yuliang Zhao, Zhiyong Zhang, and Weiyue Feng-Wiley-VCH (2016)
15. Nanorobotics in Nanomedicine from Visakh P. M. - Nanomaterials and Nanotechnology in Medicine-Wiley (2022)
16. Introduction to Bionanotechnology-Young-Chul Lee, Ju-Young Moon - Springer (2020)

Course Outcomes: On successful completion of the course the learner would be able to:

CO1: Understand various types of pollution, their monitoring, latest mitigation strategies and management of the same.

CO2 : Understand various Health hazards of pollution and waste, solid waste management, biodiversity concepts and data management, ecology and environmental monitoring.

CO3: Understand various concepts of environmental biotechnology, latest developments in the area and use of microbiological, molecular and analytical methods in environmental biotechnology.

Modules	Topics	Credits	No of lectures
Module I: Microbial Diversity & Ecology	Introducing biodiversity informatics, Global patterns of distribution of Microbial biodiversity, biomes, Composition and distribution of biodiversity in India (5 lectures) Taxonomic Database Working Group (TDWG) standards, compatibility and interoperability, taxonomically intelligent systems (5 lectures) Global biodiversity information system-Overview of the UNEP/GEF biodiversity data management project (BDM) (5 lectures)	4	15
Module II: Environmental Degradation	Impact of anthropogenic activities, of environment: Soil/Land, Water, Air, Forest, Oceans and the coasts. Plastic and Microplastic pollution (5 lectures), Ozone Layer Depletion, Atmospheric Brown Cloud, Impact on Flora and Fauna, Impact on Crop Yield (5 lectures). Causes of soil salinity; Chemical and metallic pollution of agricultural soil; Bioleaching of metals, bioaugmentation & biomagnification for soil remediation. (5 lectures)		15
Module III: Environmental Monitoring	Environmental monitoring: Definition and process; Sampling – land (site), water & air; Biological indicators (Marine microbes, algae and crustaceans); GIS for environment monitoring and assessment (4 lectures) Physico-chemical characteristics of water; IOT for water quality monitoring – General working, Application (3 Lectures) Ecological balance and ecological footprint, concept of carbon credit, carbon footprint (2 lectures) Biosensors and biochips – mechanism, principle and working, (3 lectures) Environment Impact Assessment: EIA complete process, Importance of EIA (3 lectures)		15
Module IV: Methods to Control Pollution	Methods to control pollution: Biochar, Eco-enzymes, Garbage enzyme for environment remediation, Methods in determining biodegradability; Use of microbes (Bacteria and Fungi) (3 lectures) Catalytic Systems, Bioremediation, Biotransformation and Biodegradation. (5 lectures) Methods in		15

	determining biodegradability; Use of microbes (Bacteria and Fungi) Constructed wetlands: Phytoremediation– treatment using aquatic plants in the wetland system. (4 lectures)		
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References:

1. Chandrappa, R., & Kulshrestha, U. C. (2015). Sustainable air pollution management: theory and practice. Springer.
2. Karl B. Schnelle & Charles A. Brown, (2002) Air pollution control technology Handbook. CRC Press
3. Singh, R. L. (Ed.). (2017). Principles and applications of environmental biotechnology for a sustainable future. Springer Singapore.
4. Enger, E. D., Smith, B. F., & Bockarie, A. T. (2000). Environmental science: A study of interrelationships (p. 434). Boston, MA: McGraw-Hill.
5. Rittmann, B. E., & McCarty, P. L. (2012). Environmental biotechnology: principles and applications. Tata McGraw-Hill Education.
6. Wainwright, M. (2012). An introduction to environmental biotechnology. Springer Science & Business Media.
7. Bolan, N. S., Park, J. H., Robinson, B., Naidu, R., & Huh, K. Y. (2011). Phytostabilization: a green approach to contaminant containment. In Advances in agronomy (Vol. 112, pp. 145-204). Academic Press.
8. Pradhan, A. K., & Pradhan, N. (2015). Microbial biosurfactant for hydrocarbons and heavy metals bioremediation. In Environmental Microbial Biotechnology (pp. 91-104). Springer.
9. Rittmann, B. E., & McCarty, P. L. (2012). Environmental biotechnology: principles and applications. Tata McGraw-Hill Education.
10. Foin, T. C. (1976). Ecological systems and the environment. Houghton Mifflin.
11. Wise, D. L. (1988). Biotreatment systems: Volume II, Springer.
12. Sheng, Y., Qu, Y., Ding, C., Sun, Q., & Mortimer, R. J. (2013). A combined application of different engineering and biological techniques to remediate a heavily polluted river. Ecological engineering, 57, 1-7.
13. Maier, R. M., Pepper, I. L., & Gerba, C. P. (2009). Environmental microbiology (Vol. 397). Academic press.
14. Olguni, E.J. et al. (2000) Environmental Biotechnology and Cleaner Bioprocess, Taylor & Francis.
15. Gareth M. Evams et al., (2003) Environmental Biotechnology: Theory & Applications, Wiley.
16. Milton fingerman et al. (1999) Recent Advances in Marine Biotechnology Volume 3, AbeBooks Inc.
17. Upadhyay, L. S., & Verma, N. (2015). Role of Biosensors in Environmental Monitoring. In Environmental Microbial Biotechnology (pp. 77-90). Springer.
18. Geetha, S., & Gouthami, S. (2016). Internet of things enabled a real time water quality monitoring system. Smart Water, 2(1), 1.
19. Gibas, C., Jambeck, P., & Fenton, J. M. (2001). Developing bioinformatics computer skills. " O'Reilly Media, Inc."
20. Attwood, T.K. & Parry-Smith D.J. (2003). Introduction to Bioinformatics. Pearson Education.
21. Rastogi, S. C., Rastogi, S. C., Mendriratta, N., & Rastogi, P. (2006). Bioinformatics:

Concepts, Skills & Applications. CBS Publishers & Distributors Pvt. Limited.

22. Sensen, C. W. (2005). Handbook of genome research: genomics, proteomics, metabolomics, bioinformatics, ethics and legal issues; Vol. 1 und 2. Wiley-VCH Verlag GmbH & Co. KGaA.

23. Ecology and Environment: - P.D. Sharma, 1994.

24. Concept of Ecology: - E.J. Kormondy, 1996, Concept of modern Biology Series, Prentice Hall

25. A textbook of environmental pollution and control. S S. Dara

Course 3 – Practical–Lab Work-I**(Nanobiotechnology and Environmental Biotechnology)****Credits 4**

Course Outcomes: On successful completion of the course the learner would be able to
CO1: Synthesize, characterize & perform antimicrobial activity of synthesized nanoparticles.
CO2: Profile soil, based on Physico-chemical parameters
CO3: Screen industrially important microorganism

Topics:

1. Biosynthesis and characterization of silver nanoparticles by using plant/leaf extracts/green tea.
2. Synthesis and characterization of zinc sulphide nanoparticles by a reverse micelle method
3. Synthesis and characterization of Fluorescent Carbon Nanoparticles from Candle Soot and their separation of using the Thin-Layer Chromatographic Method
4. Synthesis of alginate beads and investigation of citric acid release from a nanoshell coating of polymer
5. Antimicrobial activity testing of Nanoparticles/nanocomposites
6. To study the soil profiles for their height, colour, texture, electrical conductivity, temp, pH, salinity, Bulk density, Specific gravity, water holding capacity of soil.
7. Screening of rhizosphere microflora for agriculture applications.
8. Detection and isolation of industrially important microorganisms – enzyme producers (for eg. lipase etc.)
9. Microbial degradation of textile dyes/pesticides/hydrocarbons and oils
10. Growth curve of metal tolerant organisms isolated from soil/ water
11. ETP: Primary, chemical and biological treatment. (Visit and report writing)
12. Identification and enlist the abiotic and biotic components of a forest ecosystem. (Visit and report writing)
13. Enlist the biotic components of a Pond ecosystem. (Visit and report writing)
14. Measurement of sounds by DB metre in silent, industrial, residential and commercial zones.
15. Detection of heavy metals concentration in soil/ water by AAS (Demonstration)

Credits**4****No. of Hours****120****References:**

1. A Laboratory Course in Nanoscience and Nanotechnology by Poinern, Gérard EddyJai Pg 97-105, Pg 106-111, Pg 116-121, Pg 155-172.
2. Njuguna, J., Vanli, O. A., & Liang, R. (2015). A review of spectral methods for dispersion characterization of carbon nanotubes in aqueous suspensions. Journal of Spectroscopy, 2015.
3. Singh, J. P., Nandi, T., Ghosh, S. K., Srivastava, J., Tripathi, S. K., & Prasad, N. E. (2018). Carbon nanoparticle synthesis, separation, characterization, and tribological property evaluation. Separation Science and Technology, 53(14), 2314-2326.
4. Qais, F. A., Shafiq, A., Khan, H. M., Husain, F. M., Khan, R. A., Alenazi, B., & Ahmad, I. (2019). Antibacterial effect of silver nanoparticles synthesized using

- Murraya koenigii (L.) against multidrug-resistant pathogens. Bioinorganic Chemistry and Applications, 2019.
5. Arintonang, H. F., Koleangan, H., & Wuntu, A. D. (2019). Synthesis of silver nanoparticles using aqueous extract of medicinal plants'(Impatiens balsamina and Lantana camara) fresh leaves and analysis of antimicrobial activity. International journal of microbiology, 2019.
 6. Ponarulselvam, S., Panneerselvam, C., Murugan, K., Aarthi, N., Kalimuthu, K., & Thangamani, S. (2012). Synthesis of silver nanoparticles using leaves of Catharanthus roseus Linn. G. Don and their antiplasmodial activities. Asian Pacific journal of tropical biomedicine, 2(7), 574.
 7. Nakhjavani, M., Nikkhah, V., Sarafraz, M. M., Shoja, S., & Sarafraz, M. (2017). Green synthesis of silver nanoparticles using green tea leaves: experimental study on themorphological, rheological and antibacterial behaviour. Heat and Mass Transfer, 53(10), 3201-3209.
 8. Rolim, W. R., Pelegriño, M. T., de Araújo Lima, B., Ferraz, L. S., Costa, F. N., Bernardes, J.S., & Seabra, A. B. (2019). Green tea extract mediated biogenic synthesis of silver nanoparticles: characterization, cytotoxicity evaluation and antibacterial activity. Applied Surface Science, 463, 66-74.
 9. Shahzadi, S., Zafar, N., & Sharif, R. (2018). Antibacterial activity of metallic nanoparticles. Bacterial pathogenesis and antibacterial control. IntechOpen, London, 51-71.
 10. <https://bmcpublichealth.biomedcentral.com/track/pdf/10.1186/1471-2458-12-594>
 11. <https://www.mdpi.com/1660-4601/14/7/815/htm>
 12. <https://link.springer.com/article/10.1134/S0020168511140184>
 13. <https://www.ijraset.com/files/serve.php?FID=17992>
 14. https://www.researchgate.net/publication/241028913_Microorganisms_in_Soil_Water_and_Air
 15. <http://www.fao.org/3/aq359e/aq359e.pdf>
 16. http://www.fao.org/fileadmin/templates/nr/images/resources/pdf_documents/manual-soil_20bioassessment.pdf

Course Outcomes: On successful completion of the course the learner would demonstrate and explain the understanding of the

CO 1: Principles of different Bioanalytical techniques, related sample preparation methods, possible data outcomes and their interpretation.

CO 2: Applications of Analytical techniques in the different study designs for investigations, estimations and analysis of technical parameters.

Modules	Topics	Credits	No of Lectures
Module I: Microscopy and Fluorescence techniques	Microscopy and sample preparation techniques: Bio AFM, ESEM, STEM, Confocal microscopy and Electron microscopy (TEM/SEM) and their respective sample preparation. Cell imaging Techniques- <i>In vitro</i> and <i>In vivo</i>; Immuno-electron microscopy. (Applications in experimental analysis for each). – (7 lectures) Fluorescent conjugates and techniques: a) Principle of fluorescence, Quantum Yield Use of Fluorescent films, fluorochromes and fluorophores/dyes used in bioanalytical techniques. b) Uses and applications of labelling/ Coupling/ conjugating antibodies with fluorophores/enzymes – (e.g. fluorescein and FITC/ rhodamine/ Texas-red/ BODIPY (Boron-dipyrromethene) etc. and Alkaline phosphatase, Horseradish peroxidase, biotin/avidin). (8 lectures)	2	15
Module II: Flow Cytometry and Cytotoxicity for Cellular Analysis	a) Types: Acoustic Focusing Cytometers, Cell Sorters (FACS), Imaging Cytometry and Mass Cytometers. (4 lectures) b) Reagents: Small Organic Molecules (Alexa Fluor), Phycobiliproteins, Metal Conjugates, Nucleic Acid Dyes, Quantum Dots etc. (4 lectures) c) Applications in Immunophenotyping, apoptosis analysis, Cell Cycle Analysis, RNA Flow Cytometry etc. (3 lectures) d) Cytotoxicity: Functional Assays – Lymphoproliferation, Cell Cytotoxicity (MTT assay), mixed lymphocyte reaction, Apoptosis (Annexin V Assay), Cytokine expression etc. (4 lectures)		15

References:

1. Wilson, K., & Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*(Seventh edition).
2. Hawley, T. S., & Hawley, R. G. (2018). Flow Cytometry Protocols. In *Methods in Molecular Biology* (Vol. 1678). https://doi.org/10.1007/978-1-4939-7346-0_18

3. Murphy, D. B., & Davidson, M. W. (2013). Fundamentals of Light Microscopy and Electronic Imaging. In *Wiley-Blackwell* (2nd ed.). John Wiley & Sons, Inc.
4. Stokes, D. J. (2008). Principles and Practice of Variable Pressure/Environmental Scanning Electron Microscopy (VP-ESEM). In *Principles and Practice of Variable Pressure/Environmental Scanning Electron Microscopy (VP-ESEM)*. <https://doi.org/10.1002/9780470758731>
5. Kuo, J. (2007). Electron microscopy. In *Science* (second edi, Vol. 156, Issue 3775). Humana Press Inc. <https://doi.org/10.1126/science.156.3775.673>
6. Echlin, P. (2009). *Handbook of Sample Preparation for Scanning Electron Microscopy and X-Ray Microanalysis*. Springer Science+Business Media, LLC. <https://doi.org/10.1007/978-0-387-85731-2>
7. Weissenberger, G., Henderikx, R. J. M., & Peters, P. J. (2021). Understanding the invisible hands of sample preparation for cryo-EM. *Nature Methods*, 18(5), 463–471. <https://doi.org/10.1038/s41592-021-01130-6>
8. Tizro, P., Choi, C., & Khanlou, N. (2022). Chapter 33 Sample Preparation for Transmission Electron Microscopy. In *Biobanking: Methods and Protocols* (Issue August, pp. 417–424). Springer Science and Business Media B.V. <https://doi.org/10.1007/978-1-4939-8935-5>
9. McKinnon, K. M. (1998). Flow cytometry: an overview. *Cell Vision : The Journal of Analytical Morphology*, 5(1), 56–61. https://doi.org/10.1007/978-94-017-0623-0_1
10. Freshney, R. I. (2005). Cytotoxicity. *Culture of Animal Cells*, 359–373. <https://doi.org/10.1002/0471747599.cac022>
11. Colyer, J., & Walker, J. M. (1996). *Protein Handbook Edited by* (Issue January). https://www.researchgate.net/profile/Robert-Akins/publication/14678357_The_Protein_Protocols_Handbook/links/0fcfd50eafc84294e7000000/The-Protein-Protocols-Handbook.pdf
12. Van Engeland, M., Nieland, L. J. W., Ramaekers, F. C. S., Schutte, B., & Reutelingsperger, C. P. M. (1998). Annexin V-affinity assay: A review on an apoptosis detection system based on phosphatidylserine exposure. *Cytometry*, 31(1), 1–9. [https://doi.org/10.1002/\(SICI\)1097-0320\(19980101\)31:1<1::AID-CYTO1>3.0.CO;2-R](https://doi.org/10.1002/(SICI)1097-0320(19980101)31:1<1::AID-CYTO1>3.0.CO;2-R)

Elective Course 1: Food Biotechnology and Nutraceuticals (Theory) Credits 2

Course Outcomes: On successful completion of the course the learner would demonstrate and explain the understanding of the following:

CO1: the basic principles and need of food fortification, GMOs and Nutraceuticals

CO2 : approaches to meet nutritional needs

CO3: the strategies for food fortification

Modules	Topics	Credits	No. of Lectures
Module I: Food Biotechnology and nutrition	Strategies for augmenting food production- Green, White, Brown and Blue revolution (3 lectures) Biofortification: Definition and its significance. Methods for biofortification of plant based foods- agronomic biofortification, plant breeding, genetic engineering/ transgenic approach. (3 lecture) Advanced food preservation techniques- electrothermal, freezing and pulse electric field methods, Ultrasound technology and ozone treatment, nanotechnology in food preservation, smart packaging (5 lectures) Nutrigenomics: Food nutrition & gene regulation, Impact of dietary glucose, fat, vitamins in gene expression (4 lectures)	1	15
Module II : Nutraceuticals	Nutraceuticals: Definition, characteristic features, and classification based on source and chemical nature. (3 lectures) Nutraceuticals-Sources (plant based, animal based, algae based. (1 lecture) Functional foods: Characteristic features and classification. (2 lectures), Prebiotics, Probiotics and Synbiotics (3 lectures) Applications of nutraceuticals and functional foods: in human health and nutrition. (3 lectures) (eg. diabetes, Obesity, Sports) Nutraceutical and functional food regulations in India. (1 lecture), Toxic Contamination of Nutraceuticals and Functional Food Ingredients- pesticides/ heavy metals/ mycotoxins and other Contaminants (2 lectures)	1	15

REFERENCES -

1. Handbook of Nutraceuticals- Yashwant Pathak, (2010) , Volume 1, CRC Press.
2. Modern Nutrition in health and disease- Goodhearth R., S. Shills. (2006), Vol. 10, Philadelphia, Pa. : Lippincott Williams & Wilkins
3. Krause's Food, Nutrition and Diet Therapy, (2000) 10th Edition by Mahan, L.K. & Ecott- Stump, S. , W.B. Saunders Ltd.
4. Dietetics- B. Srilakshmi, (2007), New Age International Publishers, 7th Edition.
5. Functional Foods (Designer Foods, Pharmafoods, Nutraceuticals)- Israel Goldberg, (1999), Aspen publication
6. Functional Food Ingredients and Nutraceuticals processing technologies -John Shi,,Taylor and francis
7. Phytochemical of Nutraceutical Importance- Dhan Prakash and Girish Sharma,.

8. Handbook of Nutraceuticals and Functional Foods, Edited By Robert E.C. Wildman, Robert Wildman, Taylor
9. Handbook of Probiotics and Prebiotics, Second Edition, Editor(s): Yuan Kun Lee Seppo Salminen
10. Print ISBN: 9780470135440 Online ISBN: 9780470432624 DOI: 10.1002/9780470432624
11. C. Wallace, Edition 2nd Edition, CRC Press, DOI <https://doi.org/10.1201/9781420006186> eBook ISBN 9780429195563 https://www.researchgate.net/publication/322658329_Nutraceuticals_and_Functional_Foods
12. Nutraceuticals and Functional Foods in Human Health and Disease Prevention (PDFDrive). pdf Edited by Debasis Bagchi Harry G. Preuss Anand Swaroop CRC Press ISBN: 13: 978-1-4822-3722-1
13. https://apps.who.int/iris/bitstream/handle/10665/42665/WHO_TRS_916.pdf;jsessionid=2502E5EC07D6C4618494A1DFA074A7C6?sequence=1
14. Joy P. P., Surya S. and Aswathy C. prsvkm_laboratory_manual_of_biochemistry, Kerala Agricultural University, Pineapple Research station 2015
15. Food-Based Strategies to Control Vitamin A Deficiency <https://journals.sagepub.com/doi/pdf/10.1177/156482650002100205>
16. Journey of food fortification (fssai document)
17. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3791249/pdf/13197_2012_Article_899.pdf
18. Jay M.J (2015) -Modern Food Microbiology, Fourth Edition, CBS Publishers and Distributors, New Delhi
19. Calcium and vitamin D deficiencies: a world issue?- S. A. Miller (FAO) <https://www.fao.org/4/W7336t/W7336t06.pdf>
20. Public health Nutrition- Meenal Dhall And Ms. Shumayla
21. National nutrition policy
22. ICAR -Reshaping Agriculture and Nutrition Linkages. - K. Sreedevi Shankar, R. Nagarjuna Kumar, Pushpanjali, K. Nagasree, G. Nirmala and N. Sowri Raju. ICAR - Central Research Institute for Dryland Agriculture Hyderabad - 500 059, India, 2016
23. Handbook for Food Safety Officials Genetically Modified Foods: Safety Assessment and Regulations Prepared by Ministry of Environment, Forest and Climate Change (MoEFCC) and Biotech Consortium India Limited, New Delhi 2019
24. Micronutrient security for India– PRIORITIES FOR RESEARCH AND ACTION, Published by Dr Alok Moitra, Executive Secretary on behalf of INSA, Bahadurshah Zafar Marg, New Delhi, 2011
25. Chapter – Indian History Of Indian Agriculture- IGNTU <https://www.igntu.ac.in/eContent/IGNTU-eContent-375577792959-BA-AIHC-6-DrJanardhanaB-ScienceandTechnologyinAncientIndia-4.pdf>
26. Preventing micronutrient malnutrition_ A guide to food-based approaches - A manual for policy makers and programme planners. prepared by- Food and Agriculture Organization of the United Nations and International Life Sciences Institute, ILSI PRESS, ISBN 0-944398-89-8

Elective Course 1: Food Biotechnology and Nutraceuticals (Practicals)
Credits 2

Course outcomes: On successful completion of the course the learner would be able to
CO1: Apply the understanding of different techniques learnt, for qualitative and quantitative analysis of food to analyse different food products.
CO2: comprehend different food standards for various categories of foods.
CO3: Understand and learn about the use of food preservatives in fruit and vegetable preservation.

Practicals based on Food Biotechnology and Nutraceuticals

1. Estimation of vitamin A from fruits/ vegetable
2. Extraction and Estimation of antioxidant properties of phytochemicals by DPPH and anthocyanins extraction
3. Qualitative test for tannins, phenols, isoflavones, alkaloids.
4. Estimation of gluten from food sample.
5. Estimation of minerals in food samples – iron, phosphorus, Zinc and calcium (In fortified and non-fortified foods)
6. Extraction & estimation of alkaloids (caffeine/ Catechin)
7. Molecular techniques in the detection of food pathogens and GM foods (Demo)
8. Estimation of Specific food Preservative / ingredients such as glycerine, vinegar, Benzoic acid from food products
9. Assignment on health benefits of nutraceutical ingredients
10. Visit to any food processing Industry

References

1. Jay M.J (2015) -Modern Food Microbiology, Fourth Edition, CBS Publishers and Distributors, New Delhi (for food preservation techniques)
2. Joy P. P., Surya S. and Aswathy C. prsvkm_laboratory_manual_of_biochemistry, Kerala Agricultural University, Pineapple Research station 2015

Elective Course 2: Clinical Biochemistry: (Theory)**Credits 2**

Course Outcomes: On successful completion of the course the learner would be able to

CO1: integrate the knowledge gained in clinical biochemistry viz hematopoietic system with day-to-day examples

CO2: Understand the role of nutrients and electrolytes in physiological functioning

Modules	Topics	Credits	No of lectures
Module I: Haem Disorders and Protein calorie Malnutrition	Haemoglobin structure and function, Met-Hb, embryonic-Hb structure and function, heme metabolism associated diseases, Hemoglobinopathies, haemoglobin bart's, haemoglobin Lepore, sickle cell anaemia, Haemolytic anaemia thalassemia, Heinz bodies, hereditary Spherocytosis, hereditary Elliptocytosis, extracorpurscular defects. Malnutrition Kwashiorkor, marasmus Keratomalacia, measurement of fuel values of foods, measurement and calculation of BMR, Calorimetry.	2	15
Module II: Electrolytes and biochemical diagnosis	Electrolytes, reabsorption of electrolytes, acid-base balance, regulation of electrolyte content of body fluids and maintenance of pH, regulation of sodium and water balance, renin-angiotensin system, clinical investigation of sodium, potassium, chloride. Biochemical diagnosis of diseases by enzymatic assays; Clinical tissue analysis, biopsy, liquid biopsy, circulating RNA and DNA as molecular diagnosis of different diseases.		15

References

1. Harpers Illustrated Biochemistry 30th Edition, McGraw-Hill Education
2. Clinical Biochemistry and Metabolic Medicine Eighth Edition by Martin Andrew Crook, CRC Press
3. Textbook of Biochemistry for Medical Students, 7th edition, by D M Vasudevan, ,Sreekumari SKannan Vaidyanathan
4. Jaypee. Clinical chemistry: Techniques, Principles, Correlations , 6th Edition, by Bishop, Fody and Schoeff
5. Biochemistry-Lippincott Williams & Wilkins

Elective Course 2: Clinical Biochemistry: (Practicals:)

Credits 2

Course Outcomes: On successful completion of the course the learner would be able to

CO1: Identify and understand Hemoglobinopathies

CO2: understand the role of enzymes in clinical diagnosis

1. Observe permanent slides for Hemoglobinopathies
2. Determine haemoglobin concentration using Sahil's method
3. Determine Protein content in commercial protein powders/health drinks by biurets method
4. Calculating BMI- demonstration
5. Determination of serum SOD, Catalase, Glutathione peroxidase activity.

Reference:

1. Practical Clinical Biochemistry Harold Varley
2. <https://sites.google.com/ignou.ac.in/bscbch-biochemistry/self-learning-material/bbcel-142-nutritional-biochemistry-practical>

Elective Course 3: Advanced Epidemiology and Applied Microbiology (Theory)
Credits 2

Course Outcomes: On successful completion of the course the learner would be able to CO1: Understand key epidemiological principles for preventing, controlling and managing pandemic and emerging infectious diseases. CO2: Gain comprehensive knowledge of viral and emerging infections, including latest developments in diagnostics and therapeutics. CO3: Acquire understanding of antimicrobial resistance mechanisms and assessment methods for managing drug resistance in populations.			
Modules	Topics	Credits	No of Lectures
Module I: Advanced Epidemiology	History and Overview of basic epidemiology (2 lectures) Descriptive epidemiology, Analytical epidemiology, Experimental epidemiology (2 lectures) Types of Epidemiological studies (5 lectures) Observational studies - Descriptive studies, Ecological studies, Ecological fallacy, Cross-sectional studies, Case-control studies, Cohort studies. Experimental epidemiology - Randomised controlled trials, Field trials, Community trials, Potential errors in epidemiological studies - Random error, Sample size, Systematic error, Selection bias, Measurement bias, Application of basic biostatistics in epidemiology (3 lectures) Case reporting – meaning, significance (1 lecture) Organisations in disease control & Research – National/ International any two of each (2 lectures)	2	15
Module II: Applied Microbiology	Viral infections and Emerging pathogens: Detailed Study of following infections including Etiological agent its structure and genome organisation, Transmission, Pathogenesis, Clinical Manifestations, Lab diagnosis, Prophylaxis, strategies for prevention & treatment, Viral infections: (3 lectures) Viral Hepatitis and Chikungunya, Emerging pathogens: (5 lectures) New Variants of <i>Vibrio cholerae</i> O1 El Tor, Nipah virus, SARS-CoV, Antibacterial susceptibility testing (2 lectures) Conventional and advanced methods of drug susceptibility testing Antiviral susceptibility testing (3 lectures)		15

	Phenotypic testing methods - Plaque reduction assay (PRA), dye uptake assay (DU), neuraminidase inhibition, PBMC cocultivation Genotypic testing methods - DNA sequencing, PCR amplification, restriction enzyme digestion, microarrays, Detection of drug resistance in - (2 lectures) Staphylococci, Enterococci, Gram negative bacteria ESBLs		
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Elective Course 3:**Advanced Epidemiology and Applied Microbiology (practical):****Credits 2**

Course Outcomes: On successful completion of the course the learner would be able to
CO1: Apply various analytical skills in diagnostics of viral and pathogenic infections.
CO2: Utilise statistical approaches in epidemiological studies.
CO3: Determine antimicrobial susceptibility and antimicrobial resistance.

1. Serodiagnosis of HBsAg infection: Rapid latex agglutination detection of HBsAg (Kit based).
2. Diagnosis for Swine flu-H1N1: Hemagglutination inhibition assay.
3. Rapid identification for Chikungunya virus (IgM & IgG) kit method.
4. Identification of *Vibrio cholerae* 0139: Cholera red test, String test, Oxidase test, & Isolation on TCBS medium.
5. Serological diagnosis for V.c.0139 using specific monotypic antisera.
6. Determination of MIC by E test.
7. Antimicrobial Synergy testing by Checkerboard Assay.
8. Biostatistics problems on epidemiology.
9. Epidemiological case reporting.

References:

1. Basic Epidemiology, WHO R. Bonita, R. Beaglehole, T. Kjellström. 2nd edition.
2. Official websites
www.icmr.org.in
www.niv.co.in
www.niv.co.in
www.naco.gov.in
www.niih.org.in
www.cdc.gov
www.unicef.org
3. Mim's Medical Microbiology , 5 th edition, Richard V. Goering, Hazel M. Dorell, Mark Zuckerman, Ivan M. Roitt, Peter L. Chiodini, ELSEVIER.
4. Microbiology An Introduction 10th Edition Gerard J. Tortora, Berdell R. Funke, Christine L. Case. Library of Congress Cataloging-in-Publication Data.
5. Fenner and White's medical virology. Academic Press, fifth edition 2016 Burrell, Christopher J., Colin R. Howard, and Frederick A. Murphy, Elsevier.
6. Ananthanarayan and Paniker's Textbook of Microbiology, Tenth edition, 2017 by Reba Kanungo, 10th ed Universities Press.
7. Principles of Epidemiology in Public Health Practice. Third edition. An

- Introduction to Applied Epidemiology and Biostatistics. US Department of Health and Human Services, CDC.
8. Medical Microbiology, Jawetz ,Melnick and Adelberg's ,26th Edition. 2013, McGraw Hill.
 9. Bailey and Scott's Diagnostic Microbiology 14th edition, 2015 Elsevier Health Sciences.
 10. *Vibrio cholerae* O139 Bengal. Albert, M J. (1994), *Journal of clinical microbiology* vol. 32(10), pp 2345-9. doi:10.1128/jcm.32.10.2345-2349.1994
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC264063/>
 11. *Vibrio cholerae* O139 in Calcutta, 1992-1998: Incidence, Antibigrams, and Genotypes. Basu, A., Garg, P., Datta, S., Chakraborty, S., Bhattacharya, T., Khan, A., Nair, G. B. (2000). *Emerging Infectious Diseases*, 6(2), 139-147. <https://doi.org/10.3201/eid0602.000206>.
https://wwwnc.cdc.gov/eid/article/6/2/00-0206_article
 12. Manual of Clinical Microbiology, 9th edition, Patrick Murray, Ellen Baron, James Jorgensen, Marie Landry, Michael Pfaller. 2000 , ASM Press, Washington DC.
 13. Textbook of Medical laboratory technology, Godkar, P. B., & Godkar, D. P. (2006). Bhalani publishing house.
 14. World Health Organization. *WHO manual on animal influenza diagnosis and surveillance*. No. WHO/CDS/CSR/NCS/2002.5. World Health Organization, 2002.
https://iris.who.int/bitstream/handle/10665/68026/WHO_CDS_CSR_NC_S_2002.5.pdf?sequence=1
 15. CDC Laboratory Methods for the Diagnosis of *Vibrio cholerae*
<https://www.cdc.gov/cholera/pdf/laboratory-methods-for-the-diagnosis-of-vibrio-cholerae-chapter-6.pdf>
 16. Koneman's Color atlas and textbook of diagnostic microbiology, seventh edition 2020. Jones & Bartlett Learning. Procop, G. W., Church, D. L., Hall, G. S., & Janda, W. M.).
 17. Antibiotics in laboratory medicine. 5th Edition Lorian, V. (Ed.) 2005. Lippincott Williams & Wilkins.

Semester - IV

Semester IV

Course 1: Omics and Systems Biology

Credits 4

Course Outcomes: On successful completion of the course the learner would be able to
CO1: Understand the fundamental concepts and applications of genomics, transcriptomics, and proteomics, including genome mapping, RNA sequencing, and protein identification techniques.
CO2: Learner will gain knowledge in the tools and methodologies of metabolomics and lipidomics, as well as an introduction to systems biology, data mining, and the use of big data in biological research.

Modules	Topics	Credits	No of lectures
Module I: Genomics, Transcriptomics and Proteomics	Genomics: (5 lectures) Genome and Genomics, Genome Mapping, Physical and Genetic maps, Genome sequencing, Genome annotation, Functional genomics and Applications of genomics. Transcriptomics: (5 lectures) RNA sequencing, Microarrays, Regulatory RNAs-small and large, Applications of transcriptomics. Proteomics: (5 lectures) Basic concepts, Tools of Proteomics- SDS PAGE, 2-D PAGE, Liquid chromatography, Protein identification by peptide mass fingerprinting, Applications of Proteomics.	4	15
Module II: Metabolomics, Lipidomics	Metabolomics: (8 lectures) Fundamental concepts, Tools of metabolomics- Capillary electrophoresis, Gas chromatography, Mass Spectrometry Electrochemical detectors, Case studies related to metabolomics, Applications of Metabolomics. Lipidomics: (7 lectures) Basic concepts, Tools of lipidomics- Mass spectroscopy, TLC, HPLC, GC Capillary electrophoresis, MALDI, Applications of Lipidomics.		15
Module III: Introduction to Systems Biology	Understanding of Biological Systems: Systems Structure, Systems Dynamics, Systems Design and Control, Systems Project (5 lectures) Models and Modelling Systems in Systems Biology: Definition of a Model, Key Properties, Basics of Computational Models, Networks, Data Integration, Standards, and Model Organism (5 lectures) Standards and Formats for Systems Biology: Computational Databases and Software Tools (2 lectures), Biological Networks: Metabolic Networks, Gene Regulatory Networks, PPI Networks (3 lectures)		15
Module IV: Data Mining and Big Data	An overview of data mining (4 lectures) Data mining process models Data collection Data preprocessing Introduction to Knowledge Discovery in		15

	Databases (KDD): (4 lectures) The KDD Process,Taxonomy of Data Science Methods Big Data (1 lectures) Drug discovery and development process. (2 lectures) Big Data in Biology (1 lecture) Big Data Resource- Public Resources, Proprietary Databases (3 lectures)		
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References:

1. Hiroaki Kitano, Foundations of Systems Biology, MIT Press (2001)
2. Klipp, Edda, Kowald, Axel, Liebermeister, Wolfram, Wierling, Chr, Systems biology, a textbook (2016, Wiley-VCH)
3. Jon Holy, Ed Perkins (auth.), Stephen Krawetz (eds.) - Bioinformatics for Systems Biology-Humana Press (2009)
4. Mikaël Lucas, Plant Systems Biology_Methods and Protocols (Methods in Molecular Biology, 2395)-Humana (2021)
5. Walhout, Marian (Auth.) - Handbook of Systems Biology-Academic Press (2012)
6. Zengyou He, Woodhead Publishing Series in Biomedicine: Number 76 Data Mining for Bioinformatics Applications, ISBN: 978-0-08-100107-3 (online)
7. Maimon, O., Rokach, L., Shmueli, E. (2023). Data Science and Knowledge Discovery Using Machine Learning Methods. In: Rokach, L., Maimon, O., Shmueli, E. (eds) Machine Learning for Data Science Handbook. Springer, Cham. https://doi.org/10.1007/978-3-031-24628-9_1
8. Bhattarai, S., Kumar, R., Nag, S., Namasivayam, V. (2022). Big Data in Drug Discovery. In: Singh, S. (eds) Machine Learning and Systems Biology in Genomics and Health. Springer, Singapore. https://doi.org/10.1007/978-981-16-5993-5_2
9. Transcriptomics: Expression pattern analysis - Virendra Gomase, Somnath Tagore.
10. Lipidomics - Technologies and Applications- Kim Ekroos.
11. Metabolomics - Methods and protocols - Wolfram Weckwerth.
12. Mass Spectrometry for Biotechnology - Gary Soiuzdak.
13. Proteomics for biological discovery - Timothy Veenstra and John Yates.
14. Introduction to proteomics - Tools for biology - Daniel C Liebler.

Course 2: Drug Discovery and Clinical Studies (Theory)**Credits 2**

Course Outcomes: On successful completion of the course the learner would be able to
CO1: Demonstrate an integrated understanding of drug development processes, drug discovery informatics, and the use of software tools in drug discovery.
CO2: Navigate the ethical and regulatory process of drug development, ensuring that new drugs are developed responsibly and in compliance with relevant guidelines and standards.

Modules	Topics	Credits	No. of lectures
Module I: Clinical Research Informatics in Drug Discovery	Drug Development (7 Lectures) Chemical Genomics - Identification of New Drug Targets Chemical Proteomics - Characterization of the Drug Target Chemical Genetics - Validation of the Drug Target; Combinatorial Chemistry. High-Throughput Screening; Fragment-Based Drug Development) Drug Discovery Informatics (4 Lectures) Information Resources- Role of different databases in CADD- Literature databases (MEDLINE); Chemical databases (DrugBank); Biological databases (Biochemical Genetic and Genomic (BiGG); Structure Databases (Protein Data Bank); Software Tools Used in Drug Discovery (4 Lecture) Chemical Drawing Tools (Chemical Sketch); Target Prediction Tools (Swiss Target Prediction); ADME Toxicity Prediction Tools (SwissADME); Docking Tools (Auto Dock)	2	15
Module II: Clinical Trial Design And Indian Regulations	Clinical Trial Design: (2 lectures) : Basic framework of clinical trial Types of clinical trials (6 Lectures): Randomised clinical trials and different phases; Adaptive randomization methods; Seamless design; Internal pilot design; Design selection factors The national regulatory body (4 Lectures) Regulations and The Roles and Responsibilities of Stakeholders in the Sharing of Clinical Trial Data (3 Lectures): Participants in clinical trials, Investigators, Research institutions and universities, Journals and Professional societies		15

References:

- Schmidt, M.F. (2022). Introduction. In: Chemical Biology. Springer, Berlin, Heidelberg. <https://doi.org/10.1007/978-3-662-64412-6>
- Reang, J. et al. (2023). Informatics: Tools and Databases in Drug Discovery.

- In: Rudrapal, M., Khan, J. (eds) CADD and Informatics in Drug Discovery. Interdisciplinary Biotechnological Advances. Springer, Singapore. https://doi.org/10.1007/978-981-99-1316-9_3
3. Kar, S., Leszczynski, J. (2023). Databases for Drug Discovery and Development. In: Kar, S., Leszczynski, J. (eds) Current Trends in Computational Modeling for Drug Discovery. Challenges and Advances in Computational Chemistry and Physics, vol 35. Springer, Cham. https://doi.org/10.1007/978-3-031-33871-7_10
 4. <https://bmcmmedicine.biomedcentral.com/articles/10.1186/s12916-018-1017-7>
 5. Brijesh Nair, Clinical Trial Designs, Indian Dermatol Online J.2019 Mar-Apr; 10(2): 193–201. DOI: 10.4103/idoj.IDOJ_475_18
 6. Bhav A, Menon S. Regulatory environment for clinical research: Recent past and expected future. Perspect Clin Res. 2017 Jan-Mar;8(1):11-16. doi: 10.4103/2229-3485.198551. PMID: 28194332; PMCID: PMC5299798.
 7. Gogtay NJ, Ravi R, Thatte UM. Regulatory requirements for clinical trials in India: What academicians need to know. Indian J Anaesth. 2017 Mar;61(3):192-199. doi: 10.4103/ija.IJA_143_17. PMID: 28405032; PMCID: PMC5372399.
 8. Lahiry, Sandeep; Sinha, Rajasree¹; Choudhury, Shouvik; Mukherjee, Ayan; Chatterjee, Suparna. Paradigm Shift in Clinical Trial Regulations in India. Indian Journal of Rheumatology 13(1):p 51-55, March 2018. | DOI: 10.4103/injr.injr_110_17
 9. Committee on Strategies for Responsible Sharing of Clinical Trial Data; Board on Health Sciences Policy; Institute of Medicine. Sharing Clinical Trial Data: Maximizing Benefits, Minimizing Risk. Washington (DC): National Academies Press (US); 2015 Apr 20. PMID: 25590113.
 10. <https://cdsco.gov.in/opencms/opencms/en/Home/> (For updates)
 11. AnnapurnaSA, RaoSY. New drug and clinical trial rules, 2019: an overview. Int J Clin Trials 2020;7(4):278-84. (For updates)
DOI: <http://dx.doi.org/10.18203/2349-3259.ijct20204486>

Course Outcome: On successful completion of the course the learner would be able to

CO1: Demonstrate the skill of online tool utilization for the analysis of drug molecule properties.

Sr. No	Experiment
1	A finding of a drug-gene interaction or potentially druggable category using The Drug Gene Interaction Database (DGIdb)
2	Predicting ligands and recognition of binding patterns common to a set of protein structures using ProBiS.
3	Draw or edit the molecule of interest, and generate SMILES or InChI descriptors.
4	Predict ADME parameters, pharmacokinetic properties, druglike nature and medicinal chemistry friendliness of small molecules to support drug discovery.
5	Prediction of toxicity of chemicals using ProTox 3.0 web server.
6	Computational protein-ligand docking using AutoDock (DEMO)
7	Case study on clinical trials

Reference

1. Cannon M, Stevenson J, Stahl K, Basu R, Coffman A, Kiwala S, McMichael JF, Kuzma K, Morrissey D, Cotto K, Mardis ER, Griffith OL, Griffith M, Wagner AH. DGIdb 5.0: rebuilding the drug-gene interaction database for precision medicine and drug discovery platforms. Nucleic Acids Res. 2024 Jan 5;52(D1):D1227-D1235. doi: 10.1093/nar/gkad1040. PMID: 37953380; PMCID: PMC10767982.
2. [Chemical Sketch Tool \(rcsb.org\)](https://www.rcsb.org/chemical-sketch), <https://www.rcsb.org/chemical-sketch>
3. Daina, A., Michielin, O. & Zoete, V. SwissADME: a free web tool to evaluate pharmacokinetics, drug-likeness and medicinal chemistry friendliness of small molecules. Sci Rep 7, 42717 <https://pubchem.ncbi.nlm.nih.gov/> <http://www.swissadme.ch/>
4. Banerjee P, Kemmler E, Dunkel M, Preissner R. ProTox 3.0: a webserver for the prediction of toxicity of chemicals. Nucleic Acids Res. 2024 Apr 22:gkae303. DOI: 10.1093/nar/gkae303, PMID: 38647086. [ProTox-3.0 - Prediction of TOXicity of chemicals \(charite.de\)](https://www.protox3.0.org/)
5. Forli S, Huey R, Pique ME, Sanner MF, Goodsell DS, Olson AJ. Computational protein-ligand docking and virtual drug screening with the AutoDock suite. Nat Protoc. 2016 May;11(5):905-19. doi: 10.1038/nprot.2016.051. Epub 2016 Apr

14. PMID: 27077332; PMCID: PMC4868550.
6. <http://autodock.scripps.edu/downloads/autodock-registration/autodock-4-2-download-page/>
7. https://journals.lww.com/hrtv/fulltext/2017/18030/guidelines_to_writing_a_clinical_case_report.7.aspx
8. <https://www.nejm.org/doi/full/10.1056/nejm200006223422507>
9. <https://www.sciencedirect.com/science/article/pii/S0002916523017008>
10. <http://probis.cmm.ki.si/>
11. <http://probis.cmm.ki.si/download/ProBiS-2012-Users-Guide.pdf>

Course 3: Molecular Enzymology (Theory)**Credits 2**

Course Outcomes: On successful completion of the course the learner would be able to understand the

CO1: Role of enzymes as diagnostic tools and its industrial applications.

CO2 : Methods of enzyme engineering to enhance their activity and half life.

CO3: Outcome of enzyme deficiencies, significance of enzymes as a diagnostic tool in therapy and as biosensors.

Modules	Topics	Credits	No of lectures
Module I: Enzyme engineering and applications of engineered enzymes	Introduction to enzyme engineering and engineering tools for enzymes - brief history; molecular modifications of enzymes - irrational designs (directed evolution & random mutagenesis, molecular breeding of DNA - homologous DNA shuffling, circular permutation, random insertion/deletion mutations), rational design and computational design (precise design); de novo enzyme design and semi - rational design (focus on few mutation sites) (7 lectures) Applications of engineered enzymes - medicine; food and drink industry; detergent industry; feed industry; pharmaceutical industry; textile industry. (8 lectures)	2	15
Module II: Enzyme deficiencies, diagnostic enzymes and therapeutics	Inherited metabolic diseases and enzyme deficiency- Alkaptonuria, Maple Syrup Urine disease, Galactosemia, Pompe disease, Gaucher disease, Fabry disease. HGPRT deficiency (5 lectures) Enzymes and Isoenzymes in diagnosis of diseases- liver diseases, cardiac diseases, GI tract diseases, muscle and bone diseases, malignancies (3 lectures) Enzymatic Biosensors As Diagnostic Tools- Biosensors- basic instrumentation, Biosensors for detection of- Glucose in Blood, Urea in Blood and Urine (2 lectures) Enzymes of therapeutic value- Asparaginase, DNase, Glucocerebrosidase, α -Galactosidase, urate oxidase and laronidase, Superoxide dismutase, Application of enzymes as Debriding agents, Digestive aids and Thrombolytic agents (5 lectures)		15

References (Theory) :

1. Fundamentals of Enzyme Engineering. (2017) Young Je Yoo, Yan Feng, Yong-Hwan Kim, Camila Flor J. Yagonia, Springer Netherlands.
2. Current developments in Biotechnology and Bioengineering. Sudhir Singh, Ashok Pandey, Sudesh Kumar. Synthetic Biology, Cell Engineering and Bioprocessing
3. Trevor Palmer – Understanding Enzymes-E. Horwood (1991)
4. Biomass, Biofuels, Biochemicals: Advances in Enzyme Technology, First edition (2019), Ram Sarup Singh, Reeta Rani Singhanian, Ashok Pandey and Christian Larroche, Elsevier
5. Atlas of Inherited Metabolic Diseases, Third edition, (2011), William L Nyhan, Bruce A Barshop and Aida I Al-Aqeel, CRC Press Taylor & Francis Group
6. Textbook of Medical Biochemistry, fourth updated edition (2020), Dinesh Puri, Elsevier
7. Textbook of Medical Biochemistry, eighth edition (2012), MN Chatterjea, Rana Shinde, Jaypee Brothers Medical Publishers Pvt. Limited
8. Pharmaceutical Biotechnology Concepts and Applications (2007), Gary Walsh, John Wiley & Sons Ltd
9. Industrial Enzyme Applications (2019) Vogel, Andreas. May Oliver, WILEY-VCH
10. Directory of therapeutic enzymes (2006), Barry M. McGrath and Gary Walsh, CRC Press Taylor & Francis Group
11. Enzyme Engineering <https://amazingbiotech.blogspot.com/2013/11/enzyme-engineering.html>
12. Enzyme engineering video <https://in.video.search.yahoo.com/search/video?fr=hp-ddc-bd&p=enzyme+engineering#id=4&vid=327f3aca94dfa81003b314b45bde908f&action=click>
13. Recent advances in rational approaches for enzyme engineering <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3962183/>
14. What Is Enzyme Engineering? Application of Enzyme Engineering <https://infinitabiotech.com/blog/application-of-enzyme-engineering/>
15. Industrial Enzymes(chapter 13, Industrial Bio refineries and White Biotechnology) Elsevier article link: <https://www.researchgate.net/publication/311997374>
16. Inborn errors of Metabolism (chapter 3- Advances in Biochemistry & application in medicines) link: [inborn-errors-of-metabolism.pdf](https://openaccessbooks.com/inborn-errors-of-metabolism.pdf) (openaccessbooks.com)
17. [.\(PDF\) Enzymes as Diagnostic Tools \(researchgate.net\)](https://www.researchgate.net/publication/311997374)

Course 3: Molecular Enzymology and Enzyme Technology - Practical Credits 2

Course Outcomes: On successful completion of the course the learner would be able to
CO1: Study the effects of inhibitors on microbial enzymes
CO2: Learn techniques of enzyme purification and its importance
CO3: Design enzyme assays to measure enzyme activity under different conditions

Topics:

1. Microbial Enzyme production:
 - a. Partial purification using ammonium sulphate precipitation.
 - b. Dialysis of the salt-precipitated protein.
 - c. Assessing the enzyme activity and the protein content.
2. Effect of inhibitors/ chemicals on enzyme activity.
3. Extraction of enzymes from plant sources.
4. To determine Specific activity of α Amylase.

REFERENCES:

1. Lehninger Principles of Biochemistry (4th Ed. Nelson, D., and Cox, M.; W.H. Freeman and Company, New York, 2005.
2. Satyanarayan and Chakrapani, Biochemistry. New Delhi, Elsevier Health Sciences APAC, 2013.
3. Berg JM, Tymoczko JL, Stryer L (2002): Biochemistry, 5th ed., Freeman WH and Co., New York.
4. https://shodhganga.inflibnet.ac.in/bitstream/10603/100595/7/07_chapter%201.pdf General Introduction to enzymes.
5. <https://iopscience.iop.org/book/978-0-7503-1302-5/chapter/bk978-0-7503-1302-5ch1> Introduction to enzymes and their applications.
6. Biochemistry by Lehninger, 2nd Ed, Kalyani publication 2008.
7. Understanding enzymes (3rd edition). Edited by Trevor Palmer, Ellis Horwood, Chichester, 1991.
8. Protein purification principles, High Resolution Methods, and Applications, 3rd Edition, Jan-Christer Janson, John Wiley & Sons, Inc., Hoboken, New Jersey.
9. <https://www.biotecharticles.com/Applications-Article/Methods-of-Purification-of-Enzymes-583.html>
10. https://www.creative-enzymes.com/service/enzyme-purification_307.html Enzyme Purification
11. http://web.sungshin.ac.kr/~spark/class/enzchem/EnzChem_ch02.pdf Chapter 2 - purification of enzymes
12. <https://www.labome.com/method/Protein-Purification.html>
13. <http://www1.lsbu.ac.uk/water/enztech/index.html> Chapter 6 Enzyme preparation and use
14. <https://docplayer.net/20937505-Protein-purification-nison-sattayasai-khon-kaen-university-thailand-1-introduction-2-extraction-of-protein.html>
15. http://www.processdevelopmentforum.com/ppts/posters/Protein_purification_methods-overview,_29155460.pdf
16. https://www.researchgate.net/publication/281102215_How_to_purify_proteins.
17. Fundamentals of Enzyme Engineering, Young Je Yoo, Yan Feng, Yong-Hwan Kim Camila Flor J. Yagonia, : Springer Netherlands 2017.

Elective Course 1 Biologics and Regulatory Affairs (Theory)
Credits 4

Course Outcomes: On successful completion of the course the learner would be
CO1: Familiar with the basic concepts and significance of Biologics/Biosimilar in addition to having knowledge about its therapeutic applications.
CO2: Knowledgeable in the steps involved in the production of Biologics/Biosimilars
CO3: Aware of the protocols/techniques required for characterization of the Biosimilar relative to the Reference Biologic
CO4: Acquainted with the regulatory aspects of approval of Biosimilars.

Modules	Topics	Credits	No of Lectures
Module I: Introduction to Biologics and Biosimilars	Definition and Introduction of: Drugs, Small molecules, Generics, Large molecules/Biologics; Introduction to Biologics (reference drug) and Biosimilars. Synonyms of Biosimilars. Need for Biosimilars (2 Lectures) Similarities and Differences: Small molecules and generics, Biologics and Biosimilars. small molecules (Generics) and Large molecules (biosimilars). (2 lectures) Categories of Biologics: (2 examples each with description, production, applications) protein-based hormones, enzymes, monoclonal antibodies, vaccines, blood products, and gene & cellular therapy products (6 lectures) USFDA Approved- Small Molecules, Generics, Biologics and Biosimilars (two examples of each) (2 lectures) The three tenets of Biosimilarity Small versus large molecule regulation in the US (2 lectures) Acceptable quality differences between approved Biosimilar and innovator product (reference drug) (1 lecture)	4	15
Module II: Biosimilars Drug Substance Development and Manufacturing: Effective CMC Strategy	Introduction to the Chemistry, Manufacturing and Controls (CMC) strategy and understanding of the Reference Drug (1 lecture) Choice of Expression Systems and Clonal Selection (1 lecture) Development of upstream and downstream processes and scale up to manufacturing. (2 lectures) Effect of Raw Materials on Product Quality (1 lecture) Effect of Manufacturing Conditions on Product Quality and Control Strategy for Biosimilars (1 lecture) Implementing a Successful CMC and Analytical Strategy for the Development of Biosimilars (3		15

	lectures) Example: Production of Monoclonal antibody, downstream processing of Mab (4 lectures) Introduction to the concept of Biobetters vs Biosimilars (2 lectures)		
Module III: Characterization of Biologics and Biosimilars	(Protein product characterization, Reference product characterization, Biosimilar product characterization) Appearance, particulates, pH, osmolality, particle size-To check homogeneity and general properties. (1 Lecture) Molecular Weight, Protein Sequence/ amino acid composition- To check identity of biologic.(2 Lectures) Post translational Modifications: Glycosylation, Sialylation, Phosphorylation, Acetylation, and Myristoylation- To check active/ inactive form of biologic.(1 Lecture) Size and Purity on HPLC / MALDI - To check homogeneity & absence of impurities.(2 Lectures) Isoform pattern -To check conservation of secondary structure. (1 Lecture) Gel electrophoresis:IEF, SDS PAGE and Native PAGE, Western blot -To check purity/ nativity.(2 Lectures) Fluorescence spectrum -To check presence of impurities such as quenchers.(1 Lecture) FTIR spectrum and NMR spectrum-To check presence of prosthetic group & conservation of tertiary structure. Bioassays. (3 Lectures) Example of characterization using Monoclonal Antibody as an example.(2 Lectures)	15	
Module IV: Quality assurance & regulatory affairs of Biologics and Biosimilars	Introduction to Regulatory Affairs and approvals of Biosimilars. (1 Lecture) Products approved under the FD&C (505) (b) (2) pathway/Act .(3 Lectures) PHS/BCPI Act 2009: Innovator Biologics Approval, Biosimilar Pathway, Totality of Evidence, Information required to demonstrate biosimilarity, Interchangeability, Product Switching, Product Naming. (6 Lectures) Global regulatory framework in ● India (1 Lecture) ● Europe (1 Lecture) ● UK (1 Lecture) ● Brazil (1 Lecture) ● China (1 Lecture)	15	

References:

1. Biosimilars,Regulatory, Clinical and Biopharmaceutical Development,Editors: Hiten J. Gutka •Harry Yang • Shefali Kakar,AAPS Advances in the Pharmaceutical Sciences Series Volume 34,Pg 173-182.
2. Biosimilars of Monoclonal Antibodies,A Practical Guide to Manufacturing Preclinical,and Clinical Development Edited by Cheng Liu, Ph.D., K. John Morrow, Jr., Ph.D.Copyright c 2017 by John Wiley & Sons, Inc. All rights reserved Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
3. Introduction to Biologic and Biosimilar Product Development and Analysis Karen M. Nagel AAPS Introductions in the Pharmaceutical Sciences Editor-in-Chief:Robin M. Zavod Midwestern University, Downers Grove, IL, USA
4. Biosimilars: Key regulatory considerations and similarity assessment tools: Carol F. Kirchhoff, Xiao-Zhuo Michelle Wang, Hugh D. Conlon, Scott Anderson, Anne M. Ryan, and Arindam Bose.
5. https://ibkp.dbtindia.gov.in/DBT_Content_Test/CMS/Guidelines/20181115140059519_Guidelines-on-Similar-Biologics-2016.pdf.
6. Regulatory Requirements of 'Similar Biologics' for Marketing Authorization in India. Review Article. Sharmila et al.,International Journal of Drug Regulatory Affairs;2017, 5(1), 20-24.
7. Introduction to Biosimilars and Regulatory Requirements. Fact Sheet 3. International Federation of Pharmaceutical Manufacturers & Association (Geneva) & International Alliance of Patients Organization (UK)
8. Regulatory guidelines for approval of Biosimilars in India, Europe, Brazil and China: A comprehensive overview
9. <https://www.fda.gov/drugs/drug-approvals-and-databases/approved-drug-products-therapeutic-equivalence-evaluations-orange-book>
10. <https://www.fda.gov/drugs/therapeutic-biologics-applications-bla/purple-book-lists-licensed-biological-products-reference-product-exclusivity-and-biosimilarity-or> <http://nib.gov.in/>

Elective Course 2: NGS and Bioinformatics (Theory)
Credits 2

Course Outcomes: On successful completion of the course the learner would be able to
CO1: Perform NGS library preparation techniques for DNA and RNA sequencing.
CO2: Interpret sequencing data to identify genetic variants, gene expression patterns, and genomic features.

Modules	Topics	Credit	No of lectures
Module I: Human Genomics and Next Generation Sequencing (NGS)	Human Genome Overview (2 lectures) , DNA Sequencing Technologies (3 lectures) , Library Preparation for NGS (2 lectures) , NGS Applications with Case Studies (2 lectures) , Genome Assembly and Human Genome Projects (3 lectures) , Human Genome Reference Sequences (Formats and Builds (3 lectures))	2	15
Module II NGS Alignment & Quantification	Essential NGS File Formats (FASTQ, SAM/BAM, VCF) (3 lectures) Quality Control (FastQC) (1 lecture) , DNA-Seq Read Alignment Algorithms (BWA, Bowtie2), (2 lectures) RNA-Seq Read Alignment with Splice Junction Detection (HISAT2, STAR), (3 lectures) Read Quantification (RPKM, FPKM, TPM (3 lectures)) Normalisation Techniques for Differential Expression Analysis (DESeq2, EdgeR) (3 lectures)		15

References :

1. Human molecular genetics, 5th ed., Tom Strachan & Andrew Read, CRC press.
2. Next-Generation Sequencing Data Analysis, 2nd ed., Xinkun Wang, CRC press.
3. Next Generation Sequencing and Data Analysis, 1st ed., Melanie Kappelman-Fenzl, Springer International publishing
4. Bioinformatics: A Practical Guide to Next Generation Sequencing Data Analysis, 1st ed., Hamid D. Ismail, CRC press

Course outcomes: On successful completion of the course the learner would be able to
CO1 : Demonstrate proficiency in using R for data manipulation and analysis.
CO2: Create and execute shell scripts to automate system administration tasks.

Practicals based on NGS and Bioinformatics

1. Navigating the Linux Command Line
2. Managing Files and Text in Linux
3. Getting Started with R Programming
4. Data Handling and Cleaning in R
5. Integrating Linux and R for Automated Data Analysis
6. Setting Up Environment with Miniforge
7. RNA-Seq Data Preprocessing
8. Alignment with Splice-Aware Aligners
9. Read Counting and Quantification
10. Differential Expression Analysis
11. Submission of Assignments - Data analysis using suitable databases.
12. Data plots using R or any other programming language.



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